Regional Investment Plan Continental South East

Final

European Network of
Transmission System Operators
for Electricity

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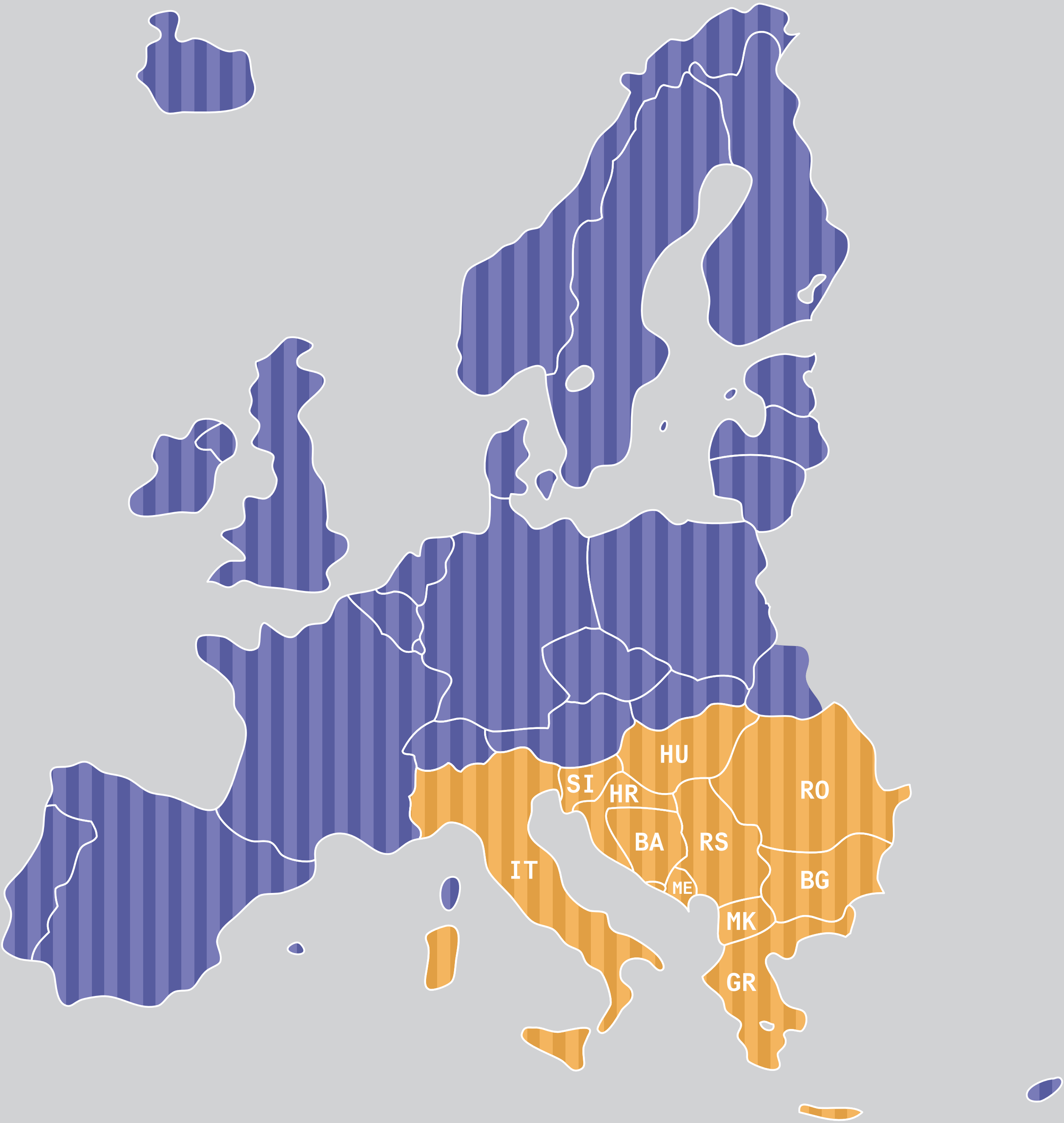
Regional Investment Plan Continental South East

Final

5 July 2012

Content

1 Executive Summary



The 3rd Legislative Package for the Internal Market in Electricity entered in to force on the 3 March 2011. It promotes cooperation within the European Electricity Industry, the development of the Electricity Infrastructure both within and between Member States, and looks at Cross-border Exchanges of Electricity between the Member States.

In this framework, the TSOs of the Regional Group Continental South East within ENTSO-E present this Regional Investment Plan 2012-2022. The region covered includes Hungary, Slovenia, Romania, Serbia, Bulgaria, FYR of Macedonia, Montenegro, Bosnia and Herzegovina, Croatia, Italy and Greece.

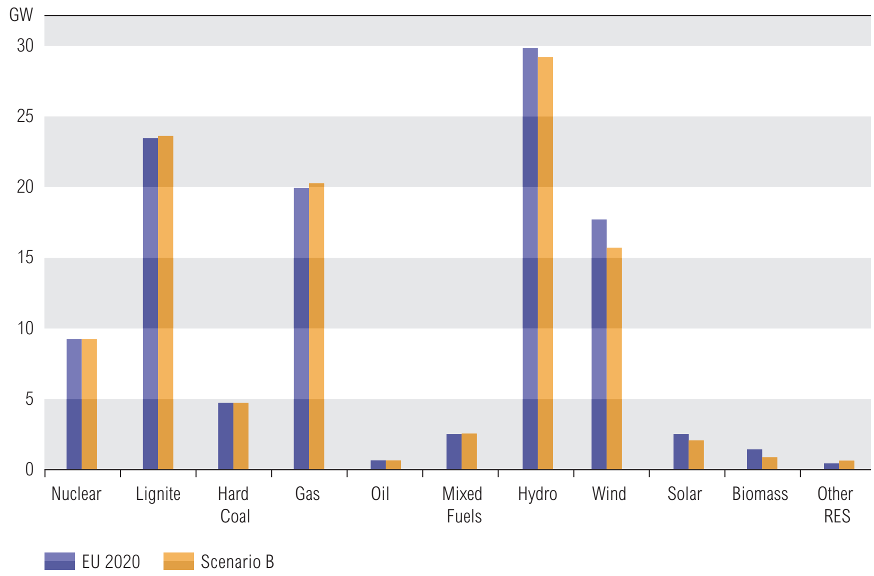
Today, the transmission system of the CSE Region of ENTSO-E is a rather sparse network with predominant power flows in specific power directions, namely East to West (E→W) and North to South (N→S). Concerning the generation mix, thermal production has the largest share (with a significant portion of lignite units). There is also significant hydro capacity while RES have low development (except Greece where ~2GW of RES have been installed).

The methodology used in the regional studies is based on the assumption that integration of internal markets and proper enhancement of networks should lead to 'least cost' generation. Uncertainties concerning the evolution of future generation capacity (location, type and capacity) are treated with a scenario-based approach. For each determined scenario, annual market simulation is performed on an hourly basis, leading to 'least cost' economical dispatch of all available generation. Based on the hourly market simulation results, DC power flows are performed, thus providing the loading duration curves of critical network elements. Grid Transfer Capability (GTC) is calculated for every boundary of the RG CSE and compared to hourly power flows in order to establish whether networks can support the 'least cost' dispatch found. Finally, proposed transmission projects are evaluated through the calculation of the energy efficiency (losses) indicator, the social welfare indicator and the CO2 emission indicator.

Two different scenarios have been simulated for the entire region, both for the year 2020. They represent different possibilities of the main variables involved in the behavior of the systems and thus, the markets.

- The first scenario has been referred to as the **"EU 2020"**, and represents a context in which all objectives of the European 20-20-20 are met (20% of RES in the final energy, 20% reduction of GHG, and 20% increase in energy efficiency).
- A second scenario has been referred to as **"Scenario Best Estimate"**, or **"Scenario B"**, and represents the best estimate conditions of the TSOs, regardless of whether or not European objectives are globally met.

In addition to these two scenarios, a sensitivity analysis **"Nuclear Phase Out (NPO)"** was conducted. In this analysis part of the nuclear units in Germany will be shut down (the total phase out is expected for 2022). It is built upon "Scenario B".



	Nuclear	Lig-nite	Hard Coal	Gas	Oil	Mixed Fuels	Hydro	Wind	Solar	Bio-mass	Other RES
EU 2020	9,2	23,4	4,8	20,0	0,8	2,5	29,9	17,8	2,6	1,4	0,5
Scenario B	9,2	23,6	4,8	20,2	0,8	2,5	29,3	15,8	2,4	1,1	0,6

Figure 1:
Installed capacity in the RG CSE per fuel type in the year 2020
(CSE total: EU 2020 = 113 GW, Scenario B = 110 GW)

Aggregated installed capacities in 2020 on a regional level in both scenarios are almost the same, as can be seen in Figure 1. Lignite and hydro plants are anticipated to remain the dominant generation types in the CSE region in the year 2020, with a 21% and 26,5% share of total installed capacity respectively.

Investment needs identified in the region for the next decade concern the increase of security of supply, supporting RES integration, strengthening of the interconnections between countries and increasing transfer capacity towards West Europe. In this context, the following map depicts the locations of expected new generation and load growth.

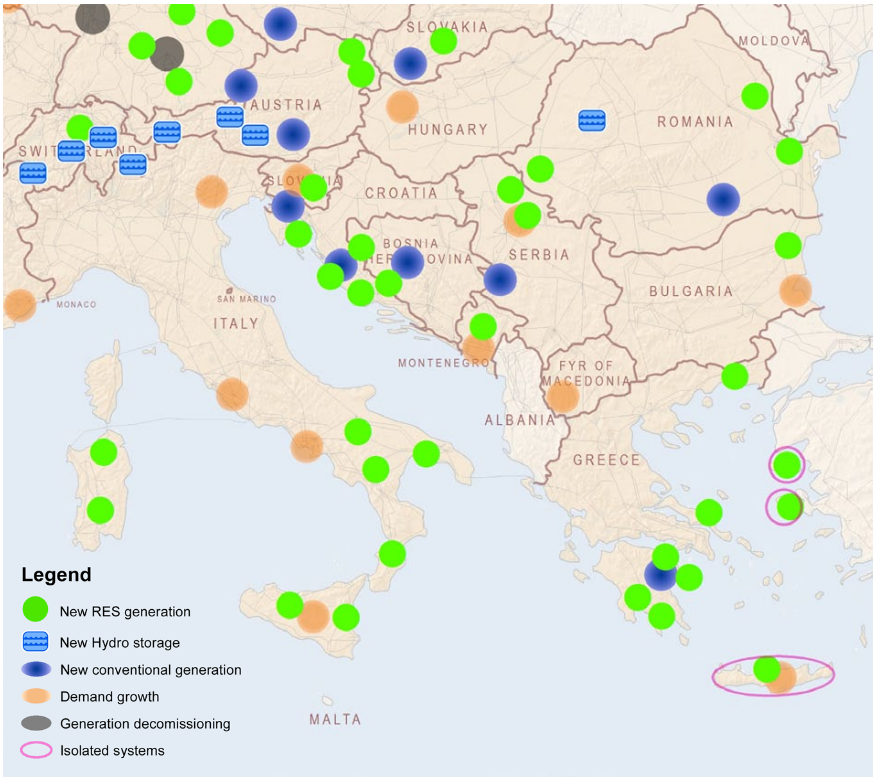


Figure 2:
Foreseen investment drivers in CSE region

Following the methodology described above, 9 main boundaries were identified. With respect to these boundaries, 9 projects (consisting of approximately 49 investments – not considering Italian projects) of pan-European significance have been planned by local TSOs. The cost of these projects is in the order of 10.8 billion Euros also including the portfolio of Italian projects.

The results of the exhaustive analysis based on the two scenarios examined and their variants, lead to the following main results/conclusions:

- Due to the sparsity of the network:
  - There is a strong interdependency in power flows and current GTCs are considerably limited in N-1 contingencies.
  - Planned projects (although using the TYNDP criteria are not valued for this benefit) significantly increase the SoS of the area and contribute to a considerable increase of GTC.
- For the scenarios analyzed, the planned projects seem to lead to a transmission network adequate enough to accommodate the expected power transfers up to the year 2020.

- From a Regional point of view, forecast installed generation up to the year 2020 is sufficient to reliably meet the anticipated demand in all examined cases.
- Due to the high portion of coal-fired generation, the area is sensitive to CO_2 prices; CSE's region seems to be an exporter in Scenario B (low CO_2 prices) but an importer in scenario EU2020 (high CO_2 prices).
- RES targets and their fast evolution necessitate the acceleration of several grid developments.
- The predominant power flow directions (E→W and N→S) still exist in 2020. The exchanges with TR and the possible interconnection of UA/MD in the future (since it was not taken into account in the studies) is expected to further increase the E→W bulk power transfers.
- Market integration with Western Europe (especially Italy) is a key driver for the development of the transmission system in CSE Europe.
- Nuclear Phase Out in Germany is expected to only moderately affect the region.
- Concerning the environmental impact of the transmission investments it seems to be rather low; in addition, the construction of the projects does not seem to face strong public opposition.
- Due to the sparsity of the network and the strong interdependency of power flows, close and efficient coordination among the TSOs is needed not only in the planning but also in the implementation/construction phase to achieve the timely commissioning of the required investments.

As a general conclusion, it is apparent that the realization of the scheduled transmission projects in the CSE region has a significant impact on the transfer capability over the networks in the area, thus improving security of supply and facilitating further integration of internal markets by enabling larger power exchanges among the countries of the Region and the rest of Europe.

2 Introduction

2.1 Expectations of the 3rd Legislative Package

The 3rd Legislative Package for the Internal Market in Electricity[1)] (hereinafter the 3rd Package), which entered in to force 3 March 2011, imposed a number of requirements on the European Electricity Industry in terms of regional cooperation to promote the development of the Electricity Infrastructure both within and between Member States, and looking at Cross-border Exchanges of Electricity between the Member States.

The key requirement of the 3rd Package which forms the legislative driver for the "2012 Ten Year Network Development Plan" suite of documents is Article 8.3(b) of The Regulation, whereby "The ENTSO for Electricity shall adopt: (b) a non-binding Community-wide network development plan,… including a European generation adequacy outlook, every two years".

The specific requirements are elaborated upon under Articles 8.4, 8.10 and 12.1 of The Regulation, covering the scope and content required in the publication. This includes; time frames for assessing overall generation adequacy, the relationship between National Development Plans and the Community-wide Network Development Plans, identification of investment needs and the requirement to publish Regional Investment Plans every two years.

The relevant text referred to above can also be found in the Ten Year Network Development Plan 2012-2022 document.

An explanation of how the TYNDP package meets these requirements is contained in Section 2.3.

2.2 ENTSO-E

ENTSO-E was established on a voluntary basis on 19 December 2008 and became fully operational on 1 July 2009, in anticipation of the entry in to force of the 3rd Package on 3 March 2011.

Today, 41 TSOs from 34 European countries are members of ENTSO-E. The working structure of the association consists of Working and Regional Groups, co-ordinated by three Committees (System Development, System

1) The 3rd Legislative Package for the Internal Market in Electricity refers to Directive 2009/72/EC, Regulation (EC) 713/2009 and Regulation (EC) 714/2009

Operations and Markets), supervised by a management Board and the Assembly of ENTSO-E, and supported by the Secretariat, the Legal and Regulatory Group, and Expert Groups. A list of countries and TSO members can be found at the end of this document.

The main purposes of ENTSO-E are:

– to pursue the co-operation of the European TSOs both at the pan-European and regional level; and

– to have an active and important role in the European rule setting process in compliance with EU legislation.

2.3 Documents in the TYNDP Package

The objectives of the TYNDP are to ensure transparency regarding the electricity transmission network and to support decision-making processes at regional and European level. The report is the most comprehensive and up-to-date European-wide reference for the transmission network. It points to significant investments in the European power grid in order to help achieve European energy policy goals.

The Ten Year Network Development Plan 2012-2022 (TYNDP), the Regional Investment Plans and the Scenario Outlook and Adequacy Forecast combine to meet the above aims and fulfil the requirements of Articles 8.3(b), 8.4, 8.10 and 12.1 of The Regulation as detailed in Section 2.1.

The focus of each document in the package is outlined below:

1. **Ten Year Network Development Plan 2012-2022:** The TYNDP focuses specifically on the projects of pan-European significance detailed within each Regional Investment Plan, covering those with significant contributions to cross-border flows and meeting large areas of demand. Further information on the content, methodology and selection criteria can be found in the TYNDP document itself.

2. **Regional Investment Plans:** [Comprising 6 individual, regional documents] The Regional Investment Plan documents overlap between the National Development Plans, which TSOs are bound to publish to their regulatory authority every year (under Article 22 of Directive 2009/72/EC) and the TYNDP document outlined above. It provides a more focused view of the development needs and project planning for all levels of investment at a regional level within Europe (as opposed to those solely of pan-European significance in TYNDP 2012-2022).

3. **Scenario Outlook and Adequacy Forecast:** The Scenario Outlook & Adequacy Forecast (SO & AF) assesses the future system adequacy at a mid- to long- term time horizon. It provides an overview of generation adequacy analyses for all of ENTSO-E, its regions as well as for individual countries, including an assessment of the role of the transmission capacities and security of supply on a regional basis.

More information about the history and evolution of the Ten-Year Network Development Plan can be found in the TYNDP document.

2.4 Regional Groups

As described in section 2.2, co-operation of the European TSOs both on the pan-European and regional level in order to undertake effective planning is the main requirement of the 3rd package, and therefore one of ENTSO-E's key purposes. To achieve this, ENTSO-E has divided itself into 6 regional groups for grid planning and system development tasks. The Member States belonging to each group are shown in Figure 3.

ENTSO-E considers the regional approach to be the most appropriate framework for grid development in Europe, and contains numerous instances of overlapping to ensure overall consistency of the **Regional Investment Plans.**

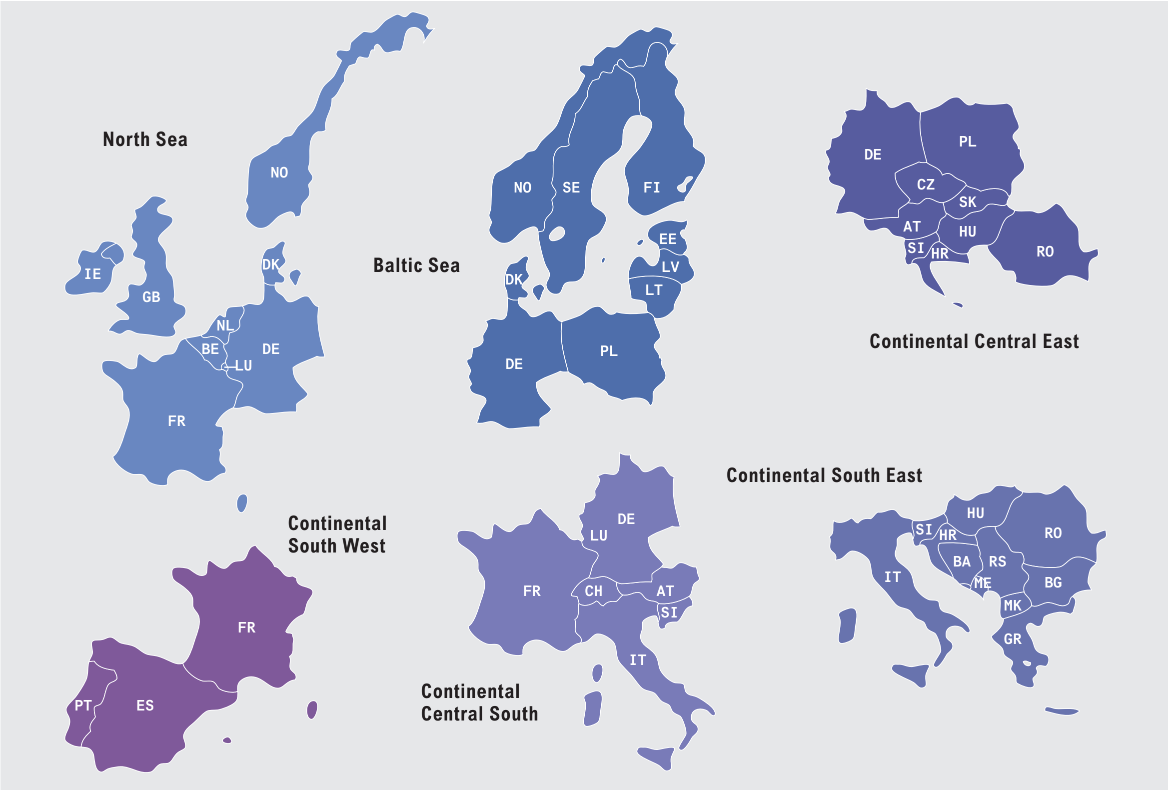


Figure 3:
ENTSO-E Regions (System Development Committee)

2.5 How to Read the Document

Chapter 3 identifies and explains the main changes which have occurred in the investments including the TYNDP 2010 submission.

Chapter 4 describes the specific methods used in the regional market and network studies, giving justifications of the models utilized.

Chapter 5 thoroughly examines the scenarios considered in developing the Regional Investment Plan, looking at the scenarios common to all plans contributing to the TYNDP 2012-2022 but also highlighting any regionally specific scenarios.

Chapter 6 presents the current Net Transfer Capability of the European electricity transmission networks, looking at present congestion and experienced flows. It then proceeds to look at how this will evolve over the ten year plan period, and identifies the main challenges and needs of the region.

Chapter 7 focuses on the Projects of European significance and National projects of interest identified to meet the investment needs identified in Chapter 6, split up into medium-term (2012 to 2016 inclusive) and long-term (2017+) projects.

Chapter 8 then looks at the overall adequacy of the transmission network after the proposed investments, and identifies any remaining challenges.

Chapter 9, where applicable, underlines the process of environmental assessment utilized in the course of constructing the Regional Investment Plan.

Chapter 10 revisits the resilience principles highlighted in the TYNDP 2012 – 2022 and justifies the planned investments, as well as highlighting and describing the adverse scenarios which may occur in the region and which require special attention and possible future investment.

Finally, the summary presents aggregates figures and statistics for the entire Regional Investment Plan.

3 Assessment of the TYNDP 2010 (Regional Focus)

The present chapter presents an overview of the main changes in the project consistency, commissioning date and status compared to the information presented in the pilot TYNDP 2010. More detailed monitoring data on every project is available in Appendix 1.

3.1 Delays in Commissioning Date

Lack of financial support influenced the uncertainty for implementation and postponed investments

- Postponed projects for strengthening the South-East part of the Bulgarian network and transfer capacity with Turkey with new 400 kV lines. Several projects in the East of Romania for RES and conventional generation have been delayed due to financial shortcomings. There is uncertainty for the interconnection between Serbia and Romania but efforts are being made by both sides to ensure the realization of the project as expected in the pilot TYNDP.

Projects delayed by implementation of other projects

- 400 kV interconnection Maritsa East 1 (BG) – N. Santa (GR) has lower priority after interconnection of Turkey and has been moved to LT.

Delays in permitting procedures

- The commissioning date has been pushed back 1 – 2 years for projects in Greece which have sought to bring a 400 kV corridor to Peloponnesus, thus strengthening the North-South corridor and future RES and conventional generation.
- The connection of TPP Sisak on existing line 220 kV Mraclin (HR) – Prijedor (BA) via a new double circuit line in Croatia (investment No 230) has been postponed by 2 – 3 years due to the prolonged permitting procedures and due to the harmonization with installation of a new generating unit in TPP Sisak.

Environmental problems

- Projects for connection of Cyclades island group in Aegean sea to the Greece mainland with the subsea DC and AC connections have been delayed although most of the problems pertaining to these technically complex projects have been resolved.

Delays in investment need

- Three new 400 kV substations in Hungary, which are needed for the connection of conventional generation will follow the dynamic of investment need and have been postponed to later dates.
- New 2 x 400 kV OHL line Plomin – Melina, together with new 400 kV switchyard and transformation 400/220 kV in TPP Plomin (Investment No 229). This is needed to connect new generator in Croatia but has been moved from a MT to LT time horizon due to the postponed commissioning date of a new unit in TPP Plomin.

3.2 Earlier Commissioning

Rapid development of RES increased the importance of the projects and moved them forward

Earlier commissioning to accommodate investment need(s)

- The need for the integration of more 2000 MW high penetrating new wind generation in the North-East part of Bulgaria. This project has been moved from LT to MT.
- Commissioning of 400 kV interconnection line Bitola (MK) – Elbasan (AL) set to earlier date to facilitate market integration and to resolve problems in supply in South-West FYR of Macedonia.
- As a result of Negotiations/bilateral studies, the new interconnection 2 x 400 kV Gabčíkovo (SK) – Gőnyü (HU) has been moved from LT to an earlier date.

3.3 Cancelled Investments

Implementation of the project became obsolete due to the implementation of other project(s)

- Construction of planned 400 kV lines in South-East Bulgaria eliminates the necessity for upgrade of 220 kV network.
- Investment in additional 400 kV line Konjsko (HR) – Mostar (BA) is postponed since it must be observed together with the previously planned new HVDC interconnection between Croatia and Italy, which is also postponed.
- Upgrade of 400 kV line Felsozsolca – Sajoivanka to double circuit is not justified since interconnection line R.Sobota (SK) – Sajoivanka (HU) will be mounted with one circuit.

Results of the new studies

- New studies suggest that installation of PST in 400 kV SS Sajoszoged in Hungary is not necessary.

3.4 Changes in Project's Consistency

Changes due to results of relevant studies

- Almost all projects in Romania have constructive characteristics and cost estimation updated as a result of progress of feasibility and design studies.
- Investment in new 400 kV interconnection between Croatia and Bosnia and Herzegovina from TYNDP 2010 is defined as the 400kV interconnection line Banja Luka (BA) – Lika (HR) (Investment No 27.227), which will enable integration of RES and conventional generation in Croatia, simultaneously strengthening the regional network in the East-West direction.

Project to accommodate additional investment need

- Apart form strengthening of the North to South corridor in Montenegro with 400 kV line Pljevlja – Lastva, the line will also enable the evacuation of future RES. Interconnection line between Romania and Serbia

will alleviate the congestion limiting export from East to West and enable integration of RES in both countries.
– The new 400 kV line Dobrudja-Burgas in Bulgaria will enable the safe integration of 2000 MW RES in Dobrudja region and will increase transfer capacity from the region and in North-South direction.

Updated investment costs

– Slovenia has updated their investments costs. The first was due to reassessment of the internal project "upgrade of the existing 220 kV network to 400 kV voltage level" along the corridor Divača-Kleče-Beričevo-Podlog-Cirkovce because previous investment cost included only part of the project (internal upgrade between Podlog-Cirkovce). The second change of the investment cost has been done on the project "double OHL 400 kV Okroglo(SI) – Udine(IT)" due to the exclusion of investment cost in the in-line PST.

3.5 Status Change

Completed projects

- Despite problems faced by other projects, six projects in the CSE region were fully completed and put into operation in the course of 2010, whilst two of them are interconnection projects: construction of double circuit 400 kV line Ernestinovo (HR) – Pecs (HU) and installation of the 2nd circuit on the Austrian side of the 400 kV line Wien SO (AT) – Szombathely (HU) were completed and put into operation in 2010.
- PST 400/400 kV in SS Divaca (SI) on 400 kV interconnection line between Italy and Slovenia is fully completed and has been in operation since 2010.

From the overview it can be concluded that the most frequent change is that of the commissioning date. The projects are either set to an earlier date or postponed due to various reasons. Out of 68 projects in the CSE region (not including new projects), almost half of them have commissioning dates changed, whilst 22 projects are postponed due to financial or permitting difficulties, environmental problems or have been delayed due to the implementation of another investment. As a result of high RES penetration and urgency in investment need, nine projects have been moved to an earlier date. The figure below depicts an overall view of the project's evolution, compared to the pilot TYNDP version.

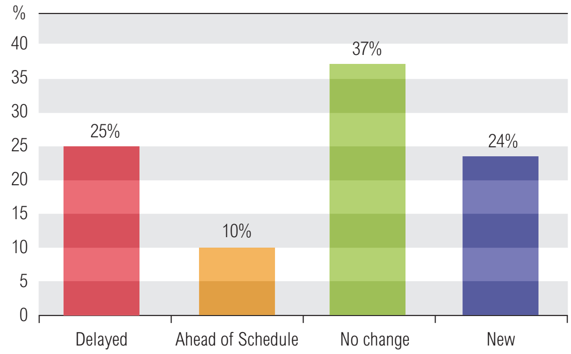


Figure 4:
Statistics of projects evolution in CSE region

4 Specific RG Methodology and Assumptions

4.1 TYNDP 2012 Methodology

Common main scenarios build the base of the analysis for the TYNDP and the Regional plans. These scenarios are described in Chapter 5. In addition, during the process of preparing the TYNDP and the Regional plans, a Pan European Market Database (PEMD) has been developed containing scenario supply and demand data as well as common data such as fuel prices. This common data is the basis for Regional analysis, both market model analysis and network analysis.

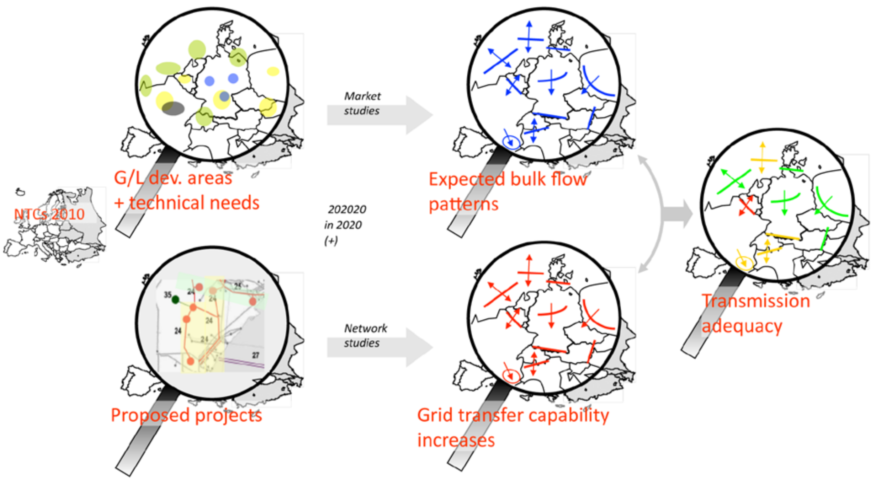


Figure 5:
Common TYNDP 2012 methodology

Market study results have also been used in defining the benefits of the planned investments. Common guidelines have been defined for project assessments.

Market studies have been performed at the regional level taking advantage of the existing competence and tools.

A common grid model is used to assess the future grid transfer capability with the planned investments and the resilience in stressed grid situations.

A more detailed description of the common method can be found in the TYNDP 2012.

4.2 Brief Description of the Overall RG CSE Methodology

The methodology is based on the assumption that integration of internal markets and proper enhancement of networks should lead to 'least cost' generation. Uncertainties concerning the evolution of future generation capacity (location, type and capacity) are treated with a scenario-based approach. For each determined scenario, annual market simulation is performed on an hourly basis, leading to 'least cost' economical dispatch of all available generation. Based on the hourly market simulation results, DC power flows are performed, thus providing the loading duration curves of critical network elements. Grid Transfer Capability (GTC) is calculated for every boundary of the RG CSE and compared to hourly power flows, in order to verify whether networks can support the 'least cost' dispatch found. Finally, proposed transmission projects are evaluated through the calculation of the energy efficiency (losses) indicator, the social welfare indicator and the CO_2 emission indicator.

The methodology was applied to the entire RG CSE, considering joint operation of the generation systems of Albania and Turkey with the CSE Region. The main steps of the methodology are analyzed in the following paragraphs.

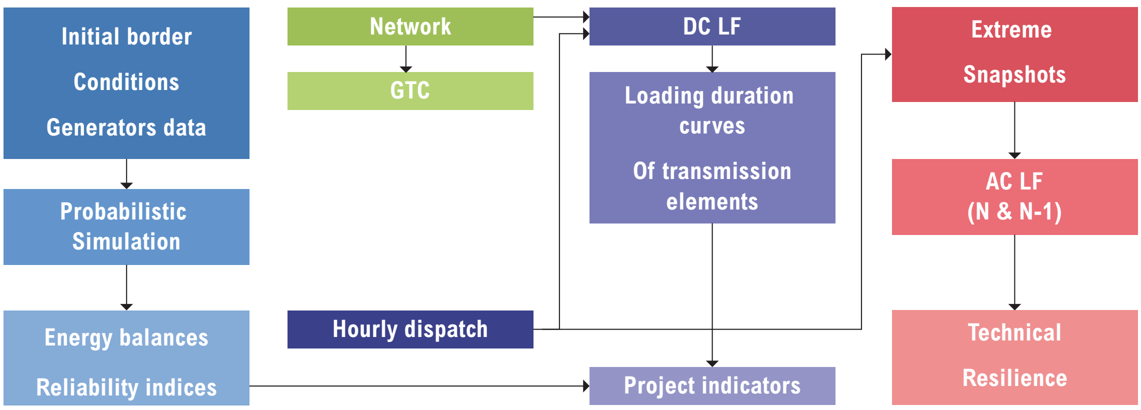


Figure 6:
Schematic description of the methodology

4.3 Market Studies

Market studies were performed for the entire RG CSE, considering joint operation of the generation systems of Albania and Turkey with the CSE Region. Italy was not fully modeled in the market simulation due to its large size (compared to the rest of RG CSE) and because it is also present in the RG CCS.

A software tool which simulates the joint operation of production systems of different areas was utilized for performing the Market Studies. The model performs two tasks:

– Annual probabilistic simulation, appropriate for adequacy studies, resulting in the annual energy balance and typical reliability indices (Loss of Load Probability, LOLP and Expected Unserved Energy, EUE)

– Hourly deterministic simulation resulting in hourly generation dispatch snapshot to be used as input for power flow studies (DC load flows are performed)

4.3.1 Basic Assumptions for Market Studies

The model developed for market/network simulation assumes detailed information regarding supply, demand and transmission data and therefore it was not possible to include RGs outside of the CSE in the simulation. As a result of this, all interconnections of the RG 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 RG CSE with ROW were assumed fixed and equal to the cross-border market flows provided by the Market Simulation Group under RG CCE.

The necessary data for performing the Market Studies of the CSE Region was obtained mainly from the PEMD. However, because this data is aggregated at a country level it was not sufficient for the detailed modeling of the production system and it was necessary to collect additional data, mainly concerning thermal units, from the TSOs of the CSE region. More specifically, net capacities and technical minimum values for the thermal units, as well as must-run obligations were requested and delivered from the TSOs. Furthermore, TSOs provided a detailed mapping of all generators in the network model (CSE Regional Winter Peak EU 2020) in order to link each generator to a specific generation type. All other data (loads, generation of RES etc.) was obtained from the PEMD, while standard values, according to the ENTSO-E guidelines, were used for thermal unit efficiency, availability and costs (fuel and O&M), as well as emitting coefficients.

Market studies were performed for the entire RG CSE, considering joint operation of the generation systems of Albania and Turkey with the CSE Region. Detailed data regarding supply, demand and transmission was provided by the Albanian TSO and therefore the Albanian system was fully modeled in the performed market studies. The interconnected to ENTSO-E system of Turkey was modeled with 5 nodes in the network file and a fixed schedule of 500 MW exports to Turkey was assumed. It should be pointed out that Italy was also considered as Rest of World, due to its large size (compared to the rest of RG CSE) and because it is also present in the RG CCS.

4.3.2 Market Simulation Model

Market simulation is performed by a probabilistic production costing model, which simulates the joint operation of multi-are generation systems for a given time horizon, using a weekly time step. The model computes the energy balance, the cost of operation, the polluting emissions and finally generation reliability. During each week, the generation mix and the loading order of the generating units are assumed to be fixed. The hourly loads of the period under consideration are assumed known and deterministic.

Initially, the model simulates the impact of interconnections with neighboring countries outside the CSE region, and then the operation of non-dispatchable renewable energy sources (wind, run of river hydros, solar and others). Following this, storage and pump storage hydro plants are simulated. The resulting load must be served by the thermal units of the system. More specifically, simulation of the generation system is performed through the following steps:

- On an annual basis and for each country of the CSE region separately, the model:
  - i. Modifies the chronological load series to account for imports and exports with countries outside the CSE region, the operation of non-dispatchable units, storage hydro units and pump storage units.
  - ii. Determines the annual maintenance scheduling based on the levelized criterion, taking into consideration maintenance requirements of generating units.
- The timeseries data of each country are aggregated into single regional timeseries. From this point on, the CSE region is considered as a single control area.
- The operation of the thermal units is simulated; for each week the model performs the following tasks:
  - Determines the dispatch order of the blocks of the thermal units. Blocks are placed in a priority list in ascending order of their incremental cost taking into account adopted practices of the system.
  - Dispatches the blocks of the thermal units according to the priority

list. Probabilistic techniques are utilized in order to account for the forced outage rates of the units. Hours of operation, required fuel and emissions for each thermal unit are determined.

  - Determines the reliability of the system in terms of the Loss-of-Load Probability (LOLP) and Expected Unserved Energy (EUE), the expected cost and expected CO_2 emissions.

- After the annual probabilistic simulation has been completed, deterministic hourly simulation is performed for the same set of input data:

  - Based on the previously obtained weekly merit order, thermal units are dispatched again, this time not taking into account their forced outage rate (FOR). Hourly generation for every thermal unit is determined.

4.4 Calculation of Bulk Power Flows

In order to calculate the bulk power flows on the CSE region boundaries the DC Load Flow model (a simplified linear approach to solving the power flow problem) is applied. This approach is commonly used in market related issues, such as NTC calculations, congestion management and so on, due to the simplicity and transparency which it provides. The use of the DC load flow (DC-LF) method decouples the problem of active power flows from reactive power and voltages which are in any case local issues. The DC-LF solution assumes that all voltages are equal to nominal values and therefore there is only one feasible solution, as opposed to the full AC load flow where various solutions can be achieved, depending on assumptions regarding compensating devices, transformer tap positions, reactive power provided by generating units and other parameters. Furthermore, the DC-LF solution can easily be reproduced by third parties, thus guaranteeing greater transparency.

Based on the hourly results obtained from the market simulation, snapshots for every hour of the year were created. Due to a lack of other information, aggregated timeseries provided in the PEMD (such as loads, RES generation and interconnections) were distributed to the appropriate nodes of the CSE regional model by appropriately scaling (up or down) the information available in the network file. The DC-LF problem was solved for every hour of the year, resulting in the loading of every transmission device (lines and transformers) of the CSE region for the entire year under consideration.

Hourly power flows on all tie-lines which form a boundary were appropriately summed, thus providing the desired Bulk Power Flows on each boundary on the RG CSE. Maximum and average values of the Bulk Power Flow on the dominant direction of each boundary are depicted on the maps.

4.5 Calculation of GTC

The process of capacity assessment on short-term level deals with the determination by TSOs of cross-border capacity available to the market. In operational planning for the calculation of available transmission capacity most of the TSOs used a technique based on NTC calculation.

$NTC = BCE + \Delta E - TRM$

where:

BCE: Base Case Exchange

ΔE: Maximum shift of generation which can be assigned to control areas involved in the interconnection preventing any violation of the N-1 security principle.

TRM: Transmission Reliability Margin

In long-term planning TSOs are more interested in obtaining a general image of border flows, and transmission capacities between different price zones. TRM values are not important in long-term planning bearing in mind that they are covering unexpected unbalanced situations in real-time as well as inaccuracies in data collection and measurements.

In order to separate the values of transmission capacity of the transmission network in the long-term and short-term planning rather than using the term NTC, ENTSO-E introduce the term GTC.

Grid Transfer Capability (GTC) is the ability of the grid to transport electricity across a boundary, that is, from one area (TSO, area within a country or price zone) to another, compatible with security standards applicable in the concerned areas. It depends on the considered state of consumption, generation and exchange, as well as the topology and availability of the grid.

4.5.1 Calculation Procedure

GTC[1] is calculated by simulating extra power transfer (ΔE) in addition to the base case exchange (BCE):

GTC = BCE + ΔE

In fact, extra power transfer, or maximal increase in power transfer, is simulated by appropriate changes in generation pattern in respective areas (generation shift, ΔE): by increasing the generation in source area, and in contrast, by appropriately decreasing the generation in sink area.

The Grid Transfer Capability is oriented, which means that across a boundary, there may be two different values. For the calculation of GTC a composite approach for definition of source/sink area is used (area may be single national TSO, area within a country or price zone, otherwise a set of TSOs, countries or price zones). A boundary may be fixed or may vary from one horizon or scenario to another.

This approach is based on the principle that power flows primarily from an area of relatively low generation cost to an area with a higher generation cost, and that the maximum benefit is achieved from the maximization of this flow. During the analysis, generation is increased on the exporting side of the boundary and decreased on the importing side.

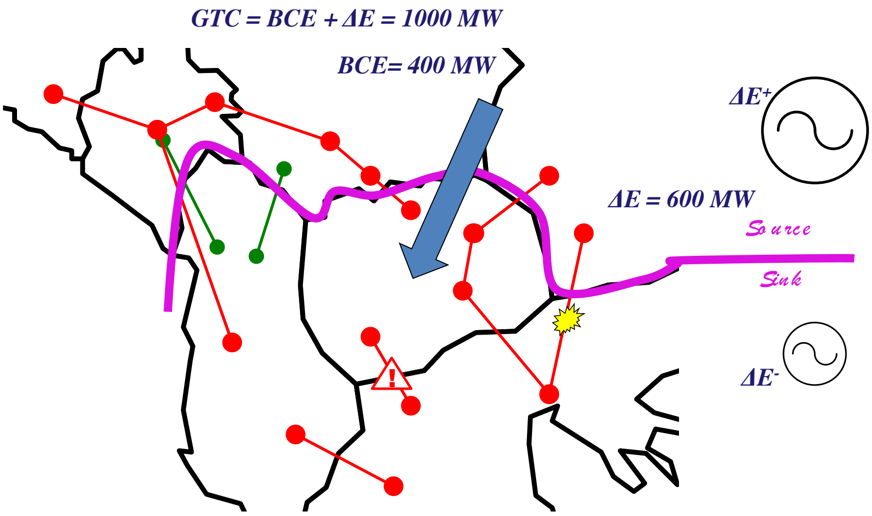


Figure 7:
Example of GTC calculation

GTC value from the source area to the sink area (see figure for illustration) is calculated by proportionally increasing the generation in the source area and proportionally decreasing the generation in the sink area. The shift of the generation is noted as ΔE^+ for the generation increase in the source area and ΔE^- for generation decrease in the sink area. If surplus of power is

[1] ENTSO-E Operational Handbook, Policy 4

exhausted in the source area, additional artificial generation reserve is considered (generation shift is achieved proportional to engagement, while ignoring generation technical limits).

GTC is assumed to be equal to TTF (Total Transfer Flow) or TBC (Total Border Capacity), that is, sum of the physical active power flows in the base case (Flowref) and the flow from maximal generation shift (PTDF x ΔE), on all tie-lines which form the boundary.

GTC = (TTF, TBC) = Flowref + PTDF x ΔE.

Although GTC is defined as an exchange program, in order to bypass the problem of parallel flows and the so-called "contractual path" of flows, maximal generation shift between investigated areas is distributed (using PTDF – power transfer distribution factors) on all interconnection lines in the model according to physical flows. In other words, the value of GTC is identical to the real physical flows between systems while maximal possible exchange is obtained and N-1 criterion is satisfied.

4.5.2 Security Standards (N-1)

For N-1 security check (contingency and monitoring) the following are taken into account:

- all 400 kV & 220 kV internal elements,
- all 400 kV & 220 kV tie-lines in the SEE.

When selecting the critical contingency which determines transfer capability limit, only the network in the vicinity of the boundary is considered.

4.5.3 Contribution of Projects in Regard to ΔGTC

The methodology is applied, considering as a starting point the WP 2020 regional model with all new investments (grouped in projects) of the investment plan IN operation.

The contribution of each project is assessed by setting the respective project OUT of operation and assessing the ΔGTC variation on the respective boundary:

$\Delta GTC_{\text{project X}} = GTC_{\text{all projects, IN}} - GTC_{\text{project X, OUT.}}$

Calculations follow this order:

- For every source>sink pair, a list of the most restrictive contingencies is generated, with ΔE (maximal generation shift) for every contingency.
- One contingency is selected as the most relevant for transfer capability assessment.

- Using distribution factors (PTDF), selected ΔE (maximal generation shift) is distributed on all interconnections in the Continental South East.
- The load flows originating from this ΔE (maximal generation shift) which are added on base case flows (Flowref), are summed as GTC values.
- For each studied project, it is assumed that the GTC on the respective border/s is given by:
- $GTC = Flow_{ref} + PTDF \times \Delta E$
- The contribution of each project on grid transfer capability on respective boundary, ΔGTC, is assessed by calculating the difference between GTC value calculated for the base case network topology with all projects are IN operation, and GTC values calculated for specific network topology while the respective project is OUT of operation:
- ΔGTC project X = GTC all projects, IN – GTC project, OUT.

4.6 Calculation of Indicators

4.6.1 Energy Efficiency Indicator

The approach adopted to evaluate the impact of new transmission projects on losses, aims to estimate annual average losses using as input the available winter peak load snapshot (Peak load, grid losses) and the forecast yearly energy consumption. With this data, equivalent hours' loss factor is calculated, that is, the average number of hours during which it would be necessary for the peak load to be carried out in order to give the same energy losses as those given by the actual load throughout the year.

With these in mind, calculations have been performed with all new projects and without one project each time, keeping the same generation and load pattern in order to assist comparison.

4.6.2 Social Welfare and CO_2 Indicators

Because the market model is a single node model (transmission is ignored) it is not possible to calculate the impact from each project on total generation costs and emissions (before and after). In order to calculate the required indicators (the impact of projects on social welfare and on emissions), the following approach was adopted:

For each project under examination:

- The model was executed with and without the project in consideration (while market results were the same, power flows varied).
- Power flows were calculated on the respective boundary (with and without the project) and compared to the appropriate GTCs.
- When calculated power flows exceeded respective GTC, the RG CSE was divided into two areas, across the boundary (North and South, or East and West).
- Simulation was performed for each subarea separately, considering the rest of the region and the outside world as ROW. Flows between the two subareas were taken from the initial model run and were adjusted within the limits set by the appropriate GTCs.
- A summation of market results for both subareas provided an estimate of the redispatching required so that flows along the boundary in question were within the desired limits.
- Variation in generation cost provided the value of the Social Welfare Indicator, while the variation of CO_2 emissions provided the value of the CO_2 Indicator.

5 Scenarios and Market Model Results

5.1 Description of Scenarios

Two different scenarios have been simulated for the whole region, both for the year 2020. They represent different possibilities of the main variables involved in the behavior of the systems, and thus the markets.

- The first scenario has been referred to as the **"EU 2020"**, and represents a context in which all objectives of the European 20-20-20 objectives are met (20% of RES in the final energy, 20% reduction of GHG, and 20% increase in energy efficiency).
  - Efficiency measures adopted result in low annual demands in all countries.
  - The prices of the main fuels, gas and coal, were taken from the reference scenario of the International Energy Agency in its World Energy Outlook. CO_2 price is higher, and CCGT units are generally cheaper than coal plants, except for the coal with "must-run" conditions.
  - The installation of power from RES is optimistic, according to the National Renewable Energies Action Plans sent to the European Commission.
- A second scenario has been referred to as the **"Scenario Best Estimate"**, or **"Scenario B"**, and represents the best estimate conditions of the TSOs, regardless of whether or not European objectives are globally met.
  - Higher demand growth rates result in significantly higher demands all over the simulated region.
  - The prices of CO_2 emissions used were the central forecasts of the IEA, and result in lower variable generation cost for most coal plants in Europe (particular efficiencies of coal or CCGT plants sometimes invert this merit order).
  - The installation of power from RES was the central forecast of the TSOs, and is generally (but not always) lower than the national targets.

In addition to these two scenarios a sensitivity analysis **"Nuclear Phase Out (NPO)"** was conducted. In this analysis part of the nuclear units in Germany will be shut down (the total phase out is expected for 2022). It is built upon "Scenario B".

For both scenarios and the Nuclear Phase Out analysis, similar data with standard format has been shared among TSOs through the Pan-European Market Database (PEMD), in order to allow a simplified modeling of the entire European region. Some additional information is shared among TSOs of one RG when higher detail is needed for the simulated region (must-run constraints of specific units, ramp rates, min time ON/OFF, hourly NTCs between neighbor systems etc.).

For a more detailed description of scenarios and the history of scenarios, the reader is referred to the Ten-Years Network Development Plan 2014.

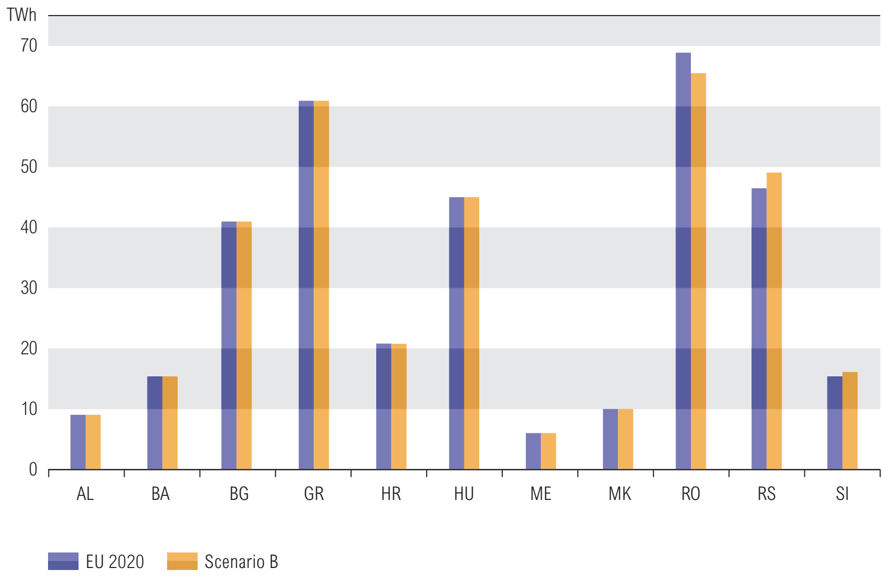
5.2 RG CSE Specific Scenarios

Market studies for the CSE region were mainly focused on the common scenarios EU2020 and B. Based on the common data in the PEMD and additional information shared by the TSOs of the RG CSE, a detailed mapping of anticipated generation and demand was formed for each scenario.

The model developed for market/network simulation assumes detailed information regarding supply, demand and transmission data and therefore it was not possible to include RGs which were outside of the CSE in the simulation. All interconnections of the RG CSE (inside and outside of ENTSO-E), with the exception of interconnections with Albania, 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 RG 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 detailed data was provided by the Albanian TSO and therefore Albania was fully modeled and considered as part of the RG CSE. Italy was not fully modeled in the market simulation and therefore was considered as ROW, due to its large size (compared to the rest of RG CSE) and because it is also present in the RG CCS. Results and figures presented here include values for Albania, but not Italy.

Foreseen demand in the year 2020 for the simulated CSE region is expected to reach almost 340 TWh and is depicted in Figure 1. Indeed, from this figure it is evident that only a few of the region's countries have considered a slightly increased demand for Scenario B.



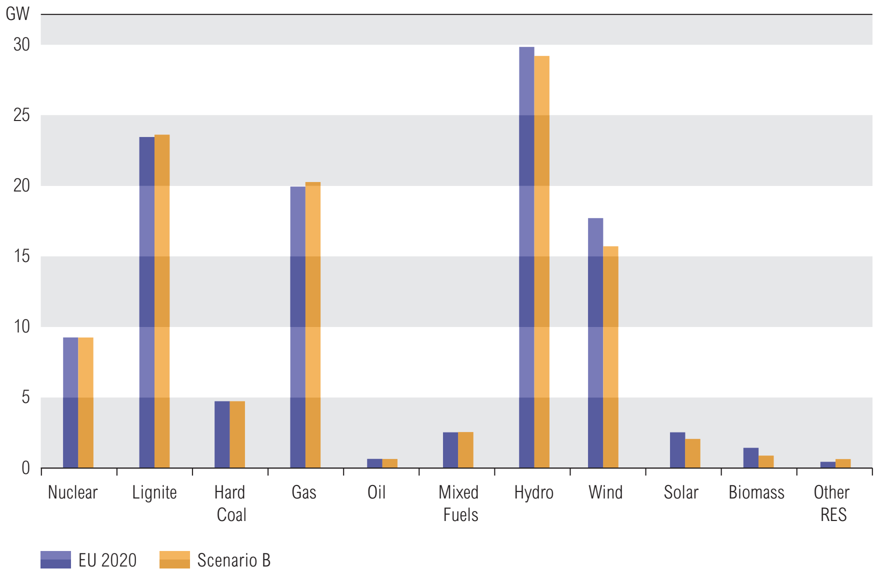
	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
	9	15	41	61	21	45	6	10	68	46	15
	9	15	41	61	21	45	6	10	65	49	16

Figure 8:

Forecast demand in the RG CSE for the year 2020

(CSE total: EU 2020 = 338 TWh, Scenario B = 339 TWh)

Aggregated installed capacities in 2020 on a regional level in both scenarios are almost the same, as can be seen in Figure 9. Lignite and hydro plants are anticipated to remain the dominant generation types in the CSE region in the year 2020, with a 21% and 26,5% share of total installed capacity respectively.



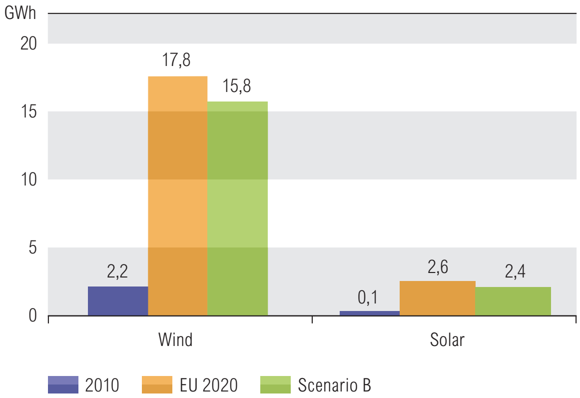
	Nu-clear	Lig-nite	Hard Coal	Gas	Oil	Mixed Fuels	Hy-dro	Wind	Solar	Bio-mass	Other RES
EU 2020	9,2	23,4	4,8	20,0	0,8	2,5	29,9	17,8	2,6	1,4	0,5
Scenario B	9,2	23,6	4,8	20,2	0,8	2,5	29,3	15,8	2,4	1,1	0,6

Figure 9:

Installed capacity in the RG CSE per fuel type in the year 2020

(CSE total: EU 2020 = 113 GW, Scenario B = 110 GW)

According to national NREAPs, scenario EU 2020 foresees a total target of 52 GW RES installed capacity (including large hydros) for the CSE region, 34 % of which refers to wind parks. In Scenario B respective TSOs project a lower RES penetration by 3 GW, compared to the scenario EU 2020, namely 2 GW less wind parks. In both scenarios, considerable growth of installed wind and solar capacities is foreseen during this decade, as can be seen in Figure 10.



	Wind	Solar
2010	2,2	0,1
EU 2020	17,8	2,6
Scenario B	15,8	2,4

Figure 10:
Foreseen growth of installed wind and solar capacities in the RG CSE

Table 1 summarizes the main differences between scenario EU 2020 and Scenario B. It can be seen that while total annual demand and aggregated installed capacity are almost identical in both scenarios, Scenario B considers 11 % lower RES generation compared to the EU 2020 scenario.

Regarding the boundary conditions, scenario EU 2020 foresees that the RG CSE imports a significant amount of energy, while in Scenario B the Region exports significant energy. This is due to the fact that the RG CSE has a considerable number of lignite-fired units, and if a low CO_2 emission price is effective, the electricity generated in the region is expected to be very competitive.

	EU 2020	Scenario B
Demand (TWh)	337,6	338,6
Peak load (GW)	55,4	55,6
Installed capacity (GW)	112,9	110,7
RES generation (TWh)	133,2	118,5
Net imports from ROW (TWh)	10,4	-11,1

Table 1:
Comparison of scenarios EU 2020 and B for the RG CSE

As previously mentioned, CO_2 emission prices have been selected in order to achieve the desired merit order of thermal units, that is, to invert the loading order of lignite and CCGTs in the EU 2020 scenario compared to the business as usual assumption of Scenario B. Figure 11 depicts the impact of selected CO_2 emission prices on the merit order of generating units, as obtained by the model utilized for performing the market studies (see Chapter 4). It can be noted that when the high CO_2 emission price is adopted, lignite-fired units become more expensive than natural gas CCGT units and are moved up in the merit order; however their minimum stable generation is dispatched before CCGT generation is exhausted, because of the inflexibility of these units.

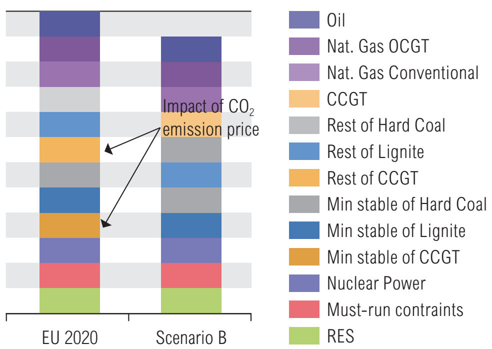


Figure 11:
Merit order for each scenario

5.2.1 Additional Market Scenarios

In addition to the base case scenarios EU 2020 and B, the impact of a Nuclear Phase Out in Germany was examined (NPO variant). All assumptions regarding generation and demand remained the same, however boundary conditions varied. Again, power flows from/to RG CSE with ROW were assumed fixed and equal to the cross-border market flows provided by the Market Simulation Group under RG CCE, shown in Table 2.

	EU 2020	Scenario B
	(TWh)	
Base Case	10,4	-11,1
Nuclear Phase-Out (NPO)	7,3	-15,4

Table 2:
Net imports from ROW

Furthermore, a sensitivity analysis of the base case results to the selected CO_2 emission prices was performed. Maintaining all other assumptions, market studies were performed for the EU 2020 scenario and Scenario B with the inverse CO_2 emission prices.

5.2.2 Aanalyzed Cases

Annual simulation was performed for every scenario. In addition to annual results, the decision was taken to focus on hourly simulation results for specific snapshots of interest. More specifically, results for the following snapshots were evaluated and used as input for network studies:

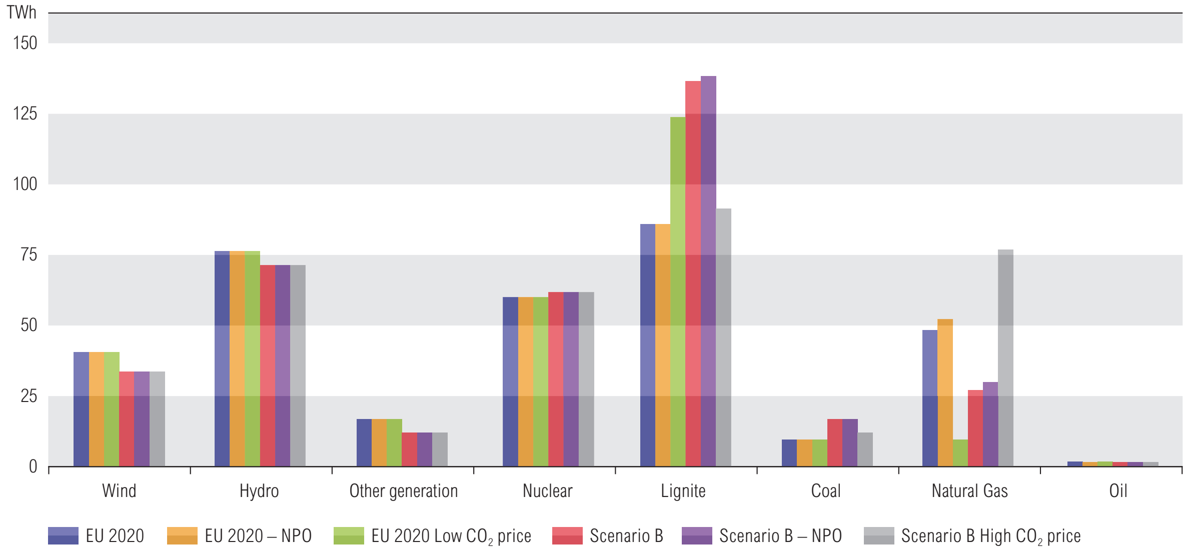
- **January 19:** 3rd Wednesday of January on the 19th hour
- **June 11:** 3rd Wednesday of June on the 11th hour
- **Max load:** Hour corresponding to the RG CSE peak load
- **Min load:** Hour corresponding to the RG CSE minimum load
- **Max Wind:** Hour corresponding to the maximum generation of wind parks in the RG CSE

Market simulation results for the January 19 and June 11 snapshots are given in the Appendix.

5.3 Market Results and Conclusions

Figure 5 depicts the expected contribution of each fuel type in the energy balance in the RG CSE (including Albania) for the year 2020 which resulted from the annual probabilistic simulation for all examined cases, namely the base case scenarios EU 2020 and B, the nuclear phase-out scenarios in Germany (NPO), as well as sensitivity analysis of the base case results for the selected CO_2 emission prices. The expected net import balance (imports minus exports) for each country in shown in Figure 13.

Variation in CO_2 emissions for the CSE region is shown in Figure 12. Detailed results of all scenarios examined are given in the Appendix.



	Wind	Hydro	Other gen.	Nucl.	Lignite	Coal	Natural Gas	Oil
(EU 2020)	41	76	16	61	85	10	48	1
(EU 2020 – NPO)	41	76	16	61	85	10	52	1
(EU 2020 Low CO_2 price)	41	76	16	61	123	9	11	1
(Scenario B)	34	71	13	62	136	17	27	1
(Scenario B – NPO)	34	71	13	62	137	17	30	1
(Scenario B High CO_2 price)	34	71	13	62	91	13	76	1

Figure 12:

Expected contribution of each generation type in the energy balance of RG CSE in the year 2020

	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI	RG CSE
	0	1	-7	-4	8	16	2	2	-8	-4	4	**10,4**
	0	1	-6	-6	8	15	2	2	-9	-3	4	**7,3**
	0	-5	-11	11	10	18	0	1	-5	-10	1	**10,4**
	0	-7	-16	-4	8	15	2	0	-8	-3	2	**-11,1**
	0	-7	-16	-6	7	14	2	0	-8	-3	2	**-15,4**
	-1	0	-9	-16	7	10	3	1	-13	2	5	**-11,1**

Figure 13:
Expected net import balance in the RG CSE for the year 2020

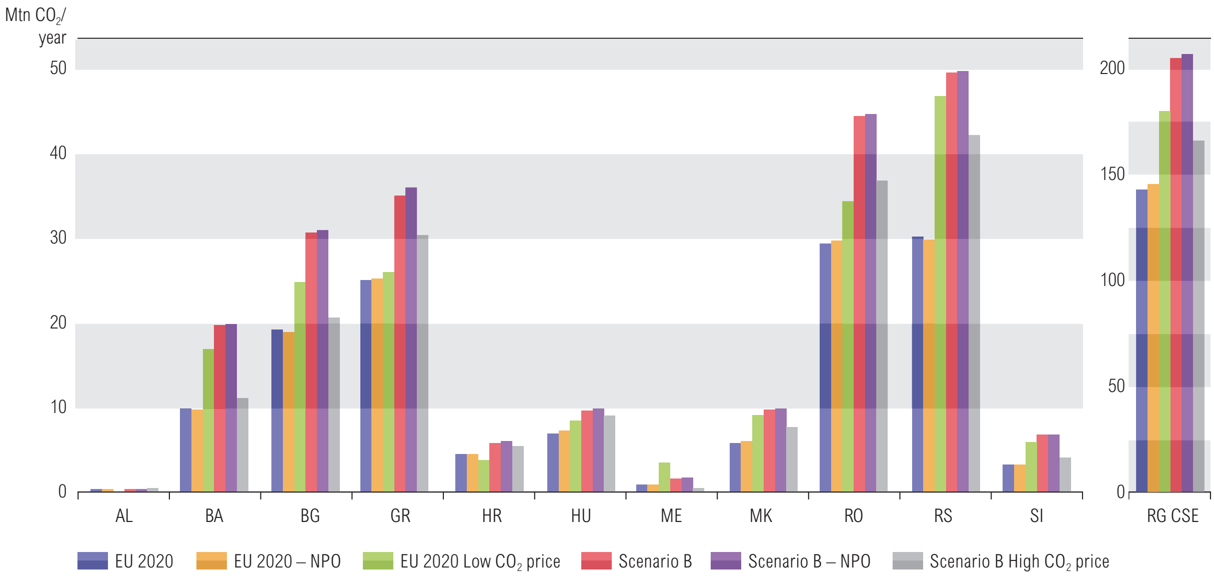
From the results displayed in Figure 14 it can be noted that significant generation from lignite and coal units remains in scenario EU 2020, despite the high CO_2 emission price assumed. This is due to the technical characteristics of these units, namely their inflexibility. The market model takes into consideration the fact that these types of units are unavoidably base loaded units (start up and shut down times are too high to turn on and off as desired). The model also assumes that if they are committed during a week, their generation may be limited to the minimum stable generation, but they will not shut down. Oil generation in all scenarios is the result of must-run constraints in Hungary and Albania.

In both base case scenarios (EU 2020 and B), Albania, Bulgaria, Greece, Romania and Serbia are expected to be exporters in the Region, while Bosnia-Herzegovina is expected to export energy only in Scenario B (where lignite generation is competitive). All other countries in the CSE region are importers, in both scenarios, with Hungary importing large amounts of energy from neighboring countries outside the region.

Focusing on scenario EU 2020, it can be seen that the Nuclear Phase Out scenario does not have a significant effect on market results. Net imports from the 'outside world' (ROW) on a regional level decrease by almost 21 % and this energy is covered by the increase of the generation of CCGTs, mainly in Greece, Hungary and Romania. Lignite generation is slightly reduced in order to accommodate cheaper generation by natural gas fired units. Conversely, the selected CO_2 emission price has a drastic, although anticipated, effect on market results. It is assumed that the low CO_2 emission price for scenario EU 2020 leads to a considerable shift of natural gas generation to cheaper lignite generation. Lignite generation is increased by 43.7 %, resulting simultaneously in the increase of CO_2 emissions by 23.8 %. The shift of generation from natural gas towards lignite turns Greece into an importing country, while Bosnia-Herzegovina also switches from an importing to an exporting energy balance.

Similarly, for Scenario B the additional energy exported from the CSE region (an increase of almost 63 %) when considering the Nuclear Phase Out scenario is again mainly covered by CCGT generation in Greece, Hungary and Romania since regional lignite generation has already been fully exploited. When examining the variant considering a high CO_2 emission price, as anticipated, lignite and coal generation are decreased by 33.2 % and 24.7 % respectively in favor of natural gas generation, resulting in a 21.7 % reduction of total CO_2 emissions. In this variant of Scenario B, FYR of Macedonia and Serbia switch from an exporting to an importing annual energy balance.

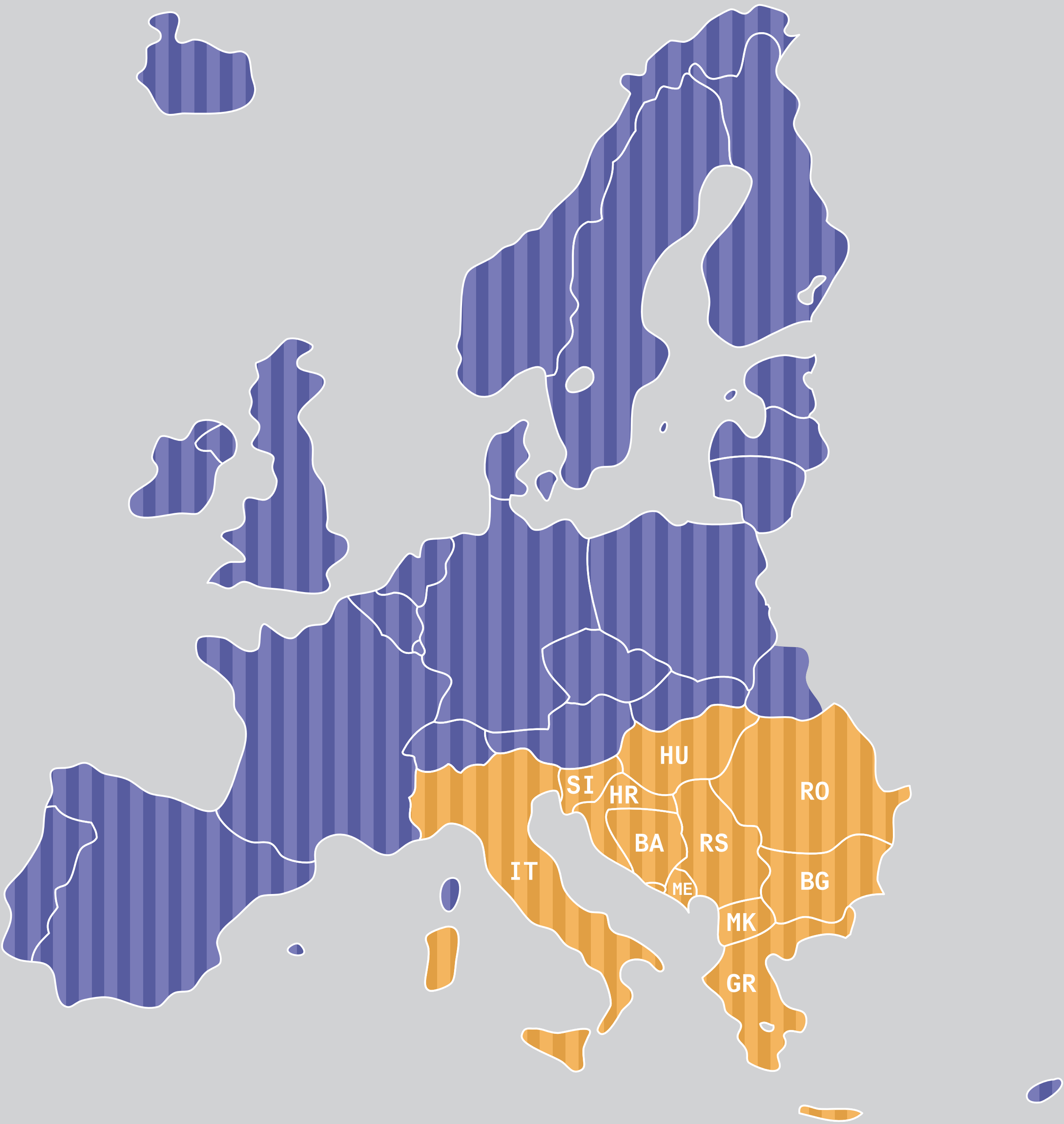
Regarding the forecast of regional adequacy, market studies have shown that the foreseen installed generation capacity in the year 2020 is sufficient to reliably meet the anticipated demand, in all cases examined. More specifically, simulation in all cases leads to zero values, on a regional level, for the probabilistic reliability indices Loss of Load Probability (LOLP) and Expected Unserved Energy (EUE).



	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI	RG CSE
	0,2	9,6	18,8	24,4	4,3	6,0	1,6	6,3	29,2	40,5	3,2	**143,9**
	0,2	9,4	18,6	25,2	4,3	6,4	1,6	6,4	29,3	39,7	3,2	**144,2**
	0,0	17,3	24,7	25,9	3,5	7,2	3,3	8,5	33,6	47,9	6,4	**178,2**
	0,2	19,6	31,3	34,1	5,4	9,5	1,8	9,7	44,0	49,1	7,2	**214,4**
	0,2	19,7	31,5	35,1	5,5	9,8	1,9	9,8	44,6	49,2	7,2	**214,4**
	0,3	11,0	20,8	30,4	4,8	8,5	0,8	7,0	36,2	42,2	3,9	**165,9**

Figure 14:
Comparison of expected CO_2 emissions for the RG CSE in the year 2020

6 Investment Needs



A picture of the current situation regarding the range of NTC values in the CSE Europe is depicted in the map below. The main characteristic of the transmission network in CSE region is inter-dependency, that is, cross border exchanges between two power systems significantly influence power flows in the rest of the network, especially in neighboring ones. This should be attributed to the sparsity of the Regional network.

As a consequence, transit power flows in the predominant East-West and North-South directions create congestion especially for countries close to the main exporters and importers of the area. Characteristic examples of countries facing such transits include Slovenia, Serbia and FYR of Macedonia.

Figure 15:
NTC values for winter 2011

6.1 Drivers of System Evolution

The transmission grid in the Continental South East European region is rather sparse when compared to the relevant grid of the rest of the continent. The main drivers of the future developments which are of European interest include:

- Contribution to market integration in the Region, in terms of necessary network reinforcements to increase cross-border capacities and consequently the volume of power exchanges.
- Accommodation of new conventional generation and future RES production.
- Enhancement of SoS in certain areas of the Region.
- Extension and further reinforcement of the synchronous zone to the East

A graphical representation of the mentioned drivers is shown in the map of Figure 16. This map displays the geographic location of future generation and areas where demand growth is expected.

Predominant power flows in the Continental South East Region are in the North-South and East-West direction. These are dictated by the power balances and market prices of the member countries. For instance, the block including Greece, FYR of Macedonia and Albania as well as Italy are usually importers. Imports of these countries from Bulgaria and Romania which have a surplus of generation, and from countries on the North borders of the South East Europe Region, define the above principal power flow directions. Strengthening of the Regional network in predominant power flow directions, in order to assist market integration, is a main driver which stimulates investment needs in the medium term as well as in the long-term. This driver is identified mainly in the North Borders of the Region as well as the South part and in the West of the CSE Europe area.

Accommodation for new conventional generation appears as an investment need to Romania, Greece Serbia, Croatia, and Bosnia and Herzegovina. Investment needs relevant to RES integration are related to the EU 2020 targets and constitute a major challenge in the area. In the mid-term such needs are identified in Romania, Bulgaria, Greece and Montenegro. In the long-term these needs extend to Serbia, Bosnia and Herzegovina, Croatia and Slovenia.

Investment needs relevant to the integration of both conventional and RES generation creates further need for increasing transfer capacities between South-East European countries and Italy, in order to extend towards the Italian and Western Europe electricity market.

Investment needs relevant to growth of demand appear in Hungary, Bulgaria, FYR of Macedonia, Greece, Montenegro and Slovenia. Regarding the

East borders of the CSE Europe, investment needs are identified in Bulgaria, Greece and FYR of Macedonia, with the aim of increasing transfer capacity of the borderers of Turkey and Continental Europe. In the long run investment needs are identified in Romania and are related to the possible interconnection of Moldova and Ukraine with the continental synchronous system. This project could cease increased flows from the East to the West.

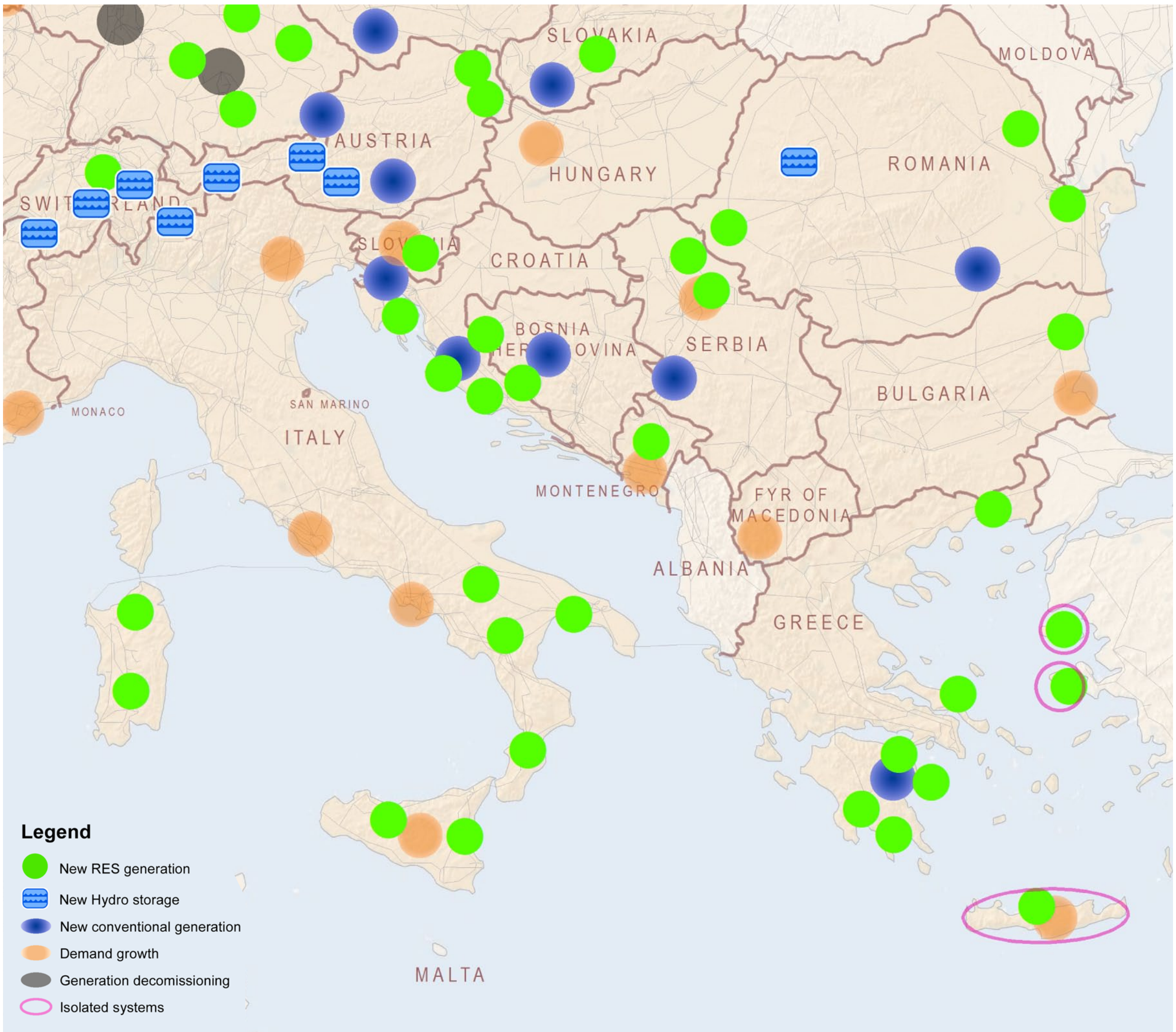


Figure 16:
Map of drivers for the CSE region

6.2 Bulk Power Flows in 2020

The investment drivers presented above will contribute to the creation of bulk power flows triggering grid developments in specific parts of the network. In the map shown below, these parts of the regional network (boundaries) are depicted, using a different color code in order to address the main concern triggering the need to increase transfer capacity in the specific part of the network. These concerns can, for the most part, be classified as one of three possible types:

- Market integration
- Direct generation connection
- Security of supply

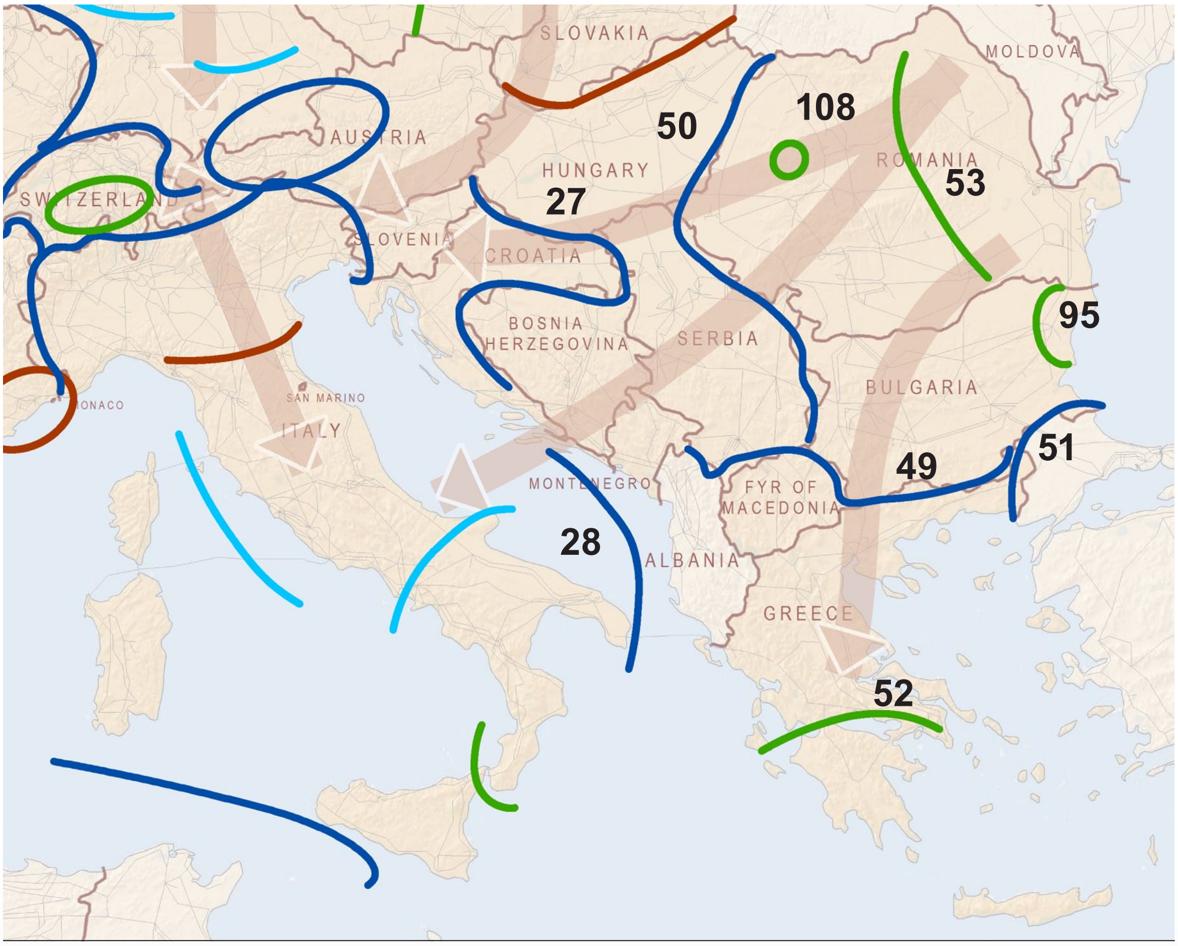


Figure 17:
Map of main concerns in CSE Europe

With reference to the numbering of the map, boundary 27 is related to network reinforcements necessary to enhance East-West corridor in the NW part of the Continental South East Region, where exports of energy from the Region to Italy through the SI-IT borders is the most relevant factor. These reinforcements also include accommodation of new RES and conventional generation expected in Slovenia, Croatia and Bosnia and Herzegovina as well as the removal of internal congestion at North-South axis in the Croatian transmission network in order to strengthen security of supply for emergency situations as well.

Boundary 28 is also relevant to exports of the South East Europe area towards Italy, but this time through existing and foreseen HVDC cables across the Adriatic Sea. Necessary reinforcements include the expansion of the capacity of HVDC links both in the mid-term and long-term as well as complementary investment needs in order to support power flow towards Italy and also to accommodate evacuation of new generation in Croatia, Bosnia and Herzegovina and Serbia.

Boundary 50 defines the West borders of Romania and Bulgaria with the rest of Continental South East Europe. Bulk power flow on this boundary "follows" the aforementioned East-West trend of predominant power flows in the area. Necessary reinforcements will increase transfer capacity in this direction and will additionally assist the safe integration of a considerable amount of RES expected in Romania and Serbia.

Boundary 49, in the South part of the CSE Europe area is related to necessary reinforcements in order to assist power transfers in the North-South direction. Boundary 51 is defined in the borders of CE Europe and Turkey. Necessary reinforcements are identified in the Bulgarian and Greek transmission networks close to these borders also aiming to assist not only power transfers from/to Turkey but also the accommodation of new conventional and RES generation in this area.

Boundary 53 is related to the foreseen interconnection between Romania and Moldova as well as necessary reinforcements in order to assist the safe integration of a large amount of RES and conventional generation in the East part of Romania. Boundary 108 is defining the section of the Romanian transmission network where reinforcements are foreseen in order to allow for the accommodation of a new pump storage hydro unit.

Boundary 95 is related to the necessity to accommodate the expected high penetrating 2000MW RES concentrated in the North-East (Dobrudja region) part of Bulgaria.

Finally, boundary 52 is related to necessary reinforcements in the West part of Greece and aims to accommodate a considerable number of wind farms and conventional generation.

Bulk power flows, that is, typical power flows triggering grid developments, have been estimated via market and grid studies for the boundaries presented earlier. In the following paragraphs, the range of these power flows is provided for every concern. The estimation of power flows, as also denoted from the title of the chapter concerns the year 2000 and is based on assumptions compatible with the 202020 EU scenario.

The map shown in Figure 18 depicts bulk power flows in the boundaries of the region which are directly related to connection of new generation. The highest power flows are identified in boundaries 50 and 53. This must be attributed to the multiple concerns served by them.

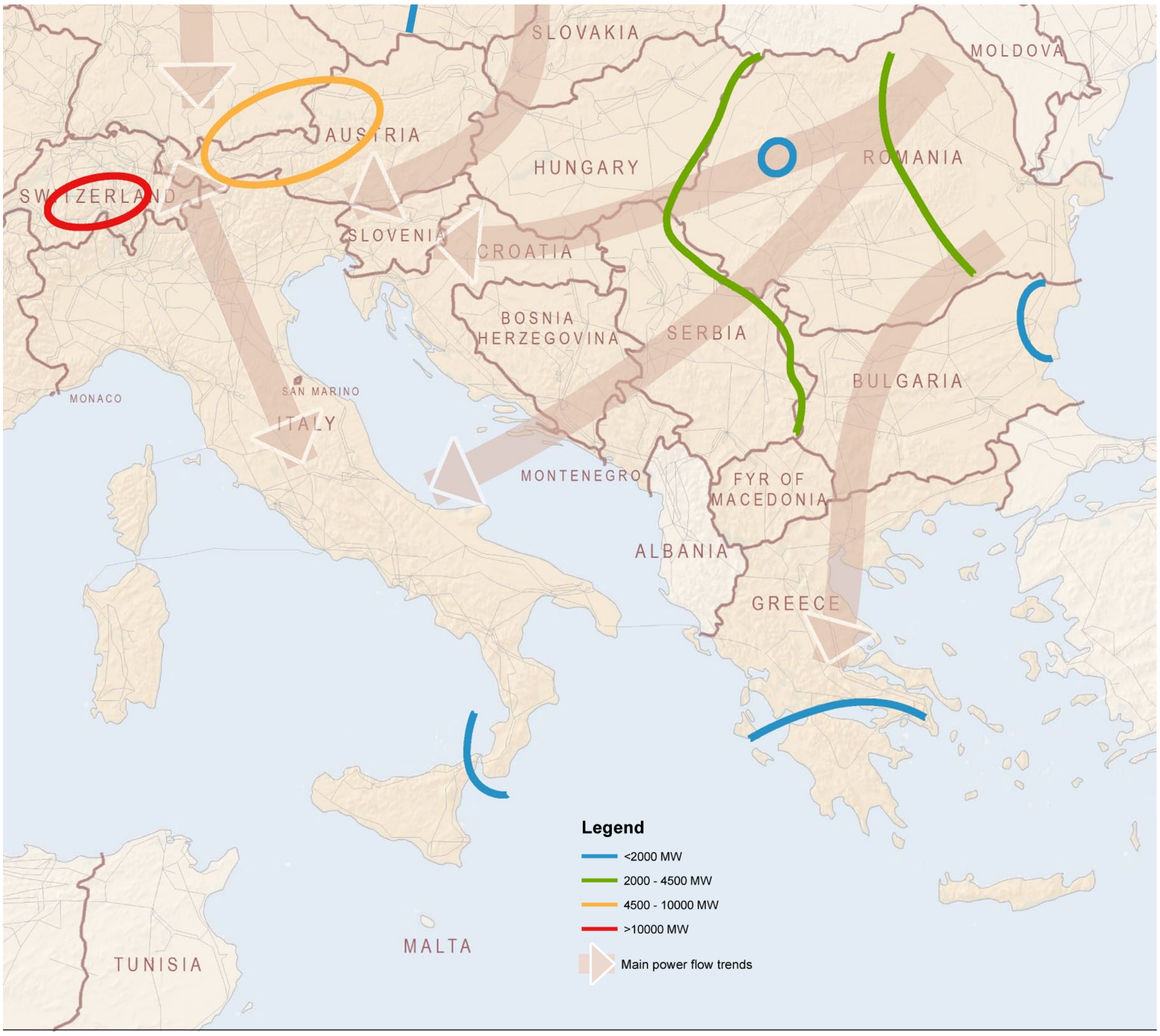


Figure 18:
Bulk power related to direct generation connection

The map shown in Figure 19 below shows bulk power flows in the Region, relevant to market integration concerns. Higher power flows are identified in the borders of Bulgaria and Romania which are the main exporters of the Region. In addition, power flows follow predominant directions North-South and East-West.

Figure 19:
Bulk power flows related to market integration

Analysis provided in the previous paragraphs regarding the origin of expected bulk power flows in the Region, provides an insight into the mechanism creating these flows. In addition to these, foreseen RES integration is estimated to be the more crucial factor affecting power flows in the Regional network. The map shown in Figure 20 depicts boundaries related directly to the connection of RES generation with light green color. In addition, market related boundaries, where significant power flows are expected from RES generation are presented with a dark green color. As can be seen, almost all of the boundaries identified in the Region are related in one way or another to RES integration in the area.

Figure 20:

Boundaries affected by RES integration in the CSE region

7 Investments

Investments in this RgIP are divided into two main categories.

- The first and most important is the category of projects of European significance. The project is assessed as European significant when it addresses at least one of the three following pillars of the EU energy policy: Security of Supply; integration of RES and fight against climate change;

Social and economic welfare and realisation of the International Electricity Market;

- Technical resilience.

The second category consists of the investments which do not contribute to grid development at pan European level; however they are important at the local level. This group of investments is further divided into the investments of regional importance and investments of national importance.

7.1 Criteria for Including Projects

Project of European significance is a set of Extra High Voltage assets, matching the following criteria:

The main equipment is at least 220 kV if it is an overhead line AC or at least 150 kV otherwise and is, at least partially, located in one of the 32 countries represented in TYNDP.

- Altogether, these assets contribute to a grid transfer capability increase across a network boundary within the ENTSO-E interconnected network (e.g. additional NTC between two market areas) or at its borders (i.e. increasing the import and/or export capability of ENTSO-E countries vis-à-vis others).
- An estimate of the abovementioned grid transfer capability increase is explicitly provided in MW in the application.
- The grid transfer capability increase meets at least one of the following minimums:
  - At least 500 MW of additional NTC; or
  - Connecting or securing output of at least 1 GW/1000 km^2 of generation; or
  - Securing load growth for at least 2 years for an area representing consumption greater than 3 TWh/yr.

Project of Regional and National significance were defined according to the two basic criteria:

- Regional project is a project which affects at least two members of RG CCE.
- National project is a project which concerns only one country.

However, if respective TSOs decide to include any project from one of the aforementioned categories to the opposite category (i.e. from Regional to National and vice versa), such change was accepted.

7.2 Projects of pan-European Significance

Clustering of investments in the CSE Region aims to identify investments contributing to the increase of transfer capacity in the same boundary between control areas and/or to the safe integration of a considerable amount of RES in a specific location, while at the same time fulfilling the criteria mentioned in the previous paragraph. Following the numbering of projects utilized in the relevant table of Appendix 1, a description of Regional benefits for each project is provided in the next paragraphs. It should be mentioned that investments proposed by the TSOs of the CSE Region often serve more than one purposes (e.g. GTC increase, RES integration, SoS). In these cases a brief description of these issues is provided. In the map which follows, a general view of the projects of pan-European significance in the CSE Region is depicted.

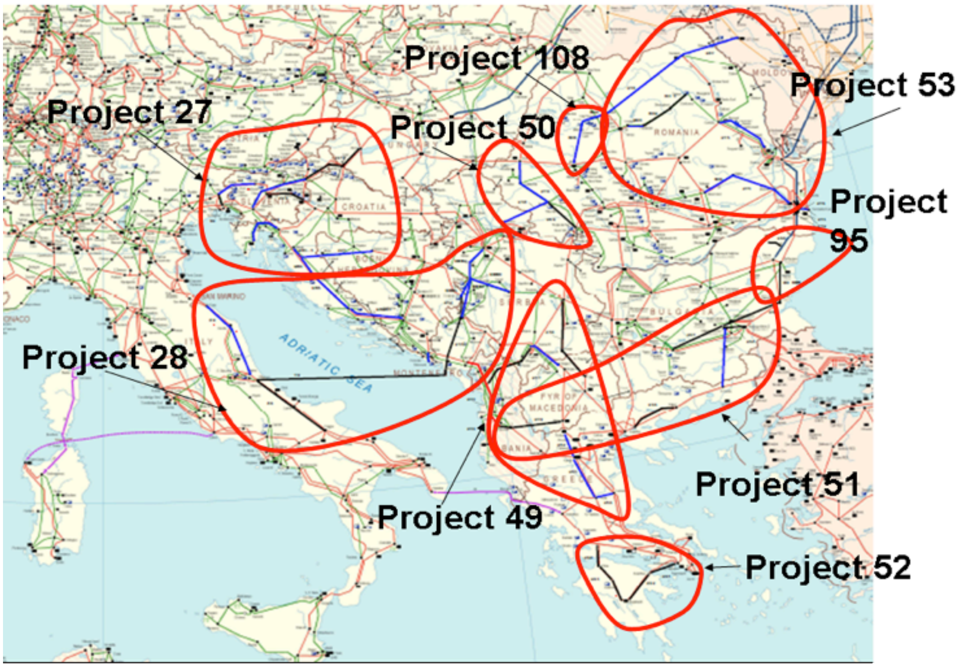


Figure 21:
Clustering of investments in CSE region

7.2.1 Mid-term (incl. 2016)

Project 28 is associated with the new DC interconnection Villanova(IT)-Lastva(ME), integration of RES in the region and the enhancement of overall SoS in the region.

The capacity of the above mentioned DC link will be 1000 MW and is expected to be completed in 2015. An extension of the 400 kV network in Montenegro is planned in the mid-term in order to support this dc-link as well as to improve security of supply and assist the integration of future hydro and wind generation. Huge investments are expected in Serbia regarding the upgrade of the whole network in Western Serbia from 220 kV to 400 kV including the construction of several new 400 kV substations.

One of the main aims of investments in Serbia will be to strengthen the corridor through Serbia toward the South-West of the CSE Europe area, and to integrate large amounts of RES including new RHPP Bistrica of 700 MW. Further investments will complete the project in the following years. The establishment of a triangle comprised of the 400 kV interconnections Bajina Basta (or Bistrica, RS)-Visegrad(BA), Bajina Basta(or Bistrica, RS)-Plevlja (ME) and Visegrad(BA)-Plevlja(ME) (or possible solution Višegrad (BA)-Buk Bijela (BA)-Brezna (ME)) as well as an extension of the 400kV network in Serbia, will create new paths from production centers in Bosnia and Herzegovina, Serbia, Montenegro and other systems from East Europe to Italy, through the new dc cable.

It should also be mentioned that the investments comprising this project will allow for the safe integration of 300 MW of RES in Montenegro, 300 MW of RES in Croatia, approximately 300 MW in BiH and more than 1000 MW of RES in Serbia.

Additionally, strengthening of the 400 kV corridor across the Adriatic coast in Croatia in LT period (New 400 kV overhead line Konjsko-Velebit, replacing aging 220 kV overhead line, together with the installation of a 150 MVAr, 400 kV reactive power device in TSS Konjsko in MT period, associated with related investments in Project 29) will accommodate power transfers from Croatia and Bosnia and Herzegovina to Italy through this IT-ME DC link. This set of relevant future investments will support the full utilization of this new DC link capacity

Investments comprising project 51 are highly related to Corridor 8 (EBRD-gas, oil and energy connection between the Bulgarian coast on the Black Sea and the Albanian coast on the Ionian Sea). This project aims to increase power transfer capacity between Turkey and the block of countries comprising Bulgaria, Greece, FYR of Macedonia and Albania. Expected increase of capacity in the respective boundary is in the order of 1300 MW upon the completion of all the investments comprising this project.

The 400 kV interconnection Bitola(MK)-Elbasan(Al) will increase grid capability to transmit power from the East of the Region towards Italy. Project 51 also includes important reinforcements in the 400 kV network in North

Greece and in the South part of Bulgaria. New investments in Bulgaria include three new 400 kV lines (256,257,258) in the South-Eastern part of Bulgaria. The calculations based on the present network topology show that the total transfer capacity through the BG-TR-GR border is approximately 900 MW. The limiting figure is the overloading of the 220kV line "Aleko –Plovdiv", when the 400 kV line "MaritsaEast-Plovdiv" is switched off. The bottleneck in the Bulgarian 220 kV grid which is limiting the transfer capacity with Turkey was detected as a result of national studies and "Complementary Technical Studies for the Synchronization of the Turkish Power System with the UCTE Power System" (Contract Number TR0303.03/01). Even now during the trial period, with a limited (up to 500 MW) exchange with Turkey, in some regimes the risk of cascade failure is real and a great many redispatch operations are needed if it is to be avoided. The construction of a new second 400 kV line "MaritsaEast-Plovdiv" (Investment 257) will eliminate the 220kV bottleneck. The construction of the three new lines (Investments 257,258,262) increases the transfer capacity with Turkey to 1000 MW, whilst also increasing the security of the generation of the region (up to 2000 MW installed capacity) and the consumption of the Burgas region. Completion of the project will also allow for the safe integration of 800 MW of RES in North Greece and an increase in security of supply in the local transmission network in South-West part of FYR of Macedonia. In the longer-run a second interconnector between Bulgaria and Greece Nea Santa (GR) – Maritsa (BG) is foreseen. This investment will further enhance the 400 kV network of the area, assisting in this way power exchanges between CESA and Turkey as well as the safe evacuation of the power from the wind farms expected to be installed in the North-East part of Greece.

Project 95 comprises the construction of two new 400 kV substations (investments 95.263, 95.264), and three new 400 kV lines (95.265, 95.266, 95.A119) in the North-Eastern (Dobrudja) part of Bulgaria in order to accommodate the high penetration of RES expected in the region. At the present time, and in this region of Bulgaria, wind farms are in operation and boast a total installed capacity of approximately 420 MW, whilst 190 MW of this amount is connected to the 110 kV network. At present a 400 kV network does not exist. The existing topology of the 110 kV network allows for a maximum export of 270 MW from the region to the rest of the system. This is the reason why WPP operates under the limit of generation. The ongoing planned extension of the 110 kV regional grid will increase the capacity to 790 MW, but it is not sufficient to accommodate the expected new RES (wind farms and photovoltaic systems) which will be approximately 2000 MW for the region. The construction of the new 400 kV substations and lines will connect the 110 kV grid to the 400 kV system and will increase the transfer capacity to fulfill the integration of the expected new RES generation in the region. In addition, the new 400 kV lines will significantly improve the voltage profile of the 110 kV regional grid and will increase the security of supply of the regional consumers. The construction of the 400 kV line Dobrudja-Burgas is very significant for the energy transfer in the NORTH-SOUTH direction and will additionally increases the security of supply in the Burgas region.

Project 52 comprises investments in Greece. The investments of this project foresee the extension of the 400 kV network in the peninsula of Peloponnese. In this way security of supply in this area will be considerably increased and the safe integration of 1000 – 1100 MW of RES will be achieved. The transfer capacity between the area of Peloponnese and the rest of the Hellenic System will be increased by approximately 600 – 700 MW. It should also be mentioned that the completion of these investments will allow for the integration of a new CC unit of installed capacity totaling 1100 MW in the area of Megalopolis.

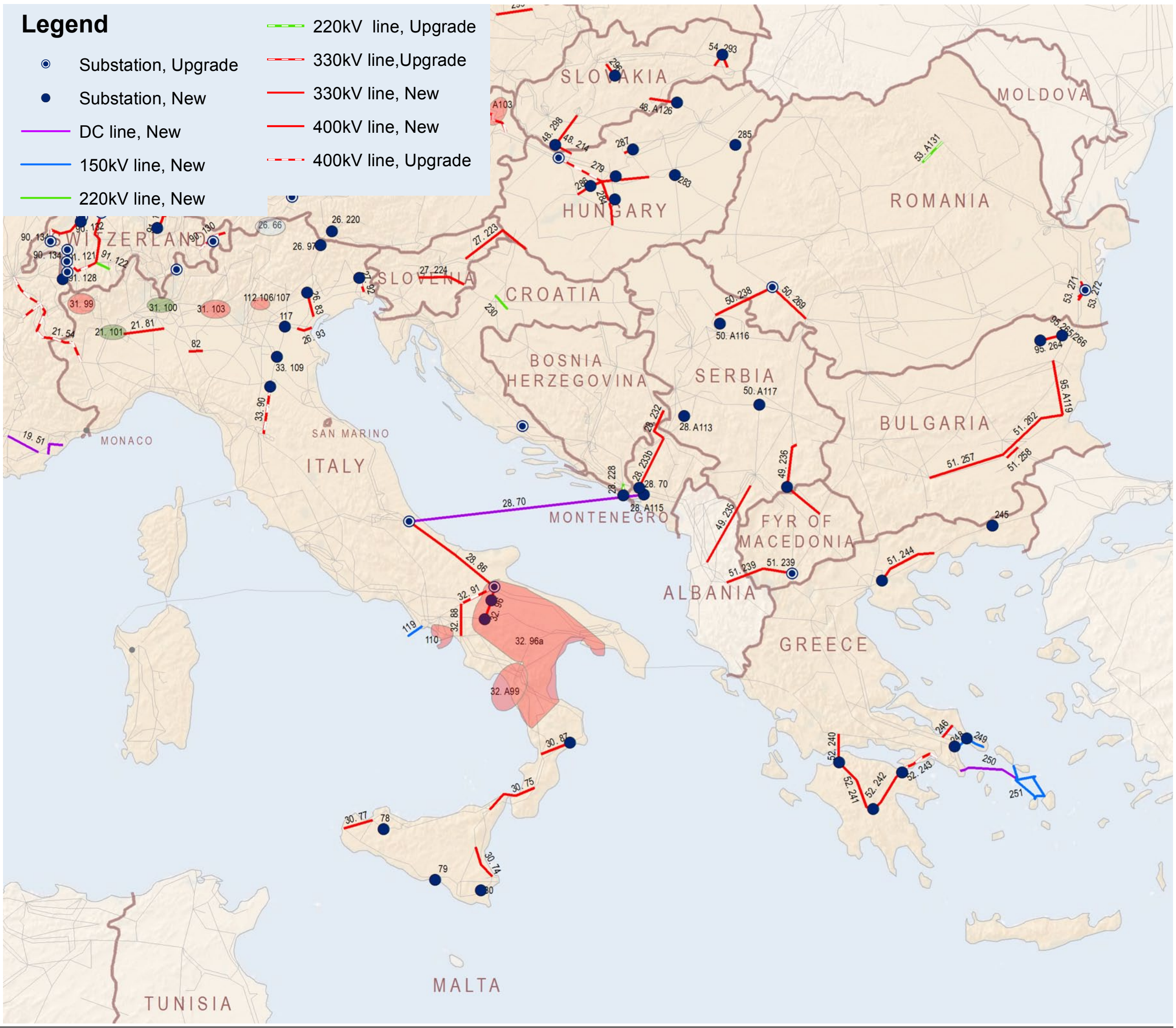


Figure 22:
Medium-term investments in CSE region

7.2.2 Long-Term (2017+)

The aims of Project 27 are to increase transfer capacity on the Slovenia – Italy, Slovenia-Hungary, Slovenia-Croatia and Croatia-Bosnia and Herzegovina borders, improving SoS and achieving diversity of SoS whilst also increasing resilience and flexibility of the transmission network in this area. This project will facilitate new RES integration and conventional generation which are expected in the related countries and will also remove congestion on the North-South and East-West axes. Expected increase in transfer capacity in the respective boundary is in the order of 1700 MW.

In order to achieve this, enhancement of the SI-IT interface is planned through the new double OHL 400 kV interconnection Okroglo(SI) – Udine(IT) as well as a new HVDC interconnection between Slovenia and Italy – investment is in pre-feasibility study.

In addition, the establishment of new 400 kV corridors in order to increase the safe transfer of power from Hungary and Bosnia and Herzegovina towards Croatia, Slovenia and Italy is foreseen. These plans include the construction of two new interconnections. The first one concerns the 400 kV line Cirkovce(SI) – Heviz(HU) – Žerjavinec(HR), which will also facilitate market integration in the region and concerns the redirection of one of the two circuits of the existing 400 kV line Heviz(HU) – Žerjavinec(HR). The second concerns the new

400 kV interconnection Banja Luka (BA) – Lika(HR), which will also support market integration and improve the security of supply in the area – South and mid Croatia and North and mid Bosnia and Herzegovina.

Considerable reinforcements are also foreseen in the internal networks of Slovenia and Croatia in order to assist power flows in the prevailing directions. These investments in Slovenia include new 400 kV double OHL Beričevo – Krško which will create internal 400 kV transmission loop and eliminate the bottleneck on existing 400 kV OHL Beričevo – Podlog. Besides the high level of safe and reliable operation and high utilization of the transmission network, the aforementioned construction will significantly reduce losses in the transmission network. The remaining network restrictions of Slovenia will be removed by upgrading internal 220 kV network to 400 kV voltage level between Cirkovce and Divača. The influence area of the new transmission line is part of the central-southern and central-eastern region, removing restrictions on the energy transfer through the Slovenian transmission network and increasing reliability whilst reducing losses in the transmission network and facilitating market integration in the region.

Considerable investments in Croatia include new single circuit 400 kV OHL replacing the aging 220 kV OHL between substations, namely Brinje and Konjsko, interdepending with the construction of two new 400/(220)/110 kV substations, namely Brinje and Lika. These investments also include a new double circuit 400 kV OHL Plomin-Melina, together with new SS 400/220 kV Plomin, which will enable connection of new 500 – 550 MW generation unit in existing TPP Plomin.

At the same time all mentioned investments will facilitate the safe integration of RES in related countries - more than 1,5 GW of RES in Croatia and Bosnia and Herzegovina and over 500 MW of RES in Slovenia.

Project 49 is related to Corridor 10 and aims to increase transfer capacity and thus contribute to security of supply of the block of countries including FYR of Macedonia, Albania and Greece. The expected increase in transfer capacity is approximately 600 MW in the predominant direction, that is, from Romania, Bulgaria and Serbia towards this block. Such an increase is expected upon the completion of all the investments comprising this project.

The 400 kV interconnection Leskovac (RS) – Stip (MK) is the most mature investment, and is expected to be in operation in 2013. This North-South corridor is to be strengthened further in the long-term through the construction of the two 400 kV interconnections Tirana (AI) – Pristina (RS) and TPP Kosovo B (RS) – Skopje (MK).

Project 49 also includes reinforcements which aim to strengthen the 400kV North-South internal corridor of Greece. These investments will contribute to the security of supply of the Greek System, by enhancing energy transfer towards large consumption centers.

Project 50 aims to increase power transfer capacity from Romania and Bulgaria which are main exporters of the area towards Serbia and Hungary. Expected increase in transfer capacity across the respective boundary is in the order of 1000 MW upon the completion of all the investments comprising this project. It is worth mentioning that this project also enhances the corridor N-S, from Ukraine and N-E Europe towards S-E Europe through Romania and combined with project 31 creates a 400 kV corridor from Romania towards the ME-IT dc cable. It must be also mentioned that investments comprising this project will allow for the safe integration of around 1500 MW of new RES installations in Serbia and 750 MW of new RES installations in Romania.

Project 53 comprises investments in Romania. It aims to accommodate the safe integration of a large number of RES (mainly wind farms) and conventional generation expected in eastern Romania in the areas of Dobrogea and Moldova. The expected increase of transfer capacity between these areas and the rest of the system is in the order of 2000 – 2500 MW. The completion of all the investments comprising this project will allow for the integration of RES of total installed capacity in the range of 2500 – 3300 MW. Besides two new nuclear units (2 x 700 MW) in Cernavoda and declarations of intent for two fossil fuel units of 800 MW each have complied with legal provisions to obtain technical permit for grid connection.

As a whole, the project is necessary for RES integration in the region. The cluster of investments will ensure transfer of generation, with a high amount of wind, from the eastern part of Romania to the rest of the system and SE European countries (e.g. Hungary, Italy, Croatia, Serbia).

The project will also increase the grid capacity to transfer power from

Ukraine to Romania and other SE European countries (e.g. Hungary, Italy, Croatia, Serbia).

Project 108 is also comprised of Romanian only investments. The completion of the relevant investments will allow for the integration of a new pump storage hydro plant of 1000 MW installed capacity in the vicinity of Tarnita. It will be connected to the grid through a new 400 kV substation and two 400 kV new lines to the existing substations Gadalin and Mintia. The network project is a project which consists of the following investments: a new 400 kV substation Tarnita, where the pumped storage hydro power plant shall be connected; a new 400 kV OHL Tarnita - Cluj Gadalin; a new 400 kV OHL Tarnita - Mintia. This plant will assist considerably the safe operation of the Romanian as well as the entire Regional power system, in the context of important amounts of RES in the area.

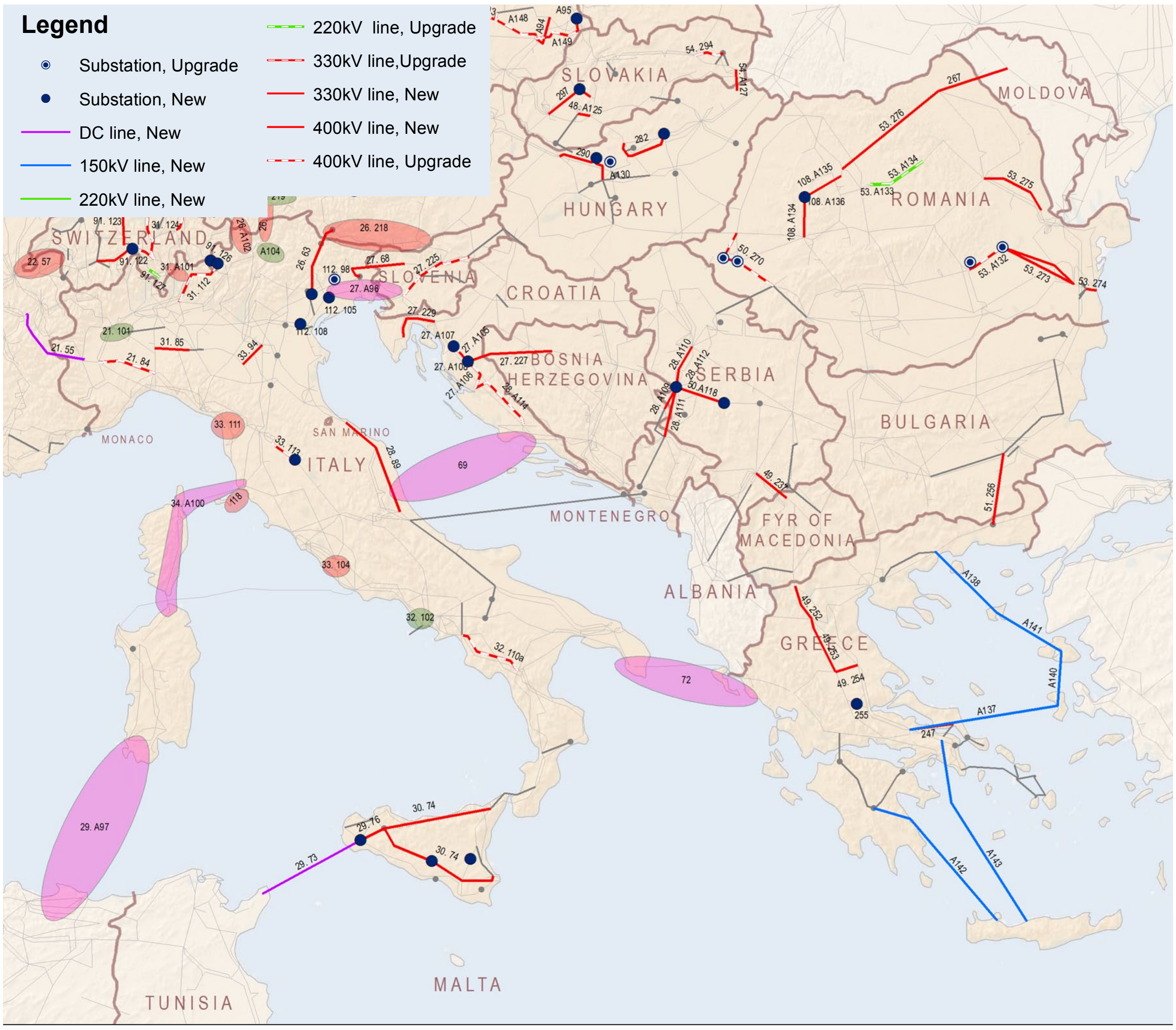


Figure 23:
Long-term investments in CSE region

7.2.3 3rd Parties Promoted Projects

In order to deliver the most comprehensive and up-to-date outlook of the electricity grid by 2020 and beyond, ENTSO-E, based on the stakeholders' feedback to the 2010 pilot TYDNP, elaborated and made available in February 2011, a set of guidelines for the inclusion of the third party projects in the 2012 release of the TYNDP:

https://www.entsoe.eu/system-development/tyndp/tyndp-2012/.

As a result, ENTSOE- received one submission for the CSE Region area, as presented in the table below. This project failed to demonstrate evidence of a transmission license or an exemption for such license granted by the relevant national regulatory authorities and EC, as required by the ENTSO-E guidelines. The non-discrimination principle (especially vis à vis similar projects which had possibly not applied for the same reason), forbids this project from being incorporated into the table of projects of the TYNDP 2012 package.

Country A	Country B	Technology	Technical description	Regulatory and legal criteria fulfillment	Brief benefits for the project
IT	AL	HVDC	Yes	No	"The project is market driven. Need to increase the cross border capacity between South East Europe area and Italy consequently allowing the transfer of energy from RES sources (wind from Valona area) but also conventional generation".

7.3 Regional and National Projects of Importance

In the following paragraphs, a short description is provided for investments in the CSE Region which do not comply with the criteria for the projects of Pan European interest. Despite this, their importance at regional or national level remains significant since they contribute to the increase of the SoS, the integration of the regional electricity market as well as the safe integration of RES generation in the area.

7.3.1 Mid-term (incl. 2016)

The investments Polypotamos-Nea Makri and Polypotamos-South Evia, despite the difficulties in permitting procedures, are the more mature projects since they are in the construction phase. The new 150 kV subsea interconnection with the mainland together with the new 150 kV double circuit overhead line will allow for the safe integration of new wind farms with an installed capacity of 200MW.

The interconnection of Cycladic islands with the mainland (Greece) includes the islands of Syros, Mykonos, Paros, Naxos and Tinos. An AC interconnection is foreseen between islands, while the part between Syros and the EHV SS in Lavrion could be either AC or DC. This project is technically innovative and will allow for the safe integration of approximately 250 MW of wind farms in these islands. It is currently in the tendering phase.

Investments of such importance in Croatia include a new 220/110 kV substation at Plat which will increase operational network security and reliability of supply in the Dubrovnik area. It is also a new connection point for future HPP and WPP. Together with the re-establishment of previously existing 220 kV tie lines Plat (HR) – Trebinje (BA), this investment, in Project 30, will increase the cross-border capacity and support better market integration in this part of the Region. These investments also include new double circuit 220 kV OHL for connection of TPP Sisak by intersecting existing OHL Mraclin (HR) – Prijedor (BA), forming through this two new OHL 220 kV: Mraclin – TPP Sisak in Croatia and TPP Sisak (HR) – Prijedor (BA). This investment ensures conventional generation integration and increases operational security by ensuring N-1 criteria. Additional investments in reactive power devices in Croatia will enable better voltage control in the 400 kV grid. The first one, rated 150 MVAr, and mentioned previously in Project 30, is to be installed in the substation Konjsko. The other, rated 50 MVAr, is to be installed in 400/110 kV substation Ernestinovo.

7.3.2 Long-Term (2017+)

In order to facilitate the interconnection of a new CC unit with an installed capacity of approximately 400 MW in the Evia Island, extension of the 400 kV network is foreseen by the construction of a new 400/150 kV EHV S/S in Aliveri and the interconnection of this substation with the mainland System via two double circuit lines. Permitting processes are facing difficulties for these projects. The first line is under construction. It should also be mentioned that these projects will increase RES capacity which can be safely interconnected in the Hellenic System by around 200 – 250 MW.

Electrical interconnection of selected Greek islands with Continental Greece is of considerable importance, in order to optimally exploit the wind potential in the Aegean Sea. Electricity in these islands is provided by autonomous power systems fed by diesel generator sets. As a result the interconnection of these islands will allow an increase in the security of supply and will achieve a reduction of electricity cost through market integration. Significant environmental benefits are also expected, due to the replacement of the already existing highly pollutant energy sources, by renewables and more environmentally friendly conventional generators. It should be mentioned that in the framework of strategic planning, interconnection of all Aegean islands is foreseen for the reasons mentioned above. A description of these projects follows in the coming paragraphs.

The mainland interconnections of islands in the North-East Aegean Sea (Limnos, Lesvos and Chios) as well as Crete are under consideration. These projects are highly motivated by the very large number of applications for issuing production licences for new wind farms in these areas. Due to the considerably high distances between the connection points, a dc interconnection solution is foreseen. Initial studies for these projects are ongoing.

Bulgarian TYNDP for the long-term perspective is developed in two variants with and without construction of the new NPP "Belene" (2 x 1000 MW), as no final decision has yet been made. The construction of NNP "Belene" requires considerable changes in the network – two new 400/110 kV substations, 990 km new 400 kV lines and 188km new 110 kV lines. This new topology will significantly improve the regional transmission network. In case the project NPP "Belene" is not realized, no more extensions of the grid would be needed if the topology foreseen in the mid-term horizon is fully realized

Concerning the foreseen extension of the synchronous zone to the East, in the long-term, a new 400 kV overhead line Suceava (Romania) – Balti (Republic Moldova) is included in the Romanian TSO network development plan. The project is associated with the connection of the Republic of Moldova and Ukraine and will increase transmission capacity between Romania and the Republic of Moldova allowing for increased power energy exchanges between Romanian and Moldavian systems as well as Ukraine and other SE European countries.

Investments of such (national) importance in Croatian 220 kV and 400 kV network, which are included in the Croatian network development plan for

LT period, comprise new substations: 400/110 kV Drava, 220/110 kV Vodnjan and 220/110 kV Vrboran/Kaštela; these also include appropriate 400 kV OHLs for connection of new power plants (TPP Slavonija, TPP Dalmacija; TPP Prevlaka, RHPP Korita, HPP Senj 2, etc.) which are planned or are under consideration as options in the national Energy Development Strategy and Croatian TYNDP in various scenarios. There are also a number of other scenarios relating to possible new investments (like new SS 400/110 kV Djakovo, new OHL 220 kV Plat-Nova Sela, than new OHL 400 kV Nova Sela-Imotski, new SS 400/220/110 kV Nova Sela, etc.). These are foreseen as future options, but (for now) after the LT period observed in this CSE RgIP.

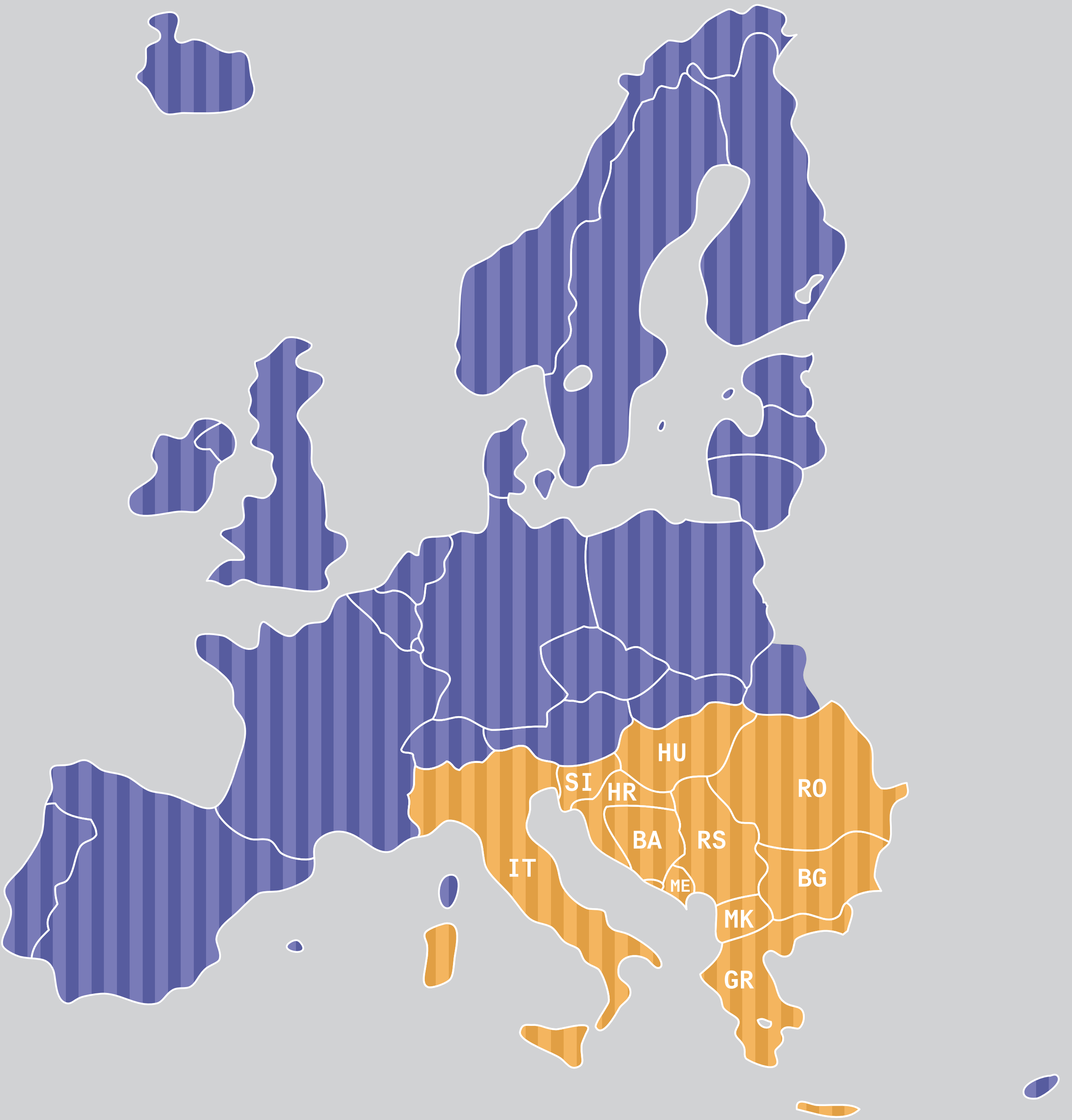
Foreseen investments of national interest in the FYR of Macedonia are focused toward:

– rehabilitation of aging 110 kV transmission network and

– extension of 400 kV network.

Taking into consideration the fact that most of the 110 kV grid was constructed in the 1960s and 1970s, during the next decade a large number of these lines will be candidates for reconstruction. The vision of MEPSO is to establish optimal structure of 400 kV networks, by creating 400 kV supply node/s in every consumer region in the country. For the next ten year period these investment activities are estimated at a value of 40 million Euros.

8 Transmission Adequacy



Transmission Adequacy shows how adequate the transmission system is in the future in the analyzed scenarios, considering that the presented projects are already commissioned. It answers the question: "is the problem fully solved after the projects are built?"

Three categories have been considered in the transmission adequacy showing that needs are solved in every situation, in almost every situation or that the need is not completely solved:

- Light purple: unlikely that with all projects in the plans, in the span of scenarios considered in the plans, further measure is reported related to the boundary;
- Purple: possibly, with all projects in the plans, in the span of scenarios considered in the plans, certain rare developments could trigger further measures on the boundary although sufficient transmission capability is provided for the vast majority of the situations ;
- Dark purple: most likely that in the span of scenarios considered in the plans, additional measures are needed on top of all projects in the plans to cope with congestion on the boundary.

A graphical representation of this assessment is depicted in the map shown below. In the CSE Region the boundaries marked purple are:

- Boundaries interconnecting eastern and western parts of the region (27, 28, 50) and further to Italy and other countries in Western Europe.
  - Boundary 27 is characterizes as such in the light of possible new undersea DC tie lines between the CSE Europe area and Italy.
  - Boundary 28 represents the backbone of overall regional SoS, market integration and the possibility to straighten transmission capabilities in the directions from East to West and from North to South of the region and further to Italy as well as other western countries with more expensive electricity. It consists of a large number of projects in Serbia, two projects in Montenegro-Italy and one project in Bosnia and Herzegovina. This boundary has a major role from a regional point of view together with boundary 50 due to the following reasons: possible new undersea DC tie lines between Balkan and Italy, connection of Ukraine and Turkey to the rest of the Europe and huge potential of RES in overall region which could, along with new transits from Ukraine, Turkey, Romania and Bulgaria, cause congestion with regard to the above mentioned directions.
  - Boundary 50 is characterized as such in light of the two reasons mentioned above: possible new undersea DC tie lines between Balkan and Italy and connection of Ukraine and due to the third reason which is connected to huge potential in RES in Serbia and Romania.
- Areas with high potential of RES (boundaries 50 and 53). In the analyzed scenarios no major congestions are expected, but if an acceleration of implementation of RES at the same time as huge change in load

flows relating to the connection of Ukraine and Turkish systems in these areas were to occur, additional investments could well be required.

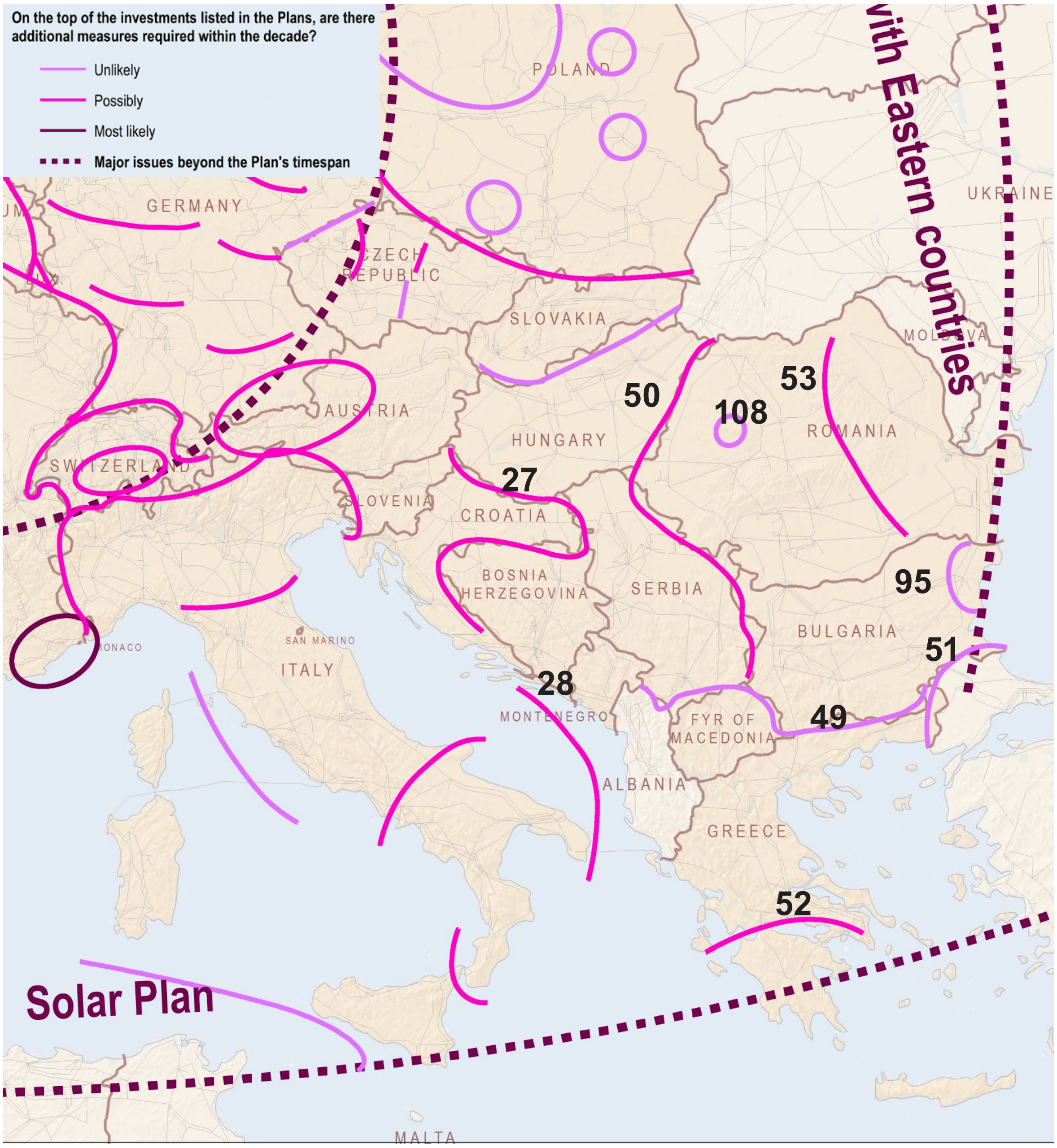


Figure 24:

Transmission adequacy assessment in CSE region

9 Environmental Assessment

The environmental impact of transmission projects is a major concern of the society in Europe; public opposition to transmission projects is one main barrier for the timely realization of them. In this framework, transmission projects are subjected to Environmental Impact Assessment (EIA) for EU member states according to Directive 85/337/EEC. The IEA procedure involves various National authorities and foresees extensive consultation with the public and the local authorities of the concerned areas.

This chapter intends to trace and roughly estimate/assess the impact of the new investments within the Regional Investment Plan 2012 on society and the environment in a general manner. This type of assessment at the regional level can provide a global overview and does not focus on individual investments. Although such an assessment of social and environmental impacts faces significant difficulties, the TSOs of the Continental South East Regional Group have collected relevant information on planned investments based on the best of the TSOs' knowledge/intuitions.

Transmission projects including overhead lines create the largest environmental impact compared to projects where the transmission of electricity is mainly utilized using subsea or underground cables. In order also to minimize this impact, TSOs often examine the capability of upgrading existing transmission projects. Figure 25 provides an overview of the foreseen total length of route for new transmission projects per type (overhead lines, cables or upgrades) for the CSE Region.

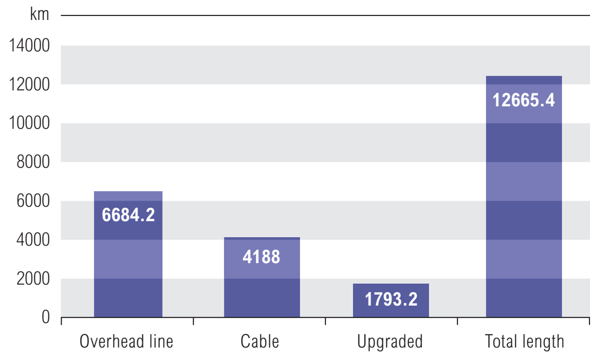


Figure 25:
Length of route for different type of projects in CSE region

The social impact is closely related to the general opposition of the society to the new transmission investments. This opposition is driven by the NIMBY syndrome. It also includes:

- The impact of the projects on the use of the land and consequently on the value of the land (e.g. touristic areas, etc.).
- The visual impact especially of transmission lines and new substations.
- The proximity to heavily populated urban areas which is strongly related to the fears of EMF impacts on human health.

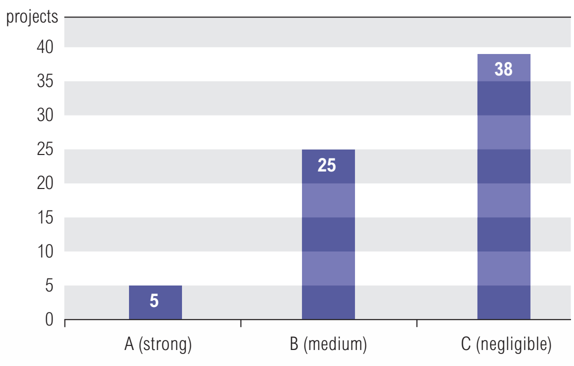


Figure 26:
Social opposition estimation for planned investments part of the projects of pan-European Significance

Figure 26 presents the CSE Region TSO's estimations of the expected difficulties for the completion of new projects according to the information and experience gained thus far. As illustrated in this figure, only a small number of the planned investments are expected to face strong public opposition.

The environmental impact is "quantified" and assessed mainly by estimating the possible influence on the flora and fauna. This estimation examines the impact of new projects on:

- Areas characterized as "sensitive" and which have been included in International Treaties for environmentally sensitive or specially sensitive areas such as Natura, Ramsar, and so on.
- Areas of special treatment such as aesthetic forests, areas characterized as "national monuments", and so on.

Figure 27, classifies the planned investments in the CSE region in terms of the expected impact (and associated realization difficulties) relevant to the above mentioned concerns.

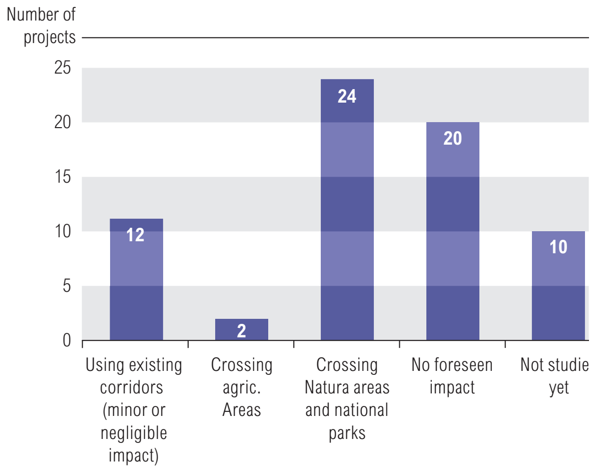
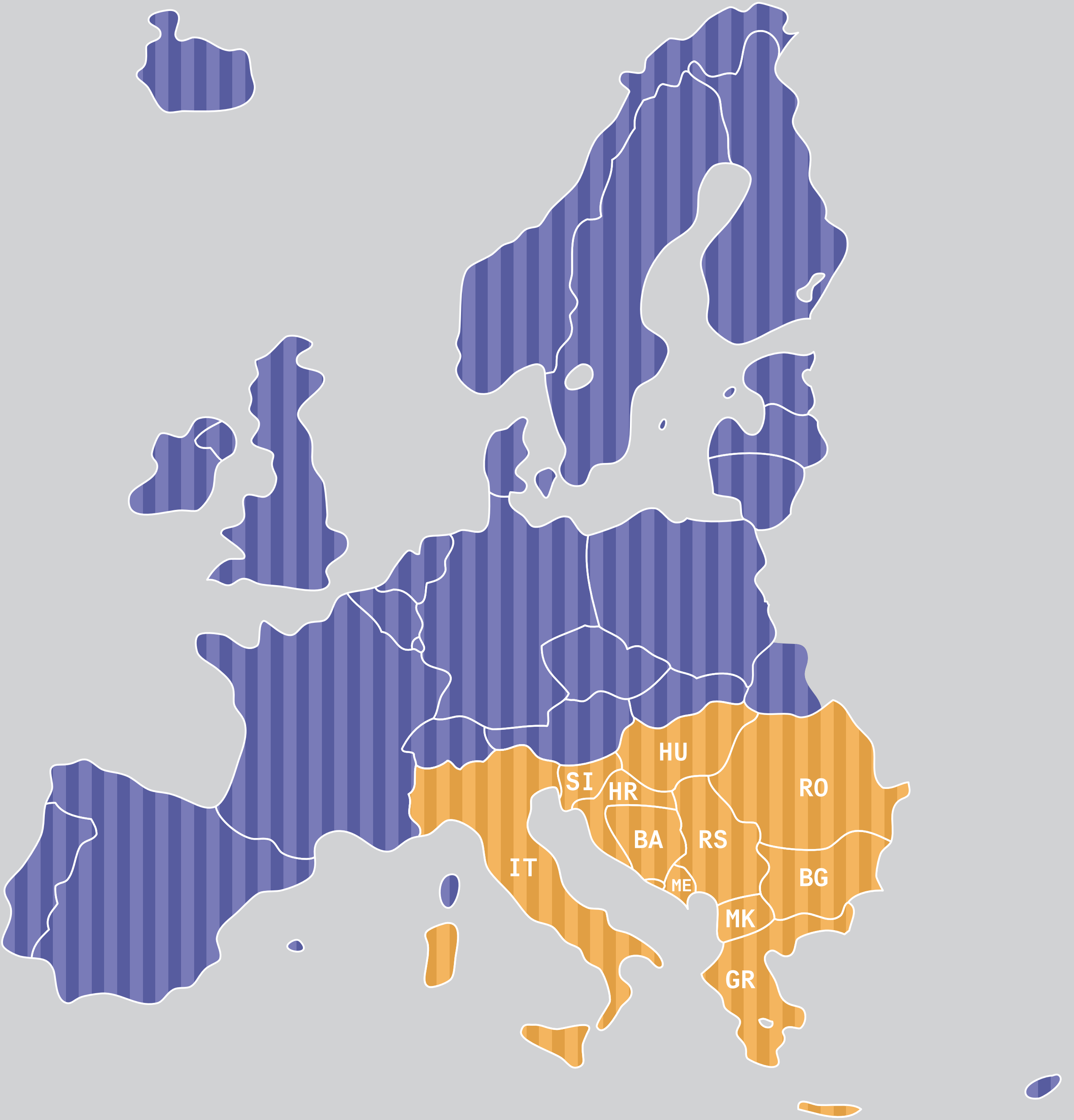


Figure 27:
Assessment of the environmental impact for investments part of the projects of pan-European Significance

10 Assessment of Resilience



Transmission system investments are expensive infrastructure projects, with a long lifetime (some more than 40 years), setting precedence for coming projects. In order to both avoid stranded costs and to meet grid users' expectations on time with appropriate solutions, TSOs assess the resilience of their investment projects. This assessment is performed in 4 major directions:

– **Security of Supply:** investment should ensure safe system operation, must not put the reliability of the system at risk and should provide a high level of security of supply;

– **Economic performance:** grid investments should prove useful and profitable in as many future situations as possible, balancing costs and benefits. Situations are assessed taking into account probability and consequences.

– **Technical sustainability:** as long lasting expensive infrastructure components, investments should take advantage of technological evolution in order to optimize their performance and ensure they do not to become obsolete in the course of their expected lifetime; TSOs strive to make the best use of existing assets considering new technologies such as FACTS, PST, HVDC links, and so on, in order to optimize grid development;

– **Compatibility with long-term visions:** present projects must be appropriate steps to meeting future concepts, such as electricity highways, looking ahead and fitting into wider and longer-term perspectives. Projects which are launched now should not jeopardize the expected grid development in the longer run. Reciprocally, long-term grid development is considered on top of existing and planned assets. This makes grid development consistent over time.

Methodologies and criteria developed by TSOs focus on risk assessment and mitigation. They assess the resilience of the system in whatever situation it may realistically have to face: high/low demand growth, different generation dispatch patterns, adverse climatic conditions (defined in the scenario phase), contingencies, and so on. With increased market integration and stochastic, climate-dependent RES generation, it becomes more and more important to use scenarios for boundary conditions with respect to power exchanges with neighboring systems.

Three basic (commonly agreed) scenarios are considered: EU2020, B-scenario and Nuclear phase-out. Regionally, most restrictive cases based on the possible future situations have been studied in market and in grid studies in order to verify the secure functioning of the grid after the projects are commissioned: High load cases, Low load cases, High/low renewable production cases, different hydro years and other regionally constrained cases have been studied (more details can be found in previous chapters).

Resilience to other severe contingencies

Contingencies more severe than those included in the N-1 criterion can be assessed in some cases defined by the TSOs based on the probability of occurrence and/or the severity of consequences:

- **Examination of rare, but severe failures.** In some cases, rare but severe failures, such as those leading to the loss of a busbar or busbar section, or multiple independent failures, may be assessed in order to prevent serious interruption of supply within a wide-spread area. This kind of assessment is carried out for specific cases chosen by the TSO depending on probability of occurrence and consequences.
- **Examination of multiple failures due to common cause.** The so-called common-mode failures include the failure of several elements due to one single cause. The potential outage of lines with double or multiple circuits will most probably become more relevant over the next years, as more and more power lines are will be bundled onto already existent routes (several circuits on the same tower) and as conductors with higher thermal ratings will be used, allowing for higher power flows.
- **Failures combined with maintenance.** Certain combinations of possible failures and non-availabilities of transmission elements are considered in some situations. The maintenance related non-availability of one element combined with the failure of another one are assessed. Such investigations are conducted by the TSO based on the probability of occurrence and/or based on the severity of the consequences. They are of particular relevance for network equipment which may be unavailable for a considerable period of time due to a failure.

New or Efficient Technologies

The challenge of grid development must be met by using cost effective solutions and without any disturbance for the overall reliability of the transmission system. The technologies employed to date in the transmission grids are efficient, reliable, well engineered and are widely available techniques for transferring energy in high-voltage grids.

New 400 kV AC OHL projects are in technical, economic, and ecological terms the most efficient solution for long distance electricity transmission. Upgrading the old 220 kV lines to 400 kV level using the same corridor, is a good example of applying efficient technology in the CSE Region (almost in every country – see the Table of projects).

In addition, other solutions are implemented to accommodate specific situations when necessary. The best illustration of applying such highly novel technologies in the CSE Region is Investment No 70 in Project No 30 - The High Voltage Direct Current (HVDC) transmission - DC link between Italy and Montenegro, crossing the Adriatic Sea. This DC interconnection Villanova (IT) – Lastva (ME), with a capacity of 1000 MW, is expected to be completed in 2015. It will have a great impact on the required development in the whole region, allowing for the integration of a significant amount of RES in the region and thus enhancing overall SoS in the region.

11 Summary and Conclusion

11.1 Main Messages

The transmission system of the CSE Region of ENTSO-E is a rather sparse network with predominant power flows in specific power directions, namely East to West (E->W) and North to South (N->S).

Concerning the generation mix, thermal production has the largest share (with a significant portion of lignite units). There is also significant hydro capacity while RES has low development (with the exception of Greece where ~2GW of RES have been installed).

Planned transmission projects (new projects and reinforcements of existing ones) by the TSOs over the next decade aim to increase security of supply, support RES integration, strengthen interconnections between countries and increase the transfer capability towards West Europe.

The analysis performed (market studies and network studies) for the two selected scenarios (EU2020 and B) as well as their variants (i.e. Nuclear Phase Out in Germany) shows that the predominant power flow directions still prevail for the 2020 time horizon. Following the methodology described in Chapter 4, 9 main boundaries were identified. With respect to these boundaries, 9 projects (consisting of around 68 investments) of pan-European interest have been planned by the local TSOs. The cost of the projects mentioned is in the order of 10.8 billion Euros (also including the portfolio of all Italian projects) split between MT and LT time periods as shown in the figure below.

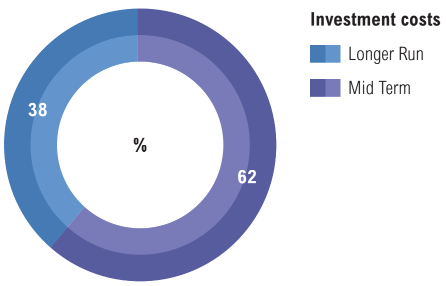


Figure 28:
Splitting of costs in MT and LT periods

The results of exhaustive analysis based on the two examined scenarios and their variants, lead to the following main results/messages:

- Due to the sparse nature of the network:
  - There is a strong interdependency on power flows and current GTCs are considerably limited in N-1 contingencies.

  - Planned projects (although using the TYNDP criteria are not valuated for this benefit) add significantly to the SoS of the area and contribute considerably to GTC.

- For the scenarios analyzed, the planned projects seem to lead to a transmission network adequate enough to accommodate the expected power transfers up to the year 2020.
- From a Regional point of view, foreseen installed generation up to the year 2020 is sufficient to reliably meet the anticipated demand in all examined cases.
- Due to the high proportion of coal-fired generation, the area is sensitive to CO_2 prices; the CSES region seems to be an exporter in Scenario B (low CO_2 prices) but an importer in scenario EU2020 (high CO_2 prices).
- RES targets and their fast evolution necessitate the acceleration of several grid developments
- The predominant power flow directions (E->W and N-S) still exist in 2020. The exchanges with TR and the possible interconnection of UA/MD in the future (since it was not taken into account in the studies) are expected to further increase the E-W bulk power transfers.
- Market integration with Western Europe (especially Italy) is a key driver for the development of the transmission system in CSE Europe.
- Nuclear Phase Out in Germany is expected to lightly affect the region.
- Concerning the environmental impact of the transmission investments it seems to be rather low; in addition, the realization of the projects does not seem to face strong public opposition.
- Due to the sparsity of the network and the strong interdependency of power flows, close and efficient coordination among the TSOs is needed not only in planning but also in the implementation/construction phase to achieve the timely commissioning of the required investments.

As a general conclusion, it is apparent that the realization of the scheduled transmission projects in the CSE region have a significant impact on the transfer capability over the networks in the area, thus improving security of supply and facilitating further integration of internal markets by enabling larger power exchanges among the countries of the Region and the rest of Europe.

11.2 Main Statistics

This section presents the main statistics for the CSE Region of ENTSO-E as derived from the ToP of TYNDP 2012. It should be mentioned that the provided figures concern all the projects of TSOs belonging to the region, also including projects presented in the investment plans of neighbor regional groups. Table 3 below shows the splitting of the total length of the planned route by technology, type and whether the circuit is new or upgraded.

		DC	AC (>300kV)	AC (<300kV)
Upgrade		358	1210	225.2
New	**OHL**	0	6672.2	12
	US	3041	15	328
	UG	590	65	149
Totals		3989	7962.2	714.2

Table 3:
Total length of new investments per category in CSE Region

Figure 29 presents the share of total length of the planned transmission investments split between MT and LT periods.

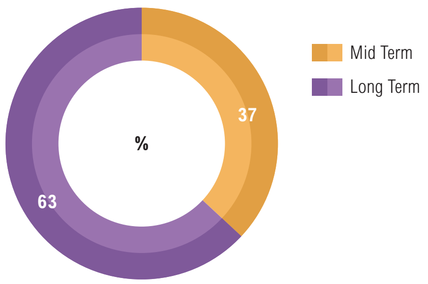


Figure 29:
Allocation of new investments in MT and LT periods

Figure 30. provides an outlook of the progress achieved thus far with the projects announced in the pilot TYNDP 2010. The statuses of the majority of the projects which appeared in TYNDP-2010 are unchanged; a small portion have already been commissioned. Some projects are ahead of schedule while a considerable number of investments are delayed. Finally, a significant number of new investments are new, mainly related to future RES development.

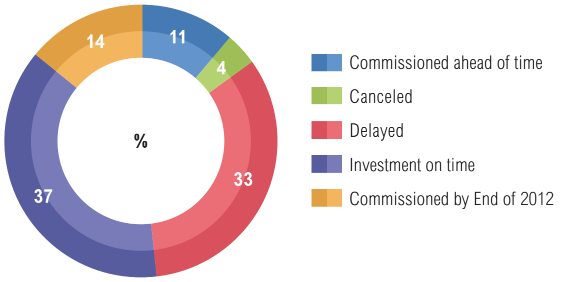


Figure 30:
Monitoring of project's summary

Figure 31 illustrates the portion of investments related to security of supply; 70 % of the investments have been classified as of low impact to SoS, 10 % of medium and 20 % of high impact.

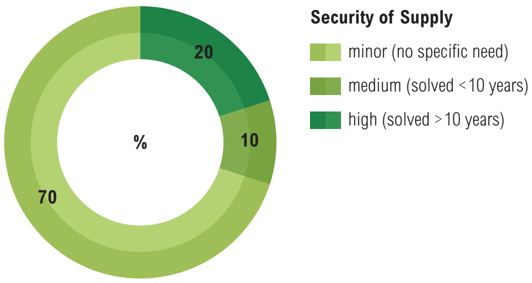


Figure 31:
Contribution of the projects to security of supply

Figure 32 demonstrates the impact of new investments on RES development; a large portion of the projects make a contribution to the integration of RES, either directly or indirectly through the accommodation of inter-area flows triggered by RES.

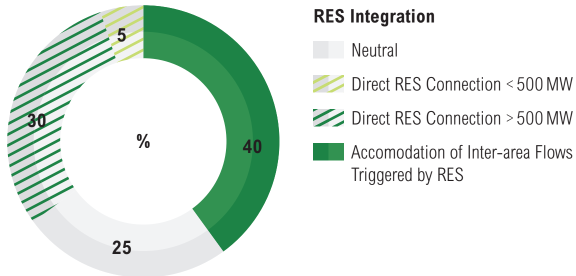


Figure 32:
Contributionof the projects to RES integration

An important aspect of the benefits expected by the projects is expressed with the Social and Economic welfare indicator. As can be seen in the figure below, a large portion of the future investments in the region provide a significant contribution in terms of the achieved production cost reduction.

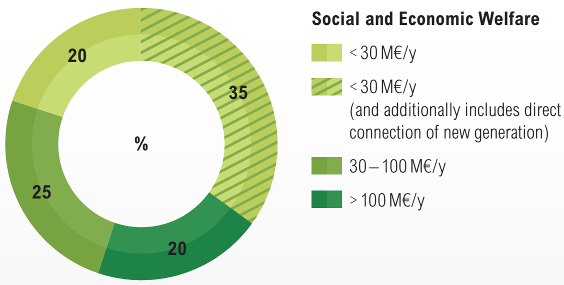
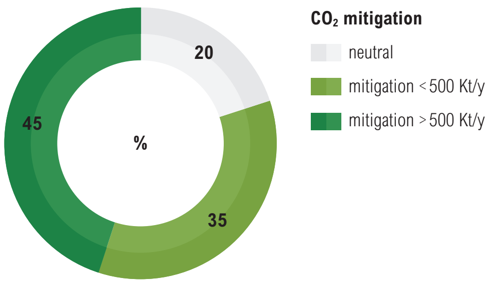


Figure 33:
Contribution of the projects to social and economic welfare

Figure 34 provides a view of the environmental impact of the new projects in terms of CO_2 savings and their impact on grid losses.



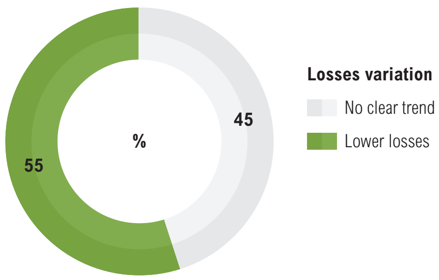


Figure 34:
Environmental impact of new projects

An overview of the social and environmental impact of new projects is presented through the summary of the relevant indicator shown in the figure 35.

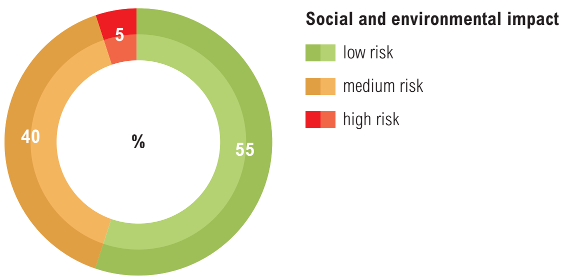


Figure 35:
Social and environmental impact of new projects

These statistics lead to the main conclusions and messages presented in the previous section.

12 Appendices

12.1 Appendix 0: Members of Regional Group Continental South East

Convenor	Company
Ioannis Kabouris	IPTO
Member	
Virginica Zaharia	Transelectrica
Rositsa Dermendgieva	ESO-EAD
Domenico Iorio	Terna
Nenad Sijakovic	JP EMS
György Ovari	Mavir
Silvia Piliskic	HEP-OPS
Nikola Rebič	Eles
Vojislav Pantić	ISO BiH
Nikola Rusanov	ISO BiH (retired)
Aleksandar Paunoski	MEPSO
Tomo Martinovic	EKC (on behalf of CGES-ME)
Substitute Member	
Edina Aganovic	ISO BiH
Aristomenis Neris	IPTO
Dragan Balkoski	JP EMS
Daniela BOLBORICI	Transelectrica
Modesto Gabrieli Francescato	Terna
Zoran Suboticanec	HEP-OPS
Kliment Naumoski	MEPSO

12.2 Appendix 1: Table of Projects

The following table provides some brief synthetic information regarding the projects mentioned in Chapter 7 of the main document. It gives a synthetic description of each project with some factual information as well as the expected impacts of the projects and commissioning information.

Project & investment items

A project in the TYNDP package 2012 can cluster several **investment items.** Every row of the table in appendix 1 to the TYNDP or Regional Investment Plan report corresponds to one investment item.

The basic rule for the clustering is that **an investment item belongs to a project if this item is required to develop the grid transfer capability increase associated to the project.**

A project can be limited to one investment item only. An investment item can contribute to two projects; in this case, it is depicted only once in the table of projects, in one of the projects (and only referred to in the other project: no technical description, status, etc., are repeated).

Labeling

Projects of pan-European significance are numbered from 1 to 112. Investment items' labels have the following structure: project_index.investment_index. They are displayed on the projects' maps in chapter 7 and in the table of projects below.

Investment items, which were present in the TYNDP 2010, have the same index in the TYNDP 2012 package. Indices of investment items, which were not present in the TYNDP 2010, start with "Axxx".

Examples:
- **79.459**
  designates an investment item, already present in TYNDP 2010 (under the label 459), contributing to project 79.
- **42.A86**
  designates a new investment item, not present in TYNDP 2010, contributing to project 42.

Projects develop grid transfer capability across the boundaries as displayed on the following map (see Figure 36). The numbers attached to every boundary on the following map correspond to the projects' indices relieving the constraints across that boundary:

Figure 36:
Projects-boundaries correspondence

For each project, the following information is displayed:

Column 1	**Project number**	
Column 2	**Investment number**	shows the label under which the investment item is referred to in the TYNDP 2012 package, especially the projects maps shown in Chapter 7.
Column 3 + 4	**Substation 1 & Substation 2**	show both ends of the investment item. The code of the country concerned is given between brackets.
Column 5	**Brief technical description**	gives a summary of the technical features (e.g. new line / upgrading of existing circuit, underground cable / OHL, double circuit / single circuit, voltage, route length …).
Column 6	**Grid transfer capability increase**	shows in MW the order of magnitude or a range for the additional grid transfer capability brought by the project.
Column 7	**Social and economic welfare**	can show 5 different displays distinguishing 1. the SEW gained via better accommodation of inter-area transits and 2. the SEW gained if the project supplies access to the grid for new generation: < 30 M€/yr < 30 M€/yr and additionally gives direct grid access for new generation ≥ 30 M€/yr and ≤ 100 M€/yr ≥ 30 M€/yr and ≤ 100 M€/yr and additionally gives direct grid access for new generation > 100 M€/yr
Column 8	**RES integration**	can show 4 different displays distinguishing the direct connection of RES (< or > 500 MW) and the accommodation of inter-area flows triggered by large amount of RES (> 500 MW): Neutral Direct access to the grid for less than 500 MW of new RES (medium, connection) Direct access to the grid for more than 500 MW of new RES (high, connection) Increasing the capacity between an area with excess of RES generation to share this with other areas[1] (in order to facilitate at least 500 MW of RES penetration)
Column 9	**Improved security of supply**	shows 3 levels of concern, and specifies the area at risk as the case may be: Minor (no specific need) Medium (supply risk solved for less than 10 years after commissioning) High (supply risk solved for more than 10 years after commissioning)
Column 10	**Losses variation**	Higher losses No clear trend Lower losses

1) Direct access can be also achieved incidentally.

Column 11	**CO_2 emissions mitigation**	☐	Neutral Medium (savings < 500 kt CO_2/yr) High (savings > 500 kt CO_2/yr)
Column 12	**Technical resilience**		Minor Medium High
Column 13	**Flexibility**		Minor Medium High
Column 14	**Social and environmental impact**		Low risk Medium risk High risk
Column 15	**Project costs**		> 1,000 M€ ≥ 300 and ≤ 1,000 M€ < 300 M€
Column 16	**Present status**		describes the progress of the project, with respect to the main typical phases of grid projects: – Under consideration, – planned, – design & permitting, – under construction and – commissioned.
Column 17	**Expected commissioning date**		gives the year by which the investment should be commissioned.[1)]
Column 18	**Evolution compared to the TYNDP 2010 situation**		explains the reasons for any adaptation of the technical consistency, evolution of the commissioning date and status of the investment.
Column 19	**Investment comment**		displays any additional information that could be of interest for every investment.
Column 20	**Project comment**		displays any additional information that could be of interest for every project.

More information on the methodology on how to calculate the indicators corresponding to the columns 6 – 15 can be found in appendix 3 of the TYNDP report.

1) This date highly depends of the duration of the permitting process, which TSOs do not master. The date given here is the most likely one, according to present status and to TSO's experience in conducting projects. The date proposed for reinforcements at a very early stage, the consistency of which is still uncertain, is likely to be further refined by the next TYNDP.

Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
Project identification					**Project assessment**														
21	21.54	Cornier (FR)	Piossasco (IT)	Replacement of conductors (by ACCS) on Albertville (FR) – Montagny (FR) – Cornier (FR) and Albertville (FR) – La Coche (FR) – La Praz (FR) – Villarodin (FR) – Venaus (IT) – Piossasco (IT) single circuit 400 kV OHLs. In addition, change of conductors and operation at 400 kV of an existing single circuit OHL between Grande Ile and Albertville currently operated at lower voltage, and associated works in Albertville 400 kV substation. Total length of lines: 257 km	FR – IT 1,800 MW (600 MW in the MT)										under construction	2012 – 2013	Mainly progresses as planned although the works on existing lines take slightly longer than initially thought.		Planned France – Italy interconnection development
	21.55	Grande Ile (FR)	Piossasco (IT)	"Savoie – Piémont" Project: New 190 km HVDC (VSC) interconnection FR – IT via underground cable and converter stations at both ends (two poles, each of them with 600 MW capacity). The cables will be laid in the security gallery of the Frejus motorway tunnel and possibly also along the existing motorways' right-of-way.											design & permitting	2017 – 2018	Progresses as planned.		
	21.81	Trino (IT)	Lacchiarella (IT)	A new 380 kV double circuit OHL between the existing 380 kV substations of Trino and Lacchiarella in Northwest Italy area. Total line length: 95 km Voltage upgrade of the existing Magenta 220/132 kV substation up to 380 kV.											under construction	2013	Authorization process ended, construction phase on going.		
	21.84	Casanova (IT)	Vignole (IT)	Voltage upgrade of the existing 100 km Casanova – Vignole 220 kV OHL to 400 kV and new 400/220/150 kV substation in Asti area.											design & permitting	long term	Delays due to authorization process.		
	21.101	Turin (IT)		Restructuring of the 220 kV network in the urban area of Turin. Some new 220 kV cables, some new 220/132 kV substations and some reinforcements of existing assets are planned. Total length: 63 km											design & permitting	long term	Progresses as planned.		
26	26.63	Lienz (AT)	Veneto region (IT)	The project foresees the reconstruction of the existing 220 kV interconnection line as 380 kV line on an optimized route to minimize the environmental impact. Total length should be in the range of 100 – 150 km.	750 MW										planned	long term	Progresses as planned.		Reinforcement of the interconnection between Italy and Austria. Also the support the interaction between the RES in mainly Italy with the pump storage in the Austrian Alps.
	26.220	Lienz (AT)		Erection of a new 220/220 kV PST in the substation Lienz (AT).											under construction	2012	Project is in errection and expected to be commissioned 2012 according to the schedule.	The investment contributes also to project 47.	
	26.47.216																	The investment contributes both to project 26 and project 47. For the technical description see project 47.	
	26.64	Bressanone (IT)	new substation near Innsbruck (AT)	New double circuit 400 kV interconnection through the pilot tunnel of the planned Brenner Base Tunnel. Total line length: 65 km.											under consideration	>2022	Progresses as planned.		
	26.66	Prati di Vizze (IT)	Steinach (AT)	Upgrade of the existing 44 km Prati di Vizze (IT) – Steinach (AT) single circuit 110/132 kV OHL, currently operated at medium voltage and installing a 110/132 kV PST.											design & permitting	mid term	Investment delayed with 2 years due to the permitting process.		
	26.83	Volpago (IT)	North Venezia (IT)	Realization of a new 380 kV line between the existing substation of North Venezia and the future 380 kV substation of Volpago, connected in and out to the 380 kV "Sandrigo – Cordignano". Total line length: 31 km											design & permitting	2015	Delays due to authorization process.		
	26.93	Dolo (IT)	Camin (IT)	New 15 km double circuit 400 kV OHL between existing Dolo and Camin 400 kV substations, to be built in parallel with the existing line.											under construction	2014	Authorization process ended, construction phase ongoing.		
	26.97	Polpet (IT)		Voltage upgrade of the existing Polpet 150 kV / medium voltage substation up to 220 kV, complying with 400 kV standards. The substation will be connected by two shorts links to the existing Soverzene – Lienz 220 kV line.											design & permitting	2015	Authorization process started, project phase ongoing.		
	26.218	Obersielach (AT)	Lienz (AT)	New 190 km 380 kV OHL connecting the substations Lienz (AT) and Obersielach (AT) to close the Austrian 380 kV ring in the southern grid area. Line length: 190 km											under consideration	long term	Progresses as planned.	The investment contributes also to project 47.	
	26.A102	new interconnection between Italy and Austria		New possible interconnection line between Italy and Austria.											under consideration	long term	This investment replaces investment n° 65 mentioned on TYNDP 2010. The previous investment evolved so much that it is substituted by a new project. Feasibility studies ongoing including internal reinforcements.		

Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environ-mental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
27	27.68	Okroglo (SI)	Udine (IT)	New 120 km double circuit 400 kV OHL with installation of a PST in Okroglo. The thermal rating will be 1,870 MVA per circuit.	>1,800 MW										planned	long term	Progresses as planned.		This project increases the capacity between Slovenia – Italy and Slovenia – Hungary. Project will remove congestion and strengthen connection on north-south and east-west axis.
	27.92	West Udine (IT)	Redipuglia (IT)	New 40 km double circuit 400 kV OHL between the existing substations of West Udine and Redipuglia, providing in and out connection to the future 400 kV substation of South Udine.											design & permitting	2015	The investment is delayed due to longer than expected authorization procedures.		
	27.A96	new interconnection between Italy and Slovenia		New interconnection between Italy and Slovenia.											under consideration	long term	Feasibility studies ongoing including the internal reinforcements.	Need for strengthening the connection between Slovenia and Italy and increasing of power exchange capability.	
	27.223	Cirkovce (SI)	Heviz (HU) Zerjavenec (HR)	The existing substation of Cirkovce (SI) will be connected to one circuit of the existing Heviz (HU) – Zerjavinec (HR) double circuit 400 kV OHL by erecting a new 80 km double circuit 400 kV OHL in Slovenia. The project will result in two new cross-border circuits: Heviz (HU) – Cirkovce (SI) and Cirkovce (SI) – Žerjavenec (HR).											design & permitting	2016	Presently in the authorization process. This investment was delayed due to permitting process.		
	27.224	Krsko (SI)	Bericevo (SI)	New 400 kV double circuit OHL. This project will strengthen connection between East and Central part of Slovenia and connect an internal loop. Line length: 80 km											under construction	2015	Authorization process ended, construction phase is on going. This investment was delayed due to permitting process.		
	27.225	Divaca (SI)	Cirkovce (SI)	Upgrading 220 kV lines to 400 kV in corridor Divaca – Klece – Bericevo – Podlog – Cirkovce. Line length: 193 km											planned	long term	Progresses as planned.		
	27.A105	Lika(HR)	Brinje (HR)	New 55 km single circuit 400 kV OHL replacing aging 220 kV overhead line.											planned	2020	Strengthening of the 400 kV corridor across the Adriatic coast in Croatia in LT period and removal of regional congestion at north-south axis , also to accommodate power transfers from Croatia and Bosnia & Herzegovina to Italy through new IT – ME DC link (Investment 70).		
	27.A106	Lika (HR)	Velebit (HR)	New 60 km single circuit 400 kV OHL replacing aging 220 kV overhead line.											planned	2020			
	27.A107	Lika (HR)		New 400/110 kV substation, 2 × 300 MVA.											planned	2017			
	27.A108	Brinje (HR)		New 400/220 kV substation, 1 × 400 MVA.											planned	2020			
	27.229	Plomin (HR)	Melina (HR)	New 90 km double circuit OHL, with two connecting substations and transformer 400/220 kV, 400 MVA.											design & permitting	>2016	Project moved to long term, due to postponed commissioning date of thermal power plant Plomin.		
	27.227	Banja Luka (BA)	Lika (HR)	New 400 kV interconnection line between BA and HR.											under consideration	2020	End points of OHL and commissioning date defined after bilateral HR – BA agreement.		
28	28.70	Villanova (IT)	Lastva (ME)	New 1,000 MW HVDC interconnection line between Italy and Montenegro via 375 km 500 kV DC subsea cable and converter stations at both ending points.	1,000 MW										under construction	2015	Authorization process ended, construction phase ongoing. The substations on the ME side has been changed.		It contributes significantly to the increase of GTC between the West Balkans and IT such contributing to market integration; complements the ME – IT cable.
	28.86	Foggia (IT)	Villanova (IT)	New 178 km double circuit 400 kV OHL between existing Foggia and Villanova 400 kV substations, also connected in and out to the Larino and Gissi substations. A PST will be installed on the new 400 kV line.											design & permitting	2015	Progresses as planned.		
	28.89	Fano (IT)	Teramo (IT)	New 200 km single circuit 400 kV OHL between the existing 400 kV substations of Fano and Teramo, providing the connection in and out to the future substation to be built in Macerata area.											design & permitting	long term	The investment is delayed due to longer than expected authorization procedures.		
	28.232	Visegrad (BA)	Pljevlja (ME)	New 70 km single circuit 400 kV OHL between Visegrad and Pljevlja.											planned	2015	Feasibility study for 400 kV interconnections RS – ME – BA proposed under Infrastructure Projects Facility for western Balkans.		
	28.233a	Lastva (ME)		A new substation will be connected to the existing line 400 kV Podgorica 2 (ME) – Trebinje(BA), with two transformers 2 × 300 MVA 400/110 kV, and convertor station for the DC cable Lastva (Tivat) – Villanova (see 70).											design & permitting	2015	Feasibility study covering the aspects of route planning, substation location, environmental and social issues and equipment selection is due to end in second half of 2011.		
	28.233b	Lastva (ME)	Pljevlja (ME)	New 160 km double circuit 400 kV OHL existing substation Pljevlja and new substation Tivat.											design & permitting	2016	Feasibility study covering the aspects of route planning, substation location, environmental and social issues and equipment selection is due to end in second half of 2011.		

Table of projects – Regional Group Continental South East

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	28.A109	Bajina Basta (RS)	Visegrad (BA)	New 400 kV interconnection OHL between RS and BA, and reconstruction of existing two OHL 220 kV between BA and Serbia.	1,000 MW										planned	>2016	New investment in TYNDP.	New 400 kV overhead line between RS and BA. It will eliminate constraints in the region for electric energy transits and exchange.	It contributes significantly to the increase of GTC between the West Balkans and IT such contributing to market integration; complements the ME – IT cable.
	28.A110	Bajina Basta (RS)	TPP Obrenovac (RS)	New double circuit 400 kV OHL between new substation Bajina Basta (see infra), and substation Obrenovac.											design & permitting	>2016	New investment in TYNDP.	Obrenovac is the "strongest" 400 kV node in Serbia, thus providing significant upgrade for evacuation and energy transfer from north to south, and further down in Montenegro, through the new line between Bajina Basta and Pljevlja (ME).	
	28.A111	Bajina Basta (RS)	Pljevlja (ME)	New 86 km single circuit 400 kV OHL connecting existing substation Pljevlja (ME) and substation Bajina Basta (RS).											planned	>2016	New investment in TYNDP.		
	28.A112	Bajina Basta (RS)		New 400/110 kV substation in Bajina Basta, upgrading an existing 220/110 kV substation.											planned	>2016	New investment in TYNDP.		
	28.A113	Bistrica (RS)		New 220/110 kV substation.											design & permitting	2015	New investment in TYNDP.	After a topology change in the area, the investment will eliminate firm connection in "Vardiste" (secure and stable operation in Serbian network and systems of Bosnia & Herzegovina and Montenegro), to eliminate constraints in the region for electric energy transits and exchange.	
	28.A114	Konjsko(HR)	Velebit (HR)	New 100 km single circuit 400 kV OHL replacing ageing 220 kV overhead line.											planned	2020	Strengthening of the 400 kV corridor across the Adriatic coast in Croatia in LT period and removal of regional congestion at north-south axis, also to accommodate power transfers from Croatia and Bosnia & Herzegovina to Italy through new IT – ME DC link (Investment 70).		
	28.231	Konjsko (HR)		Installation of a 150 MVAr reactive power device.											design & permitting	2014	Investment postponed 1 year due to permitting process.		
	28.A115	Plat (HR)		New 220/110 kV substation.											under construction	2013	New investment in TYNDP, contributing to mesh the network surrounding HVDC link IT – ME and to increase the reliability of the EHV system.		
	28.228	Trebinhe (BA)	Plat (HR)	Re-establishment of two previously existing 220 kV single circuit interconnection Trebinje (BA) – Plat (HR). Total length: 10 km											planned	2014	Progresses as planned.		
29	29.73	El Aouaria (TU)	Partanna (IT)	New 350 km 1000 MW HVDC line between Tunisia and Italy via Sicily with 400 kV DC subsea cable and converters stations at both ends.	1,500 MW										design & permitting	long term	The investment is delayed due to longer than expected authorization procedures.	This project will be realized in 2 steps. In the previous TYNDP just the first part of the investment was mentioned (500 MW).	Interconnection between Italy and North Africa. Other interconnection projects between North Africa and Italy are still under investigation and under study.
	29.76	Partanna (IT)	Ciminna (IT)	New 65 km single circuit 400 kV OHL in Sicily between existing Partanna and Ciminna substations.											planned	long term	Progresses as planned.		
	29.A97	unknown (IT)	unknown (AL)	New interconnection between Italy and Algeria – new DC submarine cable.											under consideration	long term	New investment in TYNDP.	Need for a new interconnection between Algeria and Italy and increasing of power exchange capability with North Africa frontier. Feasibility study ongoing.	

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30	30.74	Chiaramonte Gulfi (IT)	Sorgente (IT)	Realization of 380 kV ring grid, trough the construction of 3 new 380 kV lines: Chiaramonte Gulfi – Ciminna, Sorgente – Ciminna and Paternò – Priolo. It will be realized a new 380/150 kV substation in Caltanissetta area and the voltage upgrade of the existing Ciminna substation up to 380 kV. Total line length: 365 km New 380/150 kV substation in Sorgente area will be temporaly connected in and out to the existing 400 kV line Paterno – Sorgente and to the local 220 kV and 150 kV network.	1,000 MW			Palermo, Catania, Agrigento and Messina area							planned	2016 / long term	Feasibility studies carried out have led to adapt the schedule.		Sicilian 400 kV transmission ring.
	30.75	Sorgente (IT)	Rizziconi (IT)	New 90 km double circuit 400 kV line, partly via subsea cable and partly via OHL. This line is part of a larger project that foresees the creation of the future 400 kV ring grid of Sicily.											under construction	2014	Delays on construction phase.		
	30.77	Partinico (IT)	Fulgatore (IT)	New 45 km single circuit 400 kV OHL between Partinico and Fulgatore in western Sicily.											planned	2016	Feasibility studies carried out have led to adapt the schedule.		
	30.87	Feroleto (IT)	Maida (IT)	New 400 kV OHL across Calabria between the existing substation of Feroleto and the future substation of Maida, while restructuring the existing grid in North Calabria.											design & permitting	mid term	Delays due to authorization process.		
	30.A98	Mineo (IT)		New 380/150 kV substation in Mineo area connected in and out to the existing 400 kV line Chiaramonte Gulfi – Paterno and to the local HV network.											planned	long term	New investment in TYNDP.	Need to overcome the expected congestions on the central-east HV network of Sicily affected by the flows of consistent production from re-newable plants.	
31	31.85	Pavia area (IT)	Piacenza area (IT)	New 45 km double circuit 400 kV OHL between 2 substations in the Pavia area and Piacenza.	>1,000 MW										planned	long term	Initial design partially changed, with new rein-forcements and rearrangements activities on the neighboring areas resulting from further studies.		Increase interconnection capability between IT and CH.
	31.95	Mese (IT)		Voltage upgrade of the existing 220/132 kV Mese substation up to 400 kV.											design & permitting	2014	Delays due to authorization process.		
	31.99	Avise (IT)	Chatillon (IT)	Voltage upgrade of the existing 40 km Avise – Villeneuve – Chatillon single circuit 220 kV OHL up to 400 kV.											design & permitting	2014	Delays due to authorization process.		
	31.100	Milan (IT)		Restructuring of the 220 kV network in the urban area of Milan. Some new 220 kV cables (33 km), a new 220 kV substation (Musocco) and some reinforcements of existing assets (35 km) are planned.											design & permitting	mid term	The cables in the Milan area are in operation, the appropriate substations are under construction and the reinforcements are under design and permitting.		
	31.103	Brescia (IT)		New 400/132 kV substation in southeast area of Brescia, connected in and out to the existing Flero – Nave 400 kV OHL, while restructuring the 132 kV network.											planned	mid term	Progresses as planned.		
	31.112	Tirano (IT)	Verderio(IT)	New 140 km single circuit 400 kV OHL between Tirano and Verderio substations connecting also the new 400 kV substation Grosio / Piateda.											planned	long term	Progresses as planned.		
	31.124	Mettlen (CH)	Airolo (CH)	Upgrade of existing 225 kV OHL into 400 kV. Line length: 90 km											under consideration	2020	Progresses as planned.		
	31.A101	new inter-connections between Italy and Switzerland		Up to 4 interconnection projects are under discussion, one or two probably will be implemented.											under consideration	long term	This investment replaces investment n° 120 mentioned on TYNDP 2010. The previous investment evolved so much that it is substituted by a new project. Feasibility studies ongoing including the internal reinforcements.		

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Project identification					**Project assessment**														
32	32.88	Montecorvino (IT)	Benevento (IT)	New 70 km double circuit 400 kV OHL between the existing 400 kV substations of Montecorvino and Benevento II, providing in and out connection to the future substation to be build in Avellino North area, which will be also connected to the existing Matera – S. Sofia 400 kV line.	1,900 MW			Naple urban area, Sorrento Penninsul, minor Campania islands and Tirrenic South coast Italy							design & permitting	mid term	The Avelino substation is under construction, the line is in delay due to authorization process.		Reinforcement between south and central-south of Italy to accommodate increasing market flows.
	32.91	Foggia (IT)	Benevento II (IT)	Upgrade of the existing 85 km Foggia – Benevento II 400 kV OHL and installation of a PST on this line.											under construction	2013 – 2014	Authorization process ended, construction phase ongoing.		
	32.96	Deliceto (IT)	Bisaccia (IT)	New 30 km single circuit 400 kV OHL between the future substations of Deliceto and Bisaccia, in the Candela area.											design & permitting	mid term	The 2 substations are in operation from 2011. The connecting line is still in design and permitting. This delay is due to authorization process.		
	32.96a	several new 380 kV substations in Central/South of Italy for RES (IT)		It will be realized few new 380/150 kV substations. The new substations will be connected to the wind power plants in order to avoid the congestions on the 150 kV network and to dispatch the renewable energy produced.											under construction	mid term	The realization of the substations is delayed. These investments are highly sensitive to the construction of the wind / solar plants that are meant to connect.		
	32.102	Naples (IT)		Restructuring of the 220 kV network in the urban area of Naples. Some new 220 kV cables and some reinforcements of existing assets are planned. Total length: 36 km											design & permitting	long term	Progresses as planned.		
	32.110a	Aliano (IT)	Montecorvino (IT)	New connection OHL 400 kV between north Basilicata and Campania region.											planned	long term	Progresses as planned.		
	32.A99	restructuring of North Calabria (IT)		New 400 kV OHL between the existing substations of Laino and Altomonte in Calabria and a new 380/150 kV substation in Aliano connected in and out to the existing 400 kV line Matera – Laino and to the local HV network. Related to this project will be acted a great restructuring of the local HV network, downgrading the existing 220 kV lines to 150 kV level and the demolition of great part of existing 150 kV lines inside the Pollino Park.											partly under construction, design & permitting	2012 / mid term	New investment in TYNDP (initial design partially changed, evolution including new reinforcements and rearrangements activities on the neighbouring areas resulting from further studies).		
33	33.90	Calenzano (IT)	Colunga (IT)	Voltage upgrade of the existing 80 km Calenzano – Colunga 220 kV OHL to 400 kV, providing in and out connection to the existing 220/150 kV substation of S. Benedetto del Querceto (which already complies with 400 kV standards).	500 MW			central part of Italy							design & permitting	mid term	Delays due to authorization process.		Reinforcement between northern and central part of Italy to accommodate increasing market flows.
	33.94	Mantova area (IT)	Modena area (IT)	New 35 km 400 kV OHL between the 2 substations in Modena and Mantova area.											planned	long term	During the preliminary consultation process the substations have became uncertain.		
	33.104	Rome (IT)		Restructuring of the network in the Rome area. The work consists of – a new 380/150 kV substation in southwest area of Rome, connected in and out to the existing 380 kV line Rome West – Rome South, – a voltage upgrade of the existing Flaminia substation up to 380 kV to be connected in and out to the foreseen 380 kV lineRome West – Rome North and – a restructuring of the 150 kV network.											design & permitting	2013 / long term	Progresses as planned.		
	33.109	North Bologna (IT)		New 400/132 kV substation in North Bologna area connected in and out to the existing Sermide – Martignone 400 kV line.											design & permitting	mid term	Delays due to authorization process.		
	33.111	Lucca (IT)		New 380/132 kV substation in Lucca area connected in and out to the existing 380 kV line La Spezia – Acciaiolo.											planned	long term	Progresses as planned.		
	33.113	Monte S. Savino (IT)		New 400/220/132 kV substation in Monte S. Savino area connected to the existing S. Barbara 400 kV substation by upgrading an existing 220 kV line.											design & permitting	2015 / long term	Delays due to authorization process.		
34	34.A100	Codrongianos (IT)	Suvereto (IT)	Repowering of existing HVDC interconnection between Sardinia, Corse and mainland Italy via 220 kV DC subsea cable (358 km). The first connection is in operation since 1970. Total capacity of the bipolar link: 500 MW	500 MW										planned	long term	New investment in TYNDP.		Reinforcement between Sardinia, Corse and mainland Italy.

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48	48.214	Gabcikovo (SK)	Gőnyü area (HU)	New interconnection (new 2×400 kV tie-line) between SK and HU starting from Gabčíkovo substation (SK) to the Gőnyü substation on Hungarian side (preliminary decision). Project also includes the erection of new switching station Gabčíkovo next to the existing one.	SK–HU 1,100 MW / HU–SK 400 MW			(North-West Hungary)							under consideration	2016	The commissioning date has been moved to earlier term due to earlier erection of new 400 kV line Veľký Ďur – Gabčíkovo that help to evacuate power from new NPP.	Negotiations still in progress. This project is closely connected with the project of erection of new line between Rimavska Sobota substation (SK) and Sajoivanka substation (HU) (see below).	This cluster will increase the transfer capacity between Slovak and Hungarian network systems and increase security of supply. The internal interconections in Slovakia are necessary for the same objective. Also this cluster is important for support of North - South flow from RES in North of EU.
	48.298	Veľký Ďur (SK)	Gabčíkovo (SK)	Erection of new 2×400 kV line between two important substations and extension of the substation Veľký Ďur (SK) Line length: 93 km											planned	2016	The commissioning date has been moved to earlier term due to ensure security of power evacuation from new NPP in Veľký Ďur area.		
	48.A125	Veľký Ďur (SK)	Levice (SK)	The erection of new 1×400 kV line between two important Veľký Ďur and Levice substations, including extension of the Veľký Ďur and Levice substation. The driver for this project is expected connection of to new generation units in Veľký Ďur area.											under consideration	2018	New investment in TYNDP, which will significantly increase of the security and reliability of the power evacuation from new NPP.		
	48.A126	Rimavská Sobota (SK)	Sajóivánka (HU)	Connection of the two existing substations (R.Sobota (SK) – Sajoóivánka (HU)) by the new 2×400 kV line (preliminary armed only with one circuit).											under consideration	2016	New investment in TYNDP.	Negotiations / bilateral studies in progress. This project is closely connected with the project 2×400 kV line Gabčíkovo (SK) – Hungary (see above).	
	48.A127	Sajóivánka (HU)	—	Second 400/120 kV transformer and 2×70 Mvar shunt reactors in station Sajóivánka.											under consideration	2016	New investment in TYNDP.		
	48.A128	Győr (HU)	—	Third 400/120 kV transformer and 70 Mvar shunt reactor in station Győr.											under consideration	2016	New investment in TYNDP.		
49	49.235	Tirana(AL)	Pristina (RS)	New 238 km 400 kV OHL. On 78 km the circuit will be installed on the same towers as the Tirana – Podgorica OHL currently in construction (see project 233), the rest will be built as single circuit line.	600 MW										design & permitting	2013	Line in Albania is already constructed. The rest of the lines develops according to the schedule.		It increases significantly the north to south GTC thus accommodating bulk transports to GR, MK and AL.
	49.236	Leskovac(RS)	Stip (MK)	New 220 km 400 kV single circuit overhead interconnection between Serbia and FYR of Macedonia. A new 400/110 substation will be built in Serbia between connection nodes.											under construction	Serbian part commissioned, Macedonian part: 2013	Serbian part is completed. Regarding the Macedonian part, the design is finished, the land acquisition is ongoing and the construction tender is in preparation.		
	49.237	TPP Kosovo (RS)	Skopje (MK)	A new 400 kV OHL relevant to planning investment of 2,000 MW of TPP in the area of Kosovo and Metohija. Line length: 85 km											under consideration	2020	Progresses as planned.		
	49.252	Melliti (GR)	Kardia (GR)	New 400 kV double circuit OHL. Length: 40 km											design & permitting	long term	Due to new thermal generation in South Greece the investment is no more needed urgently and postponed to the longer term. (This investment mainly was initially designed to solve voltage problems in South Greece.)		
	49.253	Kardia (GR)	Trikala (GR)	New 400 kV double circuit OHL. Length: 80 km											design & permitting	long term	Progresses as planned.		
	49.254	Larissa(GR)	Trikala (GR)	New 400 kV double circuit OHL. Length: 57 km											under consideration	long term	Progresses as planned.		

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50	50.238	Pancevo (RS)	Resita (RO)	New 131 km double circuit 400 kV OHL between existing substations in Romania and Serbia (63 km on Romanian side and 68 km on Serbian side).	1,000 MW			Area Belgrade and south Banat region							design & permitting	2015 (2019?)	Due to financing gap, the commissioning deadline was postponed to 2019. RO intends to apply for funding through the Operational Programme "Increase of Economic Competitiveness" – Priority Axis 4. This would ensure realization of the project and allow for faster finalization (2015 instead of estimated 2019). Constructive characteristics were updated as a result of progress of feasibility and design studies.		This project increases the transfer capability between Serbia, Romania and accommodates new RES generation on the west / east part of Romanian, respectively Serbia. It also increases the transfer capability on the interface between RO + BG / RS + BA + ME.
	50.269	Portile de Fier (RO)	Resita (RO)	New 400 kV OHL between existing substation 400 kV Portile de Fier and new 400 kV substation Resita. Line length: 116 km New 400 kV substation Resita, with 400/220 kV and 400/110 kV transformers, as development of the existing 220/110 kV substation.											design & permitting	2016	Constructive characteristics were updated as a result of progress of feasibility and design studies. Commissioning date has been slightly shifted.		
	50.A116	Beograd 20 (RS)		New 400/110 kV substation on the Belgrade territory.											under construction	2012	New investment in TYNDP.	By taking large amount of load from other Belgrade substations, the investment will both – improve the local SoS significantly and – relieve the constraints on the EHV local network and enable greater inter-area transits.	
	50.A117	Kraljevo 3 (RS)		Upgrade of the existing 220/110 kV substation Kraljevo 3 by constructing the 400 kV level.											design & permitting	2015	New investment in TYNDP.		
	50.A118	Kraljevo 3 (RS)	Bajina Basta (RS)	New 140 km double circuit 400 kV OHL between substation Kraljevo 3 and substation Bajina Basta. Kraljevo 3 (400 kV) will be connected to Kragujevac 2 (400 kV) substation, which is connected to Sofia (Bulgaria) through a 400 kV line.											planned	>2015	New investment in TYNDP.	New axis for transits from east to west, typically from Bulgaria to Bosnia & Herzegovina, Montenegro and further to the west.	
	50.270	Resita (RO)	Timisoara – Sacalaz – Arad (RO)	Upgrade of an existing 220 kV double circuit line to 400 kV double circuit line and replacement of 220 kV substations Timisoara and Sacalaz with 400 kV substations. Line length: 156 km											design & permitting	2022	Due to financing gap, the commissioning deadline was postponed to 2022. Constructive characteristics were updated as a result of progress of feasibility and design studies.		
51	51.239	Bitola (MK)	Elbasan (AL)	New 200 km cross-border single circuit 400 kV OHL between existing substations. New 400/110 kV substation in Ohrid area connected in / out to the new 400 kV line Bitola – Elbasan.	BG – AL 1,255 MW / BG – TR >1,000 MW										planned	2015	Change of date of commissioning due to – resolving the problems in the 110 kV in southwestern Macedonia, – facilitate the market integration and – increased interest of potential investors.	Selection of consultant for preparation of feasibility study.	East-west corridor from Bulgaria to Italy. Investments 257, 258 and 262 can build up an independant sub-project, as they will both – develop altogether, specifically grid transfer capability with Turkey, and – contribute with all other investments clustered in the project to developing GTC east – west from Bulgaria to Bosnia & Herzegovina and Montenegro.
	51.244	Filippi (GR)	Lagadas (GR)	New 400 kV substation in Lagadas in Thessaloniki area and connection to the existing substation of Filippi via a new 110 km double circuit 400 kV OHL.											under construction	2013	Initial delays due to authorization process. The project is now under construction.		
	51.256	Maritsa East 1 (BG)	N. Santa (GR)	New interconnection line BG – GR by a 130 km single circuit 400 kV OHL.											design & permitting	long term	After the interconnection with Turkey, the project can be delayed to LT as it is mainly connected to further RES development. The final commissioning date is subject to change depending of the evolution in the area.		
	51.257	Maritsa East 1 (BG)	Plovdiv (BG)	New 100 km single circuit 400 kV OHL in parallel to the existing one.											design & permitting	2014	Investments 257, 258 and 262 are postponed because the permitting procedures (environmental requirements) with the land owners induced delays.		
	51.258	Maritsa East 1 (BG)	Maritsa East 3 (BG)	New 13 km single circuit 400 kV OHL in parallel to the existing one.											design & permitting	2014			
	51.262	Maritsa East 1 (BG)	Burgas (BG)	New 400 kV OHL. Line length: 150 km											design & permitting	2014			

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52	52.240	Patras (GR)	400 kV Continental System (GR)	New 400 kV substation in Patras (GIS Technology) and in/out connection to the existing Axeloos – Distomo 400 kV OHL via a new 15 km double circuit line, part of which will consist of subsea cable. The project shall constitute the first 400 kV corridor to Peloponnese.	600–700 MW			Peloponnese area							design & permitting	2013	The project is likely to be delayed mainly due to the environmental concerns. Strong opposition by the local communities resulted in the delay in permitting procedures and subsequent delay in the expected date of commissioning.		It increases significantly the GTC to/from the peninsula of Peloponnese, thus allowing the accommodation of large amount of RES in the peninsula and also contributes to market integration.
	52.241	Patras (GR)	Megalopolis (GR)	New 400 kV substation in Megalopolis and connection to Patras 400 kV substation via a 110 km double circuit OHL. 2nd corridor to Peloponnese.											design & permitting	2013			
	52.242	Megalopolis (GR)	Korinthos (GR)	Construction of a new 400 kV substation in Korinthos (GIS Technology) and connection to the Megalopolis substation via a 110 km double circuit 400 kV OHL.											design & permitting	2014			
	52.243	Korinthos (GR)	Koymoyndoyros (GR)	Replacement of the existing 150 kV double circuit line by a 87 km double circuit 400 kV OHL.											design & permitting	2014			
53	53.276	Suceava (RO)	Gadalin (RO)	New 400 kV OHL between existing stations. Line length: 260 km	2,000–2,500 MW										planned	2021	Constructive design characteristics and time schedule were updated as a result of progress of feasibility and design studies.		The project will help evacuate important amount of new generation (wind + nuclear generation) in the eastern part of Romania.
	53.A131	Stejaru (RO)	Gheorghieni (RO)	Reconductoring (with HTLS) of existing simple circuit 220 kV line.											under consideration	2015	New investment in the TYNDP, required to integrate new RES generation and maintain the GTC for the entire project.		
	53.273	Cernavoda (RO)	Stalpu	New 400 kV double circuit OHL between existing stations. Line length: 145 km											planned	2017	Constructive characteristics were updated as a result of progress of feasibility and design studies.		
	53.274	Constanta (RO)	Medgidia (RO)	New 400 kV double circuit (one circuit wired) OHL between existing stations. Line length: 75 km											planned	2020	As for other investments, the commissioning date was postponed due to financing gap. Constructive characteristics were updated as a result of progress of feasibility and design studies.		
	53.275	Smardan (RO)	Gutinas (RO)	New 400 kV double circuit OHL between existing stations. Line length: 140 km											planned	2020	As for other investments, the commissioning date was postponed due to financing gap. Constructive characteristics were updated as a result of progress of feasibility and design studies.		
	53.271	connection in/out in Medgidia (RO) of actual 400 kV OHL Isaccea(RO) – Varna (BG)		The 400 kV Isaccea (RO) – Varna (BG) is passing near 400 kV substation Medgidia S. The line shall be connected in Medgidia S through a double circuit OHL. New wind farms shall be connected to the 400 kV OHL Isaccea – Medgidia S section. Substation Medgidia S, 400 kV, shall be refurbished with GIS technology in order to provide necessary space for new connections.											design & permitting	2015	As for other investments, the commissioning date was postponed due to financing gap. Constructive characteristics were updated as a result of progress of feasibility and design studies.		
	53.A132	Stalpu (RO)	Teleajen (RO) – Brazi (RO)	Upgrade of an existing 220 kV single circuit line to 400 kV. New 400 kV substations: – Stalpu (400/110 kV, 1 × 250 MVA), – Teleajen (400/110 kV, 1 × 400 MVA)											planned	2018	New investment in TYNDP.	This investment was merged with investment 273 in TYNDP 2010. They are now presented as separate investments in TYNDP 2012, according to internal project organization. The network development is still the same.	
	53.A133	Fantanele (RO)	Ungheni (RO)	Reconductoring (with HTLS) of existing simple circuit 220 kV line.											under consideration	long term	New investment in the TYNDP, required to accomodate new RES generation not foreseen in the TYNDP 2010, by increasing the GTC for the entire project.		

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Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
	53.272	connection in / out in Medgidia (RO) of actual 400 kV OHL Isaccea(RO) – Dobrudja(BG)		Connection in / out in Medgidia (RO) of existing 400 kV OHL Isaccea (RO) – Dobrudja (BG), passing nearby. The line shall be connected in Medgidia S through a double circuit OHL. Substation Medgidia S, 400 kV, shall be refurbished with GIS technology in order to provide necessary space for new connections.											design & permitting	2015	As for other investments, the commissioning date was postponed due to financing gap. Constructive characteristics were updated as a result of progress of feasibility and design studies.	New wind farms shall be connected to the 400 kV OHL Isaccea – Medgidia S section.	The project will help evacuate important amount of new generation (wind + nuclear generation) in the eastern part of Romania.
	53.A134	Gheorghieni (RO)	Fantanele (RO)	Reconductoring (with HTLS) of existing simple circuit 220 kV line.											under consideration	2015	New investment in the TYNDP, required to accomodate new RES generation not foreseen in the TYNDP 2010, by increasing the GTC for the entire project.		
54	54.293	Voľa (SK)	point of splitting (SK)	Splitting of the existing single 400 kV line between Lemešany and Veľké Kapušany substations to connect the new 400 kV substation Voľa with transformation 400/110 kV (replacing existing 220 kV substation). New 400 kV double circuit OHL. Length: 23 km	500 MW										design & permitting	2013	Progresses as planned.		This cluster will increase the transfer capacity between Slovak and Hungarian network systems and increase security of supply. The internal interconnections in Slovakia are necessary for the same objective. Also this cluster is important for support of north-south flow from RES in north of EU.
	54.294	Lemešany (SK)	Veľké Kapušany (SK)	Erection of new 400 kV line between Lemešany and Veľké Kapušany substations. The project includes the extension both substations Lemešany and V.Kapušany. Line length: 100 km (including the loop erected under the investment 54.293)											planned	2018	Progresses as planned.		
	54.A127	Veľké Kapušany (SK)	tbd (HU)	Erection of new 2 × 400 line between SK and Hungary (substation on Hungarian side still to be defined).											under consideration	2021	New investment in TYNDP.		
95	95.A119	Dobrudja(BG)	Burgas (BG)	New 140 km single circuit 400 kV OHL in parallel to the existing one.	1,500 MW										planned	2016	New investment in TYNDP, required to accommodate 2,000 MW RES in Dobrudja region.		It contributes to the accommodation of large amount of RES in Dobrudja region (2,000 MW). It also contributes to north-south transfers and increases the security of supply in Burgas region.
	95.265	Vidno (BG)	Svoboda (BG)	New 400 kV double circuit OHL to accommodate 2,000 MW RES generation in Northeast Bulgaria (Dobruja region). Line length: 2 × 70 km											planned	2015	Moved from LT (TYNDP 2010) to MT due to high interest for very fast implementation of about 2,000 MW RES generation in Dobrudja region.		
	95.263	SS 400/110 kV Svoboda (Krusari)		New 400/110 kV substation to accommodate the expected RES generation(2,000 MW) in Northeast Bulgaria (Dobruja region).											planned	2015			
	95.264	SS 400/110 kV Vidno		New 400/110 kV substation to accommodate the expected RES generation(2,000 MW) in Northeast Bulgaria (Dobruja region).											planned	2015			
	95.266	in / out in Svoboda on actual 400 kV OHL Isaccea (RO) – Varna (BG)		New 400 kV double circuit OHL to accommodate the expected RES generation(2,000 MW) in Northeast Bulgaria (Dobruja region). Line length: 2 × 10 km											planned	2015			
108	108.A134	Tarnita (RO)	Mintia (RO)	New 145 km double circuit 400 kV OHL.	1,000 MW										planned	2018	New investment in TYNDP.	Connection of pumped storage hydro plant Tarnita Lapustesti to the grid. The plant has an installed capacity of 1,000 MW and will support system balancing, especially in order to face the intermittent RES output.	The project will connect to the grid 1,000 MW hydro pump storage.
	108.A135	Tarnita (RO)	Cluj E – Gadalin (RO)	New 40 km double circuit 400 kV OHL.											planned	2018	New investment in TYNDP.		
	108.A136	Tarnita (RO)		New 400 kV substation.											planned	2018	New investment in TYNDP.		

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Project identification					Project assessment														
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112	112.98	Pordenone (IT)		Voltage upgrade of the existing Pordenone 220 kV substation up to 400 kV. The substation will be connected in and out to the existing Udine O. – Cordignano 400 kV line.	2,150 MW			Triveneto area							planned	long term	Progresses as planned.		This projects helps to increase the security of supply in the northeastern part of Italy.
	112.105	Treviso (IT)		New 380/132 kV substation in Treviso area, connected in and out to the existing 380 kV line Sandrigo – Cordignano.											design & permitting	mid term	Project delayed by 2 years due to longer than expected permitting procedure.		
	112.106	Schio (IT)		New 220/132 kV substation in Schio area, providing the connection in and out to the existing 220 kV line Ala – Vicenza Monte Viale.											planned	mid term	Project delayed by 2 years due to longer than expected permitting procedure.		
	112.107	Vicenza Industrial (IT)		New 380/132 kV substation in the industrial area of Vicenza, connected in and out to the existing Sandrigo – Dugale 400 kV line.											planned	long term	Progresses as planned.		
	112.108	Northwest Padova (IT)		New 220/132 kV substation in Northwest Padova area, complying with 400 kV standards, providing the connection in and out to the existing Dugale – Marghera Substation1 220 kV line.											planned	long term	Progresses as planned.		

Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environ-mental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
	69	Candia (IT)	Konjsko (HR)	New 1,000 MW HVDC interconnection line between Italy and Croatia via 280 km 500 kV DC subsea cable and converters stations at both ending points.											under consideration	post 2022	These projects are very sensitive to the market and still under investigation.		
	71	Brindisi (IT)	Babica (AL)	500 MW single pole HVDC merchant line between Italy and Albania via 290 km 400 kV DC subsea cable and converter stations at both ends. On the Italian side, the new line will be connected to the existing substation of Brindisi South.											design & permitting	long term	Permitted as a merchant line (it develops according to the plan for the stakeholders).		
	72	Aetos(GR)	Galatina (IT)	Second 500 MW HVDC link between Greece and Italy via 316 km 400 kVDC subsea cable and converters stations at both ends.											under consideration	post 2022	These projects are very sensitive to the market and still under investigation.		
	120	Lavorgo (CH)	Morbegno (IT)	New 400 kV tie line between Italy and Switzerland.											cancelled	cancelled	It has been replaced by investment n° ITA-4 "New interconnection between CH and IT". Change in the design and complexity of the project.		
	230	TPP Sisak (HR)	Mraclin(HR) / Prijedor (BA)	Connection of new generator on existing line 220 kV Mraclin (HR) – Prijedor (BA) via a new double circuit OHL. Line length: 12 km											design & permitting	2012 – 2013	The commissioning date is postponed due to the prolonged permitting procedures and due to the harmonization with installation of new generating unit in TPP Sisak.		
	245	N.Santa (GR)		Construction of the new 400 kV S/S N.Santa in North Greece. This S/S will serve as the interface for the new line GR – TR, as well as for the interconnection of new wind farms and conventional generation.											commissioned	commissioned	Commissioned.		
	247	Aliveri (GR)	Larimna (GR)	Construction of the new 400 kV S/S Aliveri in Eviai area and a new 400 kV double circuit line Aliveri – System. Line length: 128 km											design & permitting	long term	Delays in the permitting procedures and uncertainties in the commission of new generation in Evia island.		
	250	Lavrion (GR)	Syros (GR)	New 150 kV subsea cable DC connection. There is also the possibility to use AC if proved technically and economically feasible.											design & permitting	2015	Due to the technical complexity of the projects and environmental problems, the project is delayed. Most of the problems have been solved; the tender for the construction released in 2011. Now the date of commissioning is identified.		
	251	Syros (GR)	Cyclades (GR)	New 150 kV subsea cables and 4 × 150 kV substations to islands of Mykonos,Paros, Naxos and Tinos .											design & permitting	2015			
	255	Lamia (GR)		Construction of a new 400 kV EHV SS in Lamia and connection to the two circuits of the existing 400 kV lines Trikala – Distomo and Larisa – Larymna.											planned	long term	No change.		
	260	Plovdiv (BG)	Aleko (BG)	Reconstruction of the existing 220 kV OHL and the building of a new second one. Line length: 40 km											cancelled	cancelled	The project is abandoned, as building the 400 kV line M. East 1 – Plovdiv (Project 139, boundary 40b, inv. index 257) will eliminate the need of building the line.		
	261	Karnobat (BG)	Dobrudja (BG)	This project concerns the reconstruction of the existing 220 kV OHL. Line length: 95 km											cancelled	cancelled	The project is abandoned, as building the 400 kV lineDobrudja – Burgas (Project 136 boundary 43, inv. index BG NEW) will eliminate the need of building the line		
	267	Suceava (RO)	Balti (MD)	New 400 kV OHL (139 km) to increase capacity of transfer between Romania and Rebublic Moldova. The project also implies new substation 400 kV in Moldova (extension of the substation Balti with 400 kV level).											design & permitting	2020	The project is associated to the connection of the Rep. Moldova and Ukraina. Delay is associated to the procedure for the connection of UA and MD.		
	268	Constanta (RO)	Pasakoy (TR)	New DC link (subsea cable) between existing stations in RO and TR. Line length: 400 km											under consideration	>2020	The delay in the investment is caused by the lack of financial means.		
	279	Gyor (HU)	Martonvasar (HU)	Upgrade of an existing 220 kV single circuit line to 400 kV double circuit. Line length: 84 km											under construction	2012	It will be commissioned by the end of 2012.		

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	282	Sajoszoged / God (HU)	Detk (HU)	New substation Detk with 2 × 250 MVA 400/120 kV transformation is connected by splitting and extending existing line Sajoszoged – God.											design & permitting	2017	The project was delayed due to a change in the generation (decommissioning of units connected to 120 kV deferred) which led to a delay in investment need.		
	284	Martonvasar / Paks (HU)	Dunaujvaros (HU)	New substation Dunaujvaros with 2 × 250 MVA 400/120 kV transformation is connected by splitting and extending existing line Martonvasar – Paks.											design & permitting	2015	2012 > 2015: Delayed due to delay in investment need, according to National Plan 2010 (load growth in the specific area will be lower than previously forecasted).		
	285	Debrecen (HU)		New substation Debrecen with 2 × 250 MVA 400/120 kV transformation is connected by changing the operating voltage of line Sajoszoged – Debrecen from 220 kV to 400 kV, this line being already designed for 400 kV.											design & permitting	2013	Progress as planned.		
	286	Martonvasar / Liter (HU)	Szekesfehervar (HU)	New substation Szekesfehervar with 2 × 250 MVA 400/120 kV transformation is connected by splitting and extending existing line Martonvasar – Liter.											planned	2016	2014 > 2016: Delayed due to delay in investment need, according to National Plan 2010 (load growth in the specific area will be lower than previously forecasted).		
	287	Albertirsa / God (HU)	Godollo (HU)	New substation Godollo with 2 × 250 MVA 400/120 kV transformation is connected by splitting and extending existing line Albertirsa – God.											planned	2015	Progress as planned.		
	288	Albertirsa / Martonvasar (HU)	Szazhalombatta (HU)	New substation Szazhalombatta is connected by splitting and extending existing line Albertirsa – Martonvasar.											planned	2015	Progress as planned.		
	289	Felsozsolca (HU)	Sajoivanka (HU)	Reconstruction of line to double circuit, installation of the 2nd transformer in substation Sajoivanka. Line length: 29 km											cancelled	cancelled	Cancelled. New cluster #53 makes this investment unnecessary.		
	290	Oroszlany (HU)		New substation Oroszlany with 2 × 250 MVA 400/120 kV transformation is connected by splitting and extending the second circuit of line Martonvasar – Gyor.											under consideration	2016	2017 > 2016: Earlier completion is foreseen for financing and organization reasons.		
	291	Sajoszoged (HU)		New 400/120 kV 250 MVA transformer with PST.											cancelled	cancelled	Cancelled according to National Plan 2010. Generation pattern in the specific area will change significantly thus this investment is no longer necessary.		
	292	Debrecen (HU)		Reconstruction of 750 kV substation.											design & permitting	2013	Progress as planned.		
	65	Curon (IT) / Glorenza (IT)	new substation close to the border in AT	New 380/220 kV substation in AT directly located near the border. Erection of a 24 km single circuit 220 kV connection via OHL and underground cable till Graun (IT) and upgrade of the existing line Graun (IT) – Glorenza (IT).											cancelled	cancelled	It has been replaced by investment n° ITA-5 “New interconnection between AT and IT”. This project which was depicted in the TYNDP 2010 suffered important changes in the design.		
	78	Palermo area (IT)		Restructuring of the network in the Palermo area. The work consists of – a new 220/150 kV substation, complying with 400 kV standards, connected to the Ciminna substation with a new 400 kV line and in & out the existing Bellolampo – Caracoli 400 kV line, – the connection of 15 kV lines Casuzze – Monreale and Casuzze – Guadalami and – a repowering of the existing Casuzze 150 MV substation. It is foreseen also large a restructuring of the 150 kV network in the Palermo area in order to increase the security and the quality of supply. Total length: 49 km											design & permitting	2015	The project has changed in terms of composition (new refurbishments were added to the initial project). The date of commissioning was advanced due to the faster need of increasing the security of Palormo area.		
	79	Agrigento (IT)		New 220/150 kV substation, complying with 400 kV standards. The new substation will be connected in and out to the existing Partanna – Favara 400 kV line.											design & permitting	2015	The authorization process is faster than expected.		
	80	Noto (IT)		New 220/150 kV substation, complying with 400 kV standards, connected in and out to the existing Ragusa – Melilli 400 kV line.											design & permitting	2014 / 2015	The authorization process is faster than expected.		

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Project identification					Project assessment														
Project number	Investment number	Substation 1	Substation 2	Brief technical description	Grid transfer capacity increase	Socio-economic welfare	RES integration	Improved security of supply	Losses variation	CO_2 mitigation	Technical resilience	Flexibility	Social and environ-mental impact	Project costs	Present status	Expected date of commissioning	Evolution compared to the TYNDP 2010 situation	Investment comment	Project comment
	248	Polypotamo (GR)	N. Makri (GR)	New 150 kV double circuit subsea cable. Line length: 33 km											under construction	2013	Delays due to authorization process.		
	110	restructuring of Sorrento Peninsula network (IT)		It is planned a new 380/220/150 kV substation in East Vesuvius area (near Naples) connected in & out to the existing 380 and 220 kV lines Montecorvino – S. Sofia and Nola – S. Valentino. Related to this project, it has been programmed also some reinforcements and restructuring of the existing 220 kV and 150 kV network in the area of Sorrento Peninsula. Total net length: 58 km											design & permitting	2014	Shifted from long term to 2014 due to the authorization process which started a little bit before the scheduled time.		
	119	Capri, Ischia, Procida (IT)		New 150 kV subsea connection between the Capri, Ischia and Procida islands to the existing substations of Cuma and Torre Annunziata (mainland Italy). Total length: 95 km											design & permitting	2014	Delays due to authorization process.		
	118	Porto Ferraio (Elba Island / IT)	Cornia (Piombino / IT)	New 40 km 132 kV connection via subsea cable between the existing substation of Porto Ferraio and the future 400/132 kV substation of Cornia that will also be connected in and out to the existing Suvereto – Piombino Termica 400 kV line.											design & permitting	2012 / long term	Delays due to authorization process.		
	114	Ittiri (IT)	Codrongianos (IT)	New 18 km 400 kV OHL between the existing substation of Codrongianos and the future 400 kV substation of Ittiri that will be also connected in and out to the existing Fiumesanto – Selargius 400 kV line.											commissioned	commissioned	Commissioned.		
	115	Fiumesanto (IT)	Latina (IT)	Second pole of HVDC link between Sardinia and mainland Italy via 400 kV DC subsea cable (420 km). The first pole is in operation since 2009. Total capacity of the bipolar link: 1,000 MW											commissioned	commissioned	Commissioned.		
	116	Casellina (IT)	Tavarnuzze (IT)	New 37 km 400 kV OHL with rearrangement of EHV grid in the area between Casellina and S. Barbara. Voltage upgrade of the existing substations of Casellina 400/132 kV and S. Barbara 400/132 kV.											commissioned	commissioned	Commissioned.		
	117	Castegnero (IT)		New 220/132 kV substation connected in and out to the existing 220 kV line Cittadella – Este and Dugale – Stazione 1, providing a restructuring of HV grid.											commissioned	commissioned	Commissioned.		
	213	Wien SO (AT)	Szombathely (HU)	Installation of the 2nd circuit on the existing interconnection from Wien SO (AT, APG) to the border (both circuits have already been installed on the Hungarian side, one is connected to Györ and the 2nd circuit to Szombathely). Line length: 63 km											commissioned	commissioned	2011 > 2010: Completed earlier. It was due to scheduling of the field work.		
	226	Ernestinovo (HR)	Pecs (HU)	New 400 kV double circuit interconnection line between existing stations. Line length: 86 km											commissioned	commissioned	Commissioned.		
	246	Aliveri(GR)	System (GR)	Construction of the new 400 kV S/S Aliveri in Eviai area and a new 400 kV double circuit line Aliveri – System. Line length: 72 km											under construction	2012	Under construction; some minor design and permitting issues are pending. The investment has been removed from projects of European significance because it doesn't fit to the criteria set in TYNDP 2012.		

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	249	Polypotamo (GR)	N. Evia (GR)	New 150 kV double circuit OHL. Line length: 40 km Along the new transmission line, 4 new 150/20 kV substation shall be build for the interconnection of new wind farms in Evia island.											under construction	2013	This line will be utilized mainly for the connection of new wind farms. The final locations of the private substations are not defined yet. In addition public opposition to the construction of the overhead line created additional time delays. The investment has been removed from projects of European significance because it doesn't fit to the criteria set in TYNDP 2012.		
	259	Plovdiv (BG)	Zlatica (BG)	New 75 km single circuit 400 kV OHL.											commissioned	commissioned	Completed and in normal operation since October 2010.		
	277	Heviz (HU)	Szombathely (HU)	New 400 kV transmission line between existing stations. Line length: 78 km											commissioned	commissioned	Commissioned.		
	278	Gyor / Liter (HU)	Gonyu (HU)	New substation Gonyu (generator connection point) is connected by splitting and extending existing line Gyor – Liter.											commissioned	commissioned	Commissioned.		
	233	Tirana (AL)	Podgorica (ME)	New 400 kV line Tirana (AL) – Podgorica (ME). Length: 157 km (128.5 km on Albanian side, 76 km of which with double circuit and 28.5 km on the Montenegrin side).											commissioned	commissioned	Commissioned.		
	234	Elbasan (AL)	Tirana(AL)	New 400 kV AC OHL. Length: 48 km.											commissioned	commissioned	Commissioned.		
	280	Gyor / Martonvasar (HU)	Bicske (HU)	New substation Bicske with 2 × 250 MVA 400/120 kV transformation is connected by splitting and extending existing line Gyor – Martonvasar line.											commissioned	commissioned	2012 > 2010: Completed earlier. It was due to financing and field organization issues.		
	283	Albertirsa / Bekescsaba (HU)	Szolnok (HU)	New substation Szolnok with 2 × 250 MVA 400/120 kV transformers is connected by splitting and extending existing line Albertirsa – Bekescsaba.											commissioned	commissioned	2012 > 2011: Earlier completion due to scheduling of the field work.		
	281	Albertirsa (HU)	Martonvasar (HU)	Adding second circuit to existing 400 kV single circuit OHL. Line length: 45 km											commissioned	commissioned	Commissioned earlier due to scheduling of the field work.		
	67	Divaca (SI)		Installation of a new 400 kV PST to assist control of power flows to Italy on secure level and secure the operation of Slovenian grid enabling full utilisation of regional market.											commissioned	commissioned	This is PST in SS Divaca and it has been in operation since 2011.		
	82	Chignolo Po (IT)	Maleo (IT)	A new 380 kV double circuit OHL between the new 380 kV substations of Chignolo Po and Maleo in Lodi area. Restructuring of HV network. Total line length: 22 km											commissioned	commissioned			
	A121	Brezna (ME)		A new substation will be connected to the planned line 400 kV Lastva – Pljevlja (ME) with two transformers 2 × 300 MVA 400/110 kV.											design & permitting	2016	New project.		
	A122	Maoce (ME)		A new TPP substation will be connected to the existing line 400 kV Ribarevine – Pljevlja (ME).											design & permitting	2018	New project.		
	A123	Andrijevo (ME)		A new HPP substation will be connected to the existing line 400 kV Ribarevine – Pljevlja (ME).											design & permitting	2016	New project.		
	A130	Albertfalva (HU)		New 220/120 kV 160 MVA transformer.											planned	2020	Appeared in National Plan 2010. Transformer capacity extension on 220/120 kV is needed for maintaining security of supply.		
	A138	Filippoi EHV (GR)	Limnos (GR)	A new substation in Limnos will be connected to the mainland grid to the existing EHV substation in Filippoi.											under consideration	long term	New project.		
	A137	Larymna EHV (GR)	Chios (GR)	A new substation in Chios will be connected to the mainland grid to the existing EHV substation in Larymna.											under consideration	long term	New project.		
	A140	Chios (GR)	Lesvos (GR)	A new substation in Lesvos will be connected to Chios substation.											under consideration	long term	New project.		

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	A141	Limnos (GR)	Lesvos (GR)	A new submarine DC link will connect Limnos and Lesvos substations.											under consideration	long term	New project.		
	A142	Megalopoli EHV (GR)	Crete 1 (GR)	A new substation in Crete will be connected to the mainland grid in Peloponese to the new EHV substation in Megalopoli.											under consideration	2018 – 2019	New project.		
	A143	Acharnes EHV (GR)	Crete 2 (GR)	A new substation in Crete will be connected to the mainland grid of the capital to the existing EHV substation in Acharnes.											under consideration	2030	New project.		
	A104	Castelbello (IT)	Naturno (IT)	New 220 kV (insulated at 400 kV level) OHL connection between existing stations of Naturno and Castelbello.											planned	long term	Overcoming the constrains in operation, due the renewable generation in the area of Trentino Alto Adige region.		

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12.3 Appendix 2: Regional Grid Studies' Results

The software package PSS™MUST[1] was used for the calculations. The purpose of the **P**ower **S**ystem **S**imulator for **M**anaging and **U**tilizing **S**ystem **T**ransmission (PSS™MUST) is to efficiently calculate the impact of transactions on key network elements, identify the most limiting contingencies and constraints, efficiently calculate electric transmission transfer capabilities in large size grids and display the impact of transactions and generation dispatch variations on transfer capabilities.

PSS™MUST employs several load flow models including a non-linear AC model and a very fast linear incremental model. PSS™MUST calculations are based on the incremental linear model around non-linear AC starting flows. The linear model has proven to be very useful for the fast investigation of multi-case scenarios and has been applied for the assessment of GTC in this study.

The scope of the calculations is the assessment on a Regional level of the expected impact of future transmission projects planned by TSOs in SE Europe, and on GTC across boundaries between different price zones in the area.

The base case model used for these calculations is a Regional Winter Peak 2020 model, compatible with EU2020. Power balances of the model (country/exchange/load/generation), as well as inter-area flows (MW) are shown in the figure below. It should also be mentioned that in this base case model, inter-area power flows were derived from country balances calculated using a top-down approach and were not provided by each TSO, due to the specifics of the EU 202020 scenario. For Turkey in particular, due to the fact that it is not an ENTSO-E member, country balance was set according to assumptions.

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1) PSS™MUST 9.0 User Manual, Siemens Power Transmission & Distribution, Inc., Power Technologies International, February 2008

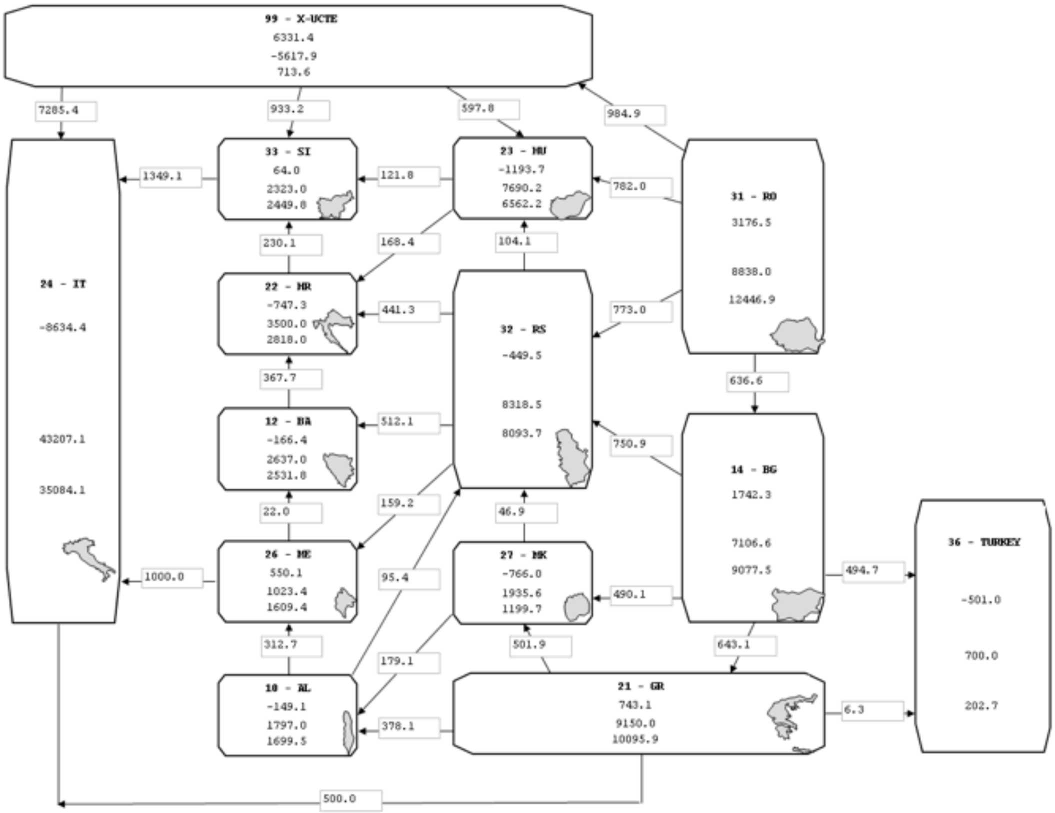


Figure 37:

Power flows in the base case model

Illustration of results

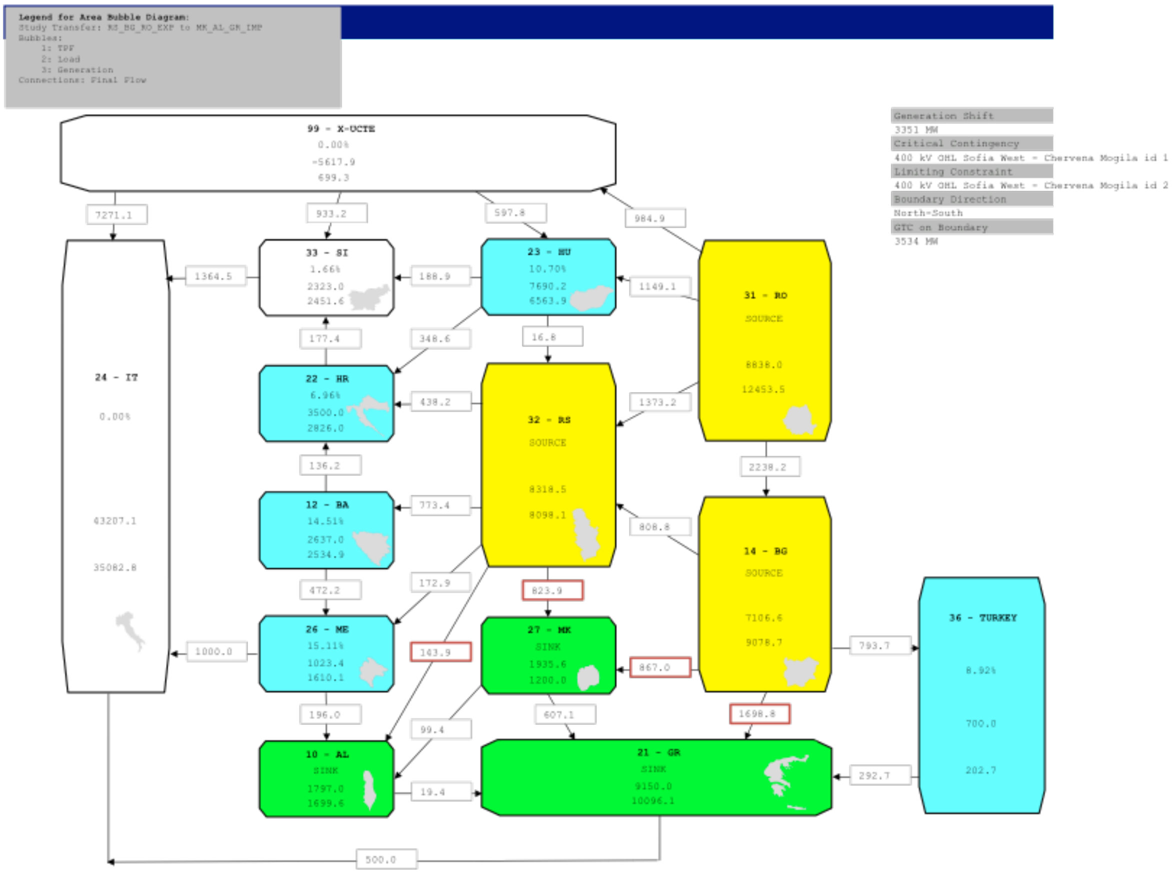


Figure 38:
Legend for diagram

Legend for the diagram

Areas are represented with bubbles, and each bubble comprises information on:

1: Role of an area:

- source (yellow),
- sink (green),
- turquoise/white (transit in %).

2: Load in area in base case.

3: Generation in area in base case.

Indications in the table in the upper right corner, Figure 2, have the following meaning:

- **Generation shift - ΔE_{max}**

– [ΔE_{max}] = max transfer between source & sink in addition to base case flow.
(value to increase GEN in source, value to decrease GEN in sink)

– **Critical contingency and limiting constraint**

Critical contingency and limiting constraint which determines the transfer capacity.

– **GTC on Boundary,**

It is results of base case flow and additional transfer ΔE_{max} ; GTC ≠ ΔE_{max}

Generation shift	3351 MW
Critical Contingency	400 kV OHL Sofia West - Chervena Mogila id 1
Limiting Constraint	400 kV OHL Sofia West - Chervena Mogila id 2
Boundary Direction	North-South
GTC on Boundary	3534 MW

Figure 39:
Info on calculation

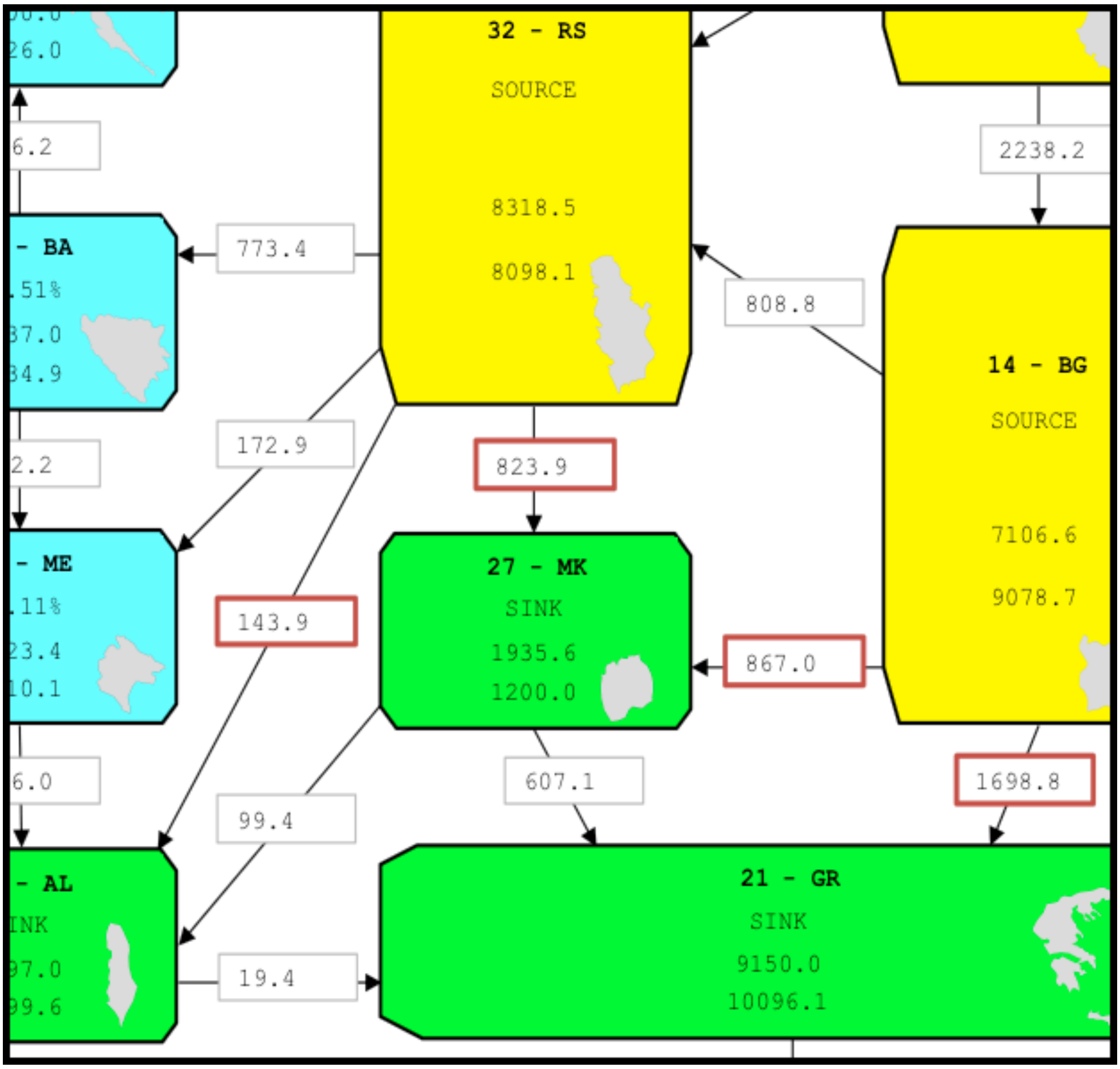


Figure 40:
GTC value

Flows on interfaces which define the BORDER are given in red bolded rectangles. GTC is the sum of all flows through border, in defined direction.

Example:

When studying transfer from RS_BG_RO to MK_AL_GR then:

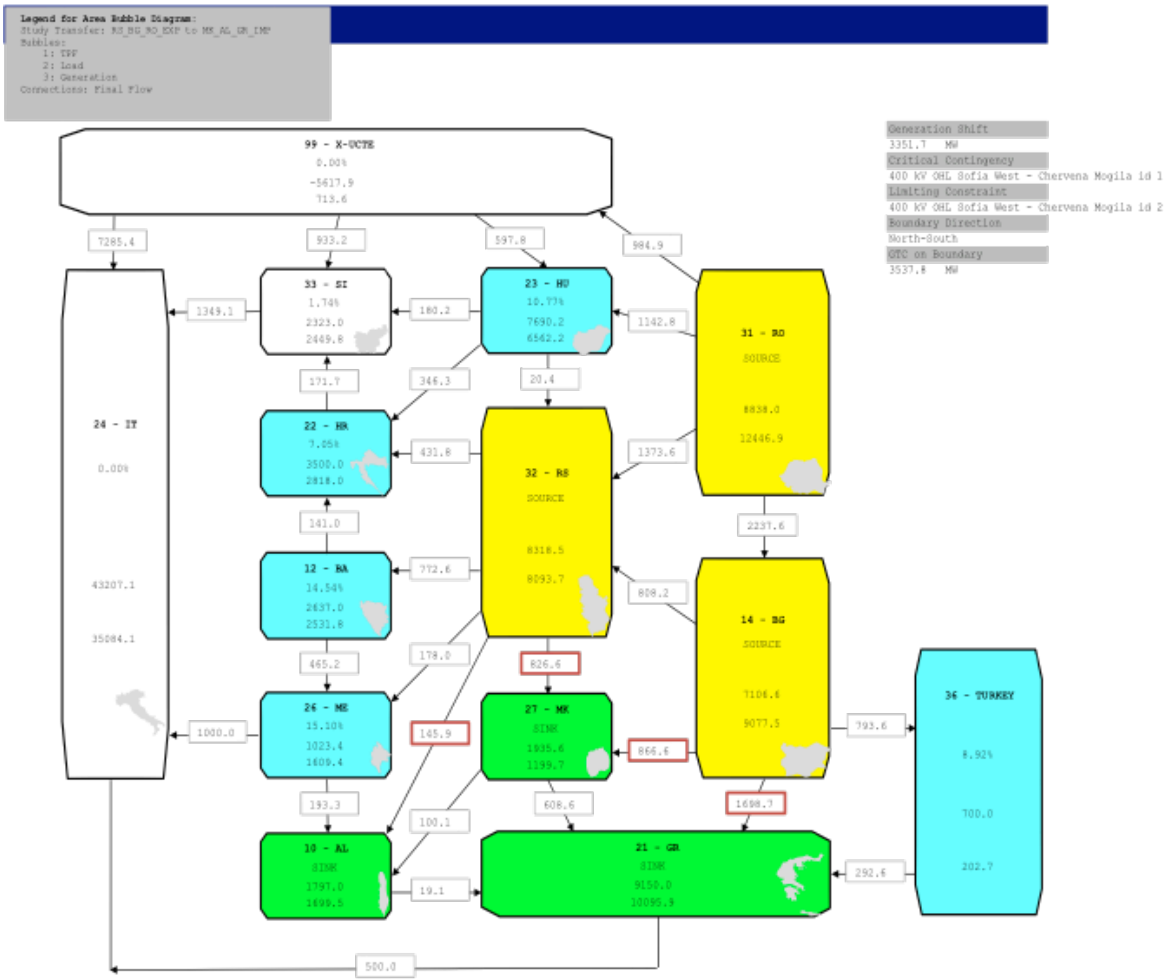
GTC = 143.9 + 823.9 + 867.0 + 1698.8 = 3534 MW.

Results for Project: 49 boundary 49,

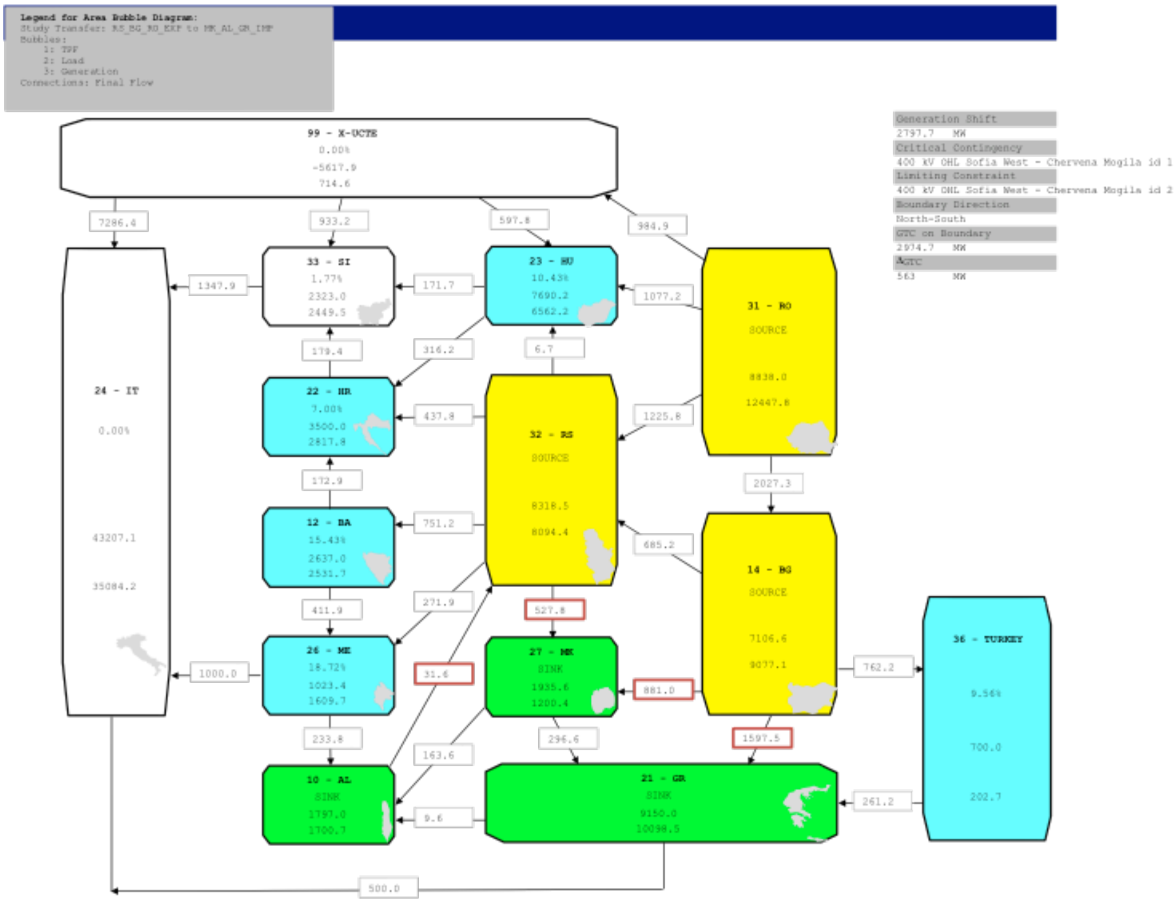
ΔGTC = 561 MW

Results for project 49 – Boundary 49
ΔGTC = 561 MW

All projects in

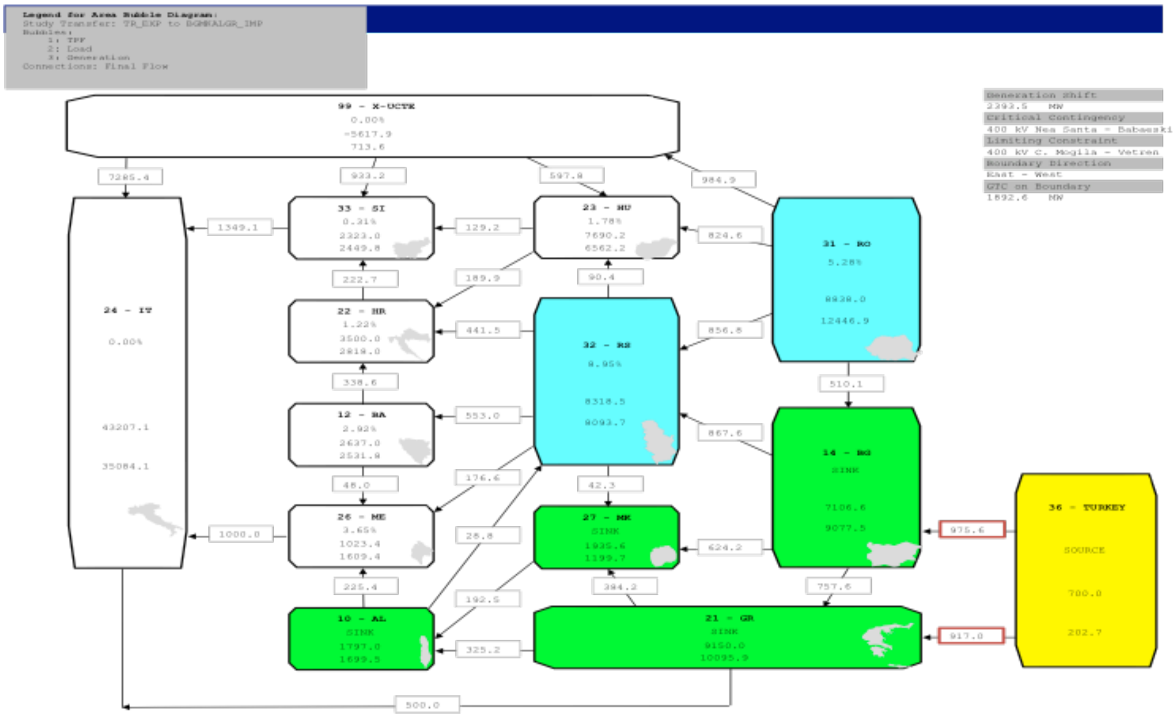


Project 49 out

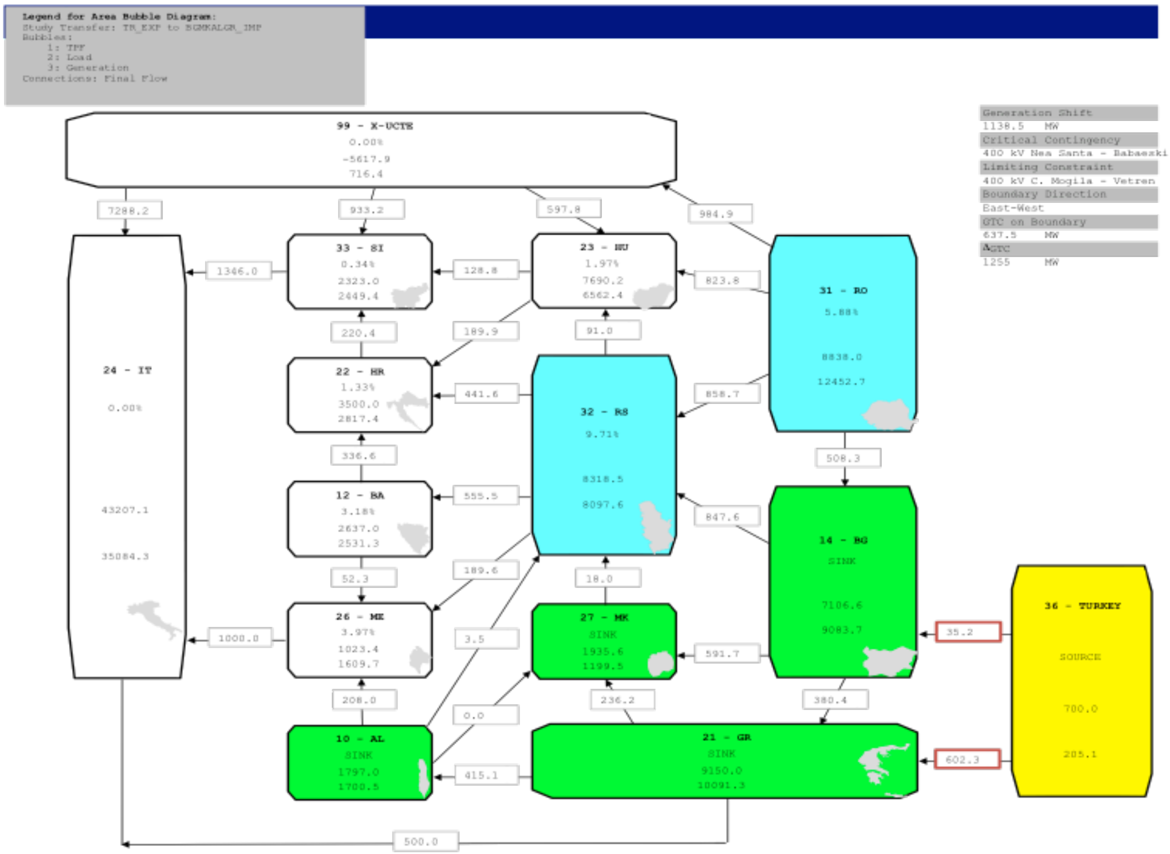


Results for project 51- Boundary 51
ΔGTC = 1255MW

All projects in

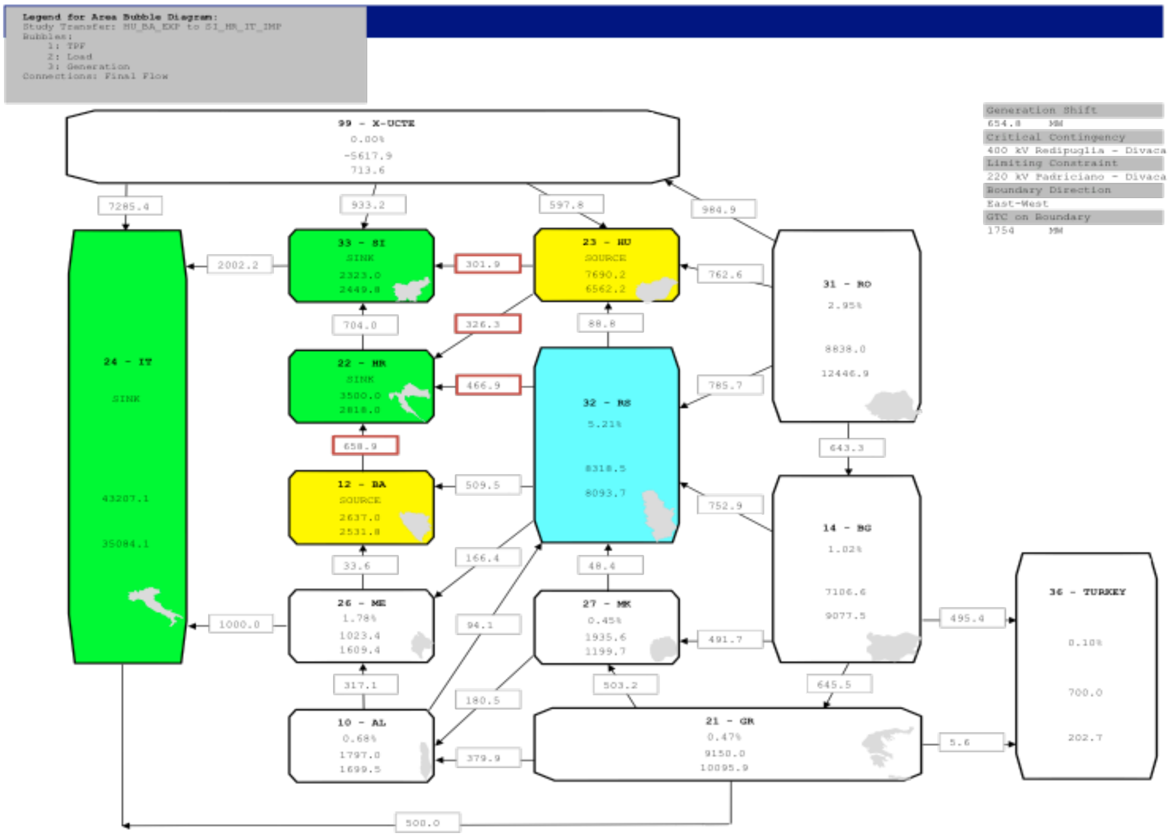


Project 51 out

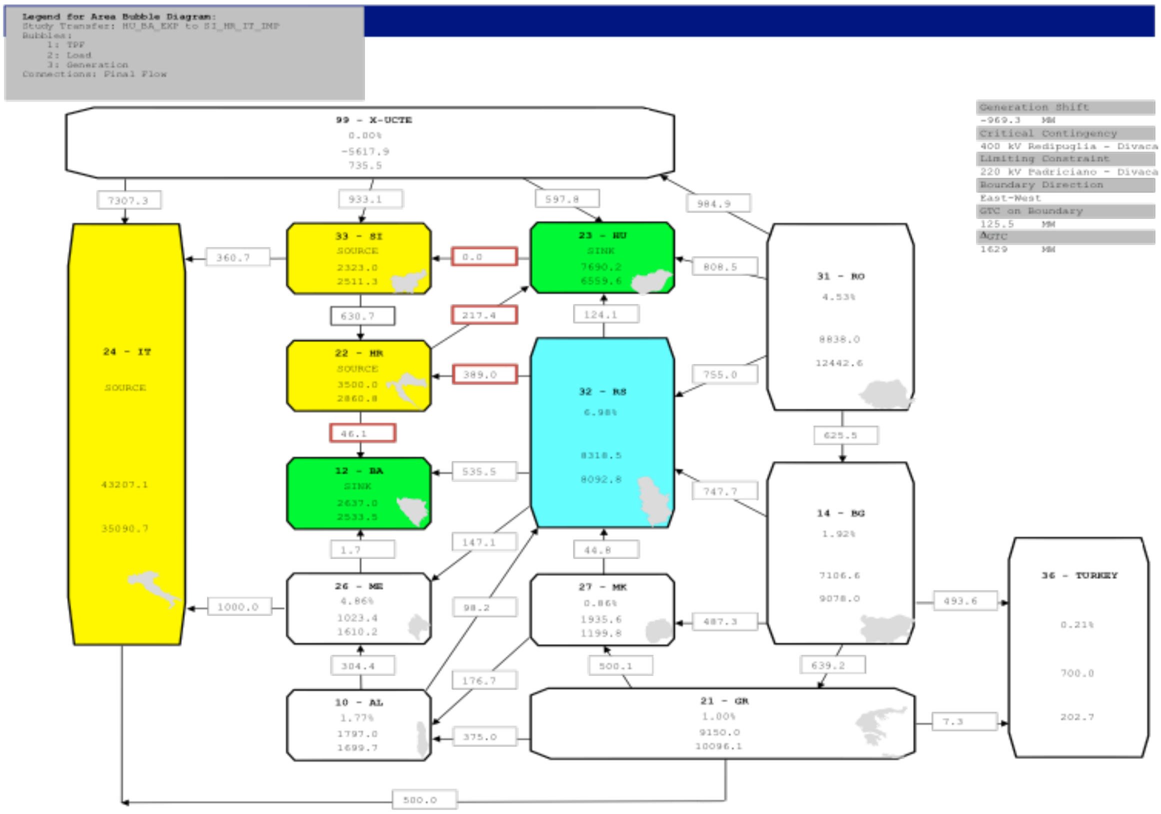


Results for project 27 – Boundary 27
ΔGTC = 1629 MW

All projects in

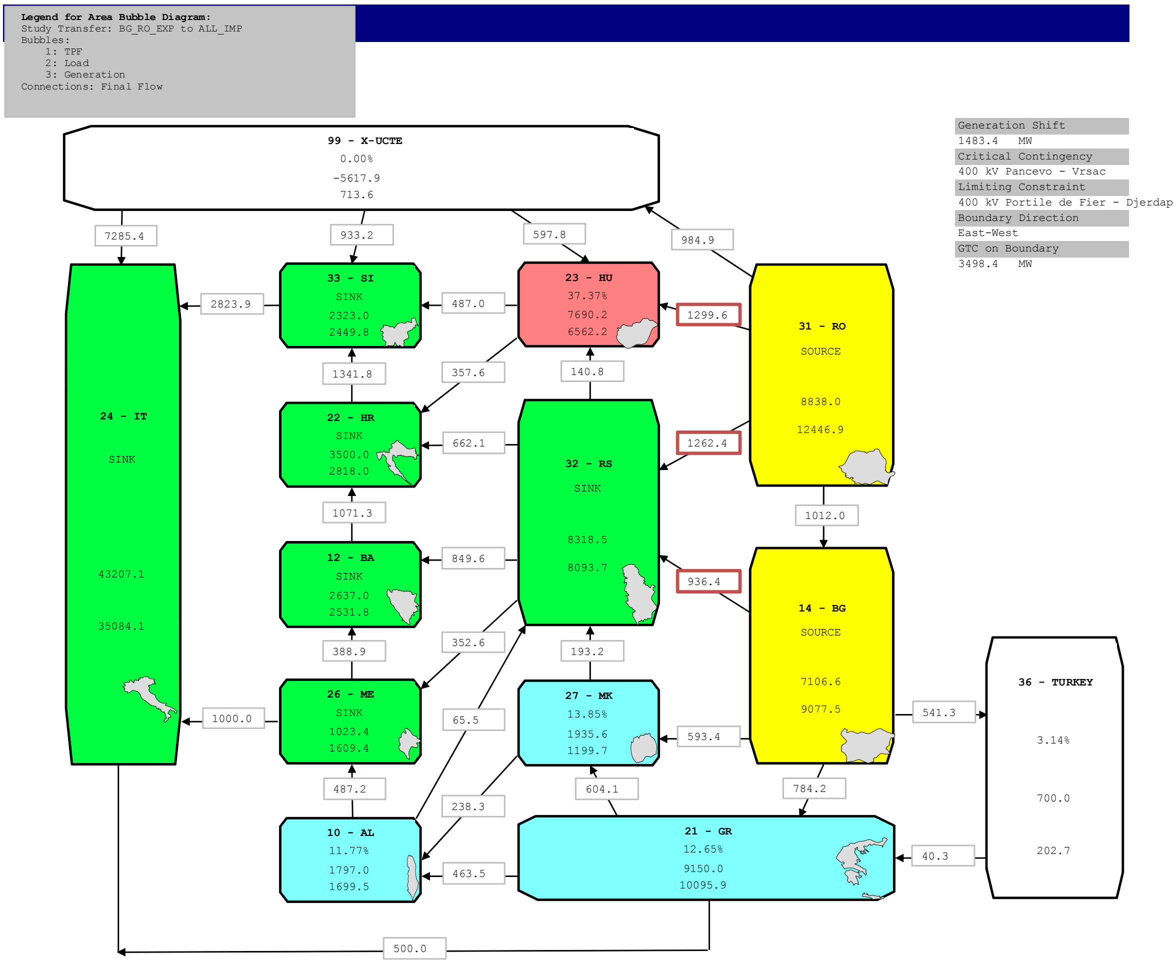


Project 27 out

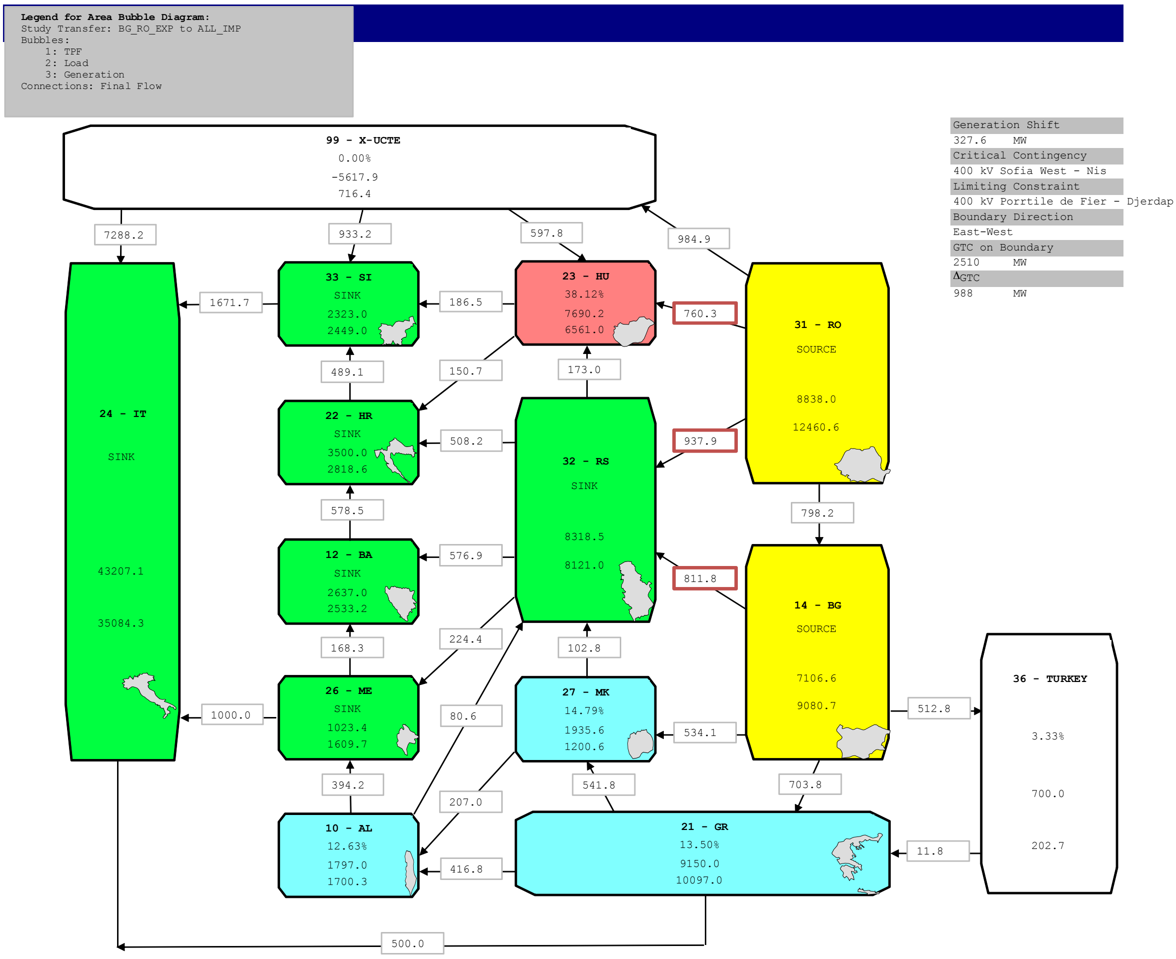


Results for project 50 – Boundary 50
ΔGTC = 988 MW

All projects in



Project 50 out



ΔGTC Values for the studied projects

Project and Boundary	Direction & ΔGTC (MW)
49 boundary 49	North-South
Corridor 10	563
51 boundary 51	East-West
Corridor 8	1255
27 boundary 27	East-West
Subalp	1629
50 boundary 50	East-West
TransBlackSee	988

Conclusion

Taking into account the results of calculations the following conclusions can be adopted:

- GTC results give good bases for preliminary evaluation of projects.
- ΔGTC on all projects in CSE fulfill the threshold > 500 MW, at least for one direction, which coincides with most of the situations with the prevailing direction of power flow.
- GTC results could be further investigated and improved by each TSO.
- European grid model added high value to regional network planning.
- Joint planning practice of regional TSOs is essential for the identification of problems and the development of optimal solutions.

New transmission projects proposed by TSOs in the Region will assist considerably the creation of a highly meshed network in CSE Europe supporting power transactions and the regional electricity market.

12.4 Appendix 3: Market Studies Results

Detailed market study results for the year 2020 of the RG CSE are presented in this Appendix. More specific annual balances and CO2 emissions are given for each country. Hourly results for snapshots of interest are also presented.

Scenario EU2020 – Base Case

Annual Energy Balance (in TWh) of RG CSE in 2020 for Scenario EU2020 – Base Case

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	337,6	9,2	15,0	40,7	60,7	21,1	45,0	6,0	10,2	67,9	46,5	15,3
Load+Pump	348,8	9,2	15,2	41,9	63,0	21,6	45,0	6,0	10,7	70,2	48,2	17,7
Net imports	10,4	-0,4	0,9	-6,6	-3,9	7,7	16,1	1,7	2,3	-7,8	-3,7	4,1
– of which from ROW	14,7	0,0	0,0	0,0	0,0	0,0	17,2	-6,3	0,0	1,0	0,0	2,9
Generation	338,4	9,6	14,4	48,5	67,0	13,9	28,9	4,3	8,4	77,9	51,8	13,7
– Wind	40,7	0,3	0,8	3,9	16,3	2,7	1,5	0,4	0,3	8,5	5,4	0,7
– Hydro	76,2	8,2	6,2	4,2	5,4	5,0	0,2	2,6	1,7	21,8	15,2	5,8
– Other generation	16,3	0,6	0,0	0,0	5,7	1,0	5,6	0,0	0,0	3,2	0,2	0,0
– Nuclear	61,3	0,0	0,0	26,3	0,0	0,0	13,4	0,0	0,0	17,2	0,0	4,5
– Lignite	85,3	0,0	7,4	11,1	10,3	0,0	2,6	1,3	3,9	15,2	31,1	2,5
– Coal	9,9	0,0	0,0	3,0	0,0	2,7	0,0	0,0	0,0	4,1	0,0	0,2
– Nat. Gas	47,6	0,5	0,0	0,1	29,4	2,5	5,0	0,0	2,0	8,0	0,0	0,1
– Oil	1,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0

Annual CO_2 emissions (in Mton CO_2) of RG CSE in 2020 for Scenario EU2020 – Base Case

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Nuclear	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lignite	113,63	0,00	9,60	15,48	13,57	0,00	3,60	1,63	5,27	21,15	40,47	2,86
Coal	11,99	0,00	0,00	3,24	0,00	3,34	0,00	0,00	0,00	5,11	0,00	0,30
Nat. Gas	17,39	0,19	0,00	0,03	10,78	0,92	1,80	0,00	0,73	2,92	0,00	0,02
Oil	0,92	0,00	0,00	0,00	0,00	0,00	0,58	0,00	0,35	0,00	0,00	0,00
TOTAL	**143,93**	**0,19**	**9,60**	**18,75**	**24,35**	**4,26**	**5,98**	**1,63**	**6,34**	**29,18**	**40,48**	**3,18**

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario EU2020 – Base Case – January 19 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	51193	1701	2526	6157	9142	3501	6510	935	1705	9239	7413	2364
Load+Pump	51193	1701	2526	6157	9142	3501	6510	935	1705	9239	7413	2364
Net imports	2104	-72	66	-1878	372	1124	2762	291	360	-1261	-281	621
– of which from ROW	2598	0	0	0	500	0	2432	-920	0	0	0	586
Generation	49089	1773	2460	8035	8770	2377	3748	644	1345	10500	7694	1743
– Wind	1431	7	22	99	234	597	45	94	8	160	139	26
– Hydro	16267	1596	1205	1615	3251	981	23	345	422	3632	2541	656
– Other generation	1594	70	0	0	311	113	750	0	0	331	19	0
– Nuclear	9368	0	0	4000	0	0	2040	0	0	2632	0	696
– Lignite	13918	0	1233	1943	1799	0	464	205	625	2289	4995	365
– Coal	1093	0	0	378	0	415	0	0	0	300	0	0
– Nat. Gas	5258	100	0	0	3175	271	326	0	230	1156	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario EU2020 – Base Case – July 11 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	45673	1181	1858	4645	10279	3199	6167	786	1195	9069	5204	2090
Load+Pump	45673	1181	1858	4645	10279	3199	6167	786	1195	9069	5204	2090
Net imports	1983	0	134	-1669	544	1267	3374	80	-17	-997	-866	133
– of which from ROW	2477	0	0	0	500	0	2532	-920	0	168	0	197
Generation	43690	1181	1724	6314	9735	1932	2793	706	1212	10066	6070	1957
– Wind	4756	5	61	412	2875	53	45	8	17	920	287	73
– Hydro	11767	1113	810	863	972	1097	29	493	415	3170	2029	776
– Other generation	3137	63	0	0	1871	179	500	0	0	505	19	0
– Nuclear	7858	0	0	3000	0	0	1530	0	0	2632	0	696
– Lignite	11666	0	853	1701	1799	0	421	205	490	2097	3735	365
– Coal	1542	0	0	338	0	415	0	0	0	742	0	47
– Nat. Gas	2804	0	0	0	2218	188	168	0	230	0	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Scenario EU2020 – Nuclear Phase-Out

Annual Energy Balance (in TWh) of RG CSE in 2020 for Scenario EU2020 – Nuclear Phase-Out

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	337,6	9,2	15,0	40,7	60,7	21,1	45,0	6,0	10,2	67,9	46,5	15,3
Load+Pump	348,8	9,2	15,2	41,9	63,0	21,6	45,0	6,0	10,7	70,2	48,2	17,7
Net imports	7,3	-0,4	1,0	-6,5	-5,7	7,5	15,2	1,7	2,2	-8,6	-3,1	4,0
– of which from ROW	11,6	0,0	0,0	0,0	-0,7	0,0	16,5	-6,3	0,0	0,8	0,0	1,4
Generation	341,5	9,7	14,2	48,4	68,7	14,1	29,8	4,3	8,5	78,7	51,3	13,7
– Wind	40,7	0,3	0,8	3,9	16,3	2,7	1,5	0,4	0,3	8,5	5,4	0,7
– Hydro	76,2	8,2	6,2	4,2	5,4	5,0	0,2	2,6	1,7	21,8	15,2	5,8
– Other generation	16,3	0,6	0,0	0,0	5,7	1,0	5,6	0,0	0,0	3,2	0,2	0,0
– Nuclear	61,3	0,0	0,0	26,3	0,0	0,0	13,4	0,0	0,0	17,2	0,0	4,5
– Lignite	84,7	0,0	7,3	11,0	10,4	0,0	2,6	1,3	4,0	15,2	30,5	2,5
– Coal	9,8	0,0	0,0	3,0	0,0	2,7	0,0	0,0	0,0	3,9	0,0	0,2
– Nat. Gas	51,5	0,6	0,0	0,1	31,0	2,7	5,9	0,0	2,2	8,9	0,0	0,1
– Oil	1,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0

Annual CO_2 emissions (in Mton CO_2) of RG CSE in 2020 for Scenario EU2020 – Nuclear Phase-Out

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Nuclear	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Lignite	112,7	0,0	9,4	15,3	13,8	0,0	3,7	1,6	5,3	21,1	39,7	2,9
Coal	11,8	0,0	0,0	3,2	0,0	3,3	0,0	0,0	0,0	4,9	0,0	0,3
Nat. Gas	18,8	0,2	0,0	0,1	11,4	1,0	2,1	0,0	0,8	3,3	0,0	0,0
Oil	0,9	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0
TOTAL	**144,2**	**0,2**	**9,4**	**18,6**	**25,2**	**4,3**	**6,4**	**1,6**	**6,4**	**29,3**	**39,7**	**3,2**

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario EU2020 – Nuclear Phase-Out – January 19 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	51193	1701	2526	6157	9142	3501	6510	935	1705	9239	7413	2364
Load+Pump	51417	1701	2526	6157	9142	3501	6510	935	1705	9239	7413	2588
Net imports	1288	-72	66	-1878	-309	1124	2762	291	360	-1625	-281	850
– of which from ROW	1782	0	0	0	500	0	1843	-920	0	-141	0	500
Generation	50129	1773	2460	8035	9451	2377	3748	644	1345	10864	7694	1738
– Wind	1431	7	22	99	234	597	45	94	8	160	139	26
– Hydro	16267	1596	1205	1615	3207	981	23	345	422	3747	2541	585
– Other generation	1594	70	0	0	311	113	750	0	0	331	19	0
– Nuclear	9368	0	0	4000	0	0	2040	0	0	2632	0	696
– Lignite	14074	0	1233	1943	1799	0	464	205	625	2445	4995	365
– Coal	1252	0	0	378	0	415	0	0	0	393	0	66
– Nat. Gas	5983	100	0	0	3900	271	326	0	230	1156	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario EU2020 – Nuclear Phase-Out – July 11 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	45673	1181	1858	4645	10279	3199	6167	786	1195	9069	5204	2090
Load+Pump	45804	1181	1858	4645	10279	3199	6167	786	1195	9069	5204	2221
Net imports	856	0	134	-1669	-520	1267	3159	80	-17	-1051	-866	339
– of which from ROW	1350	0	0	0	-500	0	2400	-920	0	300	0	70
Generation	44948	1181	1724	6314	10799	1932	3008	706	1212	10120	6070	1882
– Wind	4756	5	61	412	2875	53	45	8	17	920	287	73
– Hydro	12214	1113	810	863	1729	1097	29	493	415	2954	2029	682
– Other generation	3137	63	0	0	1871	179	500	0	0	505	19	0
– Nuclear	8113	0	0	3000	0	0	1785	0	0	2632	0	696
– Lignite	11567	0	853	1701	1799	0	359	205	490	2060	3735	365
– Coal	1804	0	0	338	0	415	0	0	0	985	0	66
– Nat. Gas	3197	0	0	0	2525	188	190	0	230	64	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Scenario EU2020 – Low CO2 Price

Annual Energy Balance (in TWh) of RG CSE in 2020 for Scenario EU2020 – Low CO_2 price

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	337,6	9,2	15,0	40,7	60,7	21,1	45,0	6,0	10,2	67,9	46,5	15,3
Load+Pump	348,8	9,2	15,2	41,9	63,0	21,6	45,0	6,0	10,7	70,2	48,2	17,7
Net imports	10,4	0,0	-5,3	-10,6	11,1	9,6	17,8	0,4	0,9	-5,1	-9,8	1,3
– of which from ROW	14,7	0,0	0,0	0,0	0,0	0,0	17,2	-6,3	0,0	1,0	0,0	2,9
Generation	338,4	9,2	20,5	52,5	51,9	12,0	27,2	5,6	9,8	75,3	57,9	16,4
– Wind	40,7	0,3	0,8	3,9	16,3	2,7	1,5	0,4	0,3	8,5	5,4	0,7
– Hydro	76,2	8,2	6,2	4,2	5,4	5,0	0,2	2,6	1,7	21,8	15,2	5,8
– Other generation	16,3	0,6	0,0	0,0	5,7	1,0	5,6	0,0	0,0	3,2	0,2	0,0
– Nuclear	61,3	0,0	0,0	26,3	0,0	0,0	13,4	0,0	0,0	17,2	0,0	4,5
– Lignite	122,6	0,0	13,6	16,0	17,9	0,0	4,3	2,6	5,7	20,2	37,2	5,2
– Coal	9,3	0,0	0,0	2,2	0,0	2,6	0,0	0,0	0,0	4,3	0,0	0,2
– Nat. Gas	10,9	0,1	0,0	0,0	6,7	0,8	1,6	0,0	1,6	0,1	0,0	0,0
– Oil	1,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0

Annual CO_2 emissions (in Mton CO_2) of RG CSE in 2020 for Scenario EU2020 – Low CO_2 price

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Nuclear	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Lignite	161,8	0,0	17,3	22,3	23,4	0,0	6,0	3,3	7,5	28,1	47,9	6,1
Coal	11,4	0,0	0,0	2,4	0,0	3,2	0,0	0,0	0,0	5,5	0,0	0,3
Nat. Gas	4,1	0,0	0,0	0,0	2,6	0,3	0,6	0,0	0,6	0,1	0,0	0,0
Oil	0,9	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0
TOTAL	**178,2**	**0,0**	**17,3**	**24,7**	**25,9**	**3,5**	**7,2**	**3,3**	**8,5**	**33,6**	**47,9**	**6,4**

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario EU2020 – Low CO_2 price – January 19 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	51193	1701	2526	6157	9142	3501	6510	935	1705	9239	7413	2364
Load+Pump	51193	1701	2526	6157	9142	3501	6510	935	1705	9239	7413	2364
Net imports	2104	-72	66	-1878	372	1124	2762	291	360	-1261	-281	621
– of which from ROW	2598	0	0	0	500	0	2432	-920	0	0	0	586
Generation	49089	1773	2460	8035	8770	2377	3748	644	1345	10500	7694	1743
– Wind	1431	7	22	99	234	597	45	94	8	160	139	26
– Hydro	16267	1596	1205	1615	3251	981	23	345	422	3632	2541	656
– Other generation	1594	70	0	0	311	113	750	0	0	331	19	0
– Nuclear	9368	0	0	4000	0	0	2040	0	0	2632	0	696
– Lignite	13918	0	1233	1943	1799	0	464	205	625	2289	4995	365
– Coal	1093	0	0	378	0	415	0	0	0	300	0	0
– Nat. Gas	5258	100	0	0	3175	271	326	0	230	1156	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario EU2020 – Low CO2 price – July 11 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	45673	1181	1858	4645	10279	3199	6167	786	1195	9069	5204	2090
Load+Pump	45673	1181	1858	4645	10279	3199	6167	786	1195	9069	5204	2090
Net imports	1983	0	134	-1669	544	1267	3374	80	-17	-997	-866	133
– of which from ROW	2477	0	0	0	500	0	2532	-920	0	168	0	197
Generation	43690	1181	1724	6314	9735	1932	2793	706	1212	10066	6070	1957
– Wind	4756	5	61	412	2875	53	45	8	17	920	287	73
– Hydro	11767	1113	810	863	972	1097	29	493	415	3170	2029	776
– Other generation	3137	63	0	0	1871	179	500	0	0	505	19	0
– Nuclear	7858	0	0	3000	0	0	1530	0	0	2632	0	696
– Lignite	11666	0	853	1701	1799	0	421	205	490	2097	3735	365
– Coal	1542	0	0	338	0	415	0	0	0	742	0	47
– Nat. Gas	2804	0	0	0	2218	188	168	0	230	0	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Scenario B – Base Case

Annual Energy Balance (in TWh) of RG CSE in 2020 for Scenario B – Base Case

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	338,6	9,2	15,0	40,7	60,7	21,1	45,0	6,0	10,2	65,5	48,8	16,4
Load+Pump	349,8	9,2	15,2	41,9	63,0	21,6	45,0	6,0	10,7	67,7	50,5	18,8
Net imports	-11,1	-0,3	-7,0	-15,7	-3,8	7,6	15,0	1,9	0,0	-7,6	-3,4	2,3
– of which from ROW	-6,8	0,0	0,0	0,0	-3,3	0,0	10,4	-8,7	0,0	-1,1	0,0	-4,2
Generation	360,9	9,5	22,2	57,6	66,8	14,1	30,0	4,1	10,7	75,3	53,9	16,5
– Wind	34,0	0,3	0,8	3,9	15,7	2,7	1,5	0,4	0,3	7,2	1,0	0,3
– Hydro	71,3	8,2	6,2	4,2	5,4	5,0	0,2	2,4	1,7	17,9	14,7	5,6
– Other generation	13,2	0,6	0,0	0,0	5,7	1,0	5,6	0,0	0,0	0,1	0,2	0,0
– Nuclear	61,5	0,0	0,0	26,3	0,0	0,0	13,4	0,0	0,0	17,3	0,0	4,6
– Lignite	136,0	0,0	15,3	19,5	20,5	0,0	5,6	1,3	6,5	23,6	38,1	5,6
– Coal	17,0	0,0	0,0	3,8	0,0	4,1	0,0	0,0	0,0	8,6	0,0	0,4
– Nat. Gas	26,9	0,5	0,0	0,0	19,6	1,3	3,1	0,0	1,8	0,7	0,0	0,0
– Oil	1,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0

Annual CO_2 emissions (in Mton CO_2) of RG CSE in 2020 for Scenario B – Base Case

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Nuclear	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Lignite	180,4	0,0	19,6	27,1	26,9	0,0	7,8	1,8	8,7	32,8	49,1	6,6
Coal	20,5	0,0	0,0	4,2	0,0	4,9	0,0	0,0	0,0	10,9	0,0	0,6
Nat. Gas	10,0	0,2	0,0	0,0	7,2	0,5	1,1	0,0	0,6	0,3	0,0	0,0
Oil	0,9	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0
TOTAL	**211,8**	**0,2**	**19,6**	**31,3**	**34,1**	**5,4**	**9,5**	**1,8**	**9,7**	**44,0**	**49,1**	**7,2**

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario B – Base Case – January 19 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	51395	1701	2526	6157	9142	3501	6510	935	1705	8906	7782	2530
Load+Pump	51395	1701	2526	6157	9142	3501	6510	935	1705	8906	7782	2530
Net imports	-864	28	-1106	-3092	1213	1292	2521	322	-90	-1588	-711	347
– of which from ROW	-370	0	0	0	-500	0	1722	-1000	0	-400	0	-192
Generation	52259	1673	3632	9249	7929	2209	3989	613	1795	10494	8493	2183
– Wind	1235	7	22	99	195	593	45	94	8	136	25	11
– Hydro	16077	1596	1205	1615	3736	983	17	294	422	3180	2469	560
– Other generation	1276	70	0	0	311	113	750	0	0	13	19	0
– Nuclear	9368	0	0	4000	0	0	2040	0	0	2632	0	696
– Lignite	21242	0	2405	3157	3179	0	850	225	1075	3521	5980	850
– Coal	1833	0	0	378	0	415	0	0	0	974	0	66
– Nat. Gas	1068	0	0	0	508	105	187	0	230	38	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario B – Base Case – July 11 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	45757	1181	1858	4645	10279	3199	6167	786	1195	8742	5463	2242
Load+Pump	45839	1181	1858	4645	10279	3199	6167	786	1195	8742	5463	2324
Net imports	-2160	0	-668	-2908	250	1066	2801	188	-377	-2229	-929	646
– of which from ROW	-1666	0	0	0	-500	0	384	-1000	0	-400	0	-150
Generation	47999	1181	2526	7553	10029	2133	3366	598	1572	10971	6392	1678
– Wind	4325	5	61	412	2860	53	45	8	17	782	52	30
– Hydro	11353	1113	810	863	1304	1096	23	365	415	2976	1741	647
– Other generation	2645	63	0	0	1871	179	500	0	0	13	19	0
– Nuclear	8113	0	0	3000	0	0	1785	0	0	2632	0	696
– Lignite	18073	0	1655	2808	3306	0	826	225	850	3518	4580	305
– Coal	2182	0	0	470	0	700	0	0	0	1012	0	0
– Nat. Gas	1248	0	0	0	688	105	187	0	230	38	0	0
– Oil	60	0	0	0	0	0	0	0	60	0	0	0

Scenario B – Nuclear Phase-Out

Annual Energy Balance (in TWh) of RG CSE in 2020 for Scenario B – Nuclear Phase-Out

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	338,6	9,2	15,0	40,7	60,7	21,1	45,0	6,0	10,2	65,5	48,8	16,4
Load+Pump	349,8	9,2	15,2	41,9	63,0	21,6	45,0	6,0	10,7	67,7	50,5	18,8
Net imports	-15,4	-0,3	-7,0	-15,9	-6,1	7,3	14,4	1,8	-0,2	-8,2	-3,5	2,3
– of which from ROW	-11,1	0,0	0,0	0,0	-3,3	0,0	7,7	-8,7	0,0	-1,6	0,0	-5,2
Generation	365,3	9,6	22,3	57,8	69,1	14,3	30,6	4,2	10,9	76,0	54,0	16,6
– Wind	34,0	0,3	0,8	3,9	15,7	2,7	1,5	0,4	0,3	7,2	1,0	0,3
– Hydro	71,3	8,2	6,2	4,2	5,4	5,0	0,2	2,4	1,7	17,9	14,7	5,6
– Other generation	13,2	0,6	0,0	0,0	5,7	1,0	5,6	0,0	0,0	0,1	0,2	0,0
– Nuclear	61,5	0,0	0,0	26,3	0,0	0,0	13,4	0,0	0,0	17,3	0,0	4,6
– Lignite	136,9	0,0	15,3	19,6	20,6	0,0	5,7	1,3	6,6	23,8	38,2	5,7
– Coal	17,2	0,0	0,0	3,9	0,0	4,2	0,0	0,0	0,0	8,7	0,0	0,4
– Nat. Gas	30,1	0,5	0,0	0,0	21,7	1,4	3,6	0,0	1,8	1,0	0,0	0,0
– Oil	1,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0

Annual CO_2 emissions (in Mton CO_2) of RG CSE in 2020 for Scenario B – Nuclear Phase-Out

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Nuclear	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Lignite	181,6	0,0	19,7	27,3	27,1	0,0	7,9	1,9	8,8	33,2	49,2	6,6
Coal	20,8	0,0	0,0	4,2	0,0	5,0	0,0	0,0	0,0	11,0	0,0	0,6
Nat. Gas	11,1	0,2	0,0	0,0	8,0	0,5	1,3	0,0	0,7	0,4	0,0	0,0
Oil	0,9	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0
TOTAL	**214,4**	**0,2**	**19,7**	**31,5**	**35,1**	**5,5**	**9,8**	**1,9**	**9,8**	**44,6**	**49,2**	**7,2**

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario B – Nuclear Phase-Out – January 19 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	51395	1701	2526	6157	9142	3501	6510	935	1705	8906	7782	2530
Load+Pump	51546	1701	2526	6157	9142	3501	6510	935	1705	8906	7782	2681
Net imports	-1647	-47	-1106	-3234	627	1007	2405	322	-90	-1365	-711	545
– of which from ROW	-1153	0	0	0	-500	0	897	-1000	0	-400	0	-150
Generation	53193	1748	3632	9391	8515	2494	4105	613	1795	10271	8493	2136
– Wind	1235	7	22	99	195	593	45	94	8	136	25	11
– Hydro	16050	1596	1205	1615	3755	983	17	294	422	3181	2469	513
– Other generation	1276	70	0	0	311	113	750	0	0	13	19	0
– Nuclear	9368	0	0	4000	0	0	2040	0	0	2632	0	696
– Lignite	21516	0	2405	3157	3306	0	966	225	1075	3552	5980	850
– Coal	2005	0	0	520	0	700	0	0	0	719	0	66
– Nat. Gas	1583	75	0	0	948	105	187	0	230	38	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario B – Nuclear Phase-Out – July 11 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	45757	1181	1858	4645	10279	3199	6167	786	1195	8742	5463	2242
Load+Pump	45757	1181	1858	4645	10279	3199	6167	786	1195	8742	5463	2242
Net imports	-3117	0	-668	-2908	229	1066	2432	188	-377	-2429	-929	279
– of which from ROW	-2623	0	0	0	-500	0	-223	-1000	0	-400	0	-500
Generation	48874	1181	2526	7553	10050	2133	3735	598	1572	11171	6392	1963
– Wind	4325	5	61	412	2860	53	45	8	17	782	52	30
– Hydro	11411	1113	810	863	1325	1096	23	365	415	2987	1741	673
– Other generation	2645	63	0	0	1871	179	500	0	0	13	19	0
– Nuclear	8368	0	0	3000	0	0	2040	0	0	2632	0	696
– Lignite	18094	0	1655	2808	3306	0	826	225	850	3299	4580	545
– Coal	2609	0	0	470	0	700	0	0	0	1420	0	19
– Nat. Gas	1262	0	0	0	688	105	201	0	230	38	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Scenario B – High CO2 Price

Annual Energy Balance (in TWh) of RG CSE in 2020 for Scenario B – High CO_2 price

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	338,6	9,2	15,0	40,7	60,7	21,1	45,0	6,0	10,2	65,5	48,8	16,4
Load+Pump	349,8	9,2	15,2	41,9	63,0	21,6	45,0	6,0	10,7	67,7	50,5	18,8
Net imports	-11,1	-0,5	-0,2	-8,8	-15,8	6,5	10,0	2,6	0,9	-12,9	2,3	4,8
– of which from ROW	-6,8	0,0	0,0	0,0	-3,3	0,0	10,4	-8,7	0,0	-1,1	0,0	-4,2
Generation	360,9	9,8	15,4	50,7	78,8	15,1	35,0	3,4	9,8	80,6	48,2	14,1
– Wind	34,0	0,3	0,8	3,9	15,7	2,7	1,5	0,4	0,3	7,2	1,0	0,3
– Hydro	71,3	8,2	6,2	4,2	5,4	5,0	0,2	2,4	1,7	17,9	14,7	5,6
– Other generation	13,2	0,6	0,0	0,0	5,7	1,0	5,6	0,0	0,0	0,1	0,2	0,0
– Nuclear	61,5	0,0	0,0	26,3	0,0	0,0	13,4	0,0	0,0	17,3	0,0	4,6
– Lignite	90,9	0,0	8,5	12,3	11,8	0,0	2,9	0,6	4,1	15,6	32,4	2,7
– Coal	12,8	0,0	0,0	3,0	0,0	2,8	0,0	0,0	0,0	6,6	0,0	0,4
– Nat. Gas	76,2	0,7	0,0	1,1	40,2	3,7	10,8	0,0	3,2	16,0	0,0	0,5
– Oil	1,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0

Annual CO_2 emissions (in Mton CO_2) of RG CSE in 2020 for Scenario B – High CO_2 price

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Nuclear	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Lignite	121,1	0,0	11,0	17,1	15,7	0,0	4,0	0,8	5,5	21,7	42,2	3,1
Coal	16,0	0,0	0,0	3,3	0,0	3,4	0,0	0,0	0,0	8,7	0,0	0,6
Nat. Gas	27,9	0,3	0,0	0,5	14,8	1,3	3,9	0,0	1,2	5,9	0,0	0,2
Oil	0,9	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,4	0,0	0,0	0,0
TOTAL	**165,9**	**0,3**	**11,0**	**20,8**	**30,4**	**4,8**	**8,5**	**0,8**	**7,0**	**36,2**	**42,2**	**3,9**

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario B – High CO_2 price – January 19 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	51395	1701	2526	6157	9142	3501	6510	935	1705	8906	7782	2530
Load+Pump	51395	1701	2526	6157	9142	3501	6510	935	1705	8906	7782	2530
Net imports	-864	28	-1106	-3092	1213	1292	2521	322	-90	-1588	-711	347
– of which from ROW	-370	0	0	0	-500	0	1722	-1000	0	-400	0	-192
Generation	52259	1673	3632	9249	7929	2209	3989	613	1795	10494	8493	2183
– Wind	1235	7	22	99	195	593	45	94	8	136	25	11
– Hydro	16077	1596	1205	1615	3736	983	17	294	422	3180	2469	560
– Other generation	1276	70	0	0	311	113	750	0	0	13	19	0
– Nuclear	9368	0	0	4000	0	0	2040	0	0	2632	0	696
– Lignite	21242	0	2405	3157	3179	0	850	225	1075	3521	5980	850
– Coal	1833	0	0	378	0	415	0	0	0	974	0	66
– Nat. Gas	1068	0	0	0	508	105	187	0	230	38	0	0
– Oil	160	0	0	0	0	0	100	0	60	0	0	0

Hourly Power Balance of (in MW) of RG CSE in 2020 for Scenario B – High CO_2 price – July 11 snapshot

	TOTAL	AL	BA	BG	GR	HR	HU	ME	MK	RO	RS	SI
Load	45757	1181	1858	4645	10279	3199	6167	786	1195	8742	5463	2242
Load+Pump	45839	1181	1858	4645	10279	3199	6167	786	1195	8742	5463	2324
Net imports	-2160	0	-668	-2908	250	1066	2801	188	-377	-2229	-929	646
– of which from ROW	-1666	0	0	0	-500	0	384	-1000	0	-400	0	-150
Generation	47999	1181	2526	7553	10029	2133	3366	598	1572	10971	6392	1678
– Wind	4325	5	61	412	2860	53	45	8	17	782	52	30
– Hydro	11353	1113	810	863	1304	1096	23	365	415	2976	1741	647
– Other generation	2645	63	0	0	1871	179	500	0	0	13	19	0
– Nuclear	8113	0	0	3000	0	0	1785	0	0	2632	0	696
– Lignite	18073	0	1655	2808	3306	0	826	225	850	3518	4580	305
– Coal	2182	0	0	470	0	700	0	0	0	1012	0	0
– Nat. Gas	1248	0	0	0	688	105	187	0	230	38	0	0
– Oil	60	0	0	0	0	0	0	0	60	0	0	0

Bulk Power Flows

In the maps shown below, power flows on the external boundaries (between different price zones) of the CSE Region are depicted. A different map exists for each examined scenario and its variant (Nuclear Phase Out). The information contained in the respective arrows, summarizes the estimated power flow duration curves calculated through market and grid studies. The first and second numbers correspond to the maximum and average values of power flow over the year, for the prevailing direction of power flow depicted by the arrow. The third number denotes the number of hours having power flows in the direction shown by the arrow.

It is worth mentioning that in all examined scenarios and their variants, power flows are following a predominant direction trend

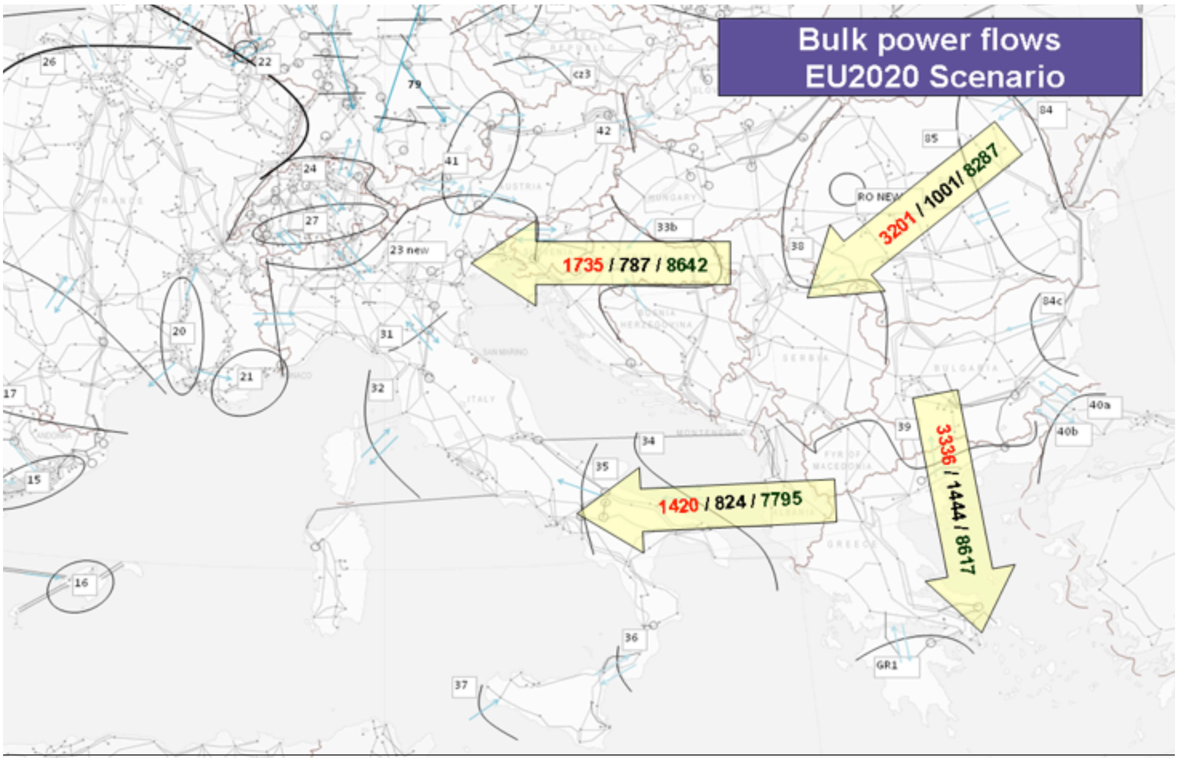


Figure 41:
Bulk power flows EU2020 Scenario

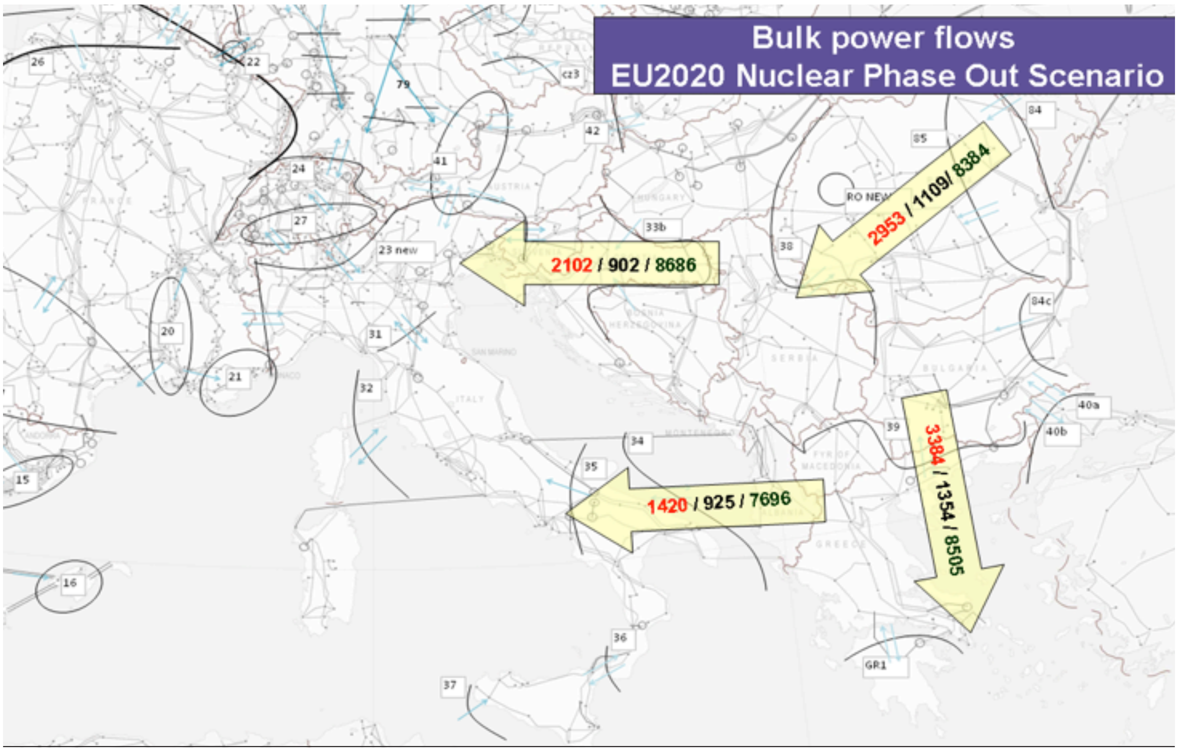


Figure 42:
Bulk power flows EU2020 Nuclear Phase Out Scenario

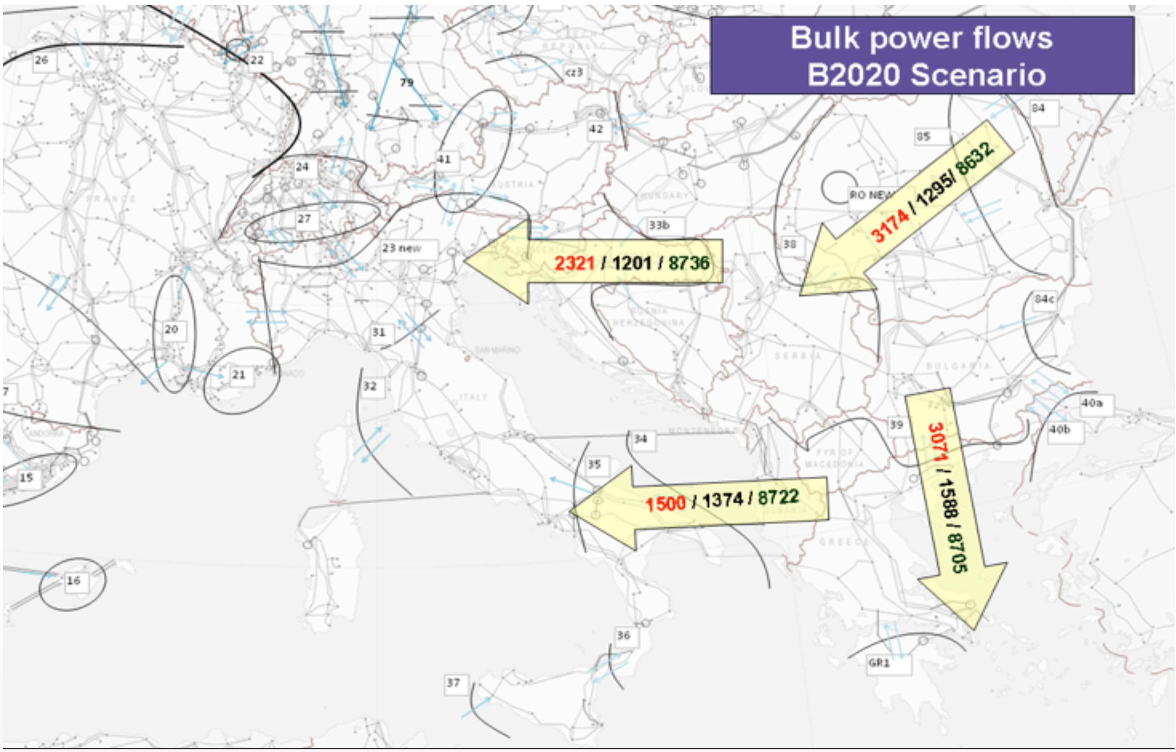


Figure 43:
Bulk power flows B2020 Scenario

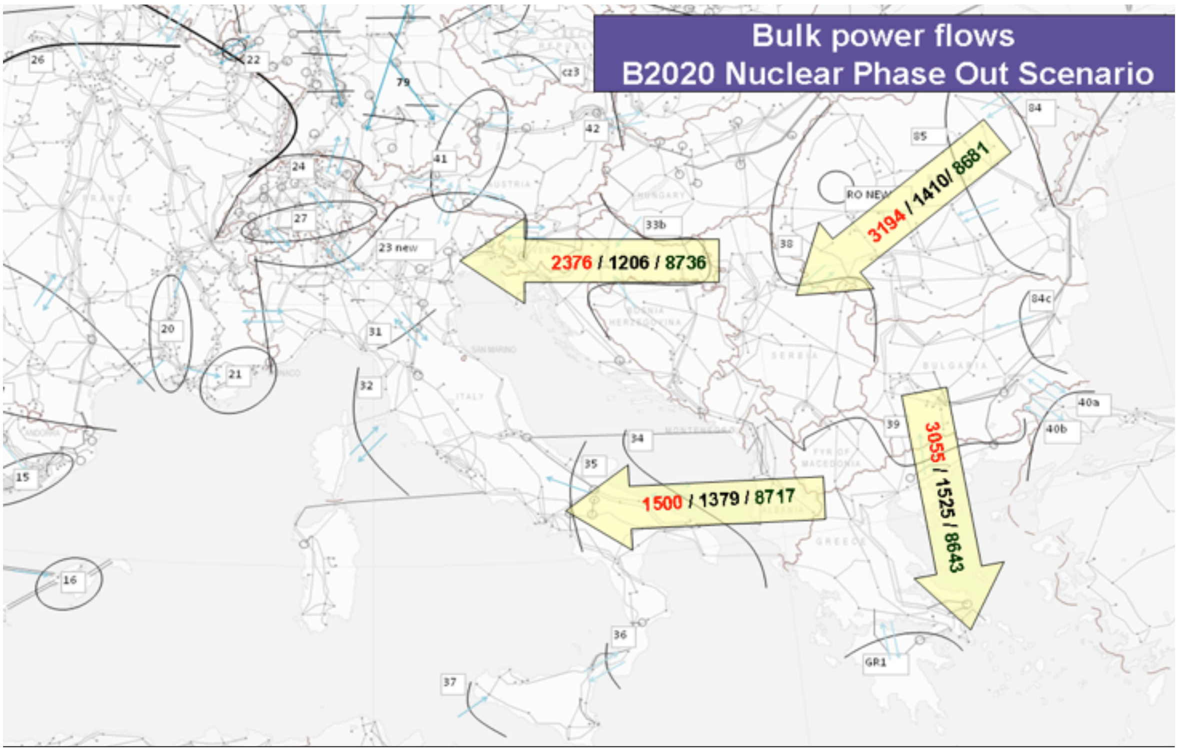


Figure 44:
Bulk power flows EU2020 Nuclear Phase Out Scenari

12.5 Appendix 4: Bulk Power Flows

In this Appendix statistics of Bulk Power Flows on the RG CSE boundaries are presented for every scenario examined. In addition, power flow duration curves for the EU2020 scenario are also depicted. All results refer to network conditions in 2020 where all projects have been completed.

Scenario EU2020 – Base Case

Bulk Power Flow Statistics on all RG CSE boundaries, for the year 2020 with all the projects in operation are given in the table below.

Bulk Power Flow Statistics on CSE Boundaries – Scenario EU 2020 – Base Case

Boundary	Direction	Energy (GWh)	Maximum charging (MW)	Hours	Average charging (MW)
Boundary 49	North-South	12447,1	3336	8617	1444
	South-North	24,7	659	119	208
Boundary 28	East-West	6424,4	1420	7795	824
	West-East	40,0	44	939	43
Boundary 27	East-West	6803,1	1735	8642	787
	West-East	13,2	744	94	141
Boundary 50	East-West	8298,8	3201	8287	1001
	West-East	110,6	1197	449	246

Scenario EU2020 – Nucleat Phase-Out

Bulk Power Flow Statistics on CSE Boundaries – Scenario EU2020 – Nuclear Phase-Out

Boundary	Direction	Energy (GWh)	Maximum charging (MW)	Hours	Average charging (MW)
Boundary 49	North-South	11511,6	3384	8505	1354
	South-North	61,4	908	231	266
Boundary 28	East-West	7118,5	1420	7696	925
	West-East	44,1	44	1038	42
Boundary 27	East-West	7833,1	2102	8686	902
	West-East	7,6	530	50	153
Boundary 50	East-West	9295,2	2953	8384	1109
	West-East	79,1	1327	352	225

Scenario EU2020 – Low CO_2 price

Bulk Power Flow Statistics on CSE Boundaries – Scenario EU2020 – Low CO_2 price

Boundary	Direction	Energy (GWh)	Maximum charging (MW)	Hours	Average charging (MW)
Boundary 49	North-South	15526,2	3336	8695	1786
	South-North	5,8	690	41	141
Boundary 28	East-West	6424,4	1420	7795	824
	West-East	40,0	44	939	43
Boundary 27	East-West	6885,6	1931	8459	814
	West-East	25,4	553	277	92
Boundary 50	East-West	5412,2	2416	7660	707
	West-East	261,9	1340	1076	243

Scenario B – Base Case

Bulk Power Flow Statistics on CSE Boundaries – Scenario B – Base Case

Boundary	Direction	Energy (GWh)	Maximum charging (MW)	Hours	Average charging (MW)
Boundary 49	North-South	13820,9	3071	8705	1588
	South-North	3,1	394	31	99
Boundary 28	East-West	11987,1	1500	8722	1374
	West-East	3,3	500	14	237
Boundary 27	East-West	10491,3	2321	8736	1201
	West-East	0,0	0	0	0
Boundary 50	East-West	11175,1	3174	8632	1295
	West-East	11,9	447	104	114

Scenario B – Nuclear Phase-Out

Bulk Power Flow Statistics on CSE Boundaries – Scenario B – Nuclear Phase-Out

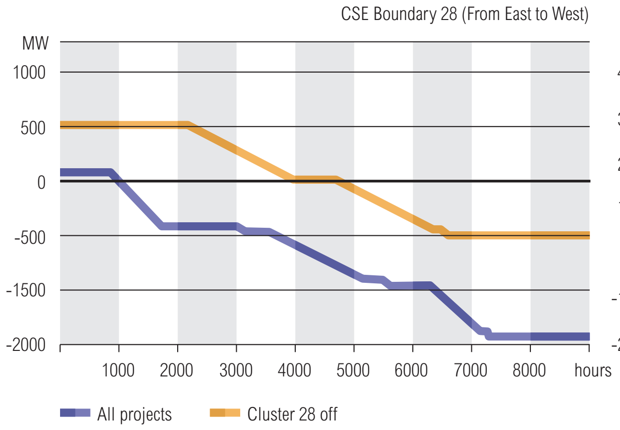
Boundary	Direction	Energy (GWh)	Maximum charging (MW)	Hours	Average charging (MW)
Boundary 49	North-South	13178,0	3055	8643	1525
	South-North	11,0	418	93	118
Boundary 28	East-West	12018,8	1500	8717	1379
	West-East	4,8	500	18	267
Boundary 27	East-West	10538,1	2376	8736	1206
	West-East	0,0	0	0	0
Boundary 50	East-West	12236,4	3194	8681	1410
	West-East	7,2	407	55	131

Scenario B – High CO_2 price

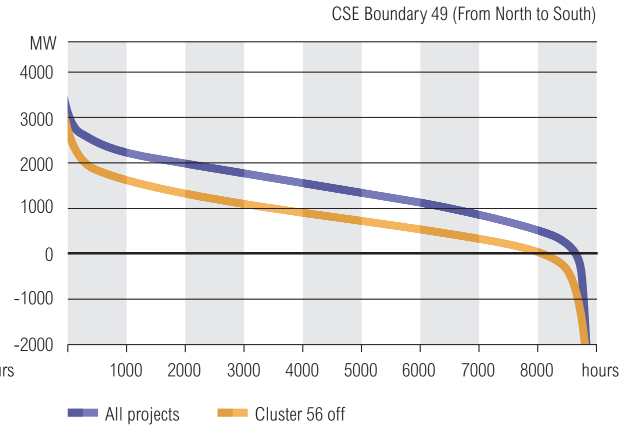
Bulk Power Flow Statistics on CSE Boundaries – Scenario B – High CO_2 price

Boundary	Direction	Energy (GWh)	Maximum charging (MW)	Hours	Average charging (MW)
Boundary 49	North-South	4725,3	2686	5450	867
	South-North	1802,7	2273	3286	549
Boundary 28	East-West	11987,1	1500	8722	1374
	West-East	3,3	500	14	237
Boundary 27	East-West	11802,1	2321	8736	1351
	West-East	0,0	0	0	0
Boundary 50	East-West	15911,3	4046	8731	1822
	West-East	0,4	191	5	82

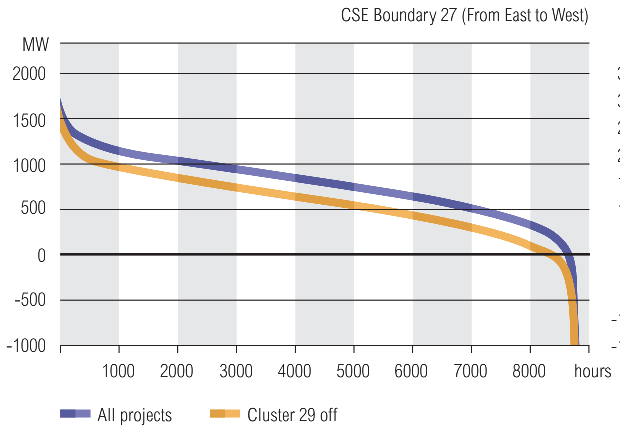
Power Flow duration curves for the EU2020 scenario



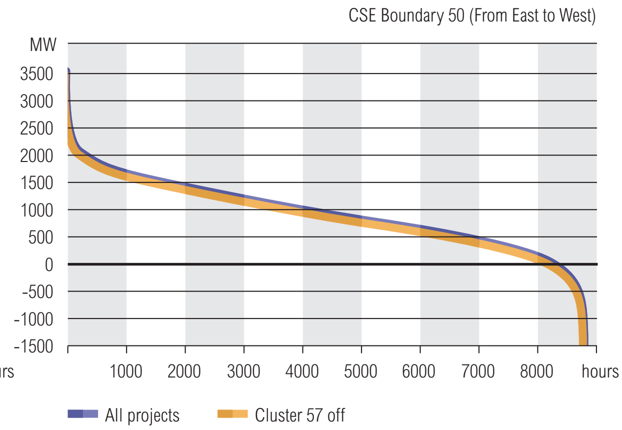
CSE Boundary 28 (From West to East)



CSE Boundary 49 (From North to South)



CSE Boundary 27 (From East to West)



CSE Boundary 50 (From East to West)

12.6 Abbreviations

AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power Generation
DC	Direct Current
EIP	Energy Infrastructure Package
ELF	Extremely Low Frequency
EMF	Electromagnetic Field
ETS	Emission Trading System
ENTSO-E	European Network of Transmission System Operators for Electricity (see § A2.1)
FACTS	Flexible AC Transmission System
FLM	Flexible Line Management
GTC	Grid Transfer Capability (see § A2.6)
HTLS	High Temperature Low Sag Conductors
HV	High Voltage
HVAC	High Voltage AC
HVDC	High Voltage DC
KPI	Key Performance Indicator
IEM	Internal Energy Market
LCC	Line Commutated Converter
LOLE	Loss of Load Expectation
NGC	Net Generation Capacity
NRA	National Regulatory Authority
NREAP	National Renewable Energy Action Plan
NTC	Net Transfer Capacity
OHL	Overhead Line
PEMD	Pan European Market Database
PCI	Project of Common Interest (see EIP)
PST	Phase Shifting Transformer
RAC	Reliable Available Capacity
RC	Remaining Capacity
RES	Renewable Energy Sources
RG BS	Regional Group Baltic Sea
RG CCE	Regional Group Continental Central East
RG CCS	Regional Group Continental Central South
RG CSE	Regional Group Continental South East
RG CSW	Regional Group Continental South West
RG NS	Regional Group North Sea
SEW	Social and Economic Welfare
SO&AF	Scenario Outlook & Adequacy Forecast
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
VSC	Voltage Source Converter

12.7 Imprint

Publisher: ENTSO-E AISBL
Avenue de Cortenbergh 100
1000 Brussels – Belgium

Design & Layout: Oswald und Martin Werbeagentur, Berlin

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