Regional Investment Plan 2017

Continental South East

Final version after public consultation and ACER opinion – October 2019

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Contents

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1 EXECUTIVE SUMMARY

1.1 Regional investment plans as foundation for the TYNDP 2018

The Ten-Year-Network-Development-Plan (TYNDP) for Electricity is the most comprehensive and up-to-date planning reference for the pan-European transmission electricity network, prepared by ENTSO-E. It presents and assesses all relevant pan-European projects at a specific time horizon as defined by a set of different scenarios to describe the future development and transition of the electricity market.

The TYNDP is a biennial report published every even year by ENTSO-E and acts as an essential basis from which to derive the Projects of Common Interest (PCI) list.

ENTSO-E is structured into six regional groups for grid planning and other system development tasks. The countries belonging to each regional group are shown in Figure 1-1.

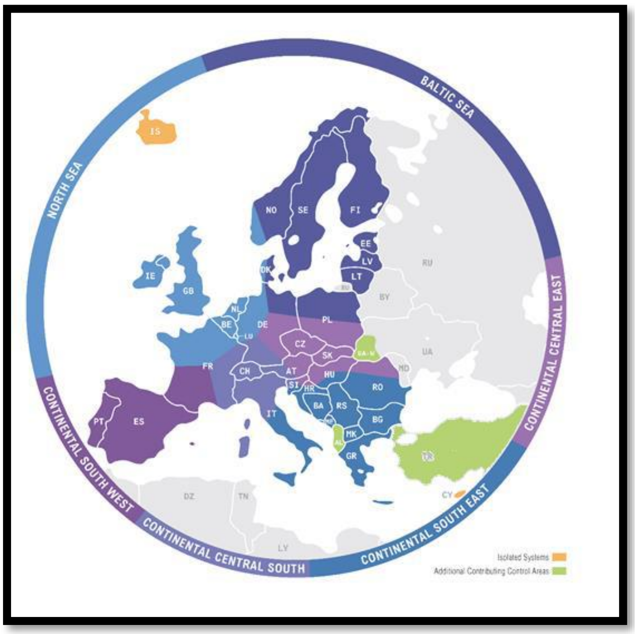


Figure 1-1: ENTSO-E System Development Regions

The six Regional Investment Plans (RegIPs) are part of the TYNDP 2018 package and are supported by regional and pan-European analyses and consider feedback received from institutions and stakeholder associations.

The RegIPs address challenges and system needs at the regional level. They are based on Pan-European market study results combined with European and/or regional network studies. They present the current situation of the region as well as future regional challenges considering different scenarios in a 2040 time horizon.

In addition to highlighting the 2040 challenges and proper scenario grid capacities to solve many of these challenges, the RegIPs also show all relevant regional projects from the TYNDP project collection. The benefits of each of these projects will be assessed and presented in the final TYNDP publication package later in 2018.

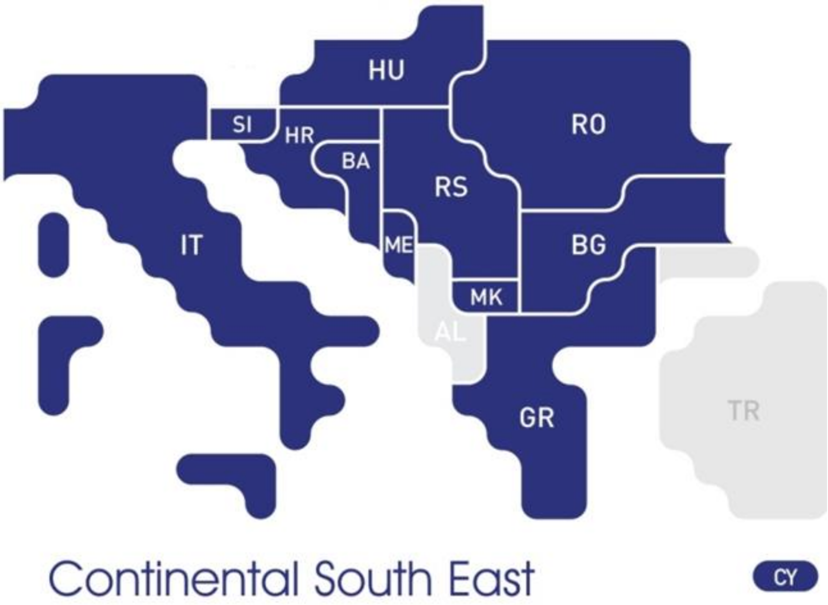
Available regional sensitivities and other available studies are included in the RegIPs to illustrate circumstances especially relevant for the region. The operational functioning of the regional system and future challenges regarding this can also be assessed and described in the reports.

Due to the fact that the RegIPs are published every second year, the Regional Investment Plan 2017 builds on the previous investment plans and describes changes and updates compared to earlier publications. Since the RegIPs provide a regional insight into future challenges, the main messages will also be highlighted in a Pan-European System Need report. The studies of the regional plans and the Pan-European System Need report, are based on the scenarios described in the scenario report.

The RegIP will strongly support one of the main challenges for ENTSO-E: to establish the most efficient and collaborative strategy to reach all defined targets of a working Internal Energy Market and a sustainable and secure electricity system for all European consumers.

1.2 Key messages of the region

The Continental South East (CSE) region covers the Balkan area and Italy. The Regional Group CSE comprises the Transmission System Operators (TSOs) of Albania (AL), Bosnia-Herzegovina (BA), Bulgaria (BG), Croatia (HR), Cyprus (CY), Greece (GR), Hungary (HU), Italy (IT), FYR of Macedonia (MK), Montenegro (ME), Romania (RO), Serbia (RS) and Slovenia (SI).



Turkey (TR) participates in ENTSO-E as an observer. The Turkish power system is connected to the Continental Europe Synchronous Area (CESA) system in parallel synchronous operation; as such, the system of TR is considered in the planning procedures of ENTSO-E.

A large number of non-EU countries participate in RG CSE; nevertheless, the vast majority of them follow the European legislation.

The transmission system of the CSE region (especially the Balkan region) is a rather sparse network with predominant power flows from East to West (E→W) and North to South (N→S). The generation portfolio of the region is dominated by thermal generation. Hydro generation has also an important share.

The main drivers for the transmission grid development in the CSE Region include:

- Increase of transfer capacities and market integration facilitation: The grid in the CSE region (especially in the Balkan peninsula) is rather sparse compared to the rest of the continent. This leads to insufficient transfer capacities; the increase of existing transfer capacities (both cross-border and

internal) is a prerequisite for the market integration in the region, also considering the price difference between the eastern part and the rest of the area. In additon, the price difference between the Balkan region and Italy comprises a major driver for increasing the transfer capacities to Italy via undersea links across the Adriatic Sea and the SI–IT borders.
- Massive Renewable Energy Source (RES) integration: The exploitation of RES in the region is lacking (except GR, BG, RO). The anticipated large RES integration (mainly wind, PV and hydro) in the region in order to achieve EU and national targets requires extensive grid developments.
- Evacuation of conventional generation in the future, mostly in the west part of the region.
- As the CSE region is located at the edge of the CESA system, it is significantly affected by the foreseen extensions of the ENTSO-E system to the east and south. Such extensions, already under consideration, include the connection of Ukraine (UA) and Moldova (MD) to the East but also Cyprus (CY) and further to Israel (IL) to the south. The recent connection of the Turkish system has also had a significant influence on the SE Balkan system. Although these future connections have not been analysed in detail, it is obvious that the need to further strengthen the East to West and North to South corridors within the region will be intensified.

The identification of future system needs in this RegIP has been based on three top-down scenarios considering the 2040 time horizon. In addition, for the first time the Turkish power system has been modelled in detail in the market studies, allowing the examination of its operation in the examined scenarios. This advancement is very crucial, considering its size compared to the rest of the regional transmission system, as well as the fact that it is connected at the periphery of the pan-European network. The derived results confirm the necessity of the transmission projects reported in TYNDP 2016 and validate the needs identified in the common planning studies reported in the CSE RegIP 2015 for the additional increase of the transfer capacity in several borders of the region according to the development drivers of the area.

In this context, on top of the mature projects defined in the previous TYNDPs, the following projects have been proposed for assessment in TYNDP 2018, based on the results of the regional identification of future system needs:

- Upgrade of existing 220 kV lines between HR and BA to 400 kV.
- New 400 kV HR-RS interconnection.
- North CSE corridor, including new 400 kV RO-RS interconnection and internal reinforcements in RS.
- Central Balkan corridor, including new 400 kV BG-RS interconnection and internal reinforcements in RS.
- Refurbishment of the 400 kV GR-MK interconnection Meliti-Bitola.

These projects aim to strengthen the East-West and North-South corridors, in order to assist market integration, support large power exports from TR, RO and GR (which are the countries with the highest wind and solar capacity increase in the 2040 examined scenarios), and enhance the security of supply (SoS) in the area.

Similar conclusions have been derived from the framework of a network sensitivity study performed to investigate the impact of the Turkish power system balance on the loading of CSE network elements in extreme conditions. In particular, the potential need to strengthen the transfer capacity in the BG–RS border as well as in the internal transmission network of RS has been identified.

1.3 Future capacity needs

The first phases of the TYNDP 2018 process were about building new scenarios for 2025, 2030 and 2040 and assessing system needs for the long-term horizon 2040. As part of this work, cross-border capacity

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increases, which have a positive impact on the system, were identified[1] for the 2040 scenarios. A European overview of these increases is presented in the European System Need report [link] developed by ENTSO-E in parallel with the RegIPs 2017. Identified capacity increases inside or at the borders of the CSE-region are shown in the map below.

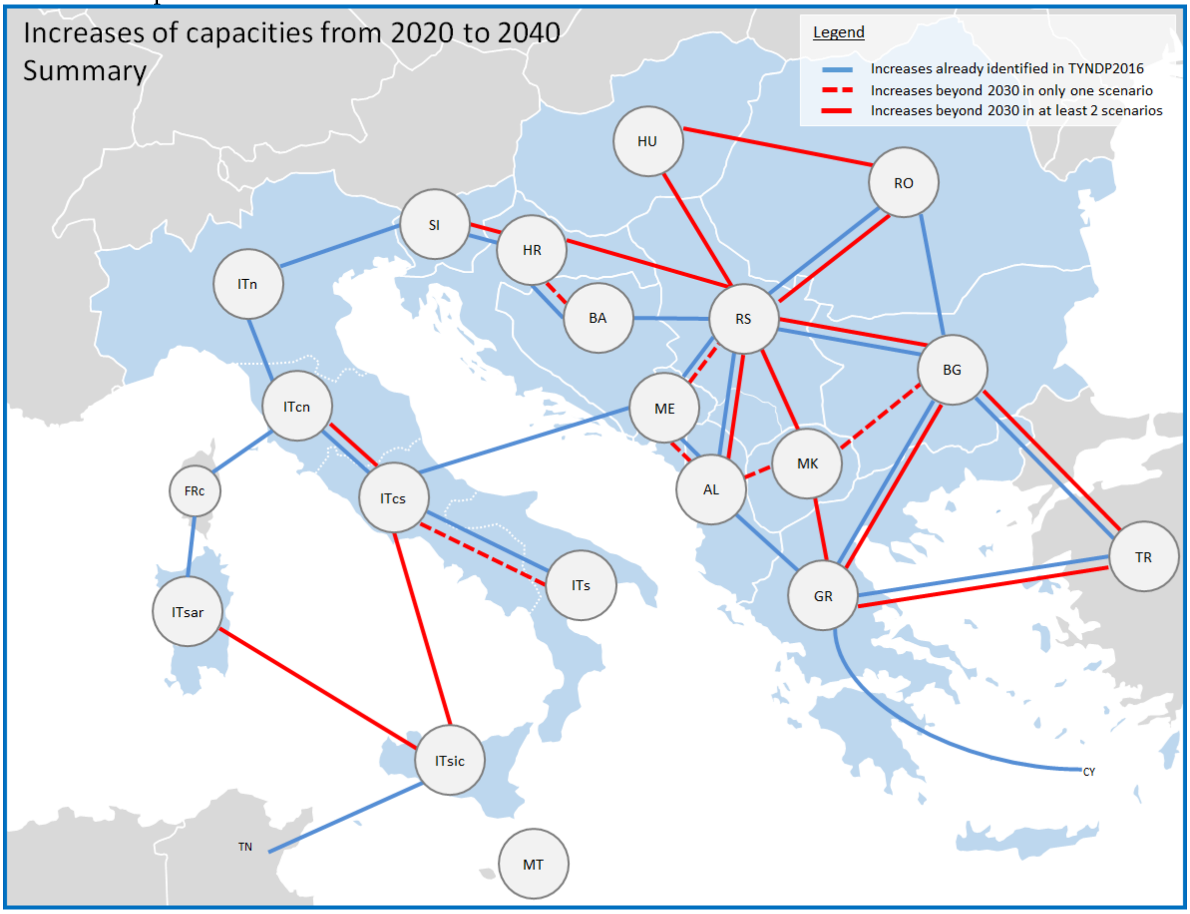

Figure 1-2: Identified capacity increase needs between years 2020 and 2040[2]

As can be observed, the need for increasing cross-border capacity is dominant in the region in the majority of scenarios. The Turkish power system size along with the very high renewable capacity assumed in the 2040 examined scenarios creates the need for capacity increases in the BG–TR and GR–TR borders. Already today, the Serbian power system has to cope with transit power flows due its position in the regional network. In the 2040 horizon these power flows increase considerably, resulting in the need to increase transfer capacity in all the RS borders with neighbouring countries.

[1] For a description of the methodology used, see chapter 2.3.

[2] 'Increases already identified in TYNDP 2016' refers to the reference capacities of TYNDP 2016 for 2030 which for some borders had been adjusted for the TYNDP 2018 purpose. Projects commissioned in 2020 are not included as increases.

2 INTRODUCTION

2.1 Legal requirements

The present publication is part of the TYNDP package and complies with Regulation (EC) 714/2009 Article 8 and 12, where it is requested that TSOs shall establish regional cooperation within ENTSO-E and shall publish a RegIP every two years. TSOs may take investment decisions based on that RegIP. ENTSO-E shall provide a non-binding community-wide TYNDP which is built on national investment plans and the reasonable needs of all system users, and identifies investment gaps.

The TYNDP package complies with Regulation (EU) 347/2013 'The Energy Infrastructure Regulation'. This regulation defines new European governance and organisational structures, which shall promote transmission grid development.

RegIPs are to provide a detailed and comprehensive overview on future European transmission needs and projects in a regional context to a wide range of audiences:

- The Agency for the Cooperation of Energy Regulators (ACER), who has a crucial role in coordinating regulatory views on national plans, providing an opinion on the TYNDP itself and its coherence with national plans, and giving an opinion on the European Commission's (EC) draft list of PCI projects;
- European institutions (EC, Parliament, Council) who have acknowledged infrastructure targets as a crucial part of pan-European energy goals, to give insight into how various targets influence and complement each other;
- Energy industry, covering network asset owners (within ENTSO-E perimeter and the periphery) and system users (generators, demand facilities and energy service companies);
- National regulatory authorities and ministries, to place national energy matters in an overall European common context;
- Organisations with a key function to disseminate energy-related information (sector organisations, NGOs, press) for who this plan serves as a 'communication tool-kit';
- The general public, to understand what drives infrastructure investments in the context of new energy goals (RES, market integration) while maintaining system adequacy and facilitating secure system operation.

2.2 The scope of the report

The present RegIP is part of a set of documents (see figure below) comprising in a first step the following reports: a Mid Term Adequacy Forecast report (MAF), a Scenario report, a Pan European Systems needs report and six RegIPs.

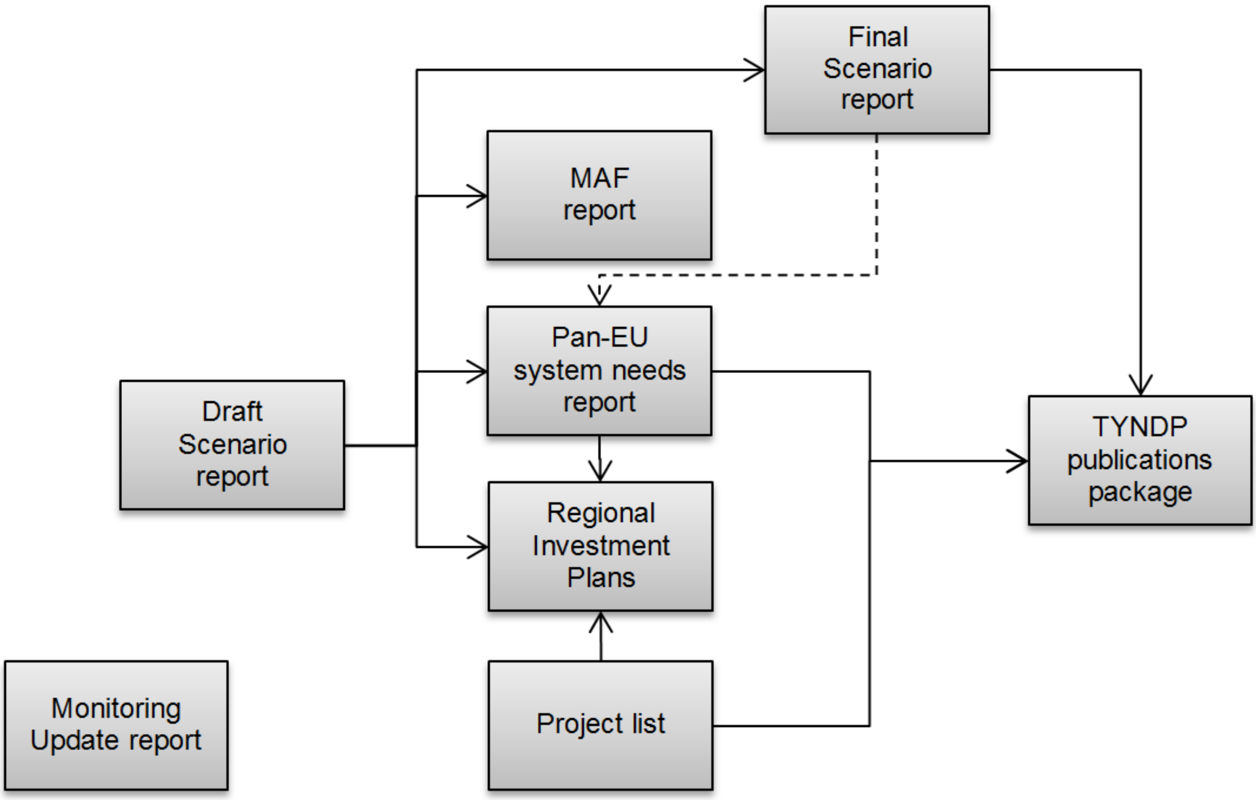

Figure 2-1: Document structure overview TYNDP 2018

The general scope of RegIPs is to describe the present situation as well as future regional challenges. The TYNDP process proposes solutions, which can help to mitigate future challenges. This particular approach is based on five essential steps presented in Figure 2- below:

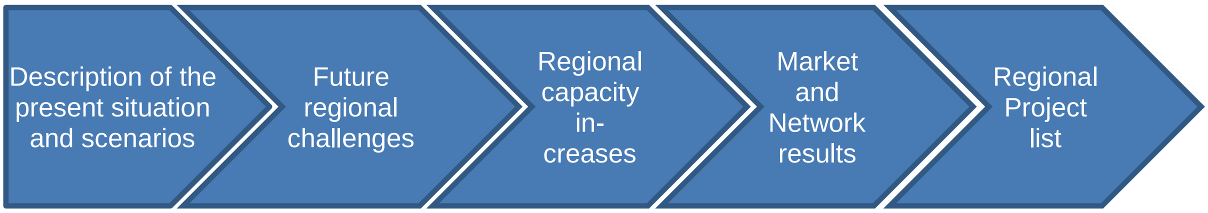

Figure 2-2: Mitigating future challenges – TYNDP Methodology.

As one of the solutions to the future challenges, the TYNDP project has performed market and network studies for the long-term 2040 time horizon scenarios to identify investment needs, i.e. cross-border capacity increases and related necessary reinforcements of the internal grid that can help in mitigating these challenges.

The current document comprises seven chapters with detailed information at the regional level:

- Chapter 1 gathers the key messages of the region.
- Chapter 2 sets out in detail the general and legal basis of the TYNDP work and provides a short summary of the general methodology used by all ENTSO-E regions.
- Chapter 3 covers a general description of the present situation of the region. In addition, the future challenges of the region are presented in when describing the evolution of generation and demand profiles in the 2040 horizon but considering a grid as expected by the 2020 horizon.

- Chapter 4 includes an overview of the regional needs in terms of capacity increases and the main results from a market and network perspective.
- Chapter 5 is dedicated to additional analyses carried out inside the regional group or by external parties outside the core TYNDP process.
- Chapter 6 links to the different NDPs of the countries of the region.
- Chapter 7 contains the list of projects proposed by promoters in the region at the Pan-European level as well as important regional projects not part of the European TYNDP process.
- Finally, Chapter 8 (appendix) includes the abbreviations and terminology used in the whole report as well as additional content and detailed results.

The current edition of this RegIP considers the experience from the last processes including improvements, in most cases received from stakeholders during the last public consultations, such as:

- Improved general methodology (current methodology includes other specific factors relevant to the investigation of RES integration and SoS needs)
- A more detailed approach to determining demand profiles for each zone
- A more refined approach to demand-side response and electric vehicles
- For the first time, several climate conditions have been considered as well.

The actual RegIP does not include the Cost Benefit Analysis (CBA)-based assessment of projects. These analyses will be developed in a second step and presented in the final TYNDP 2018 package.

2.3 General methodology

The present RegIPs build on the results of studies called ‘Identification of System Needs’ (IoSN) which were carried out by a European team of market and network experts from the six regional groups of ENTSO-E’s System Development Committee. The results of these studies have been commented and in some cases extended with additional regional studies by the regional groups to cover all relevant aspects in the regions. The aim of the joint study was to identify investment needs in the long-term time horizon triggered by market integration, RES integration, SoS and interconnection targets, in a coordinated pan-European manner also building on the grid planners’ expertise of all TSOs.

A more detailed description of such a methodology is available in the TYNDP 2018 Pan-European System Needs Report.

Regional knowledge

In the CSE Regional Group, complementary to IoSN studies, a network sensitivity study has been performed to investigate the impact of the Turkish power system balance on the loading of the transmission elements in the regional network. The regional significance of this exercise stems from the importance of the CSE area extension to the East borders from a transmission development perspective.
In addition, a UA/MD network connection sensitivity study is going to be launched, in the framework of the South East Cooperation Initiative (SECI) project, to investigate the influence of the new interconnection on the operation of the CSE network and the relative importance of CSE future transmission projects.
Details regarding these sensitivity studies can be found in Chapter 5.

2.4 Introduction to the region

The CSE Regional Group under the scope of the ENTSO-E System Development Committee is among the six regional groups for grid planning and system development tasks. The countries belonging to each group are shown in Figure 2- below.

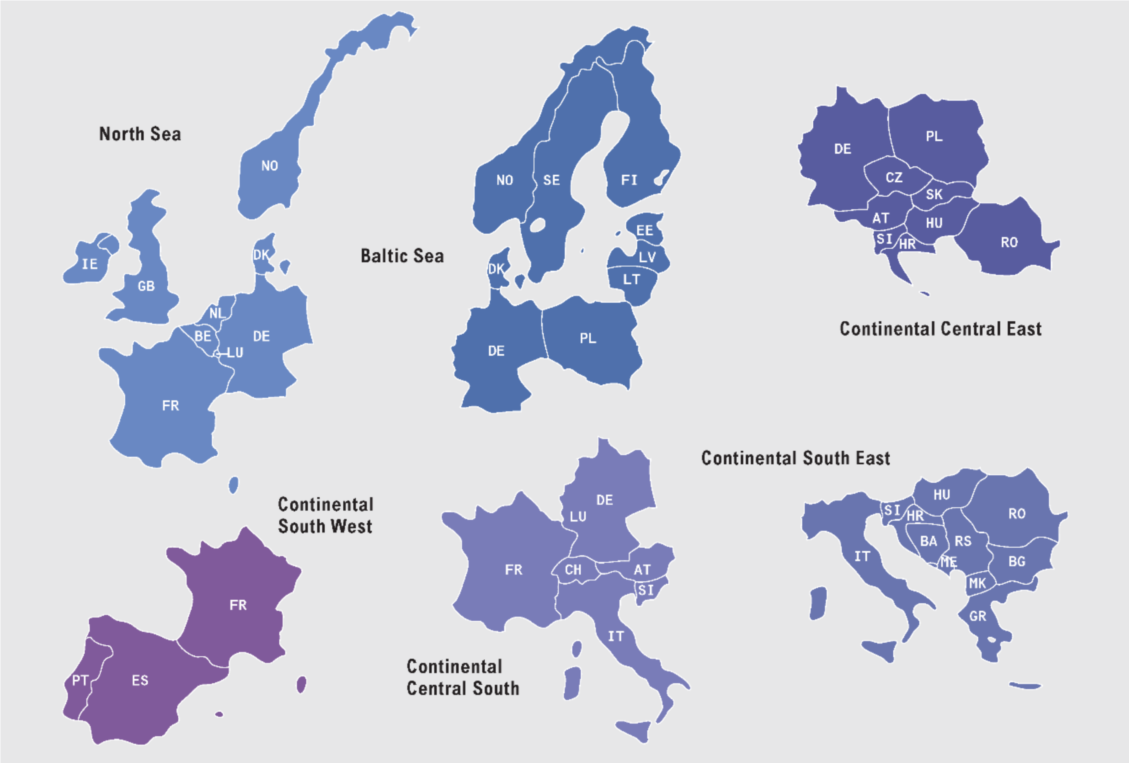

Figure 2-3: ENTSO-E regions (System Development Committee)

The CSE Regional Group comprises 13 countries which are listed, along with their representative TSO, in Table 2-1. As has been mentioned in the previous chapter, Turkey participates as an observer in the CSE Regional Group, and is represented by TEIAS.

Table 2-1: ENTSO-E Regional Group South East membership

Country	Company/TSO
Albania	OST
Bosnia-Herzegovina	NosBiH
Bulgaria	ESO-EAD
Croatia	HOPS
Cyprus	TSO of Cyprus
FYR of Macedonia	MEPSO
Greece	IPTO
Hungary	MAVIR
Italy	TERNA
Montenegro	CGES
Romania	CN Transelectrica SA
Serbia	EMS
Slovenia	ELES

3 REGIONAL CONTEXT

3.1 Present situation

The grid in the CSE region (especially the Balkans area) is rather sparse compared to the rest of the continent. This leads to insufficient transfer capacities; the increase of existing transfer capacities (both cross-border and internal) is a prerequisite for the market integration in the region, considering also the price difference between the eastern part (RO, BG and TR) and the rest of the countries in the Balkan peninsula. In addition, the price difference between the Balkan region and Italy comprises a major driver for increasing the transfer capacities to Italy through undersea links across the Adriatic Sea and the SI–IT borders.

Figure 3-1 shows the evolution of generation installed capacities for the years 2010 and 2016 in the CSE region, compared to the maximum consumption of each country. While maximum consumption remains pretty constant in most of the countries, an increase in generation installed capacities is observed mainly in GR and RO, due to the increase of wind and solar installed capacities. For both years of comparison, total generation installed capacity is higher than the maximum consumption of each country, indicating the adequacy of the generation systems in all countries to meet the demand.
The power system of the region is dominated by fossil fuel (especially coal and lignite), followed by hydropower, as shown in Figure 3-1 for the years 2010 and 2016 respectively.
Most of the high fossil fuel share of the installed capacities in the region comes from BG, GR, HU, RO, RS, IT and TR, whereas that of hydropower comes from AL, BA, BG, GR, HR, RO, RS, IT and TR.
Moving from 2010 to 2016, an increase in the total net generation capacity of the region is observed which is mainly due to the increase of solar and wind installations. This increase is followed by a decrease of the fossil fuels installed capacity percentage.

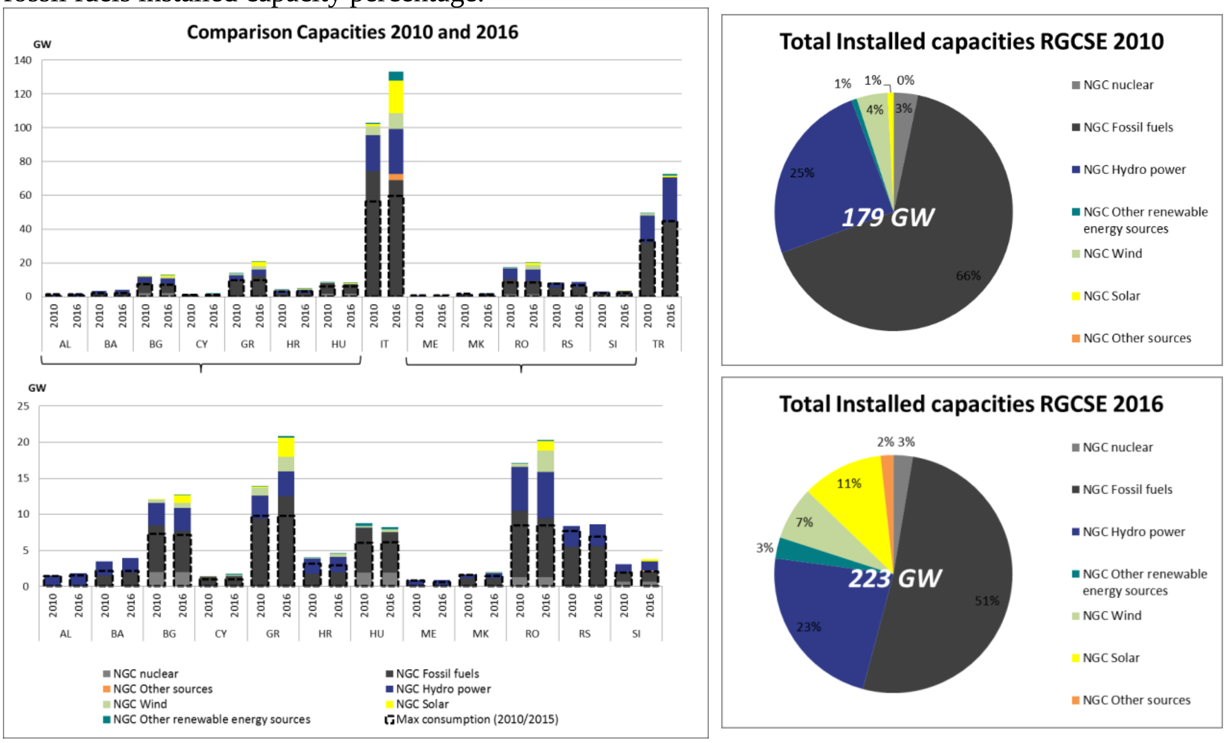

Figure 3-1: Installed generation capacities by fuel type and maximum consumption in the Continental South East Region in 2010 and 2016

Figure 3-2 shows the evolution of annual generation per fuel type for the years 2010 and 2016 in the region, compared to the annual electricity consumption of each country.

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Nuclear generation in BG, RO, HU and SI remains fairly constant, while the dominant component of the generation mix in most countries is from fossil fuel power plants. The increase of generation from wind and solar power plants is observed mostly in GR, BG and RO. The highest decrease in annual electricity consumption is observed in GR and IT due to the economic recession.
Figure 3-2 shows the evolution of the share of each fuel type in the total production of the region for the years 2010 and 2016. Electricity production from fossil fuels is the prevailing component in both years, although a reduction of the relevant percentage is observed in 2016.
As is evident from the figures, the contribution of nuclear energy is rather constant in the RG CSE electricity balance, representing 8% of the total generation (although only 3% in terms of installed capacity).
Electricity production from renewables is increased from 2010 to 2016, especially for solar generation.

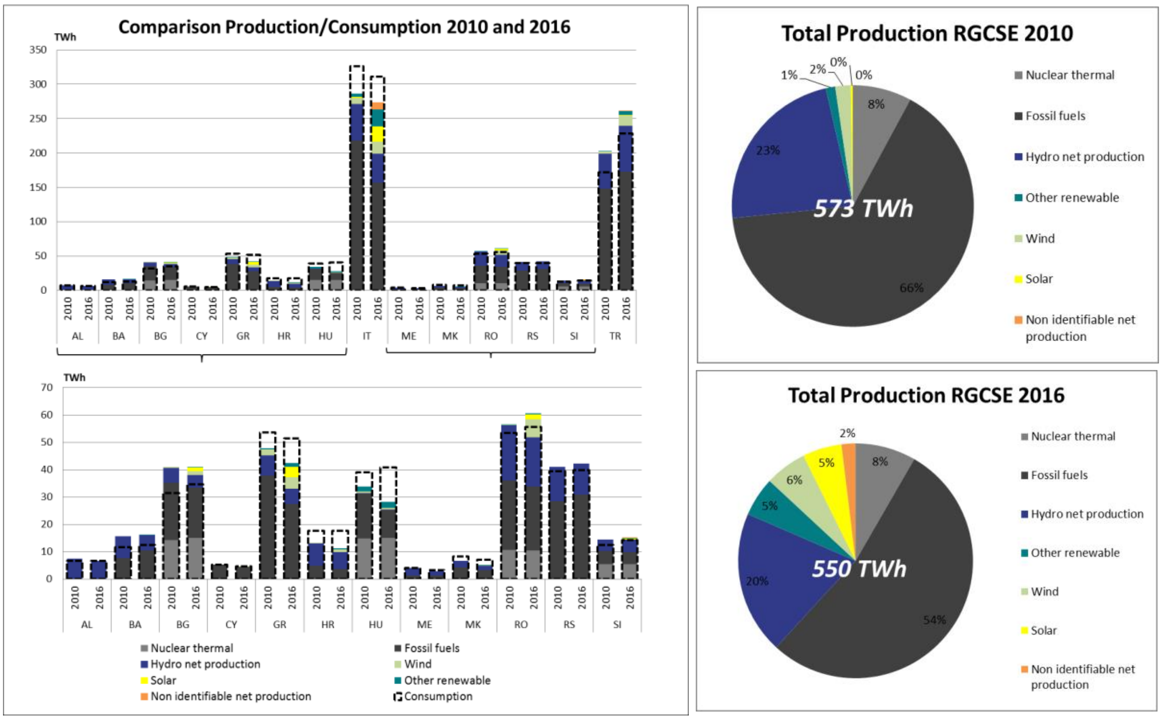

Figure 3-2: Annual generation by fuel type and annual consumption in the Continental South East Region in 2010 and 2016

The main exporters of the area are RO, BG, BA and RS, whereas the importing countries are GR, HU, HR and MK. CY is balanced, since it is an autonomous system without any interconnections.

Figure 3-3 shows the evolution of annual physical border flows per border and direction, from the year 2010 to 2015. The highest volumes of electricity exchanges appear at the North borders of the Italian transmission system. An increase of these exchanges is observed in 2015 compared to 2010. The direction of power flows at the North borders of the CSE region shows that the region is an importer for the examined years.
The inspection of power flows at the internal borders of the region reveals that the predominant power flow directions are from North to South (N→S) and from East to West (E→W).

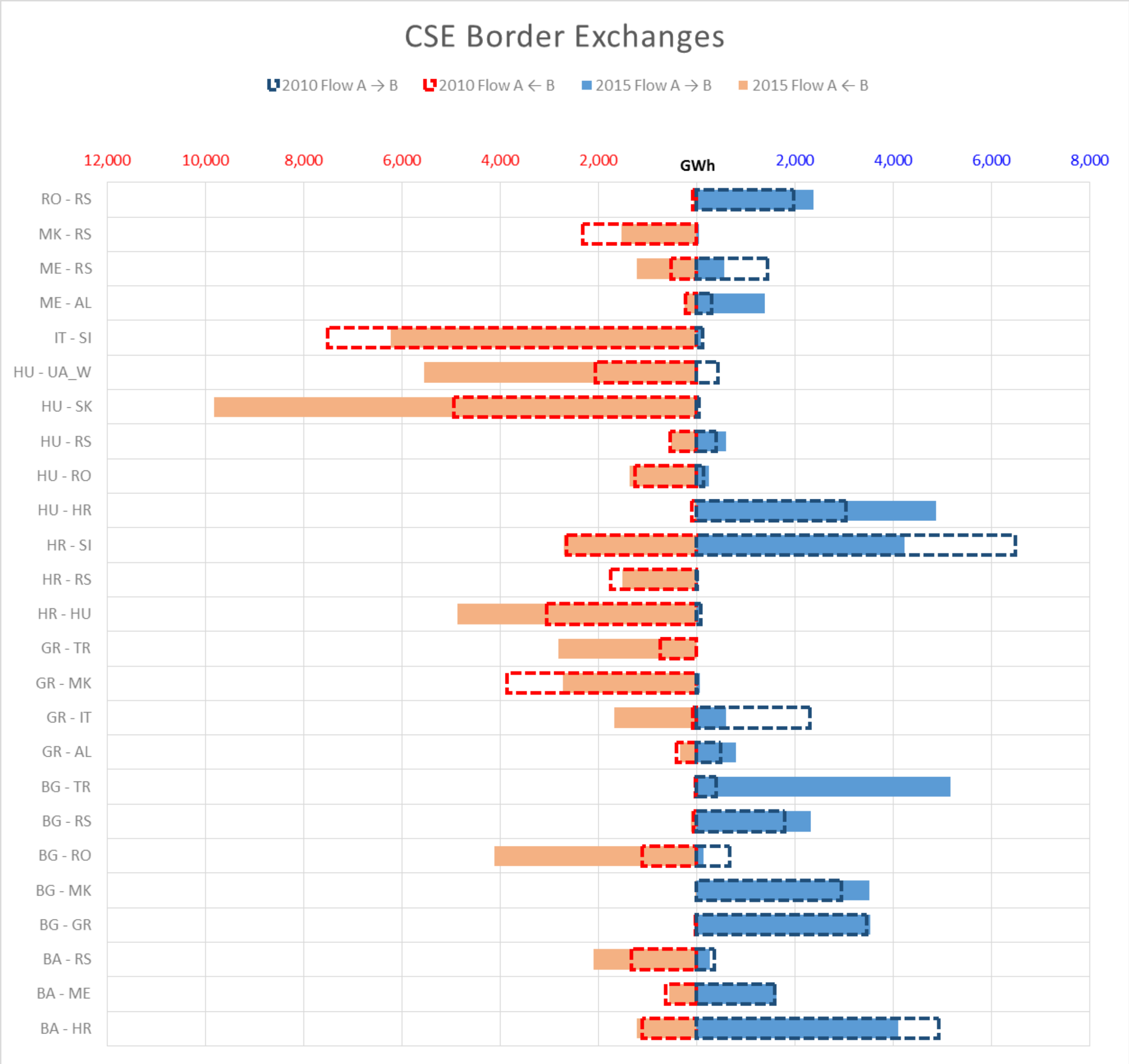

Figure 3-3: Cross border physical flows (GWh) in the Continental South East Region in year 2010 and year 2015

3.2 Description of the scenarios

Figure 3-4 below gives an overview of the timely related classification and interdependencies of the scenarios in the TYNDP 2018 and shows the transition from the actual situation, including the time points 2025 and 2030, to the year 2040.

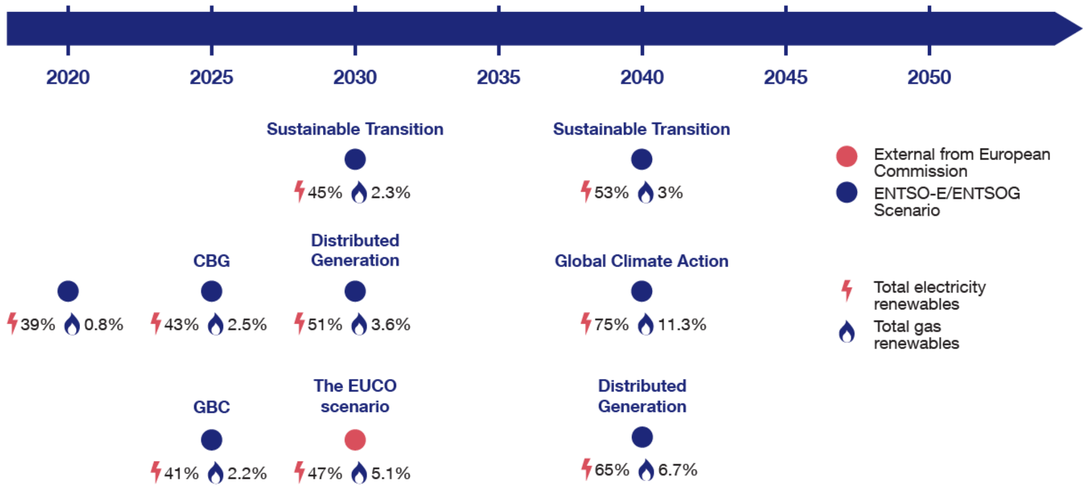

Figure 3-4: Scenario building framework indicating Bottom up and Top Down scenarios.

Within the scenario building process, two types of optimisation have been applied: thermal optimisation and RES optimisation:

1. Thermal optimisation optimises the portfolio of thermal power plants. Power plants that are not earning enough to pay for operating cost are removed and new power plants are added depending on a CBA. The methodology ensures a minimum adequacy of production capacity in the system giving a maximum of 3 hours energy not served (ENS) per country
2. RES optimisation optimises the location of RES (PV, Onshore and Offshore Wind) in the electricity system to utilise the value of the RES production. This methodology was also used in TYNDP 2016 but has been improved by utilising higher geographical granularity (more market nodes) and by assessing more climate years.

The above mentioned scenarios for the time frame 2040 consist of a top down approach and the data will be derived from the 2030 database.

A more detailed description of the scenario creation is available in the TYNDP 2018 Scenario Report[3].

Furthermore, the following scenarios at the time horizon 2040 should be highlighted:

Scenario 'Global climate action'

Scenario 'Global climate action' (GCA) is based on a high growth of RES and new technologies and has the goal of keeping the global climate efforts on track with the EU 2050 target.

The 'Global climate action' storyline considers global climate efforts. Global methods regarding CO2 reductions are in place, and the EU is on track towards its 2030 and 2050 decarbonisation targets. An efficient Emissions Trading Scheme (ETS) is a key enabler in the electricity sector's success in contributing to Global/EU decarbonisation policy objectives. In general, renewables are located across Europe where the

[3] TYNDP 2018 Scenario Report: http://tyndp.entsoe.eu/tyndp2018/

best wind and solar resources are found. As non-intermittent renewables, bio methane is also developed. Due to the focus on environmental issues, no significant investment in shale gas is expected.

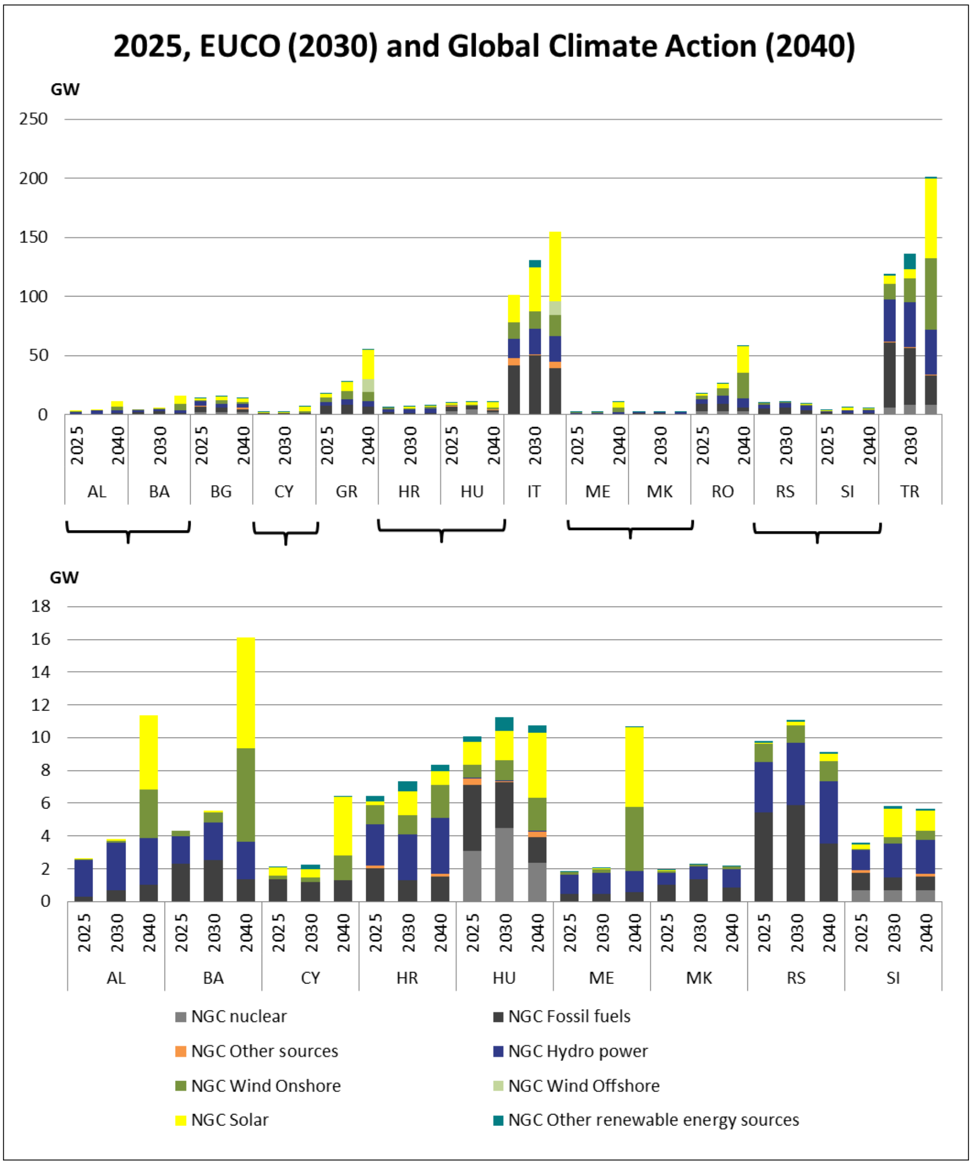

Figure 3-5: Installed net generation capacities at regional level

Figure 3-5 shows the evolution of installed generation capacities at the regional level, for the 'Global Climate Action' storyline.

The highest growth of wind onshore was assumed in this GCA scenario, having 112.5 GW more (almost four times higher) than the wind capacity in 2025. Approximately 47 GW of new wind onshore capacities are installed in TR, followed by RO, with 18 GW, IT and GR, both with about 15 GW.

In most of the countries, due to the high decarbonisation rates, a considerable reduction of the share of fossil fuel generation NGC is observed in 2040. The highest increase of total installed capacity due to the large scale of RES development is observed in AL, BA, CY, GR, ME, RO, IT and TR. In some of these countries this increase is more than double when comparing the 2040 and 2025 figures.

Scenario 'EUCO'

In addition, for the year 2030 there is a third scenario based on the EC's EUCO Scenario for 2030 (EUCO 30). The EUCO scenario is a scenario designed to reach the 2030 targets for RE, CO_2 and energy savings, considering current national policies such as the German nuclear phase out.

The EC's scenario EUCO 30 was an external core policy scenario, created using the PRIMES model and the EU Reference Scenario 2016 as a starting point and as part of the EC impact assessment work in 2016. The EUCO 30 already models the achievement of the 2030 climate and energy targets as agreed by the European Council in 2014 but including an energy efficiency target of 30%.

This external scenario does not consider non-EU member countries. For this reason, the installed generation capacities of the Sustainable Transition 2030 scenario are used for AL, BA, ME, MK, RS and TR.

Scenario 'Sustainable Transition'

Scenario 'Sustainable Transition' (ST) mainly assumes moderate increases of RES and moderate growth of new technologies and in line with the EU 2030 target, but slightly behind the EU 2050 target.

In the 'Sustainable Transition' storyline, climate action is achieved with a mixture of national regulation, emission trading schemes and subsidies. National regulation takes the shape of legislation that imposes a binding emission target. Overall, the EU is just on track with 2030 targets, resulting in being slightly behind the 2050 decarbonisation goals. However, targets are still achievable if rapid progress is made in decarbonising the power sector during the 2040s.

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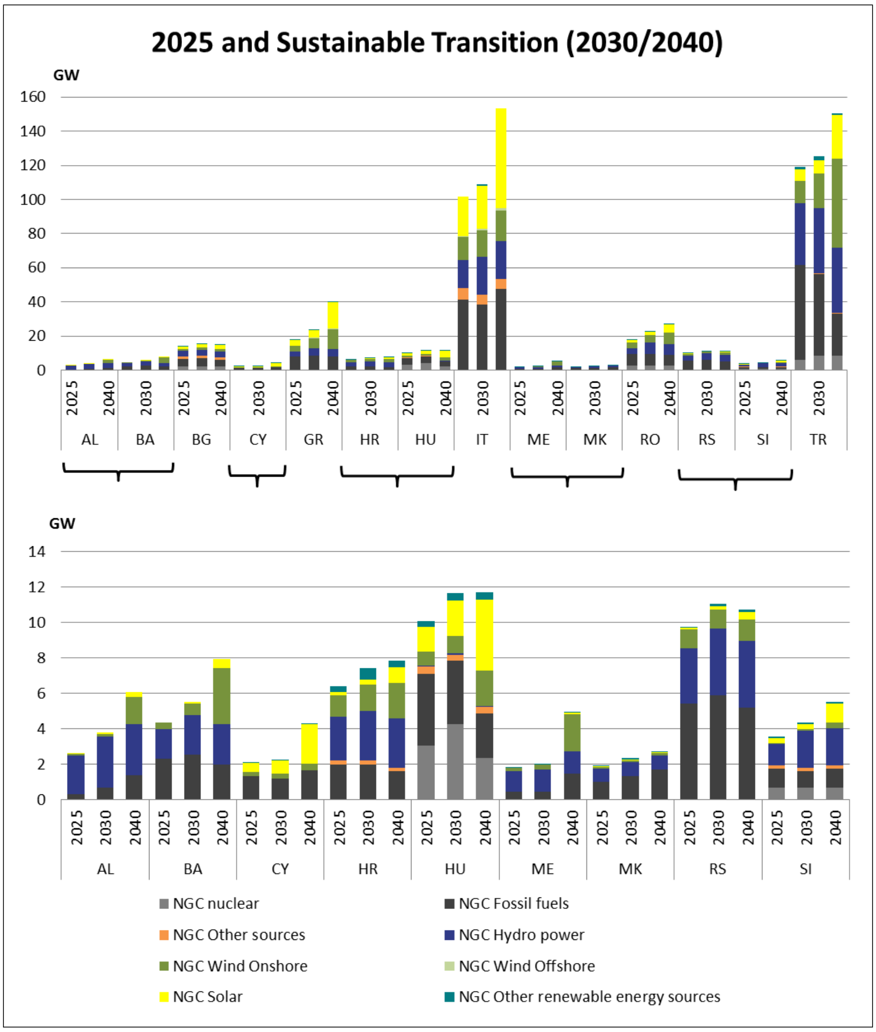

Figure 3-6: Installed net generation capacities at regional level

Figure 3-6 shows the evolution of installed generation capacities at the regional level for the 'Sustainable Transition' storyline.

In most of the countries of the region, fossil fuel units' capacity reduction is rather small, since in this scenario a replacement of coal and lignite by gas units is assumed. The TR power system constitutes an exception to this, since the installed thermal generation capacity in 2040 is reduced by approximately 50% compared to 2025. A reduction of installed fossil fuel units is also observed in HU.

The countries with the most pronounced increase of total generation capacity are AL, CY, GR, ME, RO, IT and TR. Especially for GR, RO, IT and TR, the capacity increased progressively up to the 2040 horizon at the expense of the solar and wind generation capacity, which is more than double that of 2025.

Scenario 'Distributed Generation'

The scenario 'Distributed Generation' (DG) covers a very high growth of small-size and decentralised, and often renewable based, energy generation and energy storages, including an increase of new technologies in the related area and also largely in line with both the EU 2030 and 2050 goals.

In the DG storyline, significant leaps in innovation of small-scale generation and residential / commercial storage technologies are a key driver in climate action. An increase in small-scale generation keeps the EU on track for its 2030 and 2050 targets. A 'prosumer' rich society has bought into the energy markets, so society is engaged and empowered to help achieve a decarbonised place to live. As a result, no significant investment in shale gas is expected.

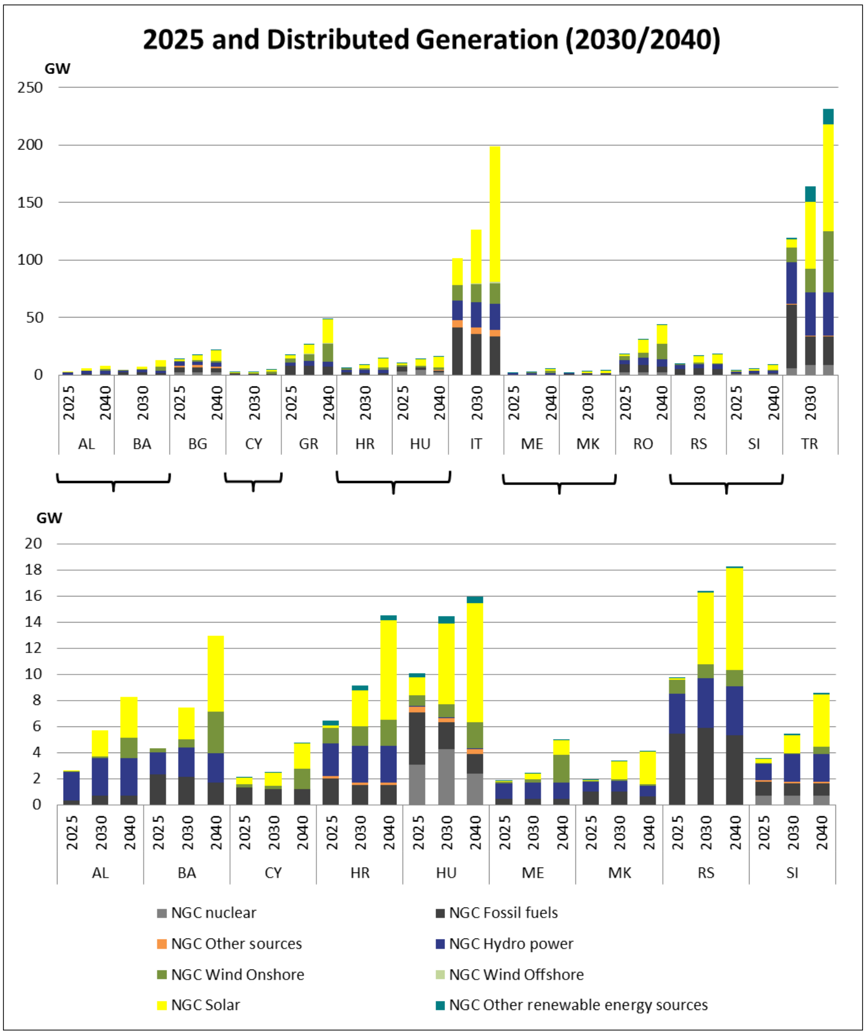

Figure 3-7: Installed net generation capacities at the regional level

Figure 3-7 shows the evolution of installed generation capacities at regional level for the 'Distributed Generation' storyline. A high share of solar generation is observed in all countries, reflecting the decentralised generation penetration levels assumed in this scenario, also motivated by the higher solar yields in Southern Europe. Consequently, a total increase of about 261 GW is considered in the region, of which 83% are located in the four countries with the highest growth in absolute values: IT, TR, GR and RO.

Distributed generation seems to build on top of the conventional generation, since in most of the countries the reduction of fossil fuel generation capacity is rather moderate, expressing the need to retain on a centralised level enough peaking capacity to balance the demand.

3.3 Future challenges in the region

The European Market and Network Study Teams have carried out simulations of all three 2040 scenarios (Sustainable Transition, Global Climate Action and Distributed Generation) with the expected grid of 2020.

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Even if these simulations were somewhat artificial (in the real world, the market and grid develops in close interaction with each other), the study revealed future challenges such as:

- poor integration of renewables (high amounts of curtailed energy)
- SoS issues
- high price differences between market areas
- high CO2 emissions
- bottlenecks between market areas and inside these areas

The charts below describe the regional challenges identified by the simulations as mentioned above. They show average results and ranges of simulations of three different climate years for all of the three long-term 2040 scenarios. All simulations have been carried out by several market models and the results might be compared with the similar charts in chapter 4, showing the 2040 market data simulations combined with an appropriate 2040 scenario grid.

Additional future regional challenges are also described as well.

The effects of having a production system and consumptions as described in the different 2040 scenarios, combined with a grid that hasn't evolved beyond 2020, will not only reveal market challenges but also issues in the grid such as overloads on cross-border lines and overloads internally in some market areas.

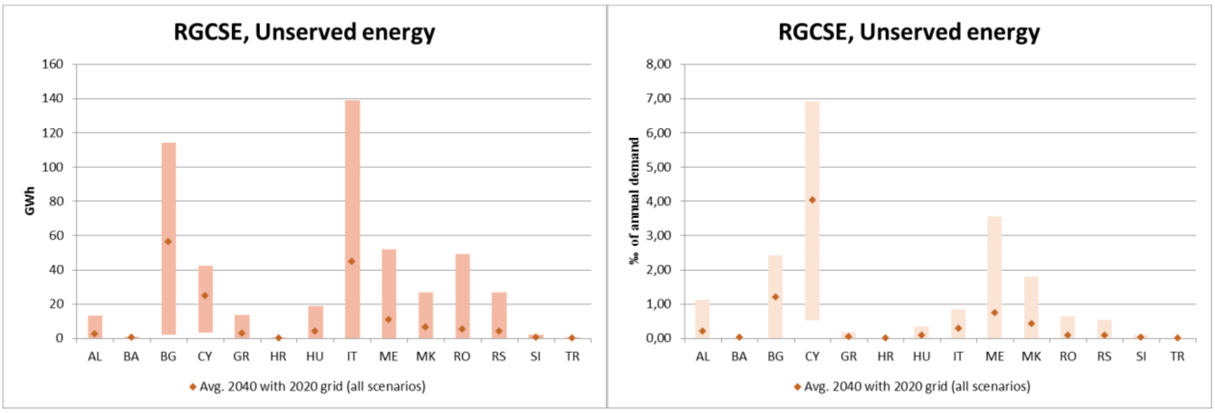


Fig 3-8: Unserved energy in the region for 2040 scenarios with 2020 grid

IT and BG are the countries with the highest unserved energy in the region. The relevant amounts are less than 1% and approximately 2% of the annual demand of the respective countries. All the other countries have lower values of unserved energy which is less than 1% of the annual demand in most of the cases, with the exception of CY (which is considered isolated), ME and MK.

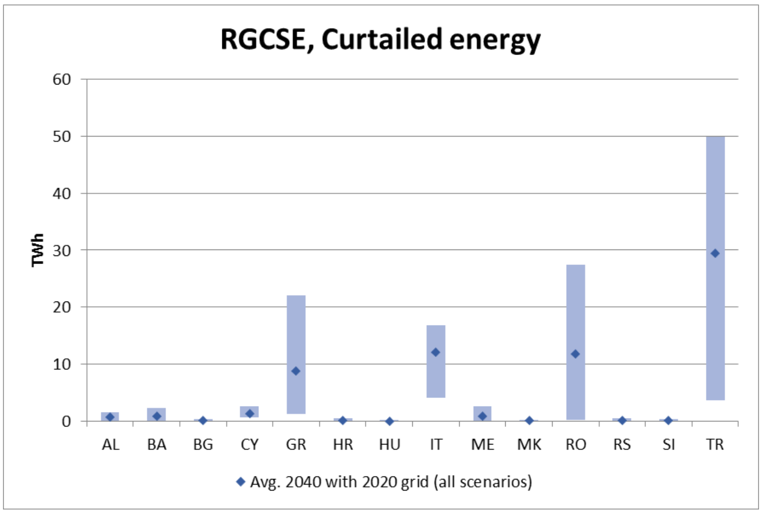


Figure 3-9: Curtailed energy in the region for 2040 scenarios with 2020 grid

The overall picture of the RES integration in the region reflects the storyline behind the RES optimisation process associated with the top - down scenario building for the 2040 horizon. The countries within RG CSE show a different contribution to reaching the overall goals of the scenarios.

On average, approximately 85% of the total wind and solar capacity increase for 2040 horizon is located within these four countries: TR, IT, GR and RO, which face high RES/load shares.

It should be noted that the 2040 grid does not help to evacuate all the excess RES capacity either, and the level of spillage remains high in these countries. This shows that the level of RES that can be integrated in the market with the contribution of reasonable grid reinforcements is lower than that considered in the extreme scenario for 2040.

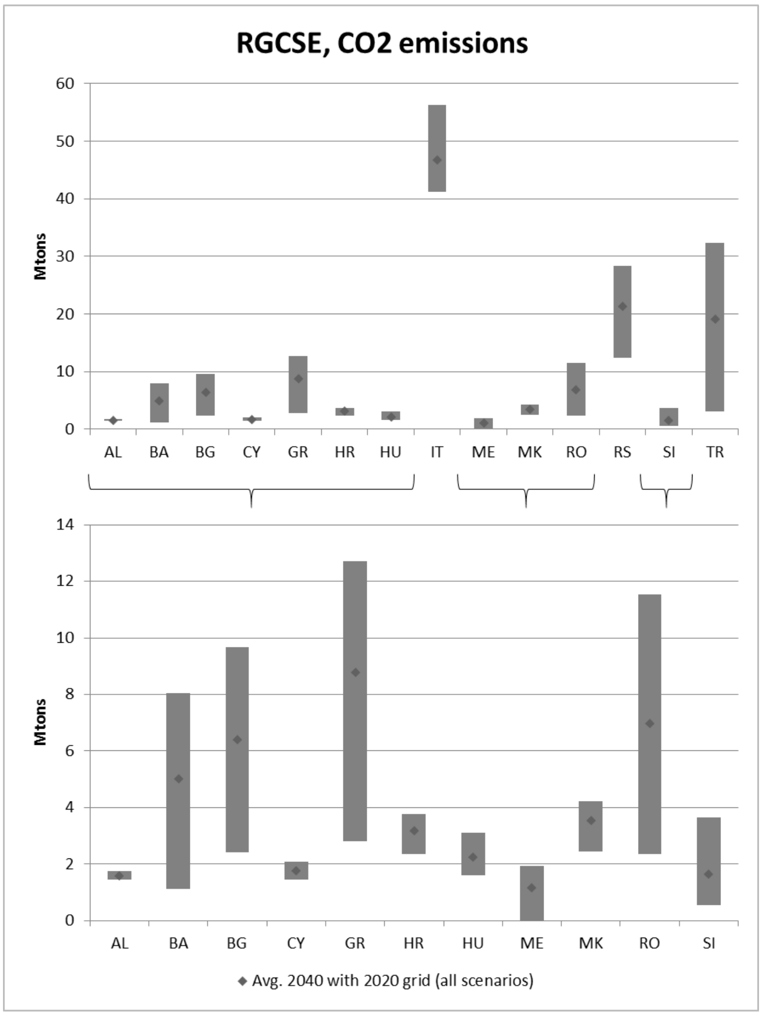


Figure 3-10: CO2 emissions in the region for 2040 scenarios with 2020 grid

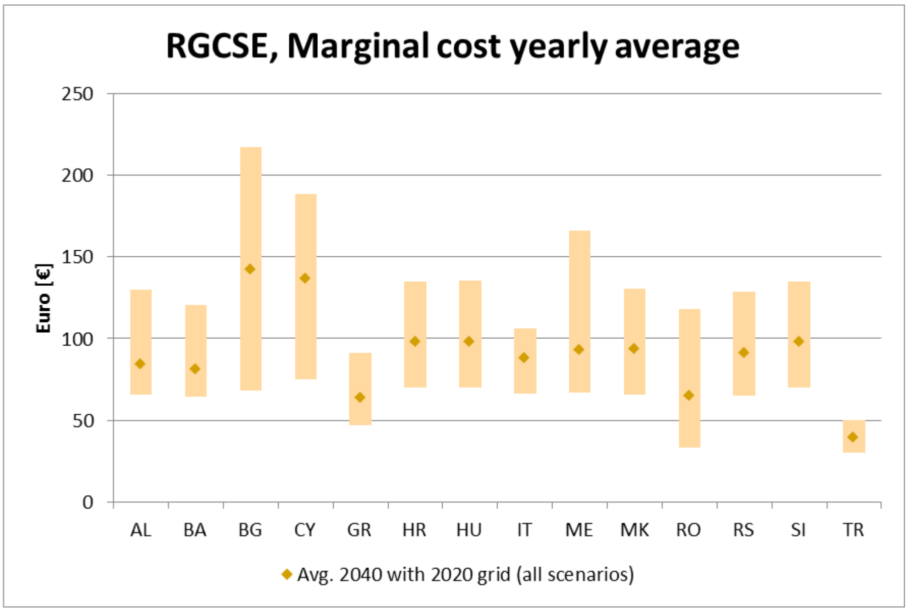


Figure 3-11: Marginal costs in the region for 2040 scenarios with 2020 grid

The countries with the highest electricity generation levels for the 2040 horizon, either to cover their own demand or also the export in the RG CSE, show the highest corresponding contribution to CO2 emissions. These countries include IT, RS, TR, GR, RO, BG and BA. CO2 levels are due to the fossil fuels component in their mix and also reflect the level of RES integration.

As a consequence of the high installed capacities on RES in the 2040 scenarios, TR, GR, RO and IT (except the northern and central–northern parts) have the lowest average costs, followed by AL and BA. The country with the highest average marginal cost is BG. For CY, the average cost is also high since it is considered an isolated system in the 2020 grid.

The marginal cost spread among HR, SI, MK, ME and RS market nodes is low, which demonstrates that this part of the region is already rather well integrated.

Consequently, as also shown in the following chart, the GR–CY border has the highest marginal cost spread since the interconnection does not exist in the 2020 grid, followed by the borders between BG and its neighbouring countries, showing the opportunity for potential increases on either the BG–GR, BG–RO, BG–RS, BG–MK and BG–TR interconnectors.

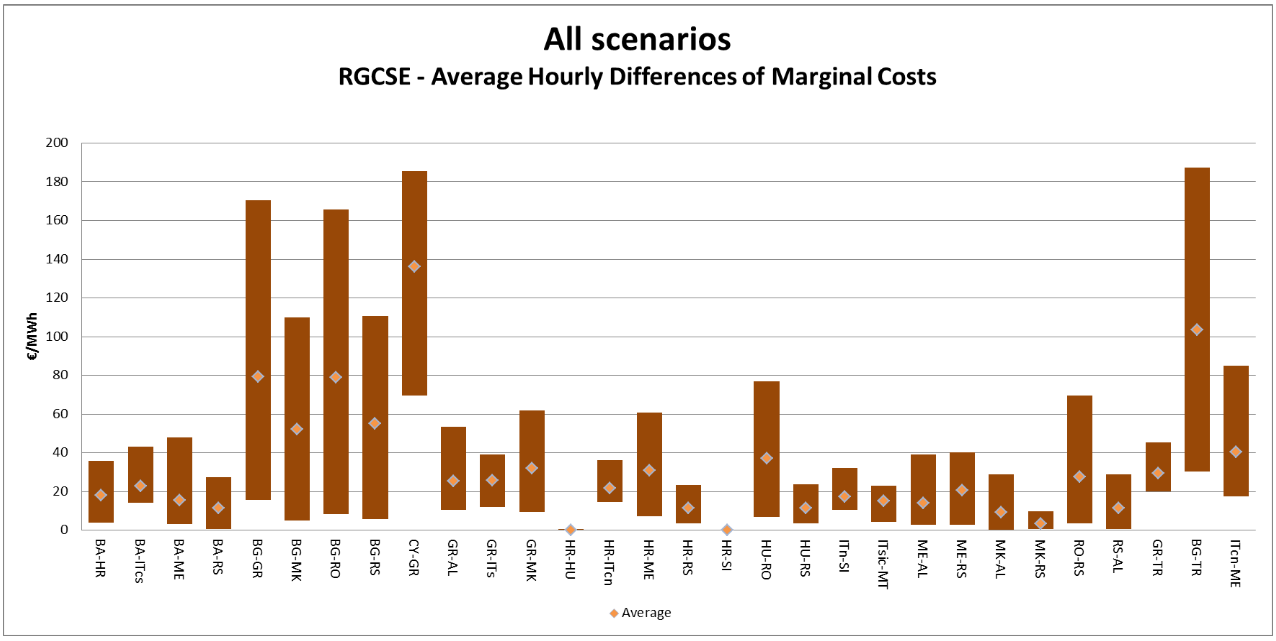


Figure 3-12: Average hourly price differences in the region for 2040 scenarios with 2020 grid

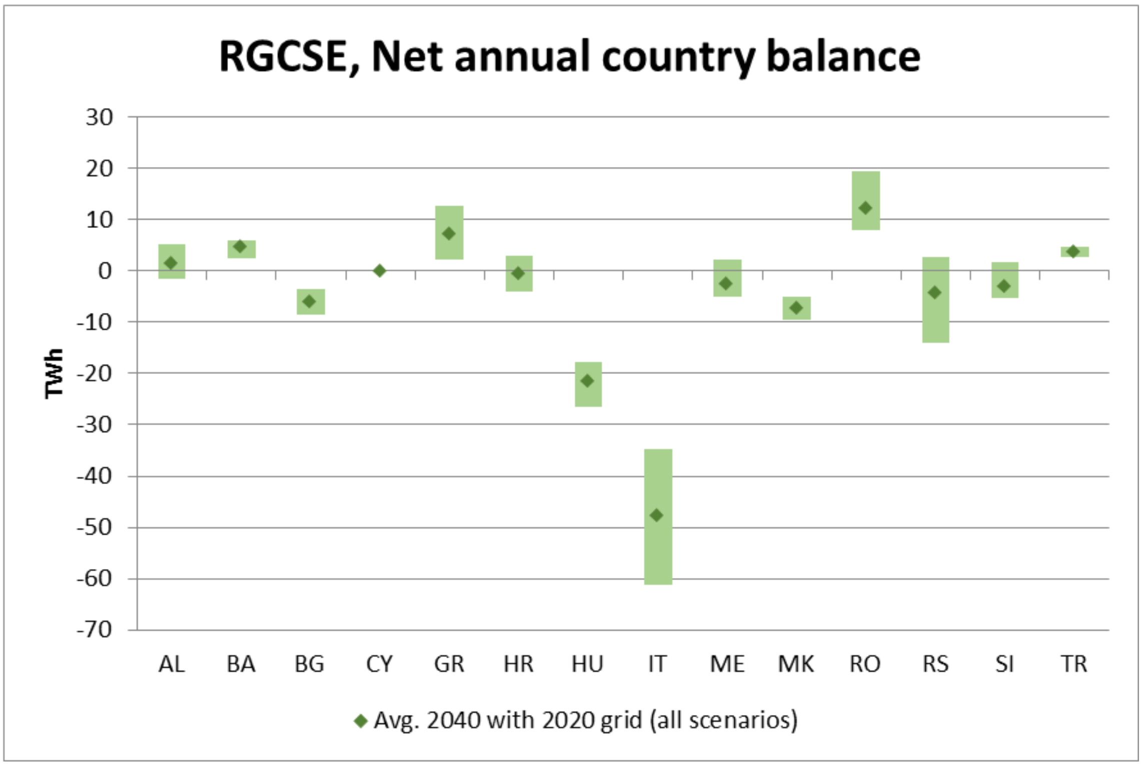


Figure 3-13: Net annual country balance in the region for 2040 scenarios with 2020 grid

Annual energy balances for 2040 scenarios reflect the impact of the assumed very high RES penetration in the Balkan Peninsula. The biggest exporters are BA, GR, RO and TR. The biggest importers are BG, MK, RS and SI due to the high levels of fossil fuels generation in their mix.

The following charts show the 99.9 percentile highest hourly ramp (up and down) of residual load. This residual load is the remaining load after subtracting the production of variable RES (wind and solar production). Again, results are presented for every country as previously mentioned, that is, the average and the maximum values in ranges of all simulations for the three different climate years and the three different long-term 2040 scenarios.

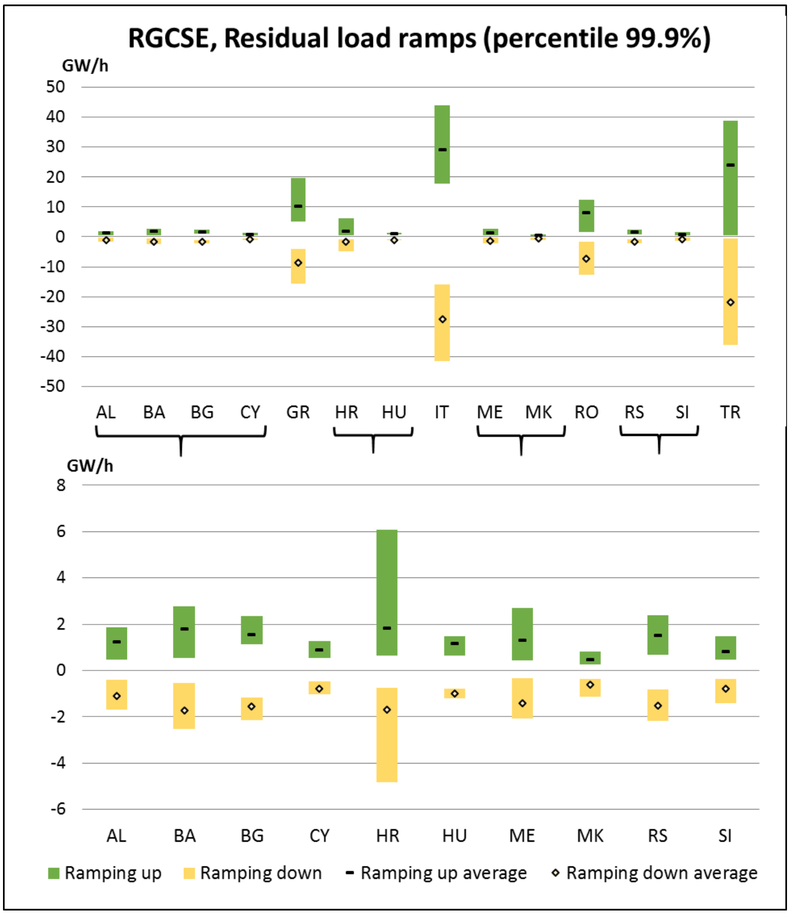


Figure 3-14: Residual ramp loads in the region for 2040 scenarios with 2020 grid

The highest values of residual load ramp appear in GR, IT and RO and TR, which are the countries with the highest RES penetration levels. In smaller countries with a small contribution to achieving the goals of the scenarios, residual load ramp values are also significant ~2000 MWh/h and are hard to achieve from an operational perspective. The need for additional flexibility measures including new interconnections, demand response, storage, etc. is obvious.

The maps below show the network study results of the 2040 scenario market data implemented in a 2020 network model. The upper map shows overloads on cross-border lines. In general, the interconnections are challenged in the 2040 scenarios by larger and more volatile flows and on higher distances flows crossing Europe, due to the intermittent renewable generations. The other maps show the need for internal reinforcements for some of the same reasons as for the cross-border connections and to integrate the considerable amounts of additional renewable power generation.

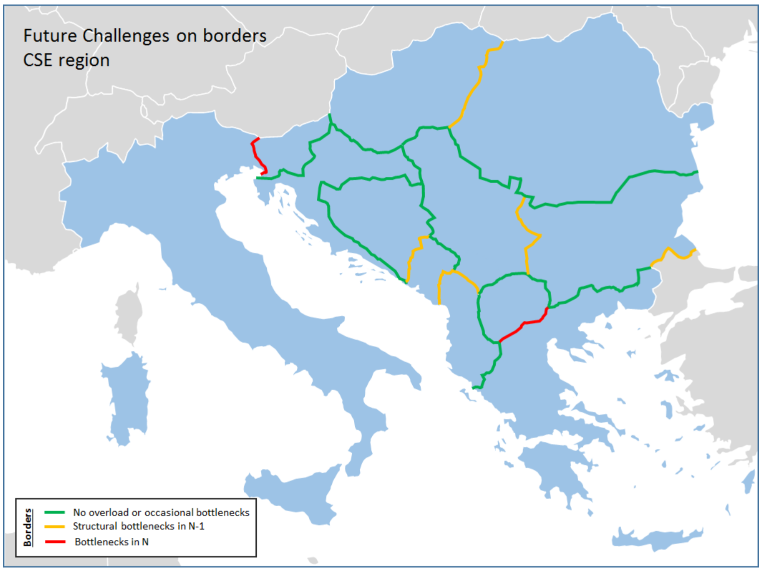
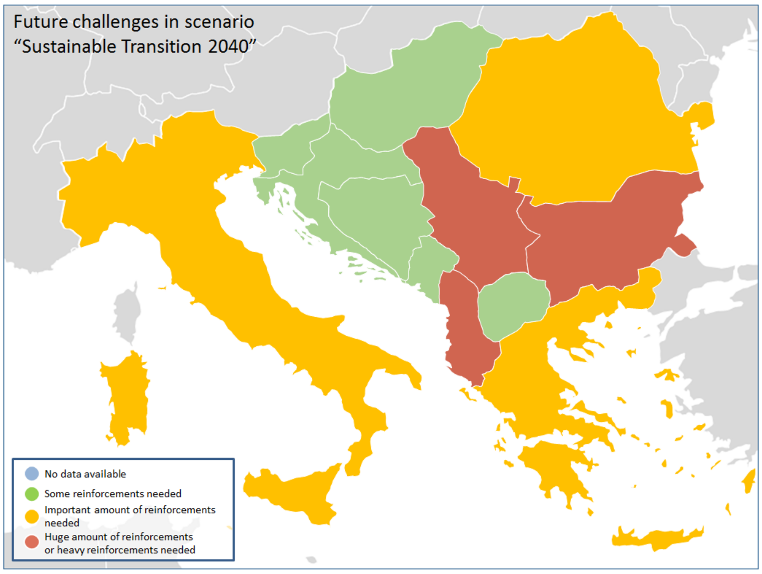
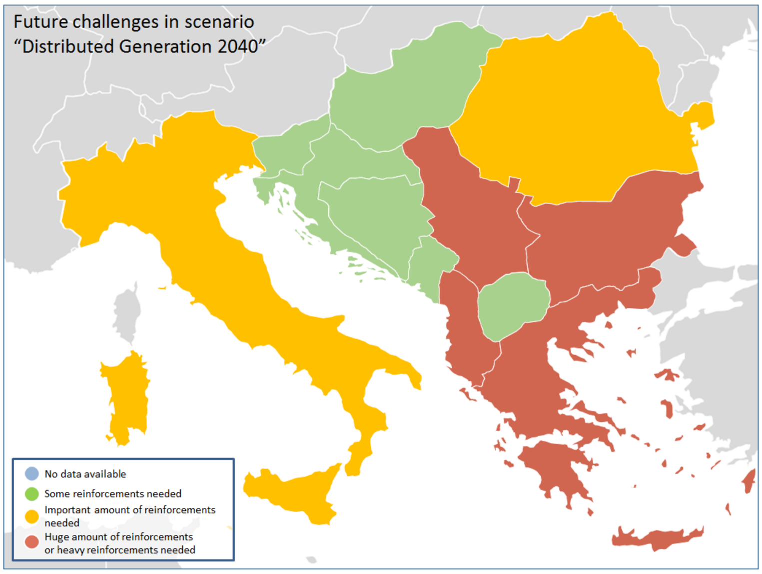


Figure 3-15: Future challenges on borders

Concerning overloads on cross-border lines, most congested borders shown with an orange and red colour are located in the East–West and North–South corridors. Concerning the SI 2020 power grid, network simulations resulted in bottlenecks in N condition on the SI–IT border. We should mention here that the HVDC between IT and SI was not part of the 2020 grid and network studies also did not include phase shifting transformer (PST) optimisation. With new project and PST optimisation (in Divaca and Padriciano), overloads on the border can be successfully managed.





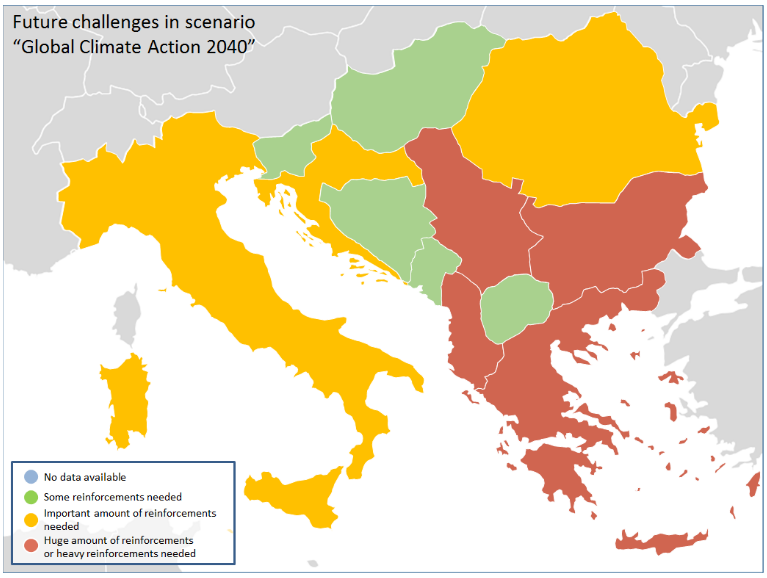


Figure 3-16: Future challenges inside the countries

Due to the very high level of RES assumed in the region, and the artificial hypothesis of the 2020 grid, it is estimated that very large reinforcements will be necessary to integrate renewable power generation and cope with the resulting level of power flows.

4 REGIONAL RESULTS

This chapter shows and explains the results of the regional studies and is divided into three sections. Subchapter 4.1 provides future capacity needs identified during the Identification of System Needs (IoSN) process or in additional (bilateral or external) studies related to capacity needs. Subchapter 0 explains the regional market analysis results in detail, whereas subchapter 4.3 focuses on the network analysis results.

4.1 Future capacity needs

The maps below show the needs for cross-border capacity increases beyond the expected 2020 grid for every 2040 scenario. Whereas mature projects from earlier TYNDPs have been added directly, other increases are shown with the need(s) they fulfil according to the 'IoSN methodology': needs triggered by market integration (SEW) in the first place and afterwards and in case not solved previously by SoS and/or renewable integration (RES) requirements. It should be clarified that cross-border capacity increases due to already planned projects may concern new interconnections in the respective border, new internal transmission projects or new interconnections in adjacent borders.

Some of the shown needs are based on simulations including standard cost estimates for every border investigated (the ratio between costs and benefit can be decisive for choosing among potential reinforcements). An overview of these standard costs can be found in Appendix 8.1.5.

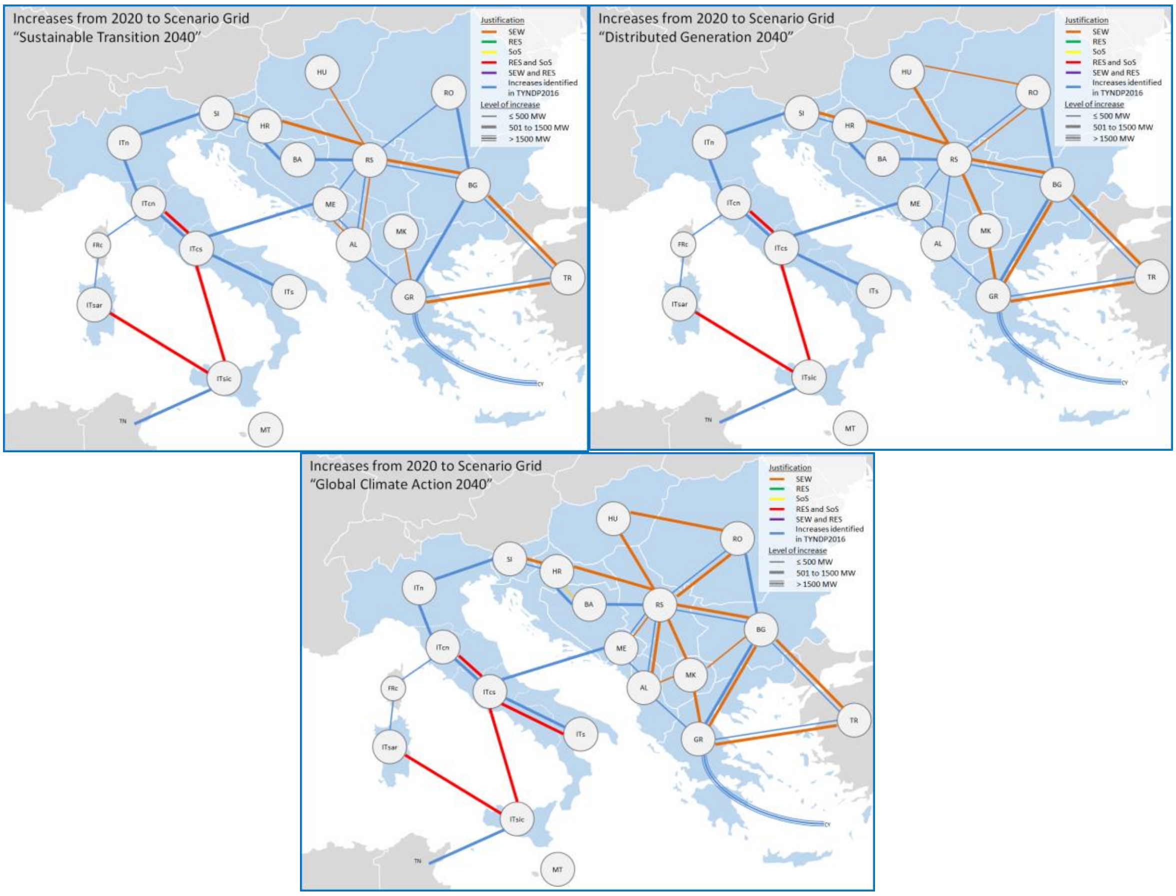


Figure 4-1: Identified capacity increase needs in the three studied 2040 scenarios in the CSE region[4]

[4] 'Increases identified in TYNDP 2016' refers to the reference capacities of TYNDP 2016 for 2030 which for some borders had been adjusted for TYNDP 2018 purposes. Projects commissioned in 2020 are not included as increases.

The table below shows different cross-border capacities as identified during the TYNDP 2018 process.

The first columns show the expected 2020 capacities, while the next columns show the capacities relevant for the CBA, which will be carried out on the time horizons 2025 and 2030. These columns show the capacities of the reference grid and the capacities if all projects pr. border are added together.

The last three (double-) columns show the proper capacities for each of the three 2040 scenarios. These capacities have been identified during the 'IoSN' phase and are dependent on the scenario.

Table 4-1: Cross-border capacities expected for 2020, for the reference grid and identified during the Identification of System Needs phase

	NTC 2020		CBA Capacities		Scenario Capacities					
			NTC 2027 (reference grid)		NTC ST2040		NTC DG2040		NTC GCA2040	
Border	=>	<=	=>	<=	=>	<=	=>	<=	=>	<=
AL–GR	250	250	250	250	350	350	350	350	350	350
AL–ME	350	350	400	400	900	900	400	400	400	400
AL–MK	500	500	500	500	500	500	500	500	1000	1000
AL–RS	650	500	500	500	1260	830	760	330	1760	1330
BA–HR	750	700	1344	1312	1844	1812	1844	1812	2344	2312
BA–ME	500	400	900	850	500	400	500	400	500	400
BA–RS	600	600	1100	1200	1100	1200	1100	1200	1100	1200
BG–GR	600	400	1350	800	1728	1032	3228	2532	3228	2532
BG–MK	400	100	500	500	400	100	400	100	900	600
BG–RO	300	300	1100	1500	1400	1500	1400	1500	1400	1500
BG–RS	500	200	350	200	1600	1350	2100	1850	2100	1850
BG–TR	700	300	1200	500	2400	2000	2400	2000	2400	2000
CY–GR	0	0	0	0	2000	2000	2000	2000	2000	2000
GR–ITs	500	500	500	500	500	500	500	500	500	500
GR–MK	1100	850	1200	1200	1600	1350	2100	1850	2100	1850
GR–TR	660	580	660	580	2200	2100	2200	2100	2200	2100
HR–HU	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
HR–ITn	0	0	0	0	0	0	0	0	0	0
HR–RS	600	600	600	600	2100	2100	2100	2100	2100	2100
HR–SI	1500	1500	2000	2000	2500	2500	3000	3000	3500	3500
HU–RO	1000	1100	1300	1400	1300	1400	1800	1900	2800	2900
HU–RS	600	600	600	600	1100	1100	2100	2100	2100	2100
HU–SK	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
ITcs–ITs	9999	4500	9999	5700	9999	5700	9999	5700	10999	6700
ITcs–ITsar	700	900	700	900	700	900	700	900	700	900
ITcs–ME	600	600	1200	1200	1200	1200	1200	1200	1200	1200
ITcs–ITsic	0	0	0	0	1000	1000	1000	1000	1000	1000
ITn–SI	680	730	1660	1895	1660	1895	1660	1895	1660	1895
ITsic–ITsar	0	0	0	0	1000	1000	1000	1000	1000	1000

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ITsic–MT	200	200	200	200	200	200	200	200	200	200
ITsic–TN	0	0	600	600	600	600	600	600	600	600
ITs–ITsic	1100	1200	1100	1200	1100	1200	1100	1200	1100	1200
ME–RS	500	600	700	700	1000	1100	1000	1100	1500	1600
MK–RS	650	800	750	750	650	800	1650	1800	1650	1800
RO–RS	1000	800	1300	1300	1450	1050	1950	1550	2950	2550
ITsar–ITCO	350	300	500	450	500	450	500	450	500	450
FRc–ITCO	50	150	150	200	150	200	150	200	150	200

The comparison of scenario capacities with reference capacities shows a need for an increase, dependent on the scenario for many borders in the region. These identified needs have been triggered from a market integration driver and are a result of socioeconomic welfare (SeW) maximisation, taking into account investment costs of potential standard projects on the examined borders. A greater need for transfer capacity growth appears in the DG2040 and GCA2040 scenarios due to the higher growth of renewable generation in the area.

The highest capacity increases occurring in all three scenarios appear in the GR–TR, BG–TR, BG–RS and BG–HR borders. This need for strengthening the transfer capacity of the E→W corridor in the Balkan Peninsula is related to the high RES penetration assumed in the Turkish and the Romanian transmission systems. Further to these increases, a need for a high capacity increase appears in the DG 2040 and GCA 2040 scenarios at the north borders of GR (GR–MK and GR–BG borders) as well as at the MK–RS, RS–HU and HR–SI borders. This need to strengthen the transfer capacity in the North–South axis is related to the considerable levels of electricity exports in GR, which is one of the countries in the region with the highest RES share. In the GCA 2040 scenario, which assumes the highest growth of renewable energy sources, a further need for a high capacity increase appears in the HU–RO and RO–RS borders.

Although the majority of cross-border transfer capacity increase needs is motivated by a market integration driver, in the GCA 2040 scenario, the need to increase the BA-HR transfer capacity by approximately 500 MW came up in order to improve security of supply in the south Balkan area.

Capacity increase on the Slovenian-Croatian border

Slovenia is located in the area with high power flow fluctuations from Balkan countries to Italy and from Austria to Italy and thus presents an important intersection for Central Europe. Slovenia is subject to high power flows on the borders in both directions, which is due to the sequential decommissioning of nuclear and conventional power plants and, on the other hand, RES integration (PV on south and wind on north), highly variable and harder to forecast than the production of conventional power plants. Due to very good interconnection with neighbouring TSOs, Croatia is also exposed to high power flows on the borders in both directions.

In all three 2040 scenarios, capacity increase needs were identified for the SI–HR borders in the IoSN process.

The needs for the SI–HR border were identified in the SEW loops: +500 MW in the 2040 ST, +1000 MW and 2040 DG and +1500 MW in the 2040 GCA scenario. New projects for covering these needs should follow a goal of minimising additional environmental impact by using existing corridors, which can be done by upgrading the voltage level of the current lines, from 220 kV up to 400 kV, or by using high-temperature conductors. Since project 2x400 kV OHL Cirkovce-Heviz(HU)/Žerjavinec(HR) is already included in the

TYNDP 2018 process and due to practical reasons, ELES and HOPS decided not to assess any future projects in the TYNDP 2018 CBA assessment phase.

4.2 Market Results

The figures below show the average results of the Pan-European market studies of all three 2040 scenarios with the 2040 Scenario grids.

The consequences of increasing the transmission capacity of the grid are captured, based on the effects on the unserved energy, curtailed energy and CO2 emissions.

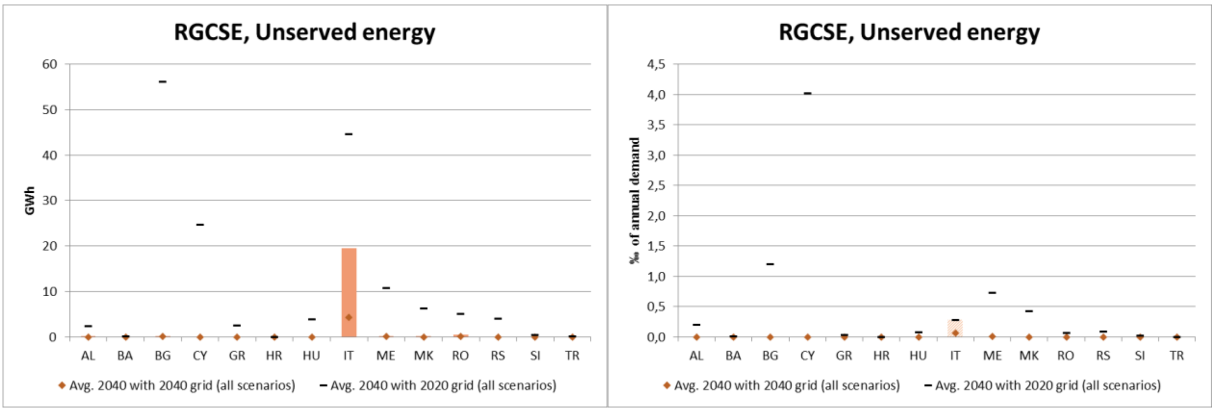

Figure 4-2: Unserved energy in the CSE region in the three studied 2040 scenarios, with identified capacity increases

Figure 4-2 shows the average values of unserved energy in GWh and as a percentage of the annual national demand for the 2040 scenarios, considering the existence of the 2040 grid. For comparison purposes, the average values of unserved energy with the expected 2020 grid are added in the graphs. The increase of cross-border transfer capacities in 2040 results in a drastic reduction of unserved energy. The calculated unserved energy as a percentage of the annual demand is less than 0.5% for most of the countries, showing that with the transmission grid of 2040 there is no security of supply issue expected in the CSE region.

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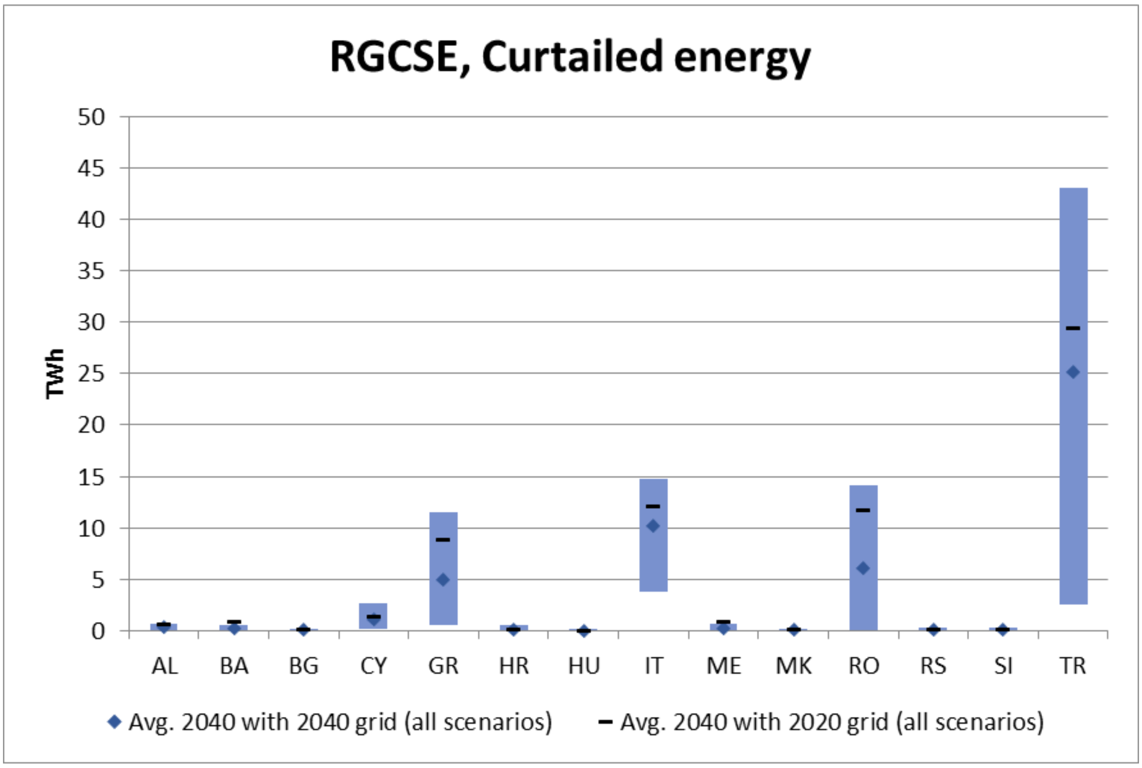

Figure 4-3: Curtailed energy in the CSE region in the three studied 2040 scenarios, with identified capacity increases

Figure 4-3 shows that RES curtailed energy is reduced with the 2040 grid, compared to the corresponding average values of the case with the 2020 grid that are also shown in the diagram. However, as was mentioned before, the 2040 grid is insufficient to evacuate all the excess RES production and as a result spillage levels for GR, IT, RO and TR remain high.

CO2 emissions shown in Figure 4-4 are slightly reduced compared to the case with the 2020 grid. This reduction can be attributed to the improvement of RES integration mentioned above. The considerable share of fossil fuel generation in the area contributes to maintaining high levels of CO2 values in the countries with the highest production levels.

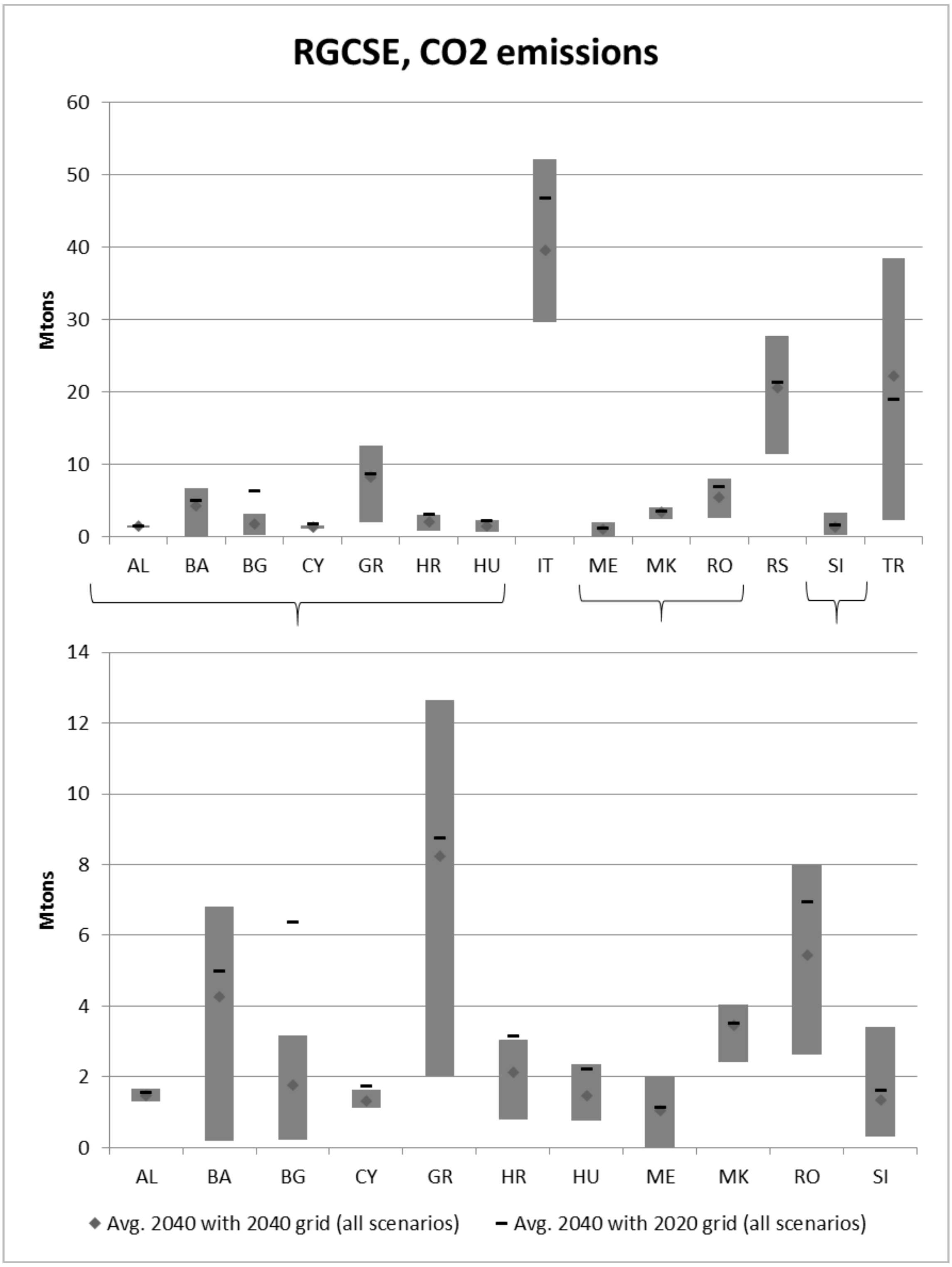

Figure 4-4: CO_2 emissions in the CSE region in the three studied 2040 scenarios with identified capacity increases

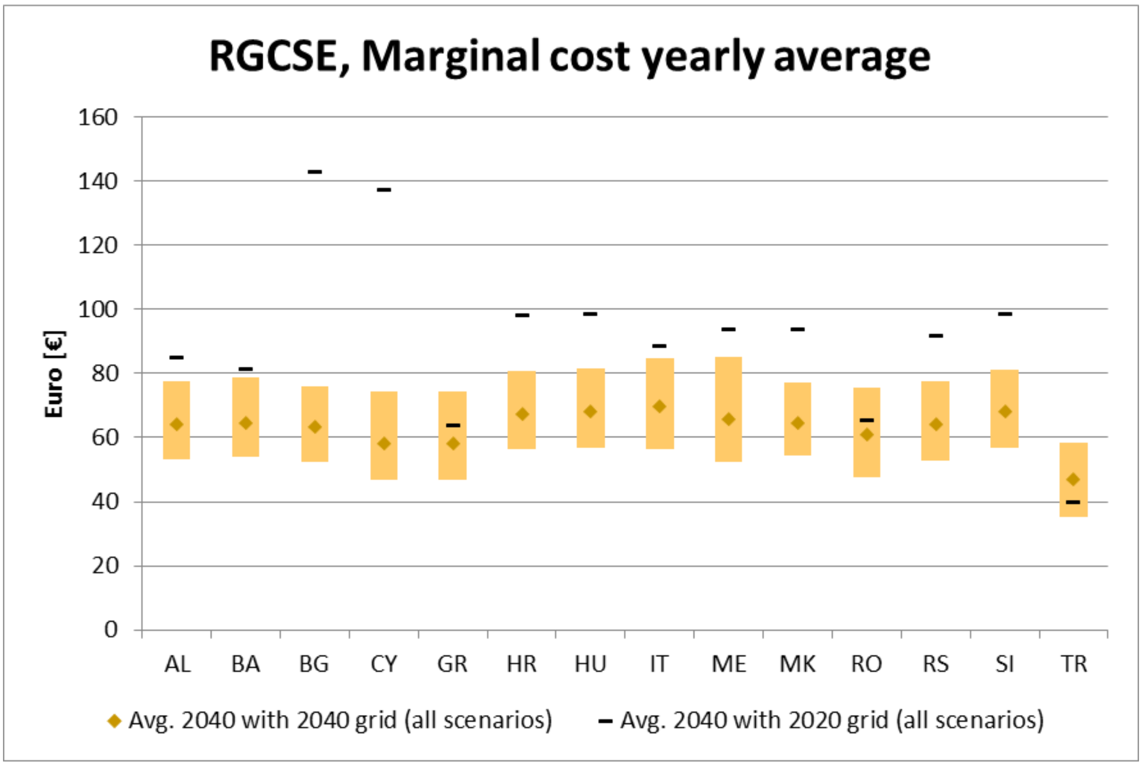

Figure 4-5: Yearly average of marginal cost in the CSE region in the three studied 2040 scenarios with identified capacity increases

The main driver for the transfer capacities increase in the 2040 scenarios is the market integration of the area. As can be seen in Figure 4-5, the spread of average marginal costs is considerably reduced compared to the average values of the case with the 2020 grid that are also shown in the diagram. A smaller reduction appears in GR and RO, which had the lowest average costs due to the high RES installed capacities. In TR, a small increase is observed. This trend is also reflected in Figure 4-7 which depicts the average hourly differences of marginal costs in all the borders of the region.

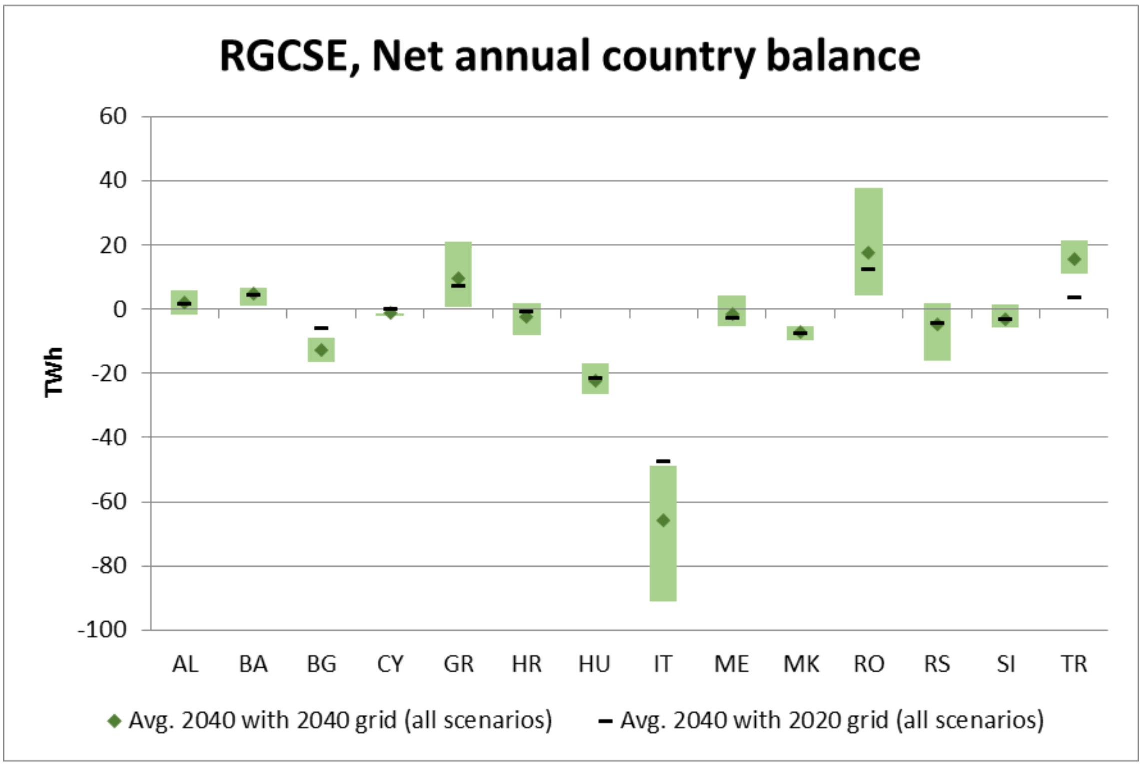

Figure 4-6: Net annual country balance in the CSE region in the three 2040 scenarios, with identified capacity increases

Annual country balances shown in Figure 4-6, compared to the respective average values for the case with the 2020 grid that are also shown in the diagram, remain in most cases unchanged. An increase of exported energy is observed in TR, RO and GR, which are among the countries with the highest RES share. In addition, an increase of imports appears in BG and IT.

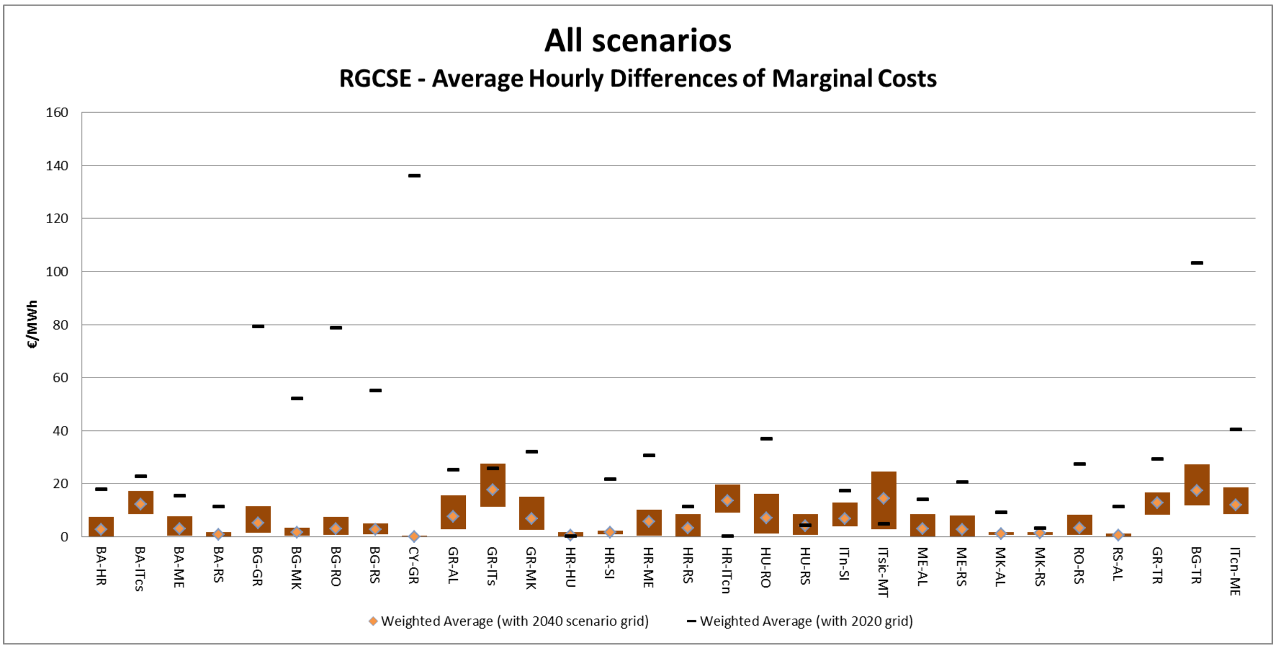

Figure 4-7: Average hourly price differences in the CSE region in the three studied 2040 scenarios, with identified capacity increases

An even clearer picture of the impact of transfer capacity increases in the market integration of the area is depicted in Figure 4-7 showing average hourly price differences with the 2040 scenario grid and the 2020 grid. The biggest change appears in the CY–GR border, since after 2020 a CY–GR interconnection is expected to be in place.

4.3 Network Results

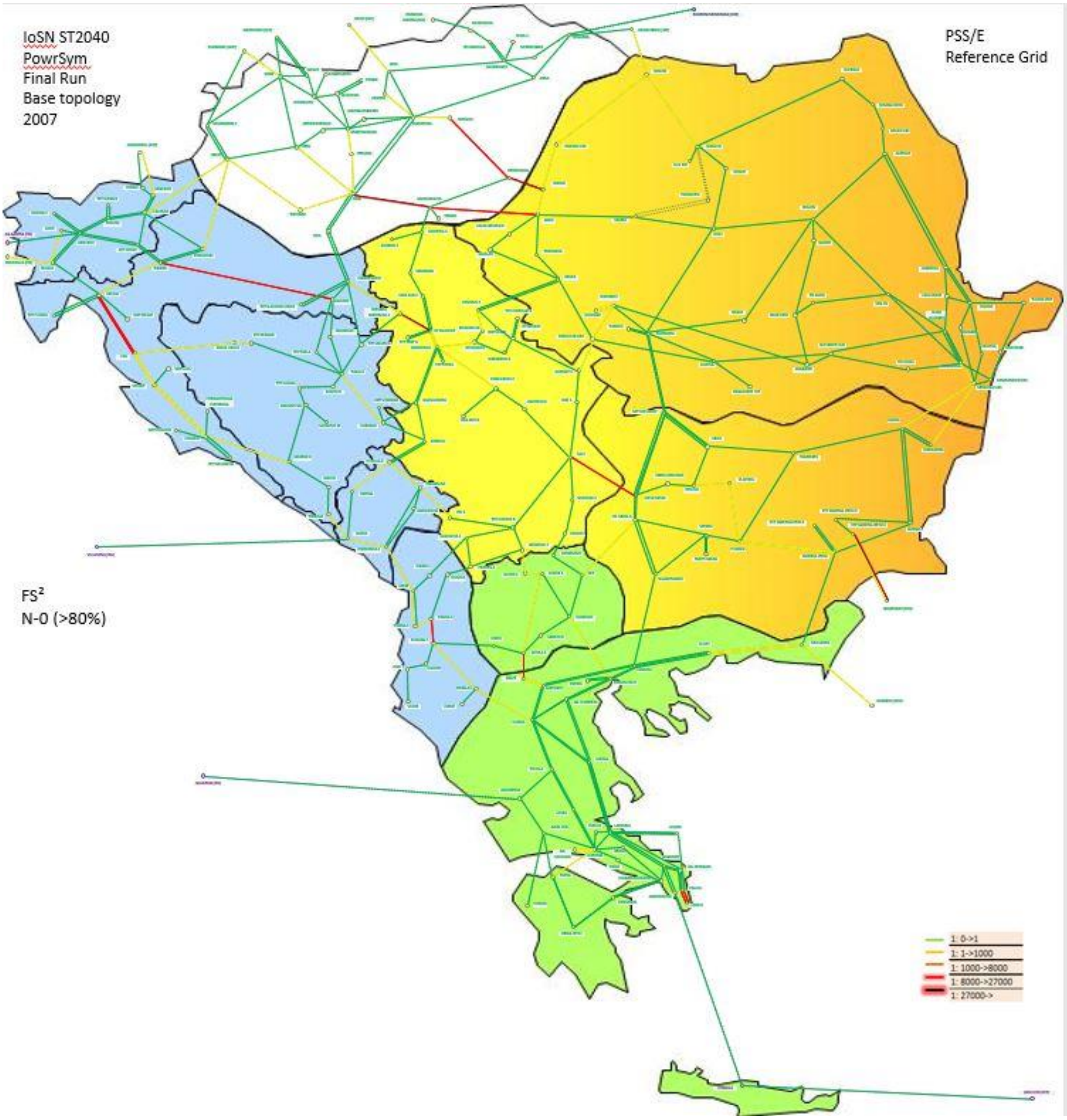

Figure 4-8: Map of bottlenecks for base case – 80% of thermal line rating

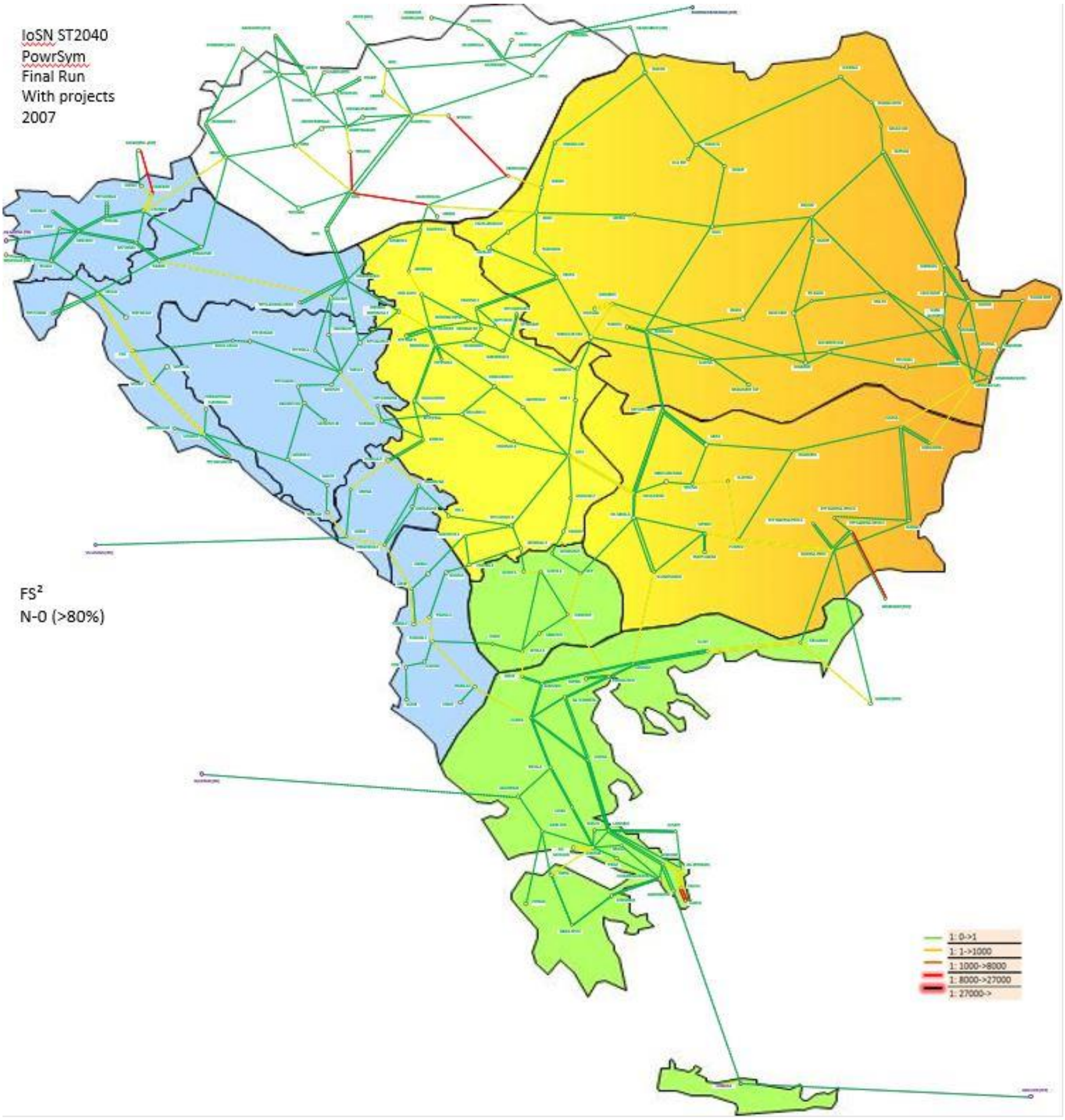

Figure 4-9: Map of bottlenecks with new projects – 80% of thermal line rating

Even with a grid including projects between 2020 and 2030 as assessed in the TYNDP 2016, the new TYNDP 2018 scenarios for 2040 cause internal bottlenecks. The maps below show the need for additional internal grids reinforcements for all three 2040 scenarios when combined with the identified 2040 cross-border capacity needs.

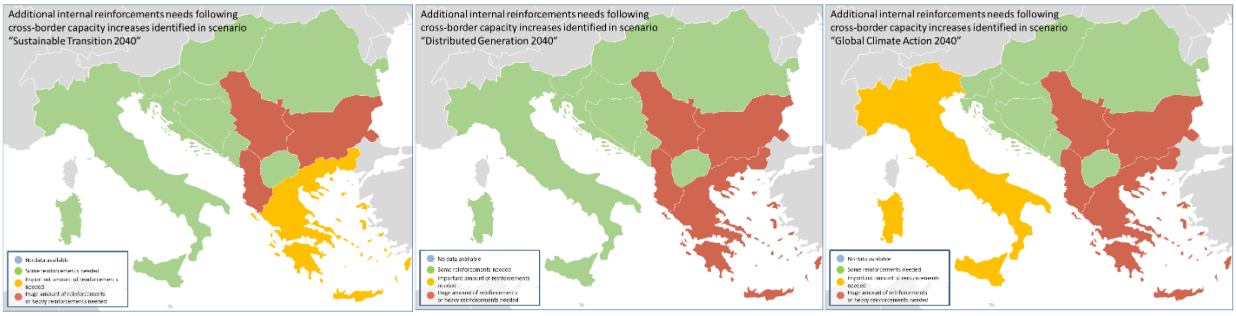

Figure 4-10: Impact of identified capacity increases on internal grid reinforcement needs in the three studied 2040 scenarios

The ST 2040 scenario is characterised by the reduction of fossil fuel capacities compared to 2025. However, in the CSE region, a moderate increase in these capacities is observed in AL, CY, ME and MK. Since a high carbon price is assumed for this scenario as a result of market simulations, gas-fired generation is replacing the lignite units. There are no new nuclear units after 2030 in the region, but the majority of old ones will not be decommissioned by 2040. In line with this, nuclear generation covers a significant part of the yearly demand in BG, HU, RO, SI and TR. This scenario assumes a moderate increase of RES, but the increase is higher in IT, GR, RO, HU and TR.

After the market simulations (SEW loop) for the ST 2040 scenario, the highest increases of NTC are observed in the BG–TR, GR–TR, HR–RS and BG–RS borders. Having in mind this and the round year market simulations performed, the dominant flows direction in the region remains E->W and N->S. Borders BG–TR, BG–RS, RO–HU and GR–MK are overloaded in more than 30% of the hours in the year. Some internal bottlenecks are observed in RS, AL and HR.

In the GCA 2040 scenario, a high growth of RES in the CSE region is observed, especially in GR, RO and TR. The Highest capacity increase after the SEW loop is observed on the RO–RS, GR–TR, HR–RS, HU–RO, BG–RS, HU–RS and HR–SI borders. There were problems with regional model convergence, due to the large amounts of installed RES capacities in some CSE countries. However, due to the distribution of solar and wind capacities, some internal bottlenecks are expected in GR, BG, RS and AL.

The DG 2040 scenario assumes the high growth of small-size and decentralised RES and energy storage. The highest increase of RES capacity, especially solar, is observed in GR, IT, RO, BG, RS, HR and TR. The highest capacity increase after SEW loop is observed on BG–TR, GR–TR, HU–RS, HR–RS, BG–GR and BG–RS borders. The same problems with the convergence of regional network model occurred as for GCA 2040 scenario. Nevertheless, the same bottlenecks in internal grid could be expected in GR, BG, RS and AL.

Main power flow directions in the DG and GCA scenarios are the same as in the ST scenario: E->W and N->S.

There are several potential new projects and reinforcements in the CSE region which will help to make the transmission grid adequate and relieve the congested corridors: E->W and N->S. New 400 kV interconnection between TR and BG could enable export of large amounts of RES energy which is envisaged in GCA and DG 2040 scenarios. Furthermore, new 400 kV interconnections BG–RS (Sofia West – Nis – 2nd line) and RS–HR (Sombor – Ernestinovo) will strengthen the East–West corridor. Congestion on the GR–MK border could be resolved by the refurbishment of OHL 400 kV Florina – Bitola. Upgrade of existing 220 kV lines between HR and BA will enable the increase of NTC on this border. More precisely, the upgrade of lines Djakovo – Tuzla, Djakovo – Gradacac and Tuzla – Gradacac is planned. A new 400 kV interconnection line between RO and RS (Portile De Fier – Djerdap – 2nd line) will increase NTC on this border.

Some internal reinforcements are envisaged in RS to help transit energy from TR, BG and RO further to the west. These reinforcements are SS 400/110 kV Belgrade West, 400 kV OHL WPP Cibuk – Belgrade West and the upgrading of the 220 kV grid from SS Nis to SS Bajina Basta. Internal projects necessary to meet grid adequacy in analysed scenarios are also foreseen in GR, RO and AL.

5 Additional Regional Studies

5.1 Sensitivity study on impact of Turkish power system balance on CSE transmission network

5.1.1 Introduction and objectives

In the framework of CSE RegIP 2017, there is the possibility to perform sensitivity network studies of specific interest for the area. In this respect, it has been decided to investigate the impact of the Turkish power system balance on the loading of the CSE transmission network. To perform this study, extreme snapshots of the regional network model developed for Vision 1 of TYNDP 2016 were chosen. Using these snapshots, sensitivity of the loading of the CSE transmission network elements were investigated for an increase of Turkish power system imports from the North borders of the region as well as an increase of Turkish power system exports towards the DC links with Italy.
The regional significance of this exercise stems from the importance of the CSE area extension to the East, from a transmission development perspective. In this respect, a complementarity exists with network studies performed in the framework of the IoSN phase, that aim to investigate needs for network reinforcements in order to serve cross-border capacity increases identified by market studies in the examined scenarios.
This sensitivity study is an update of a similar one conducted in the framework of TYNDP 2014, with the difference that generation and network topology of Vision 1 2030 have been used.

5.1.2 Selected snapshots and approach

The analysis has been performed on the regional network model of South-East Europe. Snapshots have been selected from a dataset produced by year round AC load flow calculations conducted using market simulations results (hourly generation dispatch and national loads).
The three selected snapshots were:

- 1st week, 11h – highest power flows observed in the East→West direction.
- 35th week, 44h – highest power flows observed in the North → South direction.
- 14th week, 159h – maximum wind penetration in low load conditions in the area.

These snapshots have been populated by varying for each the balance of the Turkish power system by ±1000 MW. For all these snapshots, an N-1 analysis has been performed by considering a contingency list including all the interconnections, 400 kV and 220 kV lines as well as 400kV/220 kV transformers. Especially for the Greek power system, 150 kV lines have been added in the monitoring list. For the N case, elements loading above 80% were reported, whereas for the N-1 case the loading threshold was 100%.
Similar to the initial work done in TYNDP 2014, and in order to investigate the impact of the Turkish power system balance in 'more stressed' situations, a N-1-1 analysis was performed for the snapshots corresponding to high North → South power flows and high wind – low load conditions. To perform such analysis, the maintenance lists used in the previous study were applied with small adaptations. These lists reflect the fact that maintenance schedules with a potential cross-border impact are coordinated in the area.
In this respect, the maintenance list used in the previous study for a snapshot of the 24th week 62h (June) has been applied in the snapshot of 14th week 159h (April) and the maintenance list used in the previous study for a snapshot of 37th week 156h (September) has been applied in the snapshot of 35th week 44h (August).

5.1.3 Security analysis

5.1.3.1 1st week, 11h – High power flows from East to West

Active power flows in the national borders and power system balances are shown in Figure 5.1. In this snapshot, the Turkish power system is importing approximately 244 MW. At the same time, Romanian and Bulgarian systems are heavy exporters, resulting in considerable power flows at their West borders.

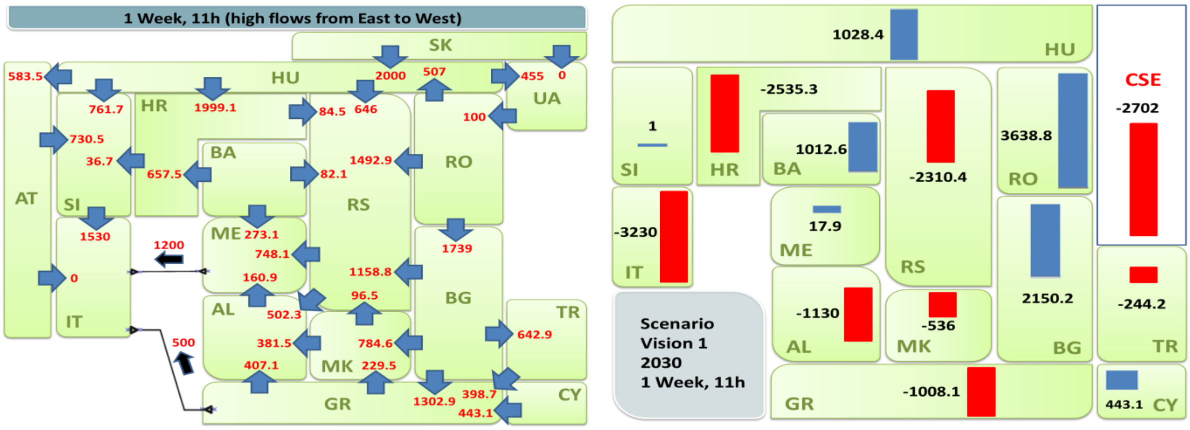

Figure 5-1: Active power flows on national borders and system balances for 1st week, 11h - Base case.

An increase of the Turkish power system balance by 1000 MW results in the situation illustrated in Figure 5.2. In this snapshot, the Turkish power system exports 756 MW, resulting in an increase of power flows in the East → West direction and as a result at the boundary in the West borders of RO and BG.

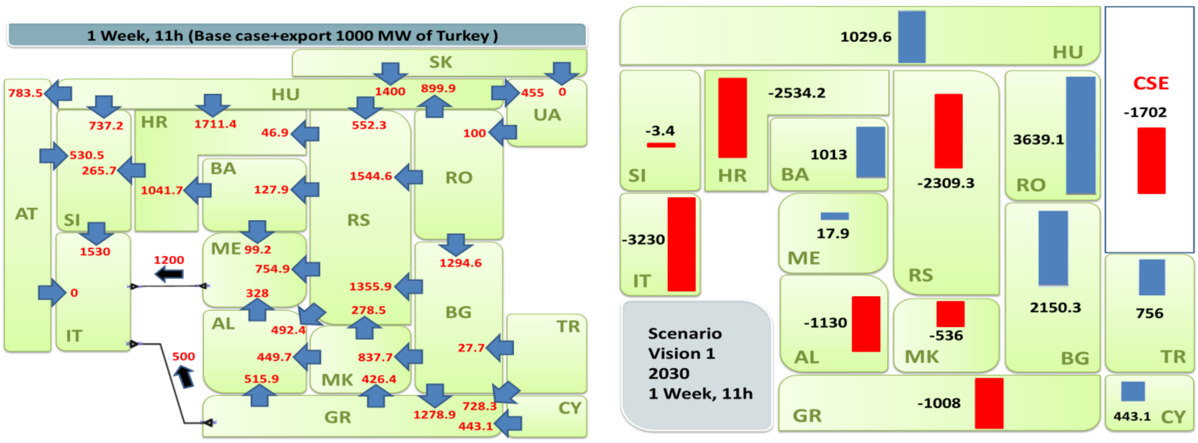

Figure 5-2: Active power flows on national borders and system balances for 1st week, 11h - TR exports variation.

A decrease of the Turkish power balance by 1000 MW results in the situation illustrated in Figure 5.3. In this snapshot, the Turkish power system imports 1244 MW.

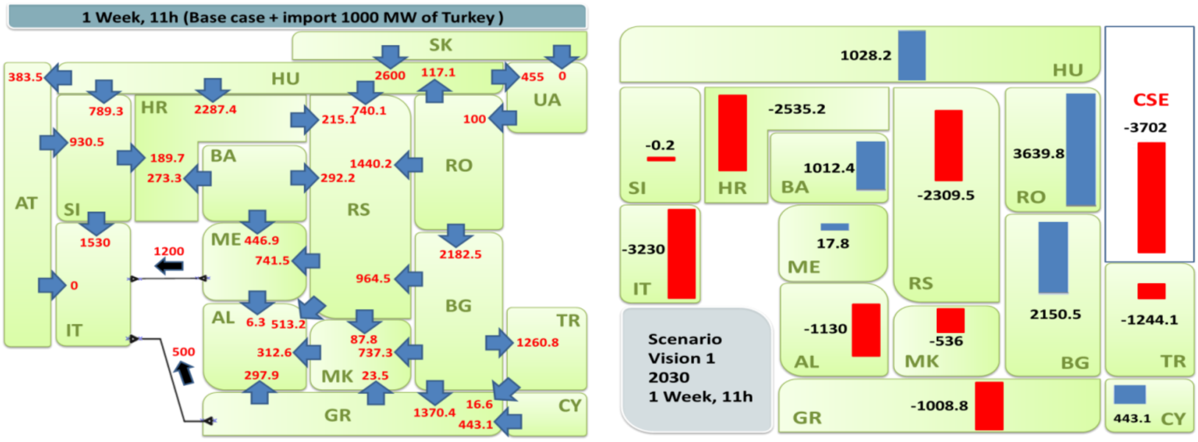

Figure 5-3: Active power flows on national borders and system balances for 1st week, 11h - TR imports variation.

In the N condition, a sensitivity of the loading of the 400 kV BG-RS interconnector Sofia Zapad (BG) – Nis (RS) to the balance of the Turkish power system is observed in Table 5.1. In the case of TR export, the loading of the line slightly exceeds 100%, since the resulting power flows add to the considerable exports of the Bulgarian and Romanian power systems in the East to West direction.

Table 5-1: – Loading of the lines above 80% in the base case

Scenario V1 2030, case large flows in E →W direction, 1st week, 11th hour

			Loading [%]		
Voltage [kV]	From Bus	To Bus	TR import 1244 MW	TR import 244 MW	TR export 756 MW
OHL 400	Sofia Zapad	Nis	<80	87.3	102.8

In the N-1 conditions, the 400 kV BG-RS interconnector constitutes a critical element with its loading being higher in TR export case. Two other elements that appear to be critical in the analysis of these snapshots are the 400 kV HU-HR interconnection Hevic (HU) – Zerjavinec (HR) and the 400 kV internal line between God and Kerepes in Hungary. The loading of these elements increases with TR imports from the North borders of the region.

Table 5.2 – Results of N-1 contingency analysis

Scenario V1 2030, case large flows in E->W direction, 1st week, 11th hour / N-1 analysis results

		Loading [%]		
Outage	Loaded Line >100%	TR import 1244 MW	TR import 244 MW	TR export 756 MW
OHL 400 kV Bor - Djerdap	OHL 400 kV Sofia Zapad - Nis	<100	110.1	125
OHL 400 kV Ch. Mogila - Stip	OHL 400 kV Sofia Zapad - Nis	<100	108.7	126
OHL 400 kV Bor - Nis	OHL 400 kV Sofia Zapad - Nis	<100	106.9	122
OHL 400 kV Heviz - Cirkovce	OHL 400 kV Hevic - Zerjavinec	114.9	106.9	100.4
OHL 400 kV God - Albertirsa	OHL 400 kV God - Kerepes	114.3	<100	<100
OHL 400 kV Drmno - Smederevo 3	OHL 400 kV Pancevo 2 - Beograd 20	<100	104.8	112.5
Tr 400/220 kV Maritsa Iztok 3	Tr 400/220 kV Maritsa Iztok 1	124.7	104.1	<100
OHL 400 kV Portile De Fier - Djerdap	OHL 400 kV Sofia Zapad - Nis	<100	102.4	120
OHL 400 kV Drmno - Smederevo 3	OHL 400 kV Pancevo 2 - WPP 1	<100	<100	102.9
OHL 400 kV Drmno - Smederevo 3	OHL 400 kV Drmno - WPP 1	<100	<100	102.4
OHL 400 kV Pancevo 2 - WPP 1	OHL 400 kV Drmno - Smederevo 3	<100	<100	101.5
OHL 400 kV Drmno - WPP 1	OHL 400 kV Drmno - Smederevo 3	<100	<100	101.1

5.1.3.2 35th week, 44h – High power flows from North to South

Active power flows in the national borders and power system balances are shown in Figure 5.4. In this snapshot, the Turkish power system is importing approximately 426 MW. At the same time, Greek power system imports are very high, resulting in considerable power flows in the North → South direction.

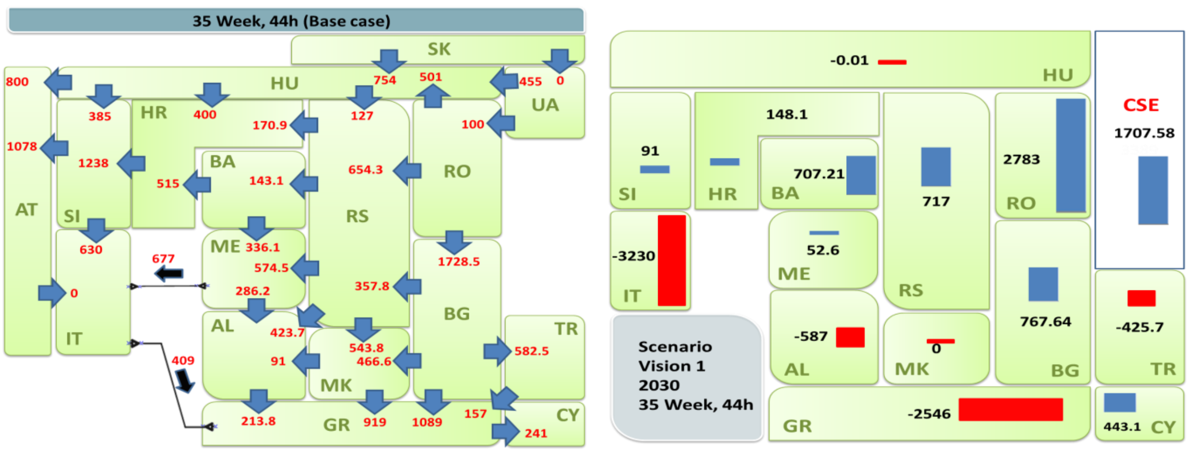

Figure 5.4 Active power flows on national borders and system balances for 35th week, 44h - Base case.

An increase of the Turkish power system balance by 1000 MW results in the situation illustrated in Figure 5.5. In this snapshot, the Turkish power system exports 575 MW, resulting in an increase of power flows in the North borders of Greece.

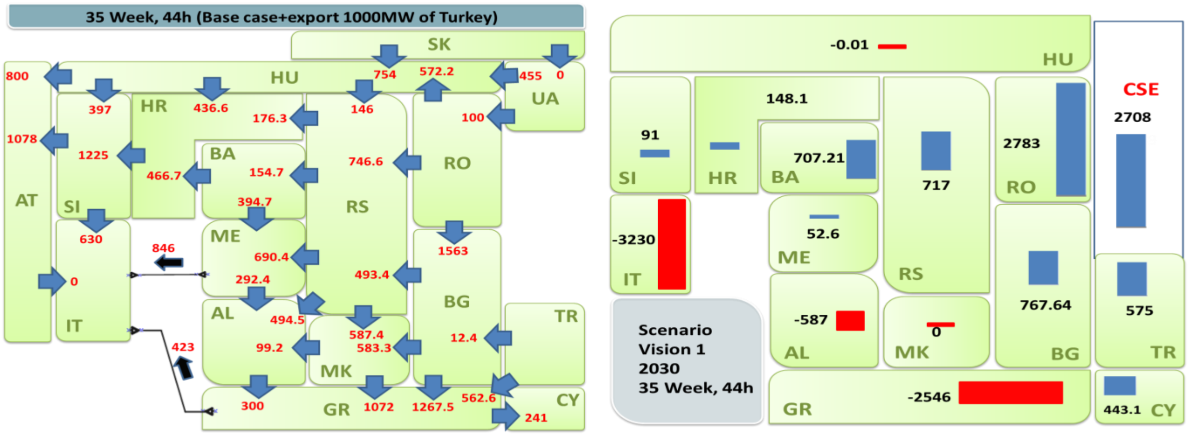

Figure 5-5: Active power flows on national borders and system balances for 35th week, 44h - TR exports variation.

A decrease of the Turkish power balance by 1000 MW results in the situation illustrated in Figure 5.6. In this snapshot, the Turkish power system imports 1426 MW.

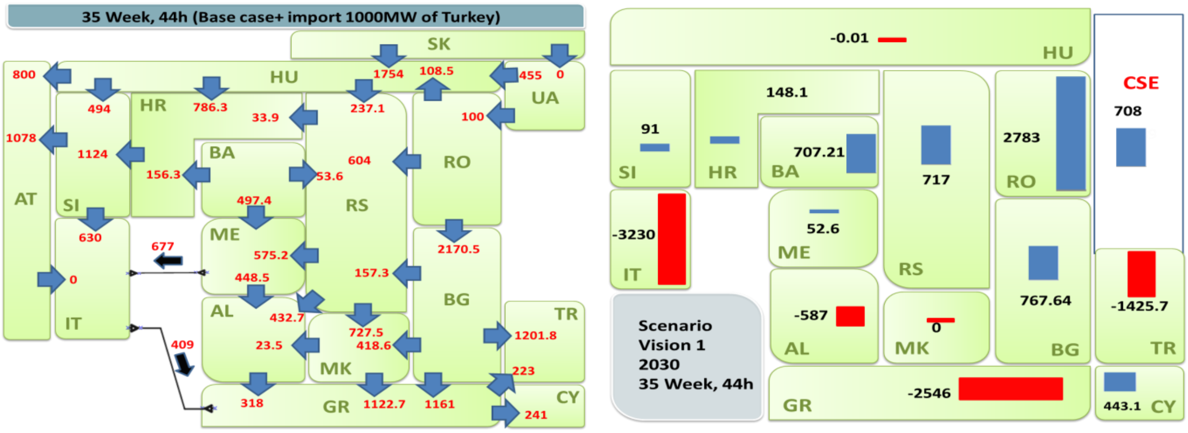

Figure 5-6: Active power flows on national borders and system balances for 35th week, 44h - TR imports variation.

In the N condition, the loading of the 150 kV transmission lines Nea Santa – Iasmos and Doxa – Thesaloniki appeared to be sensitive in the balance of the Turkish power system and exceeds 80% in the base case and in the case of TR export.

Table 5.3 – Loading of the lines above 80% in the N state

Scenario V1 2030, case large flows in N →S direction, 35th week, 44th hour	
	Loading [%]

Voltage [kV]	From Bus	To Bus	TR import 1425 MW	TR import 425.7 MW	TR export 575.4 MW
OHL 150	Nea Santa	Iasmos	<80%	87.5	105.3
OHL 150	Doxa	Thessaloniki EHV S/S	<80%	80.1	85.4

In the N-1 conditions, the same 150kV elements of the Greek power system appear to be critical. In both N and N-1 conditions, higher loading is observed in the TR export case, due to the resulting increase of power flows in the North borders of Greece.

Table 5.4 – Results of N-1 contingency analysis

Scenario V1 2030, case large flows in N →S direction, 35th week, 44th hour / N-1 analysis results

		Loading [%]		
Outage	**Loaded Line >100%**	**TR import 1425 MW**	**TR import 425.7 MW**	**TR export 575.4 MW**
OHL 220 kV Trebinje - Plat	OHL 110 kV Trebinje - Komolac	104.4	106.6	100
Tr 400/150 kV Thessaloniki EHV S/S	OHL 150 kV Doxa - Thessaloniki EHV S/S	120	117.3	130
OHL 400 kV Nea Santa - Philippi	OHL 150 kV Iasmos - Nea Santa	<100	102.2	(105.3)

In this case, an N-1-1 contingency analysis has been conducted. The following lines were put out of operation due to maintenance:

- OHL 400 kV Pljevlja (ME)- B. Basta (RS)
- OHL 400 kV Filipi (GR) – Lagadas (GR)
- OHL 400 kV Bitola (MK) – Skopje4 (MK)
- OHL 400 kV Rahman (RO) – Isaccea (RO)
- OHL 220 kV Medjuric (HR) – Prijedor (BA)
- OHL 220 kV Elbasan (AL) – Bureli (AL)

Table 5-5 depicts the loading of elements above 80% for the regional network configuration, after the disconnection of the above lines. A situation similar to the one reported in Table 5-3 is observed.

Table 5-5: Loading of the lines above 80% in the N state with maintenance

Scenario V1 2030, case large flows in N →S direction, 35th week, 44th hour, with maintenance

			Loading [%]		
Voltage [kV]	**From Bus**	**To Bus**	**TR import 1425 MW**	**TR import 425.7 MW**	**TR export 575.4 MW**
OHL 150	Nea Santa	Iasmos	<80%	88.6	107

OHL 150	Doxa	Thessaloniki EHV S/S	<80%	80.4	85.7

Also in the N-1-1 conditions, the same elements with the case without lines in maintenance appear to be critical, as can be seen in Table 5-6. One new element that is added in the list is a 400 kV/150 kV autotransformer in the Filipi substation that is loaded more than 100% in the TR export case. This is because the maintenance of one of the 400 kV lines between Filipi and Lagadas results in an increase of power transfer through the 150 kV network in this area.

Table 5-6: Results of N-1-1 contingency analysis

Scenario V1 2030, case large flows in N→S direction, 35th week, 44th hour / N-1-1 analysis results

		Loading [%]		
Outage	**Loaded Line >100%**	**TR import 1425 MW**	**TR import 425.7 MW**	**TR export 575 MW**
OHL 400 kV Nea Santa - Philippi	OHL 150 kV Nea Santa - Iasmos	<100	103.1	(107)
Tr 400/150 kV Thessaloniki EHV S/S	OHL 150 kV Doxa - Thessaloniki EHV S/S	119.3	121	128.3
Tr 400/150 kV Thessaloniki EHV S/S	OHL 150 kV Doxa - Thessaloniki III	129	131.8	143.2
Tr 400/150 kV Philippi (A1)	Tr 400/150 kV Philippi (A2)	<100	<100	100.5
OHL 220 kV Trebinje - Plat	OHL 110 kV Komolac - Trebinje	116.7	108.3	112

5.1.3.3 14th week, 159h – High wind with low load conditions in the CSE area

Active power flows in the national borders and power system balances are shown in figure 5.7. In this snapshot, the Turkish power system is importing approximately 265 MW.

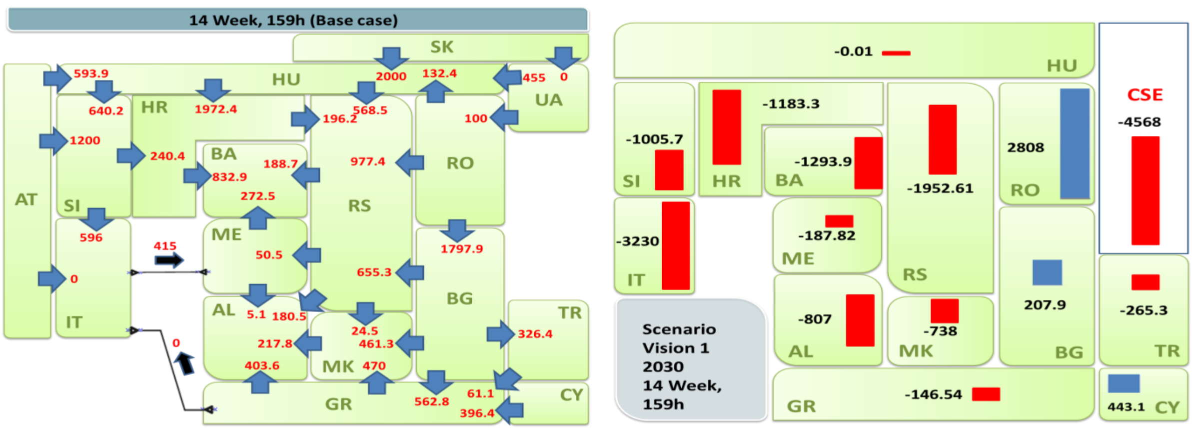

Figure 5-7: Active power flows on national borders and system balances for 14th week, 159h - Base case.

An increase of the Turkish power system balance by 1000 MW results in the situation illustrated in Figure 5.8. In this snapshot, the Turkish power system exports 735 MW, resulting in an increase of power flows in the West borders of RO and BG.

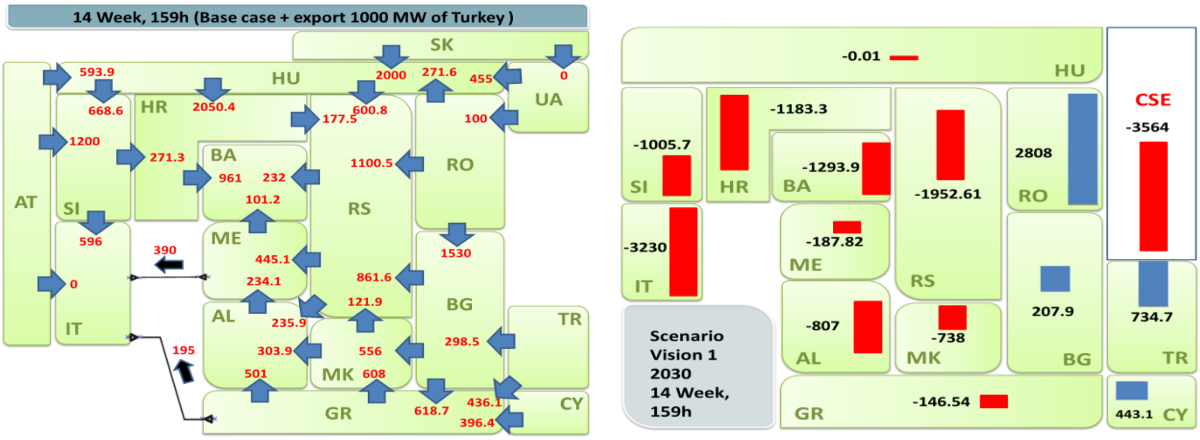

Figure 5-8: Active power flows on national borders and system balances for 14th week, 159h - TR exports variation.

A decrease of the Turkish power balance by 1000 MW results in the situation illustrated in Figure 5.9. In this snapshot, the Turkish power system imports 1256 MW.

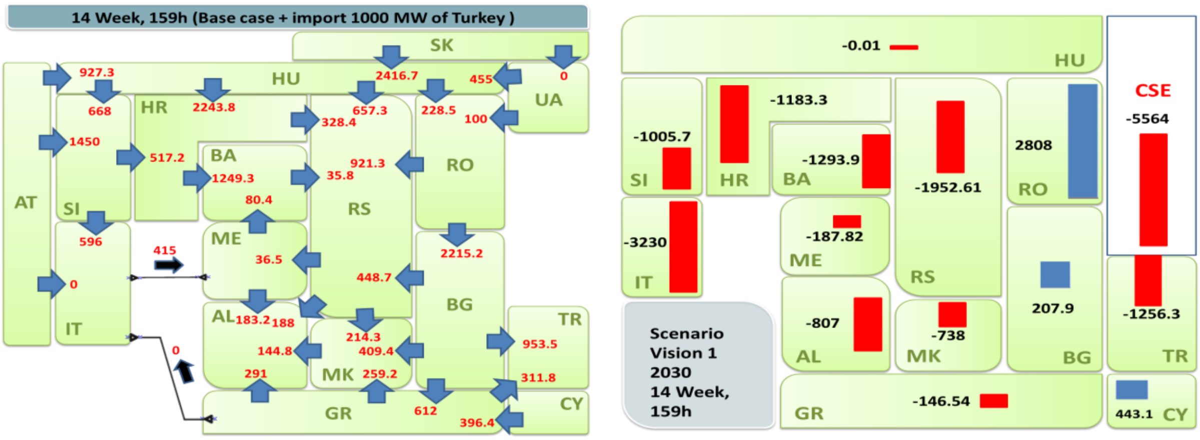

Figure 5-9: Active power flows on national borders and system balances for 14th week, 159h - TR imports variation.

In the N condition, none of the transmission elements was loaded above 80%. In addition, an N-1 contingency analysis shown that there were no overloads (above 100%). To investigate a more stressed situation, an N-1-1 analysis has been conducted, by considering the following list of lines in maintenance.

- OHL 400 kV Blagoevgrad (BG) – Thessaloniki (GR)
- OHL 400 kV Zerjavinec (HR) – Hevic (HU) 1
- OHL 400 kV Drmno(RS) – Smederevo 3 (RS)
- OHL 400 kV Ribarevina (ME) – Pljevlja (ME)
- OHL 400 kV Kozloduy (BG) – Mizia (BG)
- OHL 400 kV Konjko (HR) – RHE Velebit (HR)

- OHL 400 kV Bucuresti Sud (RO) – Gura Ialomitei (RO)
- OHL 220 kV Vau Dejes (AL) – Komani (AL)

After the removal of the above lines from the network topology, the 400 kV line in Serbia between Pancevo and Belgrade 20 is loaded over 80% in the base case as well in the case of TR export. The loading of this line is sensitive to the Turkish power system balance, but the level of loading is because of the maintenance of the 400 kV line Drmno – Smederevo 3 in Serbia.

Table 5-7: Loading of the lines above 80% in the N state with maintenance

Scenario V1 2030, case large WF generation & low load in the Balkans, 14th week, 159th hour, with maintenance

			Loading [%]		
Voltage [kV]	From Bus	To Bus	TR import 1265.3 MW	TR import 265.3 MW	TR export 734.7 MW
OHL 400	Pancevo	Bgd 20	<80 (79%)	86.1	94.8

In the N-1-1 conditions, the same line appears to be critical together with a 400 kV/220 kV transformer in Pancevo and the 220 kV line Belgrade 8 – HIP 2. The loading of these elements appears to be sensitive to the Turkish power system balance, with higher values appearing in the TR export case. The level of the loading is because of the maintenance of the 400 kV line Drmno – Smederevo 3 in Serbia in all cases.

Two other elements that appeared to be critical are the internal 400 kV line between Paks and Peks in Hungary and the 400 kV Ernestinovo (HR) – Pecs (HU) interconnector. The loading of these elements exceeds 100% in the case of high TR imports, because of the maintenance of the 400kV Zerjavinec (HR) – Hevic (HU) interconnection and the increase of imports of the Turkish power system from the North borders of the CSE area.

Table 5-8: Results of N-1-1 contingency analysis

Scenario V1 2030, case large WF generation & low load in the Balkans, 14th week, 159th hour / N-1-1 analysis results

		Loading [%]		
Outage	Loaded Line >100%	TR import 1265.3 MW	TR import 265.3 MW	TR export 734.7 MW
OHL 400 kV Bor - Djerdap 1 HPP	OHL 400 kV Pancevo - Bgd 20	<100	101.7	111
OHL 400 kV Pancevo - Bgd 20	Tr 400kV/220kV Pancevo	115.5	125.8	138.1
OHL 400 kV Pancevo - Bgd 20	OHL 220 kV Bgd 8 - JHIP 2	<100	<100	108.5
OHL 400 kV Paks - Pecs (1 or 2 circuit)	OHL 400 kV Paks - Pecs (2 or 1 circuit)	112.4	<100	<100
OHL 400 kV Ernestinovo - Pecs (1 or 2 circuit)	OHL 400 kV Ernestinovo – Pecs (2 or 1 circuit)	111.9	<100	101.6
OHL 400 kV Dobrudzha - Medigidia Sud	OHL 400 kV Varna - Medigidia Sud	102.4	<100	102.4

5.1.4 Conclusions

In this regional network study, the sensitivity of the loading of the CSE regional network elements in the Turkish power system balance has been investigated. The size of this system, which is located at the East borders of the region, as well as the uncertainty about its future operation was the main reason for this

exercise. The sensitivity analysis was carried out using extreme snapshots of the regional network in terms of elements loading.
In the case of high East →West flows, due to the high exports from BG and RO, loading of the 400 kV interconnection Sofia Zapad (BG) – Nis (RS) may become critical when the TR system is an exporter. In the same case and a scenario where the Turkish system imports electricity from the North borders of the area (Austria and Slovakia), loading of the corridor in the North – South direction, through HU and the HU–HR border may become critical. Such observation is based on the loading of the 400 kV Hevic (HU) – Zerjavinec (HR) and the 400 kV God (HU) – Kerepes (HU) transmission lines. Simplified modelling of neighbouring systems as fixed injections should be considered in the evaluation of this result.
In the case of high North → South flows, where GR is a considerable importer, loading of 150 kV elements in North Greece (150 kV lines Nea Santa – Iasmos and Doxa – Thessaloniki) is sensitive to the Turkish power system export level. Identified overloading can be alleviated with corrective actions. These actions include the engagement of generators in the Komotini thermal power plant and the closing of the 150kV bus-coupler in the Thessaloniki EHV substation.
In the same case, an N-1-1 analysis considering a maintenance list of elements coordinated at a regional level, have shown almost the same results with the N-1 analysis. The only difference was in the case of increased exports from the Turkish power system where a new potentially critical element (400kV/150kV transformer in Filipi substation) appeared due to the maintenance of one of the 400 kV lines between Filipi and Lagadas.
In the case of a combination of high wind and low load conditions in the area, no elements have been identified with a loading above 80% in the N state or 100% in the N-1 states. The N-1-1 analysis has shown that for the selected regional maintenance list, the loading of elements in the internal transmission network of Serbia (400 kV line Pancevo – Bgd 20, 220 kV line Bgd 8 – HIP 2 and 400 kV/220 kV transformer in Pancevo) and in the HU-HR borders (400 kV line Paks-Peks in Hungary and 400 kV interconnector Ernestinovo (HR) - Peks (HU)) appeared to be sensitive to the Turkish power system balance and may become critical.

5.2 The Ukraine/Moldova Network Connection Sensitivity Study

5.2.1 UA/MD interconnection

In 2006, UA and MD transmission system operators filled a request for synchronous interconnection to the system of the Union for the Coordination of Transmission of Electricity (UCTE). Later, a Consortium made of TSOs which are ENTSO-E members was formed in order to perform the ‘Feasibility Study on the Synchronous Interconnection of the Ukrainian and Moldovan Power Systems to ENTSO-E Continental Europe Power System’. The main objectives of this feasibility study were:

- To investigate the possibility of the synchronous operation of UA and MD power systems with the Continental European synchronous area respecting its technical operational standards
- To investigate the degree of implementation of ENTSO-E’s technical operational standards in the UA/MD power systems
- To analyse differences in the relevant legislation in the field of energy between UA/MD and EU countries.

The main conclusions of the study are:

- From a steady-state perspective, synchronous connection of the UA and MD to the Continental Europe power system is feasible, with infrastructure (existing and planned) expected in 2020

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- From a dynamic perspective, the interconnection is not feasible without applying proper countermeasures due to the inter-area instability risks identified in the interconnected model. The source of the instability is insufficient damping for low frequency oscillations at large generators in UA. The interconnection is not feasible without applying proper countermeasures due to the inter-area instability risks identified in the interconnected model.
- The inter-area stability can be improved if one of the proposed countermeasures is applied. The adopted solution has to be verified by the manufacturers of existing control systems in power plants in UA and MD, especially referring to the nuclear power plants.
- Only after such a revision of proposed measures and the on-site testing of selected exciters and governors can the final evaluation of efficiency of countermeasures and their influence on the small signal inter-area stability of the interconnected systems be made.

5.2.2 Objectives of the Sensitivity Study

The Energy Community Secretariat has identified priority infrastructure projects in Energy Community: PECI/PMI – Projects of Energy Community Interest / Projects of Mutual Interest. The selection of priority infrastructure projects is done in line with EU Regulation 347/2013, as adapted for the Energy Community.
Part of the PECI/PMI list are projects for the realisation of the UA/MD interconnection:

- EL_06: 400 kV OHL Vulcanesti (MD) – Issacea (RO) (existing line), new 600 MW Back to Back station in Vulcanesti, new 400 kV OHL Vulcanesti (MD) – Chisinau (MD). This project will allow energy exchanges with Moldova earlier than the synchronous interconnection.
- EL_09: Rehabilitation of OHL Mukacheve (UA) – Kapusany (SK)

At this moment, part of the information to evaluate the performance of listed projects is missing; the complete information is necessary to comply with the Regulation 347/2013 transparency provisions.
Having in mind all these considerations, RG CSE has initiated preparation of The Ukraine/Moldova Network Connection Sensitivity Study (Sensitivity Study hereinafter).
The main objectives of the Sensitivity Study are:

- To investigate the influence of UA/MD interconnection on the operation of the ENTSO-E electricity market and transmission grid, with a focus on the region of CSE.
- To study the importance of new/future projects in CSE in regard to the interconnection of UA/MD to the ENTSO-E power system; perspective transmission corridors to support the electricity trading patterns across CSE.

This study will be realised in the framework of the SECI project.

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6 Links to national development plans

Country	Company/TSO	National Development Plan
AL	OST	
BA	Nosbih	
BG	ESO-EAD	http://eso.bg/fileObj.php?oid=398
HR		www.hops.hr/wps/wcm/connect/fd338a67-3173-4235-8a6e-9c4e218cdaa5/HOPS2017_final_Part1.pdf?MOD=AJPERES
CY		Not available
MK	MEPSO	https://www.dropbox.com/s/wzqiitvs5iwciuu/STUDIJA%20RAZVOJA%20-%2082-2015%20MK%20-%20FINAL_LQ.pdf?dl=0
GR	IPTO	http://www.admie.gr/to-systima-metaforas/anaptyxi-systimatos/meleti-anaptyxis-systimatos-metaforas/archeio/document/157695/doccat/detail/Document/
HU	MAVIR	Network Development Plan for Period 2016-2031
IT	TERNA	http://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/pianidisviluppo.aspx
ME		
SI	ELES	https://www.eles.si/Portals/0/Novice/aktualne.../Razvojni%20nacrt%202017-2026.pdf
RO	Transelectrica	Ten-Year Network Development Plan for the Period 2016-2025
RS	Serbia	Not available

7 PROJECTS

The following projects were collected during the project calls. They represent the most important projects for the region. For a project to be included in the analysis, it has to fit several criteria. These criteria are described in the ENTSO-E practical implementation of the guidelines for inclusion in TYNDP 2018[5]. The chapter is divided into Pan-European and additional regional projects.

7.1 Pan-European projects

The map below shows all project applicants submitted by project promoters during the TYNDP 2018 Call for projects. In the final version of this document (after the consultation phase) the map will be updated, showing the approved projects. Projects are in different states, which are described in the CBA-guideline:

- **Under Consideration**
- **Planned but not permitting**
- **Permitting**
- **Under Construction**

Depending on the state of a project, it will be assessed according to the CBA.

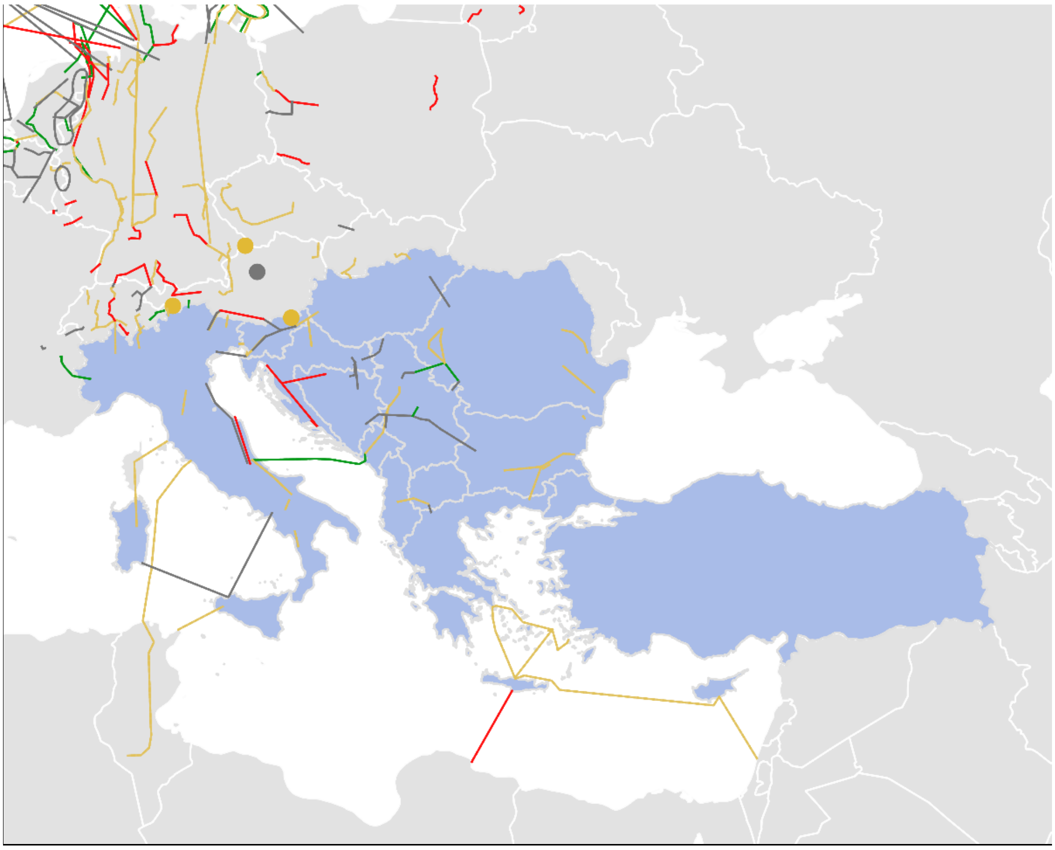

Figure 7-1: TYNDP 2018 Project: Regional Group CSE

5 https://thales.entsoe.eu/sites/tyndp2018/Steering Group and Coordination Team Documents/170822_ENTSO-E practical implementation of the guideliens for inclof proj in TYNDP 2018_after webinar 22 Aug 2017.docx

7.2 Additional regional projects

In this chapter the CSE projects of ‘regional’ and ‘national’ significance are listed, as they are needed as substantial and inherent support of the Pan-European projects inclusion into the future transmission systems. All these projects include the appropriate description and the main driver and why they are designed to be realised in the future scenarios, together with the expected commissioning dates and evolution drivers in case they were introduced in the past RegIPs.

There are no criteria for the regional significance projects’ inclusion in this list. They are included purely based on the project promoter’s decision if the project is relevant for inclusion.

Country	Project Name	Investment		Expected Commissioning year	Description	Main drivers	Included in RegIP 2015?
		From	To				
BG	New 400 kV line Venten-Blagoevgrad	Venten-Blagoevgrad		2026	This project concerns a new 400 kV line at the south part of the Bulgarian Transmission system, between the substations Venten and Blagoevgrad	Increase the transfer capability of the 400 kV interconnection Blagoevgrad(BG)-Lagadas(GR) and the security of supply in this area of the regional transmission network.	No
GR	Extension of 400 kV network to Peloponnese	Megalopoli - Acheloos		2019	This project concerns the extension of the 400 kV network towards Peloponnese. The 1st phase concerns the construction of a 400 kV / 150 kV substation in Megalopoli and a mixed (overhead line, underground and submarine cables) connection to the existing 400 kV / 150 kV substation in Acheloos. The 2nd phase concerns the construction of a new 400 kV / 150 kV substation in Korinthos and a new 400 kV overhead line connecting the substations in Megalopoli, Korinthos and Koumoundouros	The project will allow the connection of the largest thermal unit of the Greek power system with a nominal capacity of 800 MW at Megalopoli substation. In addition, it will enable the increase of RES penetration in Peloponnese.	No
GR	Extension of 400 kV network to Peloponnese	Megalopoli – Korinthos -Koumoundouros		2024			No
GR	Phase I of the interconnection of Crete with the mainland system	Molai –Chania I		2020	The project concerns a new 150 kV double circuit cable interconnection (including underground and submarine parts) between the HV substations Molai in Peloponnese and Chania I in Crete. The project also includes the construction of necessary reinforcements and upgrades in the 150 kV network of Peloponnese and Crete. A Static Var Compensatror (SVC) will be installed in Crete for the support of voltage regulation. The nominal transfer capacity of the interconnector will be 2x200 MVA.	Ensure security of supply and minimisation of the electricity generation cost of the island of Crete that it is currently supplied by local diesel generators.	No

	Phase II of the interconnection of Crete with the mainland system	Koumoundouros-Damasta	2023	The project concerns a new 400 kV HVDC interconnection between the HV substation Koumoundouros in Attica and the new substation Damasta in Crete. The transfer capacity of the project will be 2x350 MW. IPTO investigates synergies with the project 219 (EuroAsia interconnector).	Ensure security of supply, minimisation of the electricity generation cost due to the replacement of electricity produced by local diesel generators and the increase of RES penetration in the island of Crete.	No
HR	New double 400 kV line Tumbri – Veleševec	Tumbri – Veleševec	2023	This project concerns a new double 400 kV line at the center of Croatian Transmission system, between the substations Tumbri – Veleševec	Increase the transfer capability in the 400kV interconnections with RS and HU, removing the bottleneck during high transit and increasing the security of supply in the area of the regional transmission network.	No
RO	New 400 kV OHL Suceava (RO) – Balti (MD)	Suceava (RO) – Balti (MD)	2025	New 400 kV OHL (139 km) to increase capacity of transfer between RO and MD	Market integration	Yes
RO	New 400 kV OHL Suceava - Gadalin	Suceava - Gadalin	2025	New 400 kV simple circuit OHL between existing substations. Line length: 260km.	RES integration	No
RO	New 400 kV OHL Stalpu-Brasov	Stalpu - Brasov	2025	New 400 kV OHL, double circuit (initially 1 circuit wired), 170 km length between existing 400 kV substation Stalpu and Brasov;	RES integration	Yes
RO	New 400 kV OHL Constanta Nord - Medgidia Sud	Constanta Nord - Medgidia Sud	2022	New 400kV double circuit (one circuit wired) OHL between existing stations. Line length:75km.	RES integration	Yes
RO	New 400 kV OHL Stalpu – Teleajen - Brazi	Stalpu – Teleajen - Brazi	2021	Reinforcement of the cross-section between wind generation hub in Eastern Tomania and BG and the rest of the system. Upgrade of an existing 220 kV single circuit line to 400 kV. New 400 kV substations: Stalpu (400/110 kV, 1x250 MVA), Teleajen (400/110 kV, 1x400 MVA)	RES integration	Yes
RO	400 kV substation Teleajen	Teleajen	2021	The 220/110 kV substation Teleajen is upgraded to 400/110 kV (1x400 MVA). The new 400 kV OHL Cernavoda-Stalpu is continued by the OHL Stalpu-Teleajen-Brazi Vest, upgraded to 400 kV from 220 kV, reinforcing the E-W cross-section. The 220 kV substations on the path are upgraded to 400 kV. SoS in supplied area increases.	RES integration	Yes
RO	400 kV substation Medgidia Sud	Medgidia Sud	2018	Substation Medgidia Sud 400 kV extended with new connections (400 kV OHL Rahmanu (RO) – Dobrudja (BG), 400 kV OHL Stupina (RO) – Varna	RES integration	Yes

				(BG) and refurbished with GIS technology to provide the necessary space.		
RO	400 kV OHL Medgidia Sud (RO) – Dobrudja (BG)	Medgidia Sud (RO) – Dodrudja (BG)	2019	In-out connection of the existing OHL of 400 kV Rahman – Dobrudja in the existing 400 kV substation Medgidia Sud	RES integration	Yes
RO	400 kV OHL Medgidia Sud (RO) – Varna (BG)	Medgidia Sud (RO) – Varna (BG)	2019	In-out connection of the existing OHL of 400 kV Stupina – Varna in the existing 400 kV substation Medgidia Sud	RES integration	Yes
RO	220 kV OHL Stejaru – Gheorghieni	Stejaru - Gheorghieni	2021	Increasing the transmission capacity by replacing the wires on the 220 kV OHL Stejaru – Gheorghieni with high thermal capacity.	RES integration	Yes
RO	220 kV OHL Gheorghieni - Fantanele	Gheorghieni - Fantanele	2021	Increasing the transmission capacity by replacing the wires on the 220 kV OHL Gheorghieni – Fantanele with high thermal capacity.	RES integration	Yes
SI	Substation Ravne (SI)	Ravne (SI)	2021	Construction of the new substation 220/110 kV Ravne with new double 220-kV OHL Ravne-Zagrad (the length is approximately 4 km) and it will be included in the existing interconnection 220 kV OHL 220 kV Podlog (SI)-Obersielach (AT). Expected commissioning date 2021.	Flicker, High load growth	Yes
SI	New compensation devices on 400 kV voltage level in scope of SINCRO.GRID project	Beričevo (SI), Divača (SI), Cirkovce (SI)	2021	Installation of new compensation devices on 400 kV: - SVC (150 Mvar) in substation Beričevo, - VSR (150 Mvar) and MSC (100 Mvar) in substation Divača - VSR (150 Mvar) in substation Cirkovce	RES integration, Security of Supply	No

(*) These projects were in the TYNDP 2016 list

8 APPENDICES

8.1 Additional Figures

8.1.1 Present situation

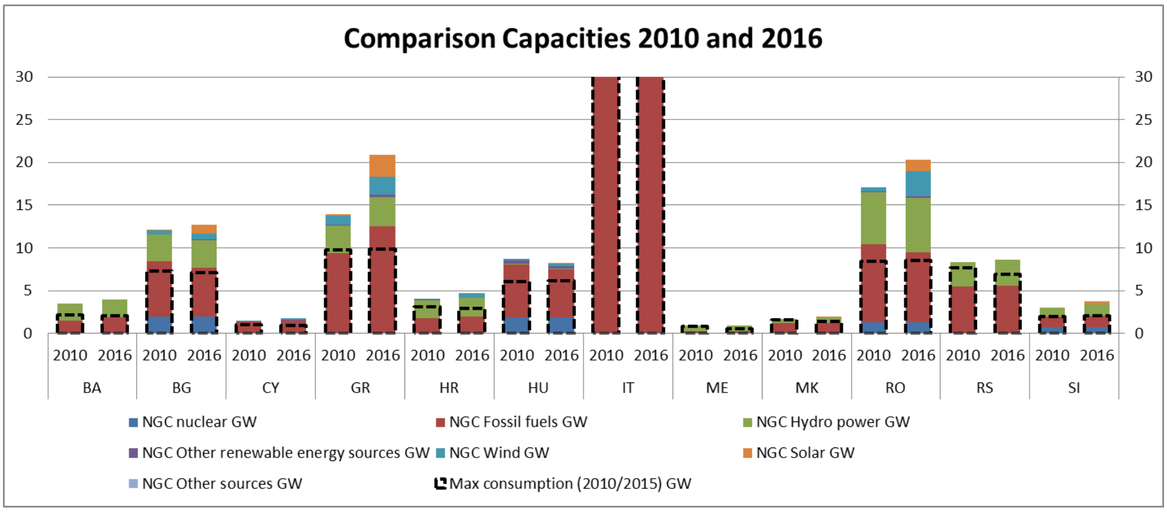

Figure 8-1: Installed capacity and peak load bar charts for the countries of the region

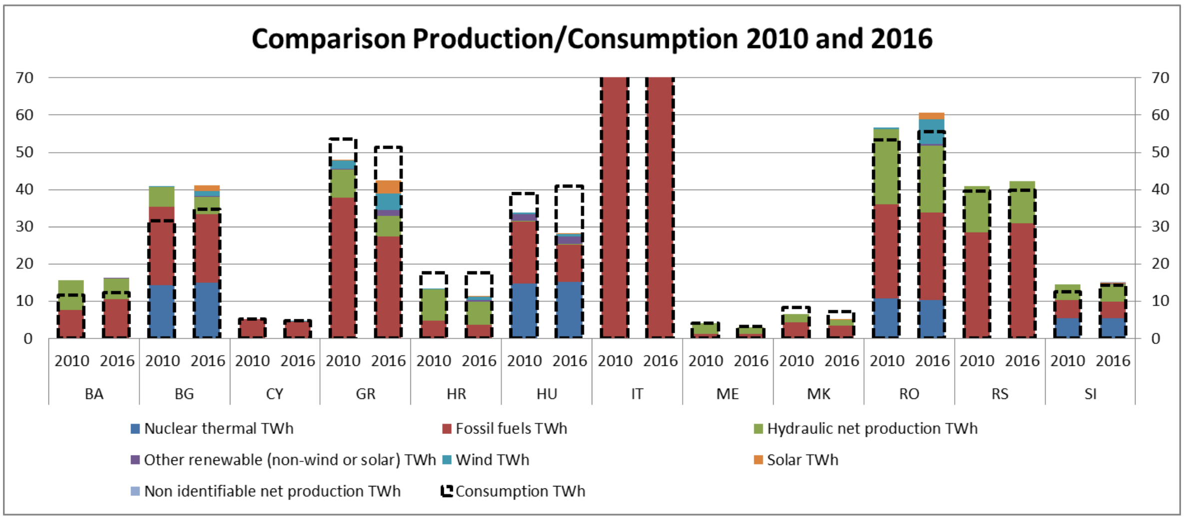

Figure 8-2: Development of generation/load pr. country also indicating percentage in pie charts

8.1.2 Scenarios

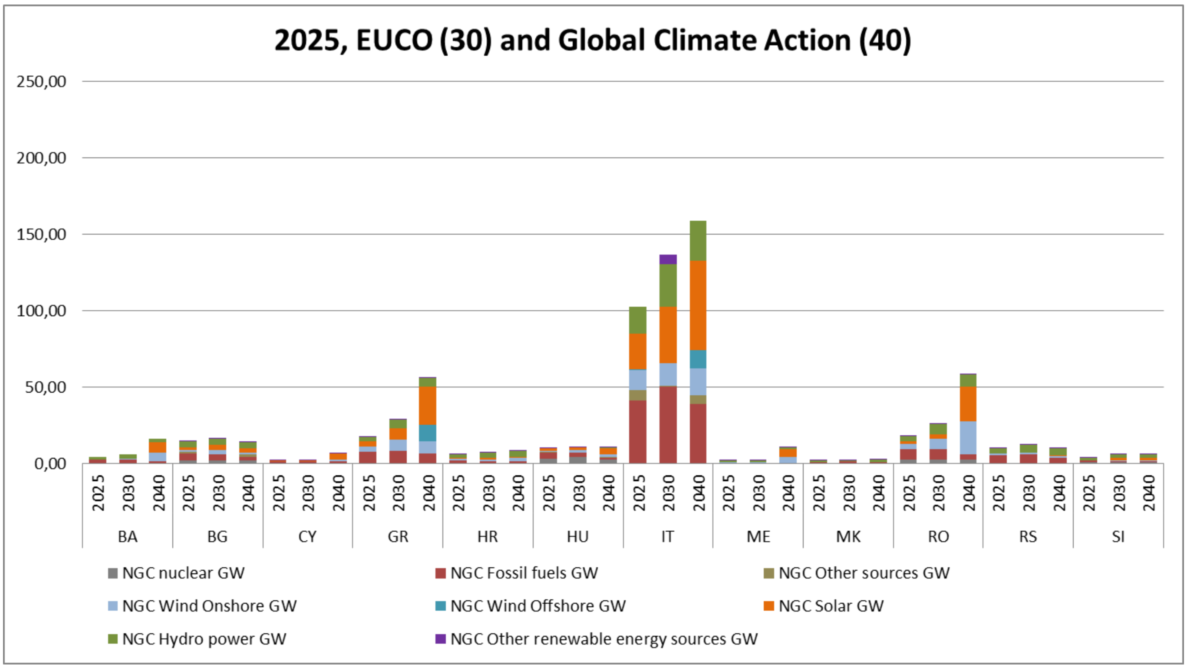

Figure 8-3: 2025BE, EUCO30 & GCA40 production

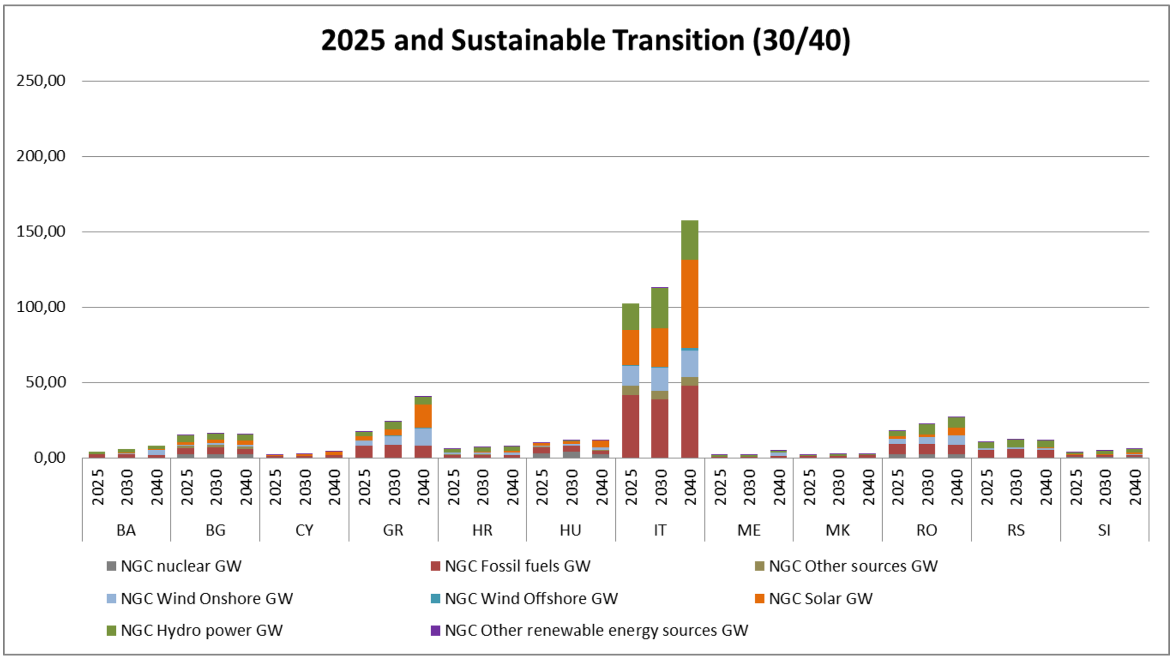

Figure 8-4: 2025BE, ST2030 and ST2040 production

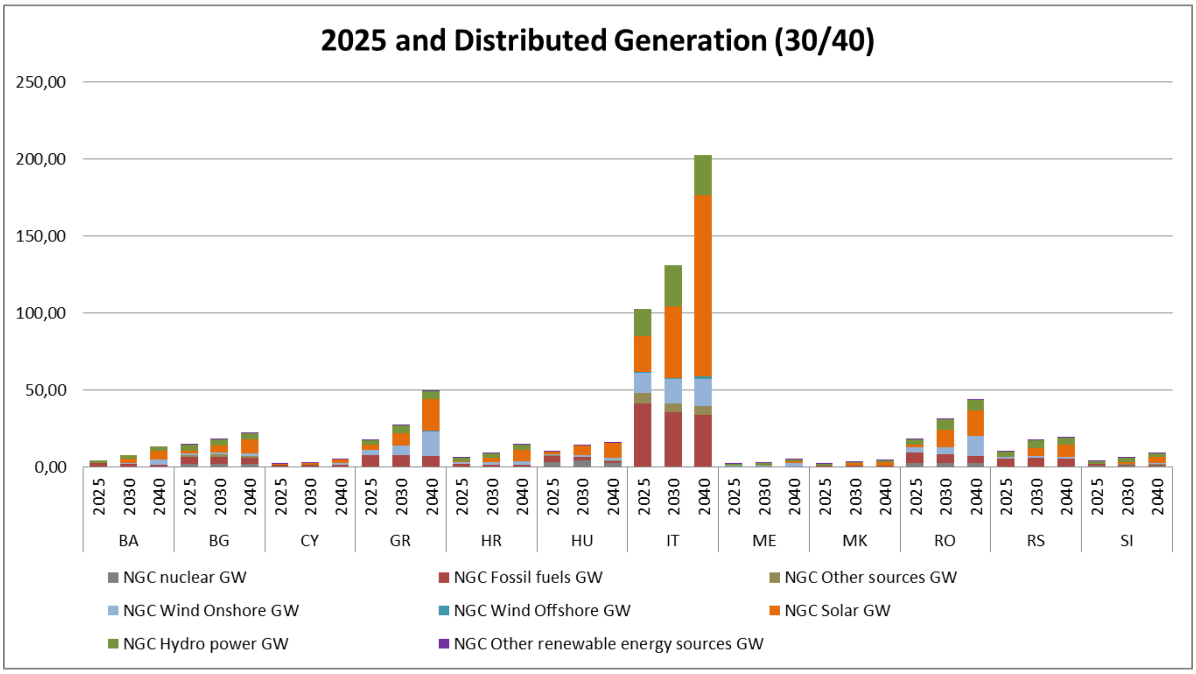

Figure 8-5: 2025BE, DG2030 and DG2040 production

8.1.3 Future challenges

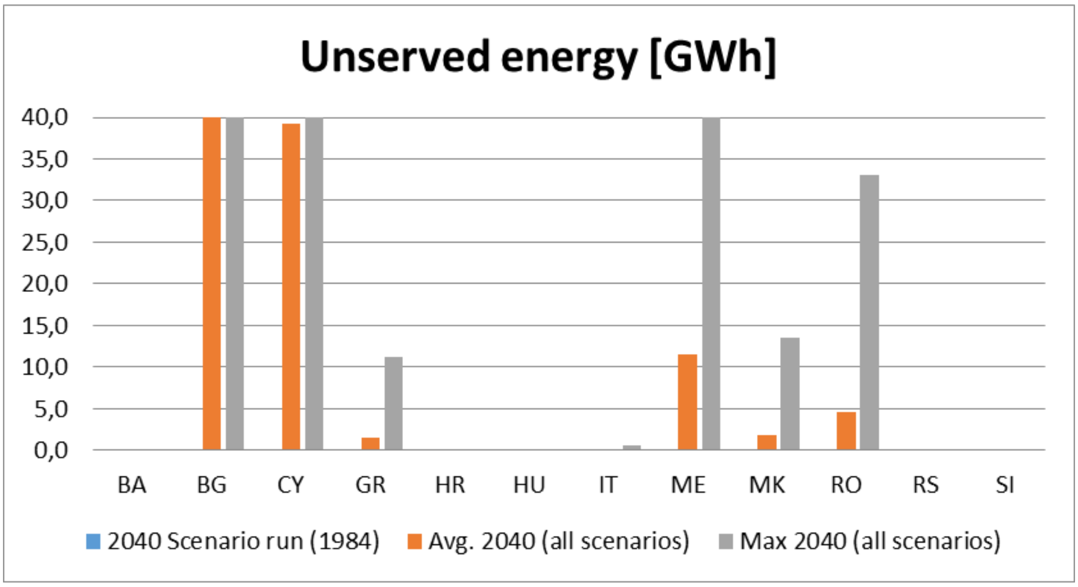

Figure 8-6: Map showing ENS pr. market area (SoS)

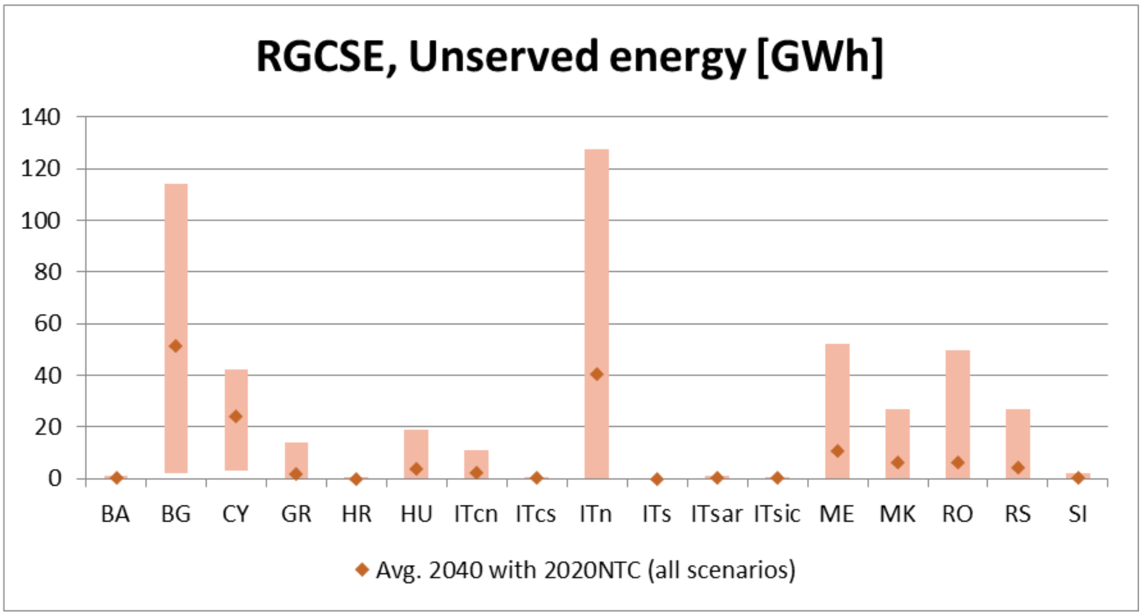

Figure 8-7: Map showing market simulation results of 2040 with a 2020 grid for all market areas of the region.

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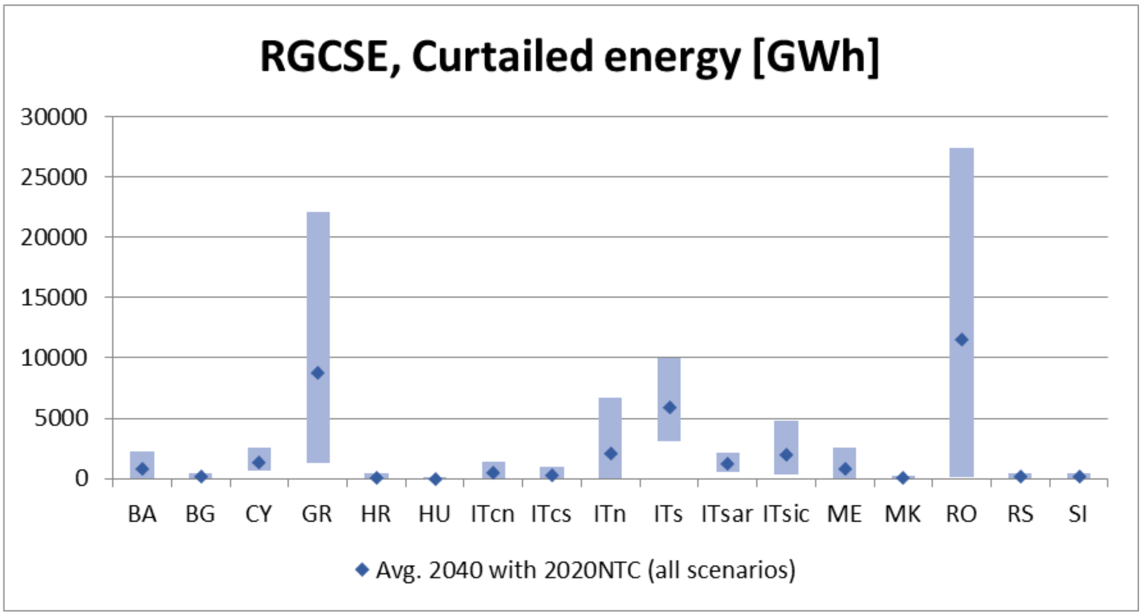


Figure 8-8 Curtailed Energy

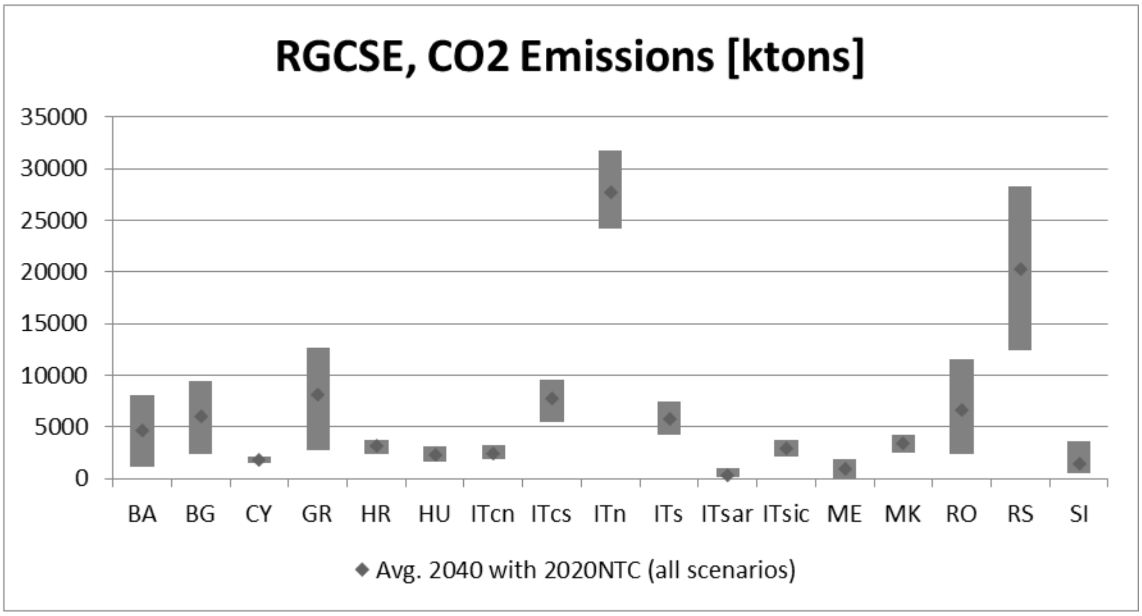


Figure 8-9: CO_2 Emissions

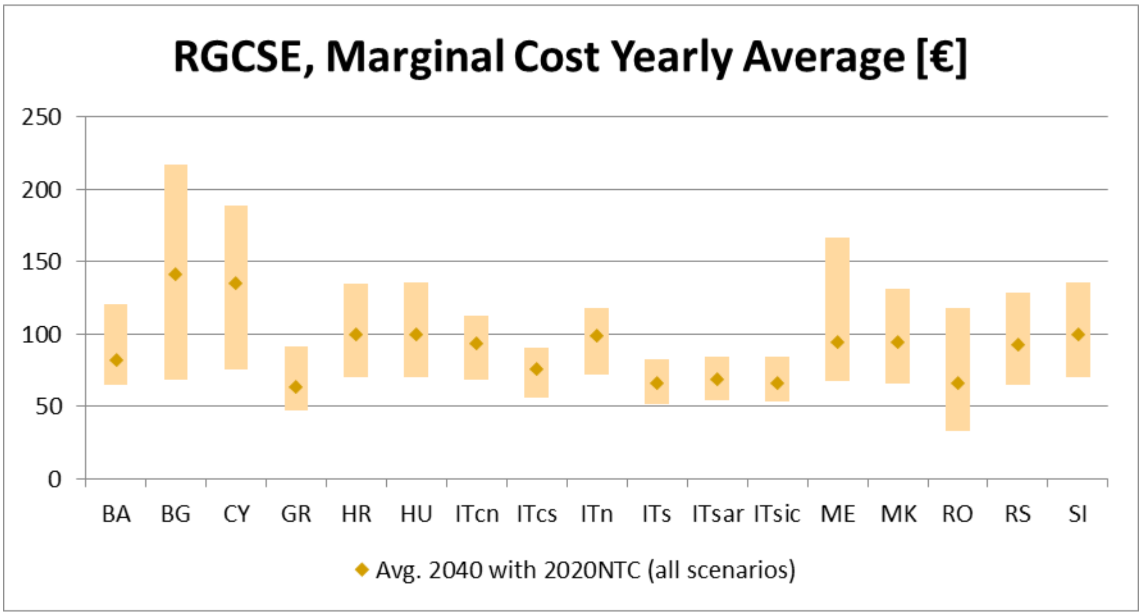


Figure 8-10: Marginal Cost Yearly Average

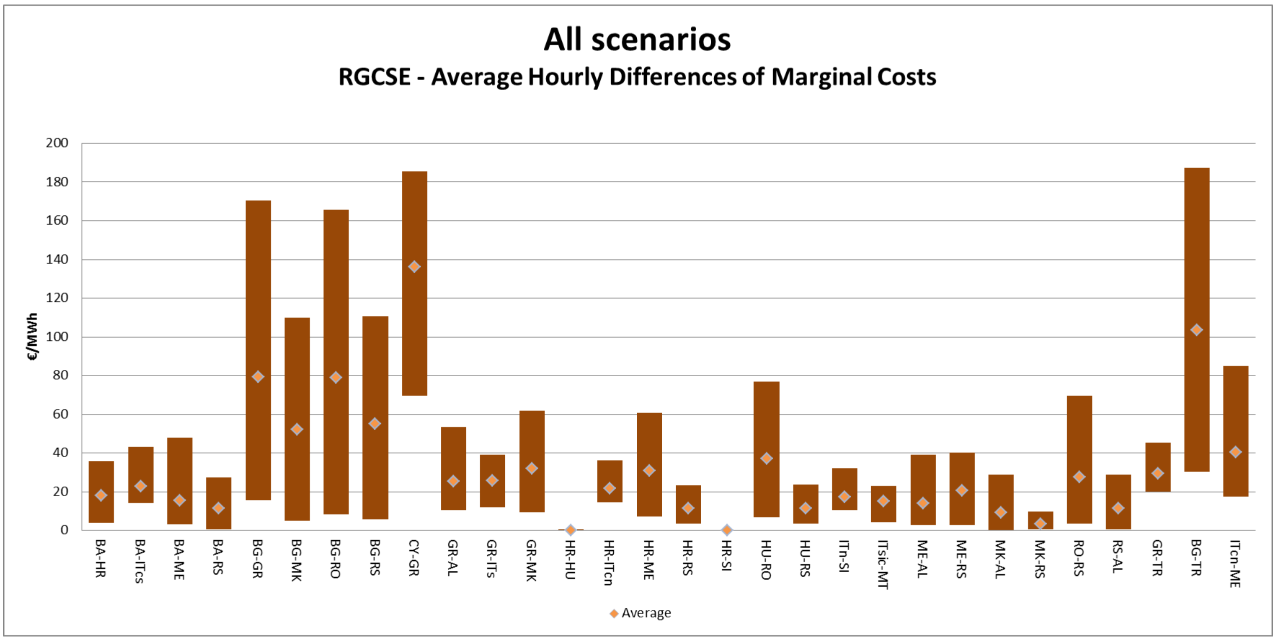


Figure 8-11: Charts showing price differences (Market integration)

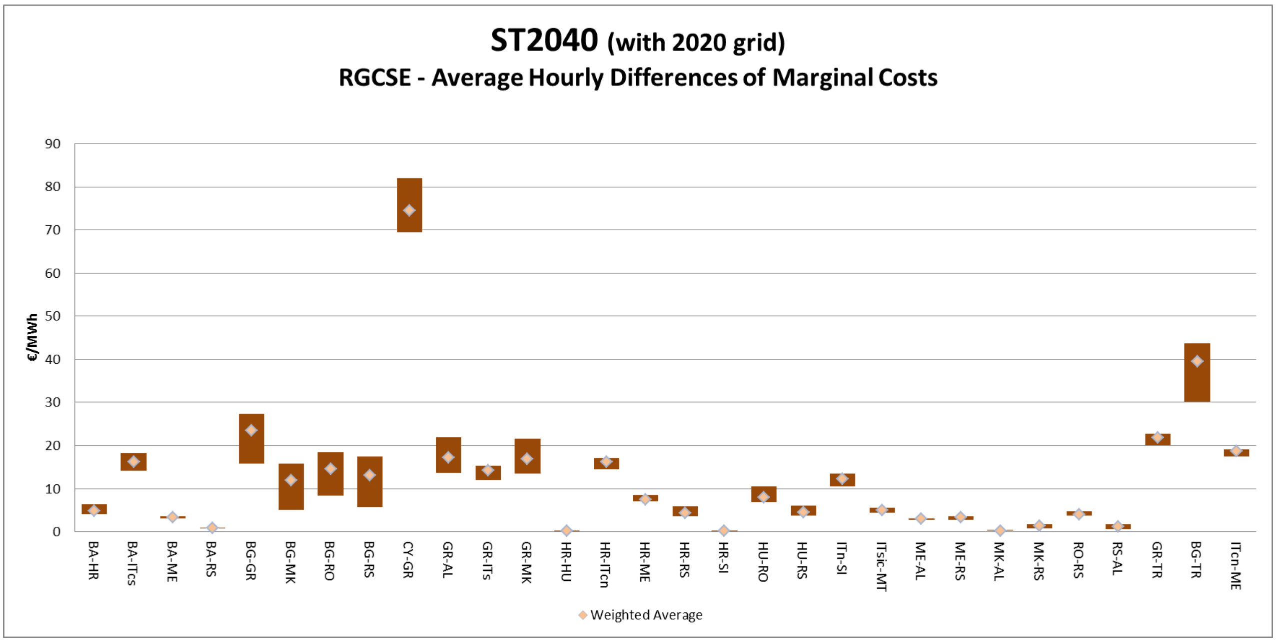


Figure 8-12: ST2040 with 2020 grid – Average hour differences of marginal costs

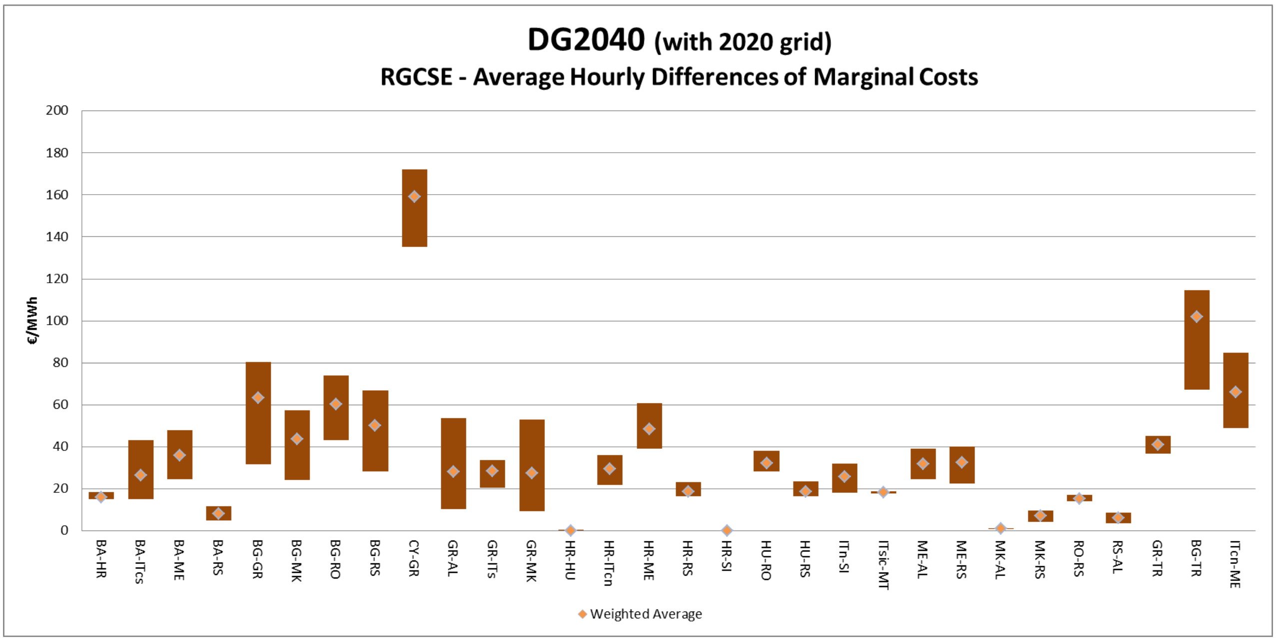


Figure 8-13: DG2040 with 2020 grid – Average hour differences of marginal costs

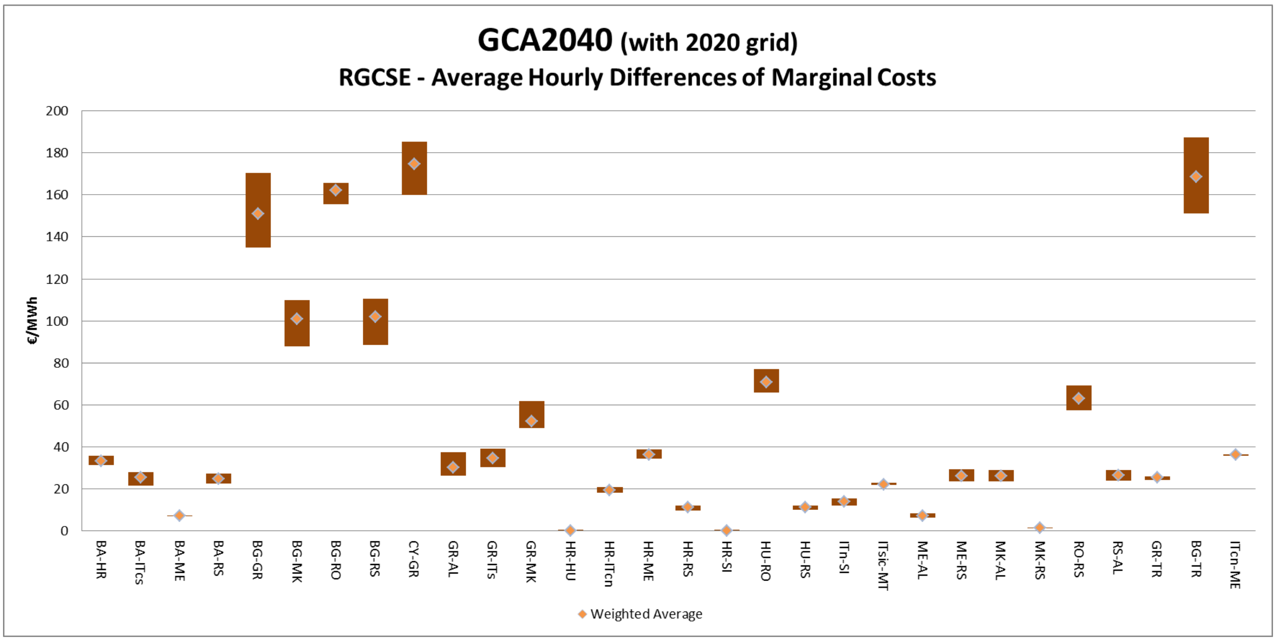
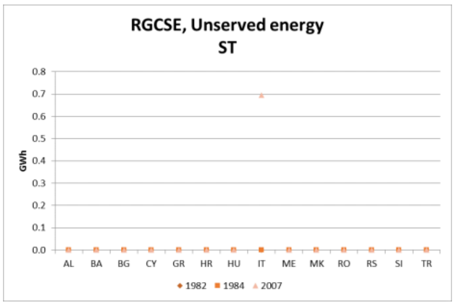
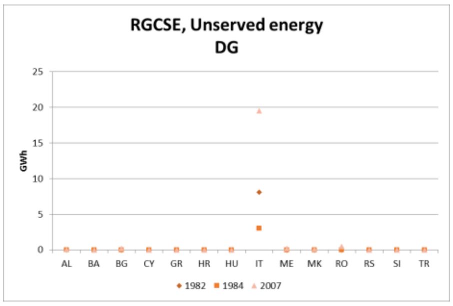


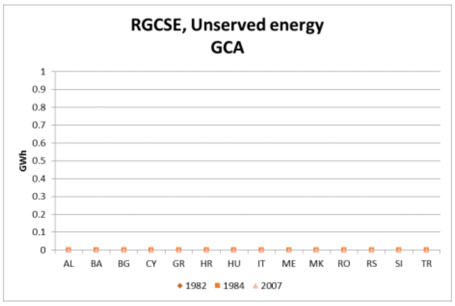
Figure 8-14: GCA2040 with 2020 grid – Average hour differences of marginal costs

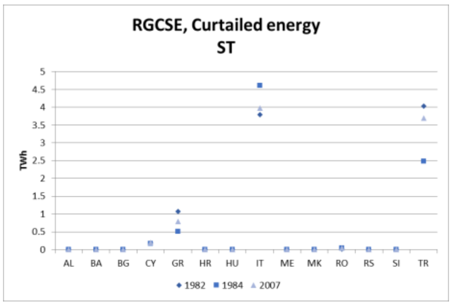
8.1.4 Market and network study results

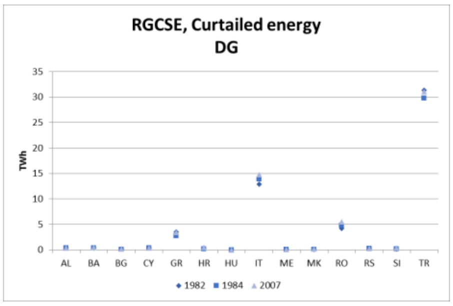
Sustainable Transition 2040	Distributed Generation 2040	Global Climate Action 2040

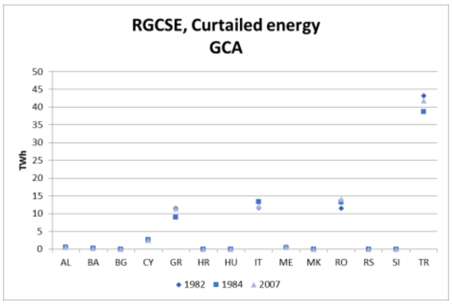


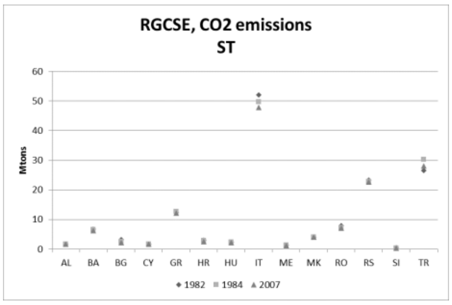


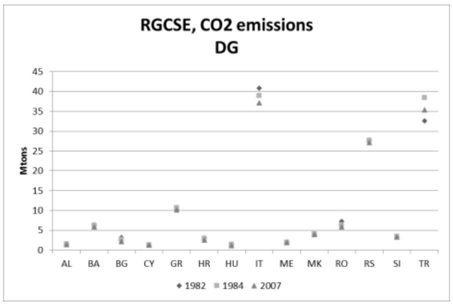


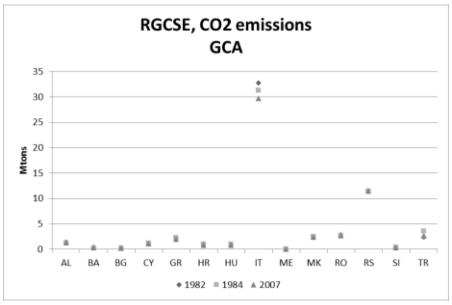


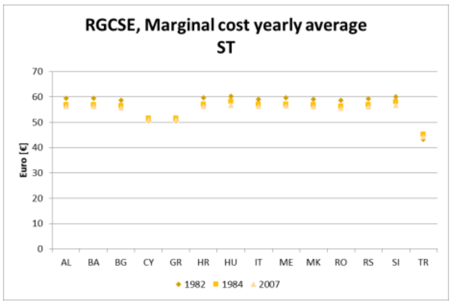


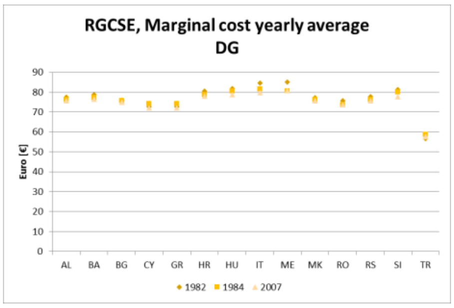


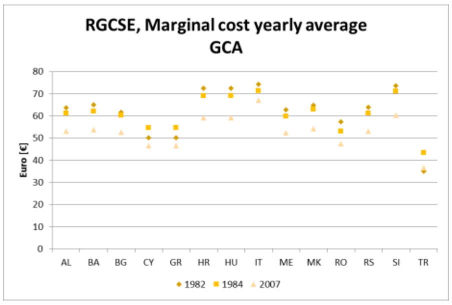


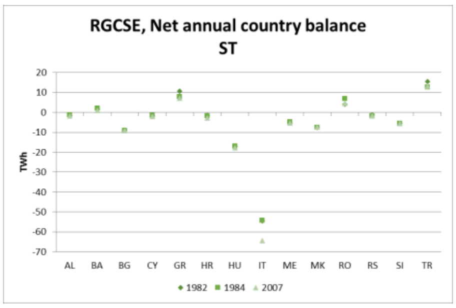


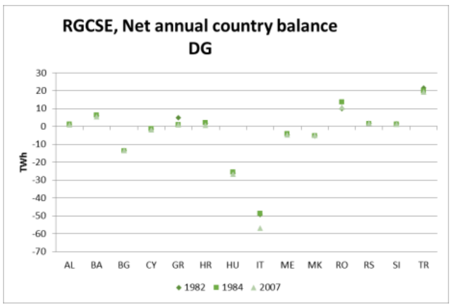


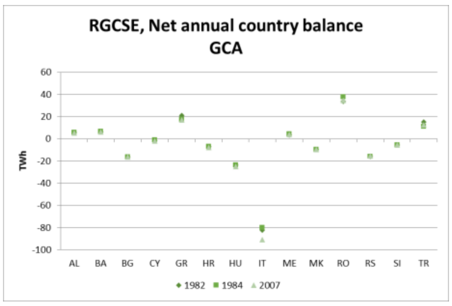












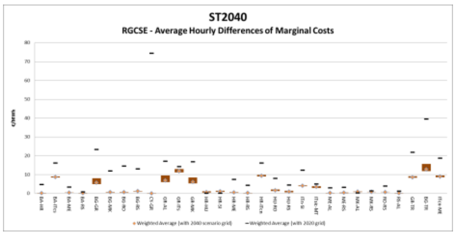
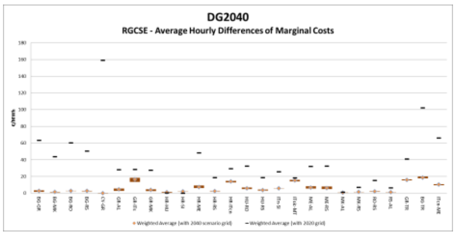
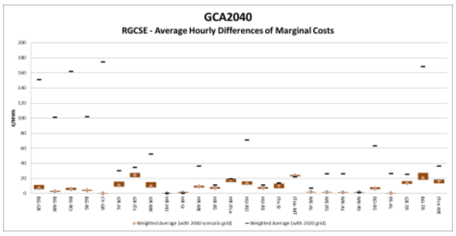
Sustainable Transition 2040	Distributed Generation 2040	Global Climate Action 2040
		

Figure 8-15: Market modelling study results

8.1.5 Standard cost map

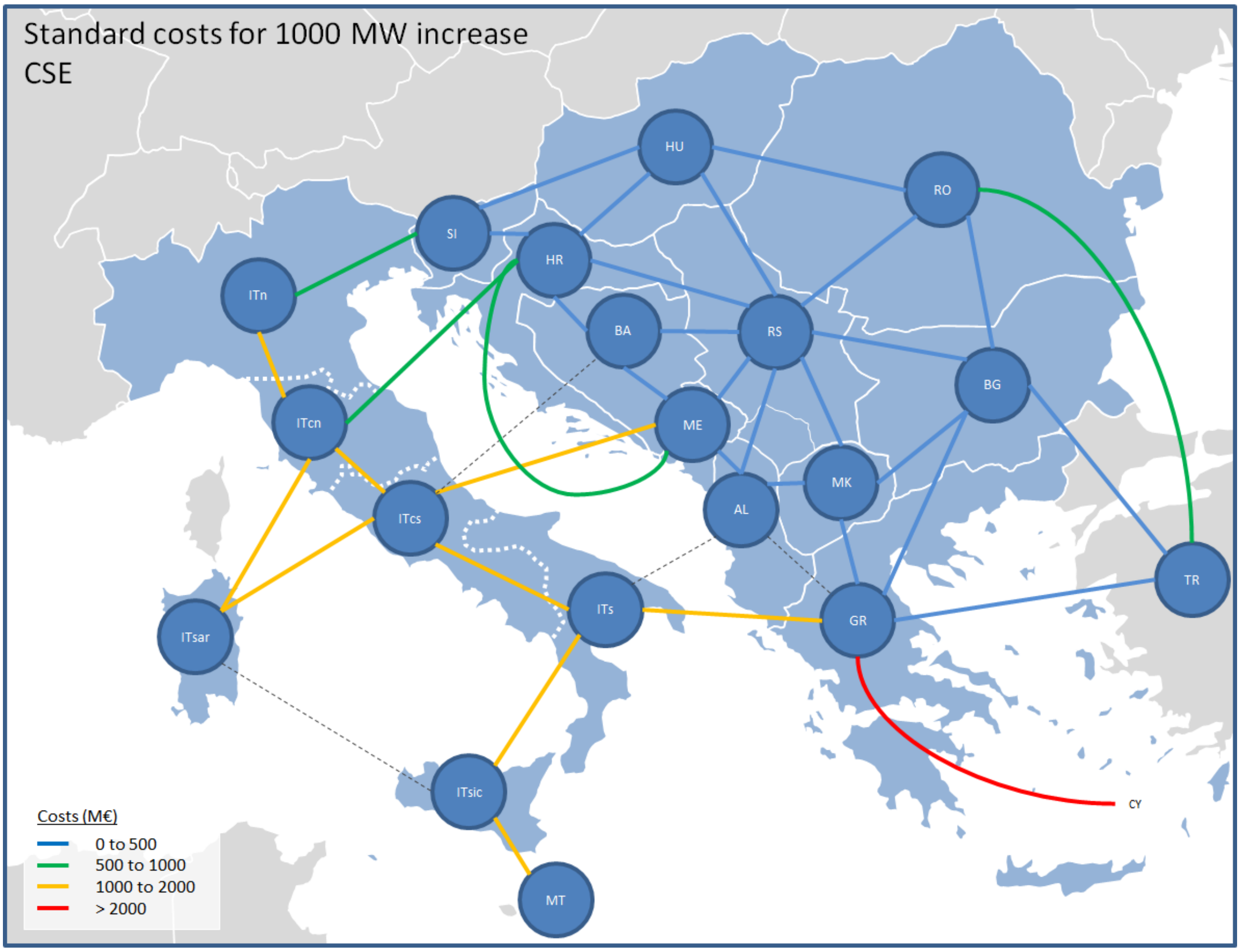


Figure 8-16: Standard cost maps

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8.2 Abbreviations

The following list shows abbreviations used in the Regional Investment Plans 2017.

- AC Alternating Current
- ACER Agency for the Cooperation of Energy Regulators
- AL Albania
- BA Bosnia-Herzegovina
- BG Bulgaria
- CBA Cost-Benefit-Analysis
- CCS Carbon Capture and Storage
- CESA Continental Europe Synchronous Area
- CHP Combined Heat and Power Generation
- CSE Continental South East
- CY Cyprus
- DC Direct Current
- EH2050 e-Highway2050
- EIP Energy Infrastructure Package
- ENTSO-E European Network of Transmission System Operators for Electricity
- ENTSOG European Network of Transmission System Operators for Gas
- EC European Commission
- ENS Energy Not Served
- ETS Emissions Trading Scheme
- EU European Union
- GR Greece
- GTC Grid Transfer Capability
- HR Croatia
- HU Hungary
- HV High Voltage
- HVAC High Voltage AC
- HVDC High Voltage DC
- IEA International Energy Agency
- IL Israel
- IT Italy
- KPI Key Performance Indicator

- IEM Internal Energy Market
- IoSN Identification of System Needs
- LCC Line Commutated Converter
- LOLE Loss of Load Expectation
- MAF Mid-Term Adequacy Forecast
- MD Moldova
- ME Montenegro
- MK FYR of Macedonia
- MS Member State
- MWh Megawatt hour
- NGC Net Generation Capacity
- NRA National Regulatory Authority
- NREAP National Renewable Energy Action Plan
- NTC Net Transfer Capacity
- OHL Overhead Line
- PCI Projects of Common Interest
- PINT Put IN one at the Time
- PST Phase Shifting Transformer
- RegIP Regional Investment Plan
- RES Renewable Energy Sources
- RO Romania
- RS Serbia
- 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
- SECI South-East Cooperation Initiative
- SEW Socio-Economic Welfare
- SI Slovenia
- SOAF Scenario Outlook & Adequacy Forecast
- SoS Security of Supply
- TEN-E Trans-European Energy Networks

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- TOOT Take Out One at the Time
- TR Turkey
- TSO Transmission System Operator
- TWh Terawatt hour
- TYNDP Ten-Year Network Development Plan
- UA Ukraine
- VOLL Value of Lost Load
- VSC Voltage Source Converter

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8.3 Terminology

The following list describes a number of terms used in this RegIP.

Congestion revenue/ congestion rent – The revenue derived by interconnector owners from sale of the interconnector capacity through auctions. In general, the value of the congestion rent is equal to the price differential between the two connected markets, multiplied by the capacity of the interconnector.

Congestion – A situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned.

Cost-Benefit-Analysis (CBA) – Analysis carried out to define to what extent a project is worthwhile from a social perspective.

Corridors – The CBA clustering rules proved, however, challenging for complex grid reinforcement strategies: the largest investment needs may require some 30 investments items, scheduled over more than five years but addressing the same concern. In this case, for the sake of transparency, they are formally presented in a series – a corridor – of smaller projects, each matching the clustering rules.

Cluster – Several investment items matching the CBA clustering rules. Essentially, a project clusters all investment items that have to be realised in total to achieve a desired effect.

Grid transfer capacity (GTC) – represents the aggregated capacity of the physical infrastructure connecting nodes in reality; it is not only set by the transmission capacities of cross-border lines but also by the ratings of so-called 'critical' domestic components. The GTC value is thus generally not equal to the sum of the capacities of the physical lines that are represented by this branch; it is represented by a typical value across the year.

Investment – Individual equipment or facility, such as a transmission line, a cable or a substation.

Marginal costs – Current market simulations, in the framework of TYNDP studies, compute the final 'price' of electricity considering only generation costs (including fuel costs and CO2 prices) per technology. In the real electricity market, not only the offers from generators units are considered but taxes and other services such as ancillary services also participate (reserves, regulation up and down…) which introduce changes in the final electricity price.

Net Transfer Capacity (NTC) – the maximum total exchange programme between two adjacent control areas compatible with security standards applicable in all control areas of the synchronous area, and considering the technical uncertainties on future network conditions.

N-1 Criterion – The rule according to which elements remaining in operation within TSO’s Responsibility Area after a Contingency from the Contingency List must be capable of accommodating the new operational situation without violating Operational Security Limits.

Project – Either a single investment or a set of investments, clustered together to form a project, in order to achieve a common goal.

Project candidate – Investment(s) considered for inclusion in the TYNDP.

Project of Common Interest (PCI) – A project which meets the general and at least one of the specific criteria defined in Art. 4 of the TEN-E Regulation and which has been granted the label of PCI Project according to the provisions of the TEN-E Regulation.

Put IN one at the Time (PINT) – Methodology that considers each new network investment/project (line, substation, PST or other transmission network device) on the given network structure one-by-one and evaluates the load flows over the lines with and without the examined network reinforcement.

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Reference network – The existing network plus all mature TYNDP developments, allowing the application of the TOOT approach.

Reference capacity – Cross-border capacity of the reference grid, used for applying the TOOT/PINT methodology in the assessment according to the CBA.

Scenario – A set of assumptions for modelling purposes related to a specific future situation in which certain conditions regarding gas demand and gas supply, gas infrastructures, fuel prices and global context occur.

Transmission capacity (also called Total Transfer Capacity) – The maximum transmission of active power in accordance with the system security criteria which is permitted in transmission cross-sections between the subsystems/areas or individual installations.

Take Out One at the Time (TOOT) – A methodology that consists of excluding investment items (line, substation, PST or other transmission network device) or complete projects from the forecasted network structure on a one-by-one basis and evaluating the load flows over the lines with and without the examined network reinforcement.

Ten-Year Network Development Plan (TYNDP) – The Union-wide report carried out by ENTSO-E every other year as part of its regulatory obligation as defined under Article 8 para 10 of Regulation (EC) 714 / 2009

Total transfer capacity (TTC) – See Transmission capacity above.

Vision – plausible future states selected as wide-ranging possible alternatives.

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