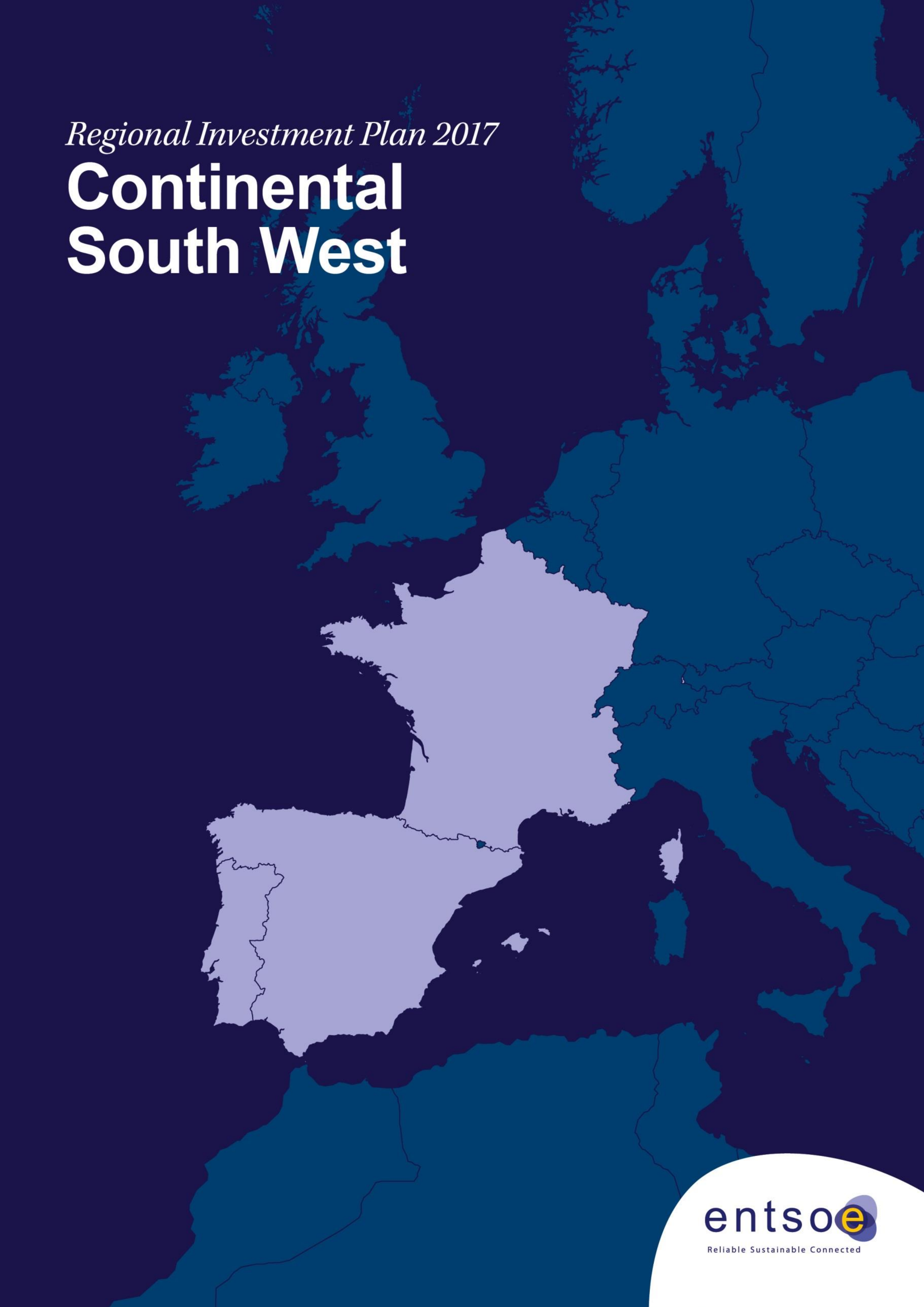
Regional Investment Plan 2017

Continental South West



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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 the 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 electricity market.

The TYNDP is a biennial report published every even year by ENTSO-E and acts as an essential basis to derive the Projects of Common Interest (PCI) list. Presently the TYNDP 2018 is under preparation.

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.

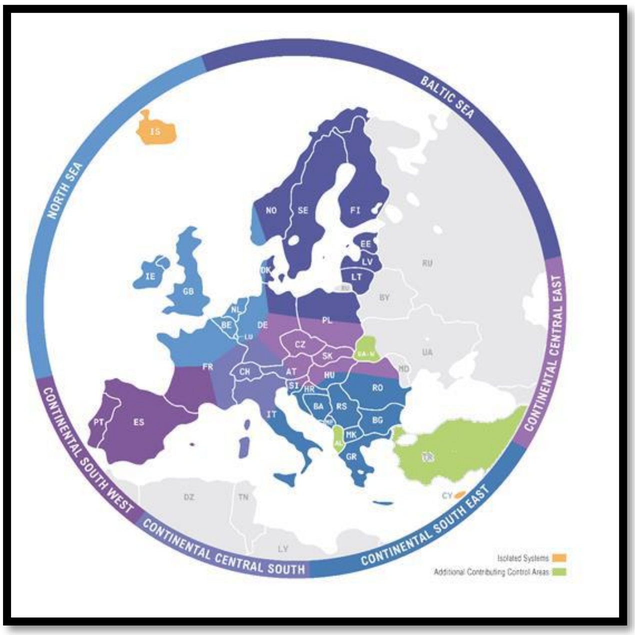

Figure 1-1: ENTSO-E System Development Regions

The six Regional Investment Plans are part of the TYNDP 2018 package and are supported by regional and pan-European analyses and take into account feedback received from institutions and stakeholder associations.

The Regional Investment Plans 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 the expected future regional challenges considering different scenarios in a 2040 time horizon.

Beside showing the 2040 challenges and proper scenario grid capacities to solve many of these challenges, the Regional Investment Plans also shows all relevant 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.

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

Due to the fact that the Regional Investment Plans (RgIPs) are published every odd year, the Regional Investment Plan 2017 builds on the previous investment plans and describes changes and updates compared to earlier publications. Since the RgIPs give 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[1].

The RgIP will strongly support one of the main challenges for ENTSO-E: to establish the most efficient and collaborative way 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 historical main drivers for grid development in the region have been reported in every release of the RgIP and TYNDP:

- On one hand the insufficient cross border capacity, in order to allow:
  - the completion of the Iberian Electricity Market (MIBEL) through the reinforcement of Portugal-Spain interconnection, and
  - the integration of the Iberian Peninsula to the European continental market, through the development of the France-Spain interconnection.
- On the other hand the RES integration. The Iberian Peninsula has been a forerunner in the installation of renewable energy (hydro, solar but mainly onshore wind), and in the integration of this production in the system, with new network infrastructure in Portugal and Spain and smart management such as the Spanish renewable control centre (CECRE).

Both issues remain a challenge in the region in the short and long term, as the most recent studies show.

In this TYNDP edition a very detailed identification of system needs was performed. This analysis is focused on the year 2040, with the three new 2040 scenarios of the Scenario Report published in October 2017, and includes an assessment of what would happen with the system in case of having these 2040 scenarios along with the 2020 grid (that is, a no network development alternative).

The main findings of this analysis are:

- **Change in the generation portfolio towards a more carbon free system**
  The 2030 scenarios already show a shift from coal to gas generation (cf. scenario report), and a shift from thermal to renewable generation, including the partial phase out of nuclear in France. The optimization of RES performed in the 2030 and 2040 top down scenarios led to the assignment to the CSW region a massive increase of RES, mainly solar in the Iberian Peninsula (based on its high potential) and France, in addition to a significant increase of wind specially in France, even offshore wind, and other RES technologies in the region.

- **Need for a further market integration in the region, with special focus on the isolation of the Iberian Peninsula**

[1] https://www.entsoe.eu/Documents/TYNDP%20documents/14475_ENTSO_ScenarioReport_Main.pdf

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In 2020, Spain won't yet fulfill the 10% objective for 2020 in spite of the strong efforts of TSO's and the support from Member States and EC through the Madrid Declaration and the High Level Group monitoring (see EC communication dated 23 November 2017 on strengthening European energy networks to the European Parliament, the Council and the European Economic and Social Committee and the Committee of the regions[2]). Moreover there will be also needs for cross border development attached to the 2030 objectives.
The current analysis also shows some additional needs in the 2040 horizon related to cross border development, especially in reinforcing the Iberian Peninsula with the rest of continental Europe that should be carefully analyzed in the future.

- **The RES integration will be a challenge and it will not have a unique solution**

The market analysis of 2040 scenarios show a high amount of spillage in the region with both 2020 and 2040 grids.
The network as it will exist by 2020, with the 2040 scenarios, will not be able to accommodate RES integration, since without new network reinforcements, the renewable curtailed energy could in average amount to around 48 TWh in Spain, 2 TWh in France and 8 TWh in Portugal.
In fact, enabling the integration of future RES will represent a key challenge. The solution for this RES integration challenge won't be unique. It should be a mixture of internal reinforcements, development of interconnections, new storage, power to gas, etc…

- **The system will experience new power flow patterns and important investment needs**

High RES (mainly solar) in Iberian Peninsula (mainly in the south) and south of France and high exports from CSW to the rest of Europe create higher flows and new flow patterns for which the grid was not designed. Therefore, these new flows of higher volume and variable directions that may be opposite to the currently known or to those identified in the previous TYNDPs, result in cross-border and internal congestions in the long term. In addition, with the 2040 scenarios, we can see higher and longer transit flows and more influence than today between the France-Iberian Peninsula border and the French-central Europe border.

If these long-term scenarios materialize, cross border and important internal reinforcements from today grid will be needed to make the grid safe. Those reinforcements solving congestions that are common to the three analyzed scenarios have more probability to be part of the National Development Plans of the next decades.

Nevertheless, these identified potential needs for the 2040 horizon should be further investigated in future TYNDPs, in order to check if each investment need is robust enough and if the benefits - SEW and others – are enough to compensate costs so it would be adequate to propose a project to solve that need.

- **The Security of Supply will have a new dimension**

Ensuring Security of Supply in the future will not be only an issue of checking conventional system adequacy (ensure enough generation capacity to cover demand) and system adequacy (ensure the fulfillment of the N-1 conditions stated in the network codes to avoid energy not supplied), but it will go beyond. For instance, flexibility, dynamic issues and system Inertia and Demand Side Response will gain importance in the security of suply.

[2] https://ec.europa.eu/energy/sites/ener/files/documents/communication_on_infrastructure_17.pdf

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 increases, which have a positive impact on the system, were identified[3] for the 2040 scenarios. A European overview of these increases is presented in the European System Need report developed by ENTSO-E in parallel with the Regional Investment Plans 2017. Identified needs for capacity increases at the borders of the CSW-region, are shown in the map below.

The overall cross-border exchange capacities obtained in the analysis are in the range of 9000-10000 MW in Spain-France and up to values of 4700-5700 from Spain to Portugal and 4000-5000 from Portugal to Spain, depending on the scenario. The borders Spain-Italy and Spain-Great Britain were considered as potential reinforcements at the beginning of the Identification of system needs analysis but were discarded as not being economically viable, since the benefits obtained did not compensate the estimated costs of the potential increases. The estimated costs also affect results within the region, such as in the French-Spanish border where it has been considered a cost of underground or submarine HVDC potential project to cross the border.

The increase of cross-border exchange capacities in Europe in such scenarios from 2020 on would have a significant impact on the electrical system and the society as a whole. In particular:

- They would reduce the annual average marginal cost in France, Spain and Portugal in a range between 2 to 5€/Mwh
- They would allow to integrate from 1000 to 39.000 GWh of renewable energy as maximums in the CSW region, that otherwise would be curtailed
- They would allow up to a 5 GWh reduction in Energy not served in the region
- They would allow an overall reduction of CO2 in Europe that in the region vary from an increase up to 3.000 ktons of CO2 to a reduction up to 4.000 ktons of CO2 emissions. Increases in CO2 emissions are produced in the sustainable transition scenario, where a moderate increase on renewable sources is considered and consequently, CSW region exports a high amount of energy from gas sources

Although the quantified benefits for the CSW region presented in this report result from the Europe-wide increase of cross-border capacities, the role of capacity increases inside the CSW region on Portugal-Spain border and France-Spain border is of course essential to form the major part of these benefits.

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

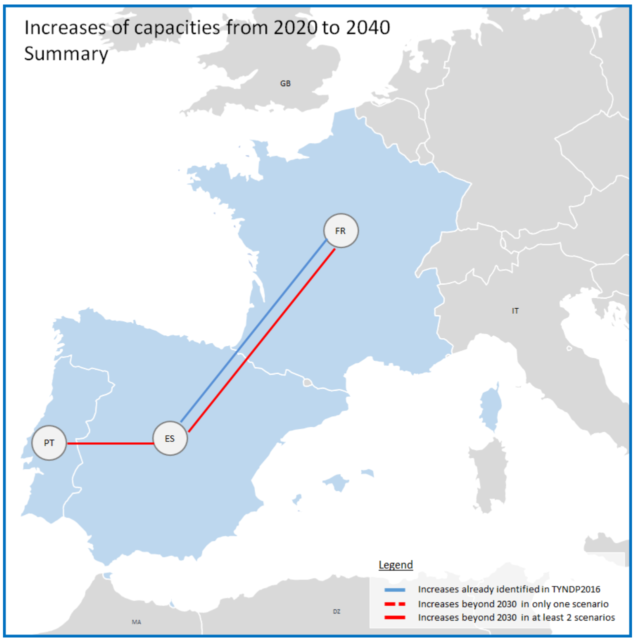

Figure 1-2: Identified capacity increase needs between years 2020 and 2040[4]

This map confirms that projects already at stake in the TYNDP 2016 respond to a real system need for more cross-border capacity and reflects that ambitious RES scenarios such as the ones used for TYNDP 2018 could require more exchange capacity.

Here are the cross-border projects already addressing this need in the 2020-2030 horizon, and that will be analyzed in the TYNDP2018. All of them have a PCI label in the 3rd PCi list published in 2017:

- New northern interconnection between Portugal and Spain in Minho\Galicia regions due to be commissioned by 2020/21, and part of the TYNDP 2018 Reference Grid;
- Biscay Gulf project between Spain and France due to be commissioned by 2025, and part of the TYNDP 2018 Reference Grid, that should bring 2.2 GW extra capacity;
- Navarra Landes and Pyrénées Atlantiques-Aragon between Spain and France that could bring together up to 3 GW extra cross-border capacity beyond the 2025 horizon;

[4] "Increases already identified in TYNDP2016" refers to the reference capacities of TYNDP 2016 for 2030 which for some borders had been adjusted for the TYNDP18 purpose. Projects commissioned in 2020 are not included as increases.

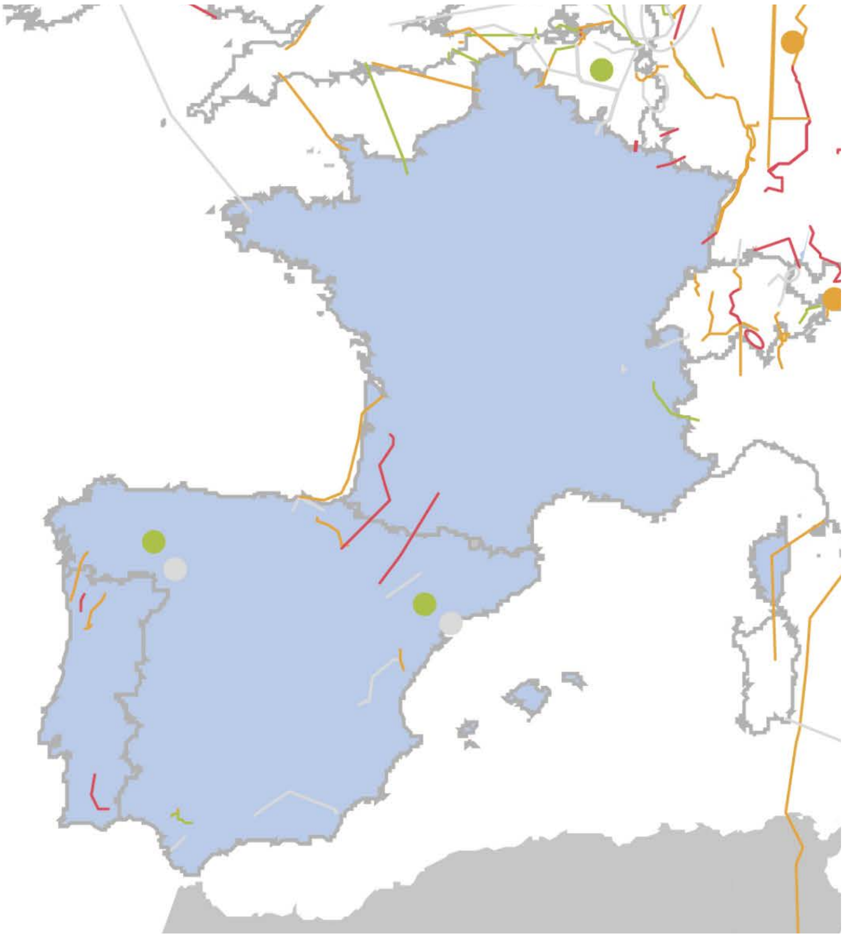

Figure 1-3: Projects to be assessed in TYNDP CBA analysis

Beyond these projects, there are still some gaps with the 2040 scenario capacities obtained in the Identification of system needs, especially in the Spain-France border. Its analysis still needs to be investigated in future releases of the TYNDP. By now it is not robust enough, so it seems too soon to propose any additional project in this border. In addition any proposal need to cope with the evolution of already planned projects, as there would be interactions among them. To summarize, some future additional projects could be considered in the future in case the trends identified in the scenarios are confirmed in the coming years.

The CBA assessment will be performed for those cross border projects previously mentioned, some internal projects and some storage projects too; all of them pumped storage units:

- Purifying Pumped Hydroelectric Energy Storage P-PHES Navaleo, in León
- Purifying Pumped Hydroelectric Energy Storage P-PHES Cúa, in León
- Reversible Pumped-Storage Hydroelectric Exploitation Mont Negre , in Zaragoza
- 2 reversible hydroelectric plants Gironés & Raimats, in Tarragona

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 Regional Investment Plan every two years. TSOs may take investment decisions based on that Regional Investment Plan. ENTSO-E shall provide a non-binding community-wide ten year network development plan which is built on national investment plans and 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.

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

- 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 EC’s 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 in 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;
- Organizations having a key function to disseminate energy related information (sector organizations, 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 Regional Investment Plan (RgIP) 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 Monitoring report, a Pan European Systems needs report and six Regional Investment Plans.

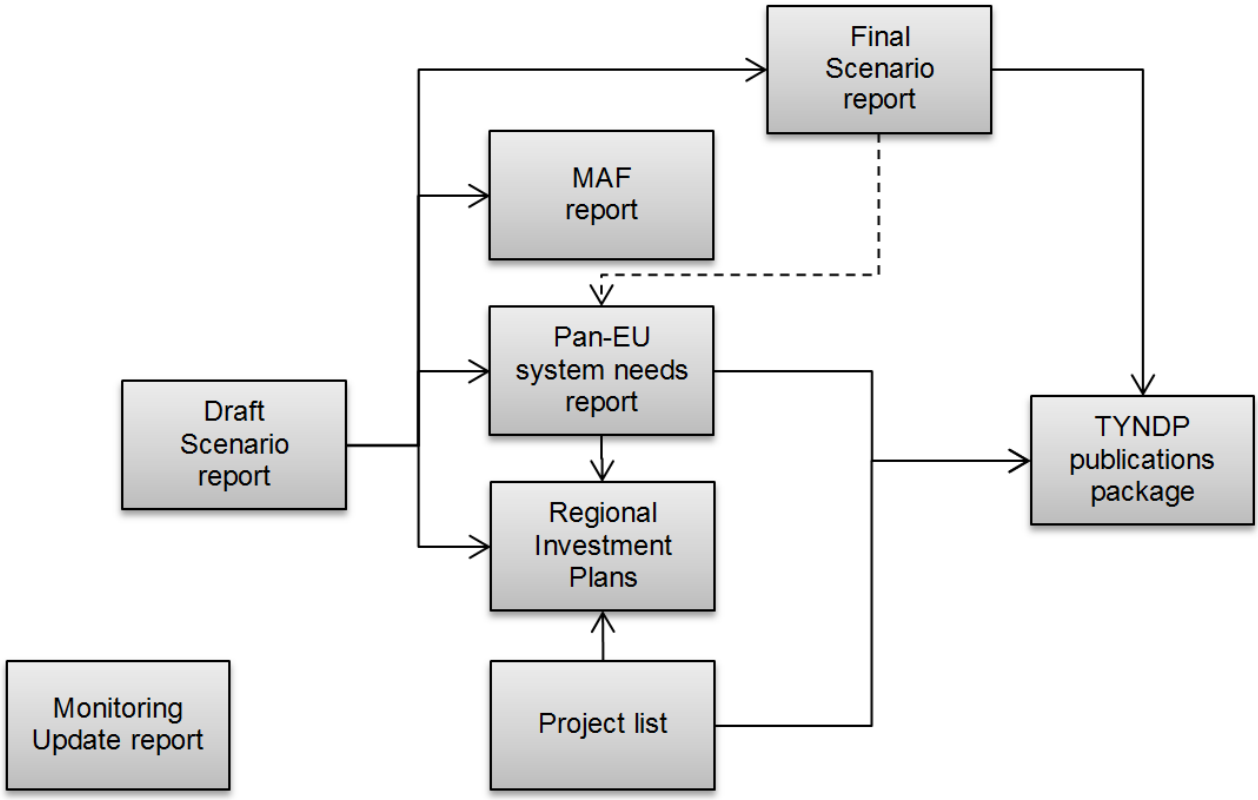

Figure 2-1: Document structure overview TYNDP2018

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

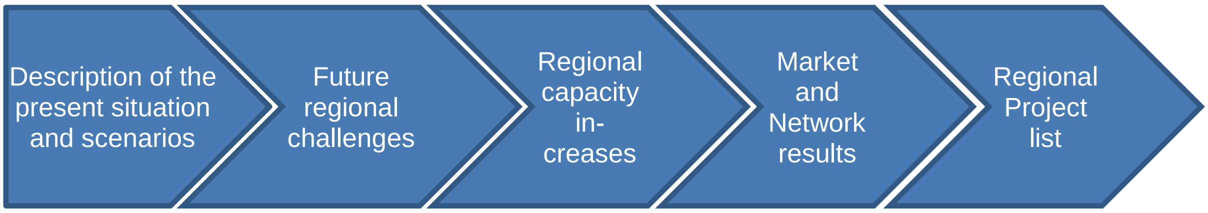

Figure 2-2: Mitigating future challenges – TYNDP Methodology.

As one of the solution 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 mitigating these challenges.

The current document comprises seven chapters with detailed information at 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 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. Also the future challenges of the region are presented in that chapter when describing the evolution of generation and demand profiles in 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 main results from market and network point of view.
- 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 Pan-European level as well as important regional projects not being part of the European TYNDP process.
- Finally Chapter 8 (appendix) includes abbreviations and terminology used in the whole report as well as additional content and detailed results.

The current edition of this Region Investment Plan takes into account the experience from the last processes including improvements, in most cases received from stakeholders during last public consultations, such as:

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

The actual Regional Investment Plan does not include the 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 Regional Investment Plans build on the results of studies called "Identification of System Needs" which were carried out by a European team of market and network experts coming 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, security of supply 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.

2.4 Introduction to region

The CSW 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 regional group are shown in Figure 2-3 below.

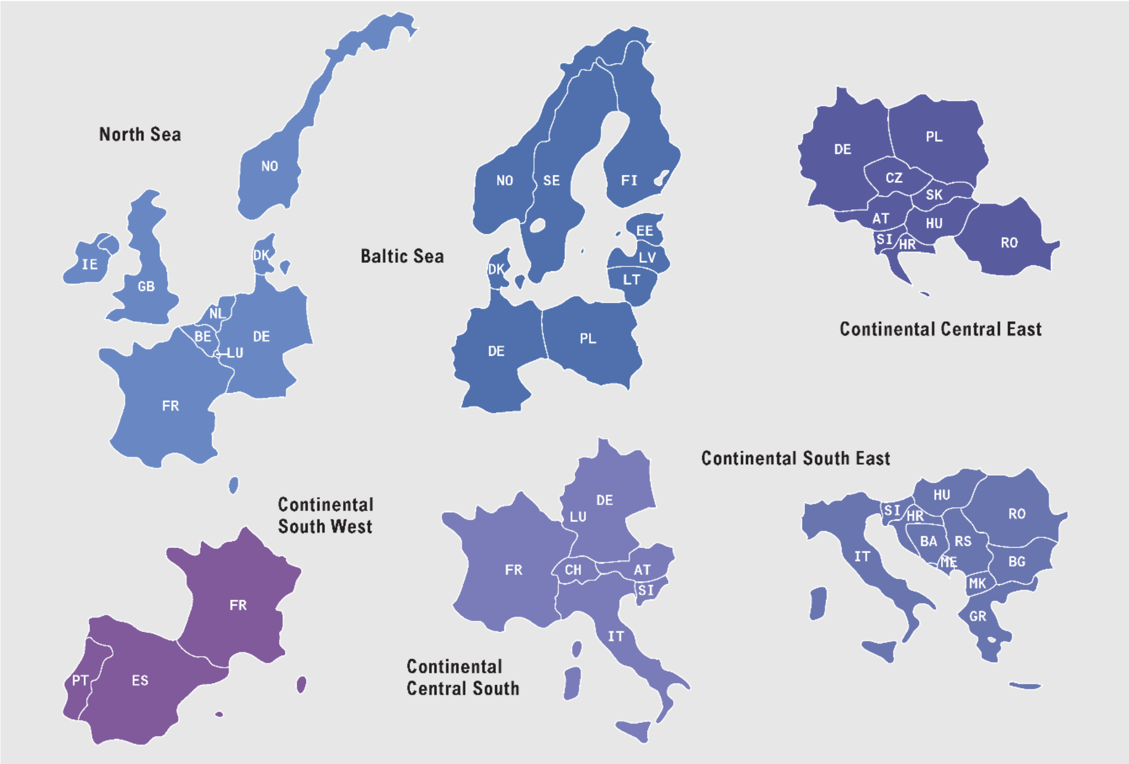

Figure 2-3: ENTSO-E regions (System Development Committee)

The CSW Group comprises three countries which are listed, along with their representative TSO, in table 2-1.

Country	Company/TSO
France	RTE
Portugal	REN
Spain	REE

Table 2-1: ENTSO-E Regional Group Continental South West membership

The CSW group is facing two main challenges related to the transmission infrastructure development currently addressed by the three countries involved: the completion of the Iberian Electricity Market (MIBEL) through the reinforcement of Portugal-Spain interconnection, and the integration of the Iberian Peninsula to the European continental market, through the development of the France-Spain interconnection. This is a today challenge that remains in the future, independently of the generation scenarios considered.

There is a political support to those cross border reinforcements, both at European and national level:

Within a European approach, with the regulation:

- The European Council established on 15 and 16 March 2002 the objective of reaching a minimum interconnection ratio of at least 10% of the installed generation capacity in every Member State[5]. In the case of Spain, this ratio is expected to amount to around 6% by 2020.
- The European Council of October 2014[6] endorsed the proposal by the European Commission of May 2014[7] to extend the current 10% electricity interconnection target (defined as import capacity over installed generation capacity in a Member State) to 15% by 2030 "*while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions*".
  To make the 15% target operational, the European Commission decided to set up a Commission Expert group on electricity interconnection targets, to provide technical advice. The conclusion of this group were published in November 2017 in the report "Towards a sustainable and integrated Europe"[8].

Within a regional approach, involving governmental commitments and facilitation groups:

- In March 2015 the Declaration of Madrid of the Energy Interconnection Links Summit among the Governments of Spain, France, and Portugal, the EC and the European Investment Bank gave support to ongoing regulations and TSOs studies. The Declaration of Madrid highlights the urgency of fulfilling the 10% objective and conducting further investigations aiming at developing and following-up on the electrical interconnection projects in order to reach 8 GW capacity for the France-Spain border.
- A high-level group with the European Commission, the National Regulatory authorities and the TSOs to monitor closely the progress of the works.

All this support allowed recently, for instance, that on 21 September 2017, French and Spanish regulators agreed on the financial scheme of a new interconnector via Biscay Gulf, which is an important boost to the cross-border development.

[5] The COM (2001) 775 establishes that "all Member States should achieve a level of electricity interconnection equivalent to at least 10% of their installed generation capacity". This goal was confirmed at the European Council of March 2002 in Barcelona and chosen as an indicator the EU Regulation 347/2013 (annex IV 2.a) The interconnection ratio is obtained as the sum of importing GTCs/total installed generation capacity

[6] Council Conclusions of 23 and 24 October 2014 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf

[7] COM(2014) 330 final.

[8] https://ec.europa.eu/energy/sites/ener/files/documents/report_of_the_commission_expert_group_on_electricity_interconnection_targets.pdf

3 REGIONAL CONTEXT

3.1 Present situation

3.1.1 Transmission grid and exchange capacities in the region

The interconnected network in the Continental South West Region is a synchronous network with the rest of the Central Europe, for which the main issue at stake is the low interconnection capacity of the Iberian Peninsula with France, compared to the overall interconnection capacity of the CSW region with its continental neighbouring countries (Belgium, Germany, Switzerland and Italy), themselves interconnected through the European 400 kV.

Due to the low interconnection capacity, Iberian Peninsula has been historically considered as an electric island, and therefore while this isolation is being reduced with a reinforced interconnection with France, it has also developed an internal highly meshed system in order to try to be stronger to withstand potential incidents.

Within the CSW region, the AC transmission voltage levels are 400 kV (380 kV in France) and 220 kV (225 kV in France), while voltage below 220 kV are considered distribution, except for Portugal where 150kV is also considered transmission. There are two HVDC connections in the region, one in service since 2010 that connects Spanish Mainland with Mallorca (the main island of the Balearic Islands in the Mediterranean Sea) and another one in service since 2015 between Spain and France in the eastern part of the border.

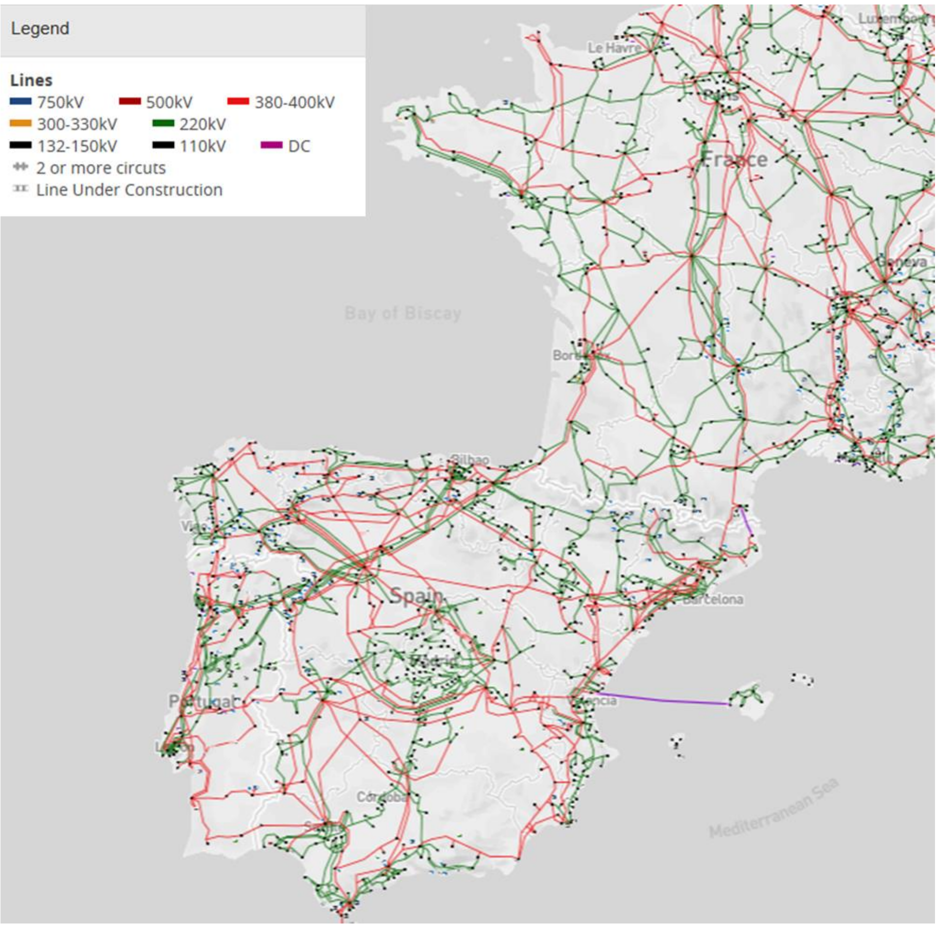

Figure 3-1: Interconnected Network of the Continental South West

The following map shows the Net Transfer Capacities (NTC) in the CSW region. The NTC is the maximum exchange program between two adjacent control areas that is compatible with security standards and applicable in all control areas of the synchronous area, whilst taking into account the technical uncertainties on future network conditions. The values represent ranges of the maximum capacity available. In real time operation, those values can vary by one hour to the other based on the availability of grid elements, changes in generation portfolio and new expected flows previously unplanned.
The figure shows the ranges of average and maximum values of NTC (in MW) based on historical values of 2016 and 2017.

Figure 3-2: Commercial Exchange Capacities in the Continental South West Region and with Morocco (non ENTSO-E)[9]

After the failure of completion two successive 400 kV AC projects, resulting in more than 30 years without new infrastructure in the France-Spain border, and the ensuing recommendation of a European mediation to resort to DC underground technologies in 2007, a new DC interconnection was commissioned in June 2015. This former TYNDP project is an HVDC connection between Santa Llogaia in the Gerona area in Spain, and Baixas in the Perpignan area in France.

After two years in operation, the historical data show that the NTC has more than doubled in both directions compared to values before this project, and power flows have also increased in similar proportions. In fact, the use of the market agents of this capacity also shows how it contributes to a higher market integration. The congestion in the border, that is the % of the hours that the market agent's interest reached the maximum NTC has decreased from around 11 percentage points, even though congestion still

[9] Source: TSO websites : http://www.mercado.ren.pt/EN/Electr/MarketInfo/Interconnections/CapProg/Pages/MktSession.aspx and http://www.esios.ree.es/

occurs around 75% of the time, and the average price differences are still in the order of 10-15 €/MWh[10]. Furthermore, the congestion income is now almost twice higher than before the HVDC (207 M€ in 2016 and 2020 M€ in 2017) mainly due to a doubled cross border capacity, and the cross border balancing energy is now almost 3 times higher than before the interconnection.

In the Spanish-Portuguese border, NTC values allow a high integration. However, some constraints still occur to achieve the main political goals of 3000 MW NTC, established for reaching a complete operational Iberian Electricity Market (MIBEL), especially in the direction from Spain to Portugal. Moreover in 2016 the congestion rate was 8%, and average price differences were 0.23€/MWh, with some maximum values above 21€/MWh.

The Continental South West region is also interconnected with Morocco, which is a non-ENTSO-E country, through 2 submarine AC cables of 400kV with a thermal capacity of 700 MW each. Current NTC values between Spain and Morocco have not changed since the commissioning of the second cable in 2006. These NTC values are 600 MW from Morocco to Spain and 900 MW from Spain to Morocco. This border experiences high and increasing flows from Spain to Morocco for almost all the hours of the year.

3.1.2 Generation, consumption and exchange physical flows in the region

The following figures report the details of the generation mix, in terms of installed capacity, annual generation and balances in 2016 and its comparison to 2010.

Maximum consumption, i.e. peak load, in the region has decreased in this 2010-2016 period mainly driven by the financial crisis, although responsibility can also be attributed to energy efficiency measures. On the other hand, the installed capacity has increased in every country, mainly due to wind (11 GW) and solar (9 GW) but also hydro and other RES, and even in spite of decreasing installed capacity based on fossil fuels in Spain (-6 GW) and in Portugal (-2 GW).

[10] and maximum values of 37 €/MWh from Spain down to France and 810 €/MWh from France down to Spain, as well as other France's neighbors on 7 November 2016 from 18:00 to 19:00, as a result of a spot market spike in France with a background of low nuclear availability. This was the second occurrence of such a situation since 2010, the previous one was on 9 February 2012.

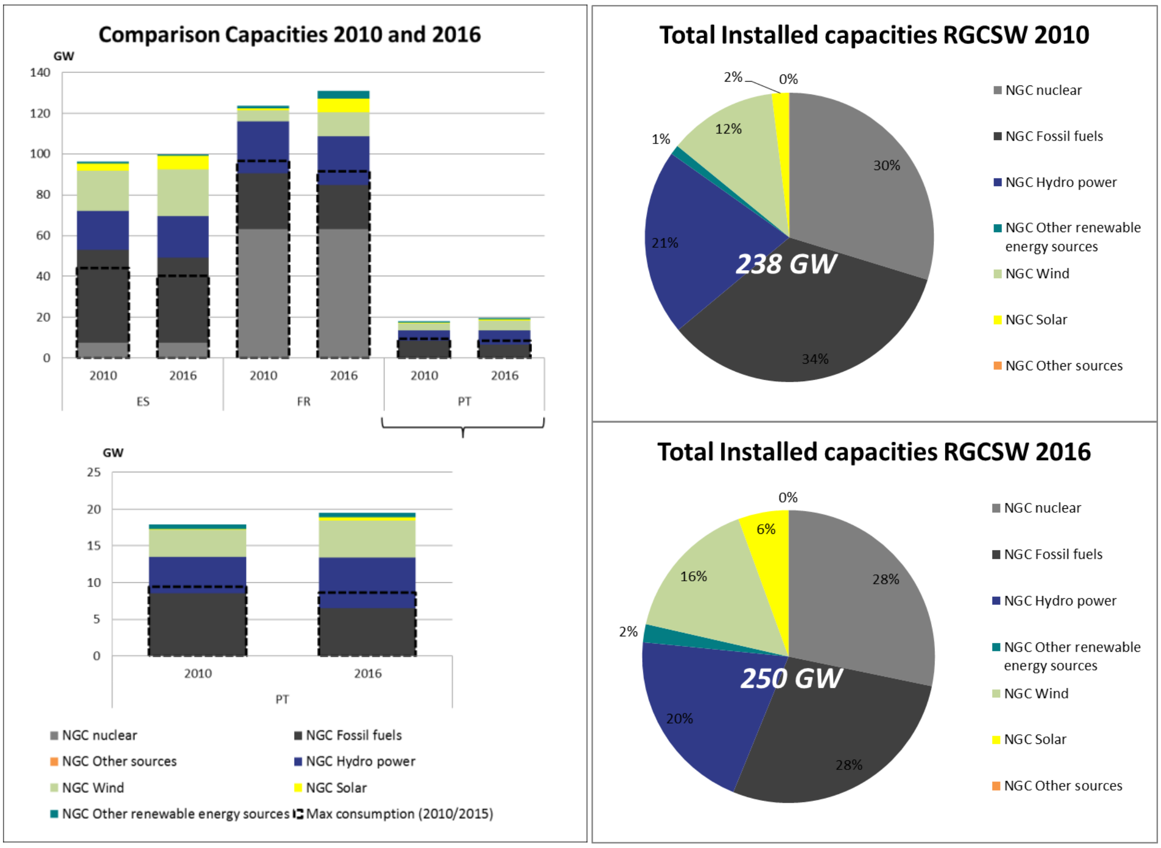

Figure 3-3: Installed generation capacities by fuel type and maximum consumption in the Continental South West Region in 2010 and 2016

Consumption in this 5 years period has decreased in Portugal and France, and have slightly increased in Spain. As for peak load, this was mainly driven by the financial crisis but also attributed to energy efficiency measures. Related to the decrease of demand, and in spite of higher exports in the region, regional production has slightly decreased: production of thermal generation has decreased more than 60TWh/y while RES has increased 34TWh/y.

Regarding country balances, that is, the equilibrium between generation and native demand, France remained net exporter in 2016 while Portugal and Spain have changed their net balances after a stable decade. In 2016 Portugal was net exporter (to Spain), while Spain was net importer, for the first time in ten years. This new trend remained in 2017.

As it can be seen in the figures, in the CSW region the main contribution to cover demand comes from nuclear energy which represents 54% of the total demand of the region (although only 28% in terms of installed capacity). Wind energy together with solar energy provide 13% of the demand while representing 21% of the total installed capacity. Overall share of RES (hydro included) supplied 29% of demand in 2016, 4 perceptual points more than in 2010.

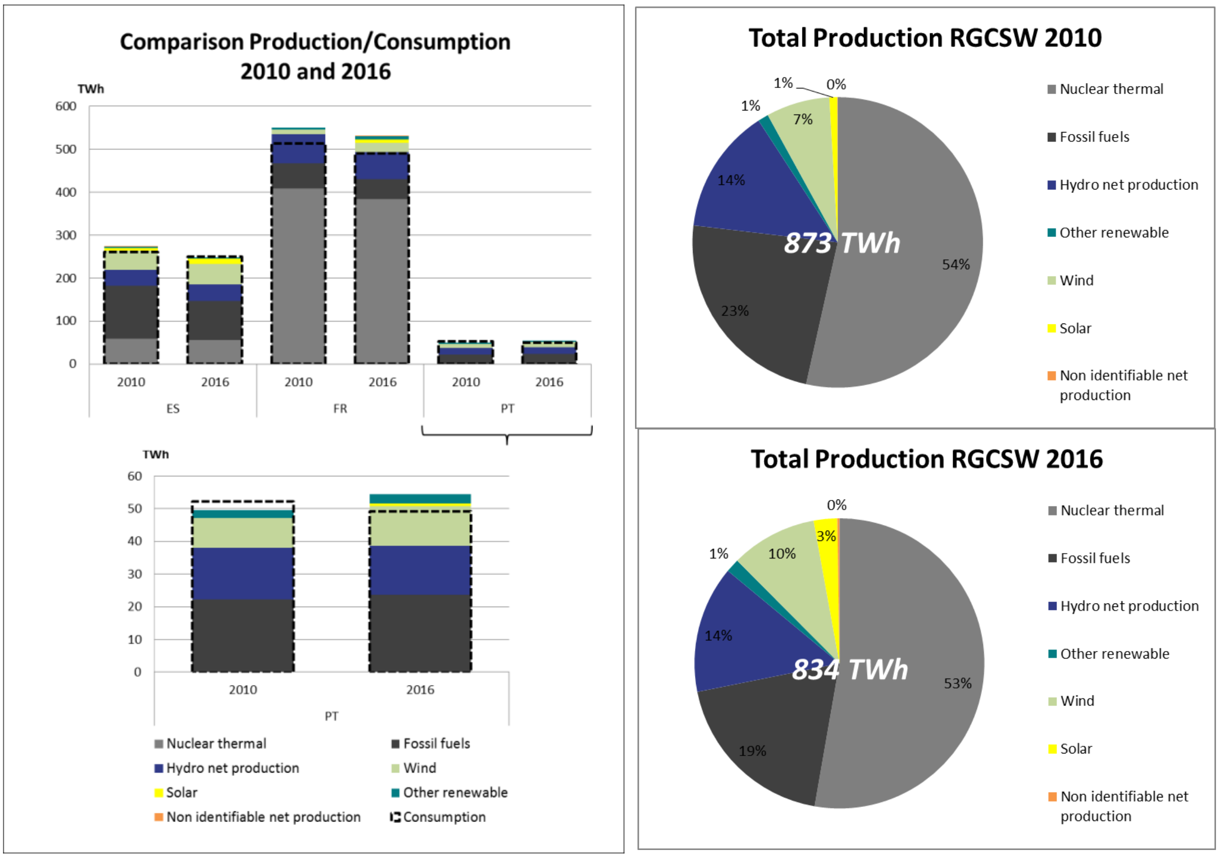

Figure 3-4: Annual generation by fuel type and annual consumption in the Continental South West Region in 2010 and 2016

Figure 3-5 shows that physical flows from 2010 has increased in almost all borders and directions of the CSW region. In the Portuguese-Spanish border it has increased in both directions due to the market interest and the commissioning of the southern interconnection between Algarve and Andalucía (in 2014). In the Moroccan-Spanish border the flows from Spain to Morocco have increased due to a result of higher consumption in Morocco and interesting prices in the MIBEL. On the other hand, the direction Morocco to Spain remains with no interest to be used.

The next figure also shows that French exports have been increased from 2010 to 2015 in all directions except Germany, whose RES exports have balanced the cross-border exchanges. Concerning French-Spanish interconnection whose exchange capacity has been doubled with the commissioning of Baixas-Santa Llogaia DC line in June 2015, the diagram shows a high increase from France to Spain and a reduction (divided by 2) from Spain to France; this shows that the new interconnector played its role of exchange increase depending of generation availability: sufficient availability of nuclear units in France in the second half of 2015 to support the Iberian balance by an increase of French exports, and too low wind conditions in Iberian Peninsula in the second half of 2015 to get extra wind generation and take benefit from the increase of cross-border exchange capacity. However, when absolute values of export and imports are added, they went from 5.5 TWh in 2010 up to 10.9 TWh in 2015, which in short means the cross-border exchanges doubled.

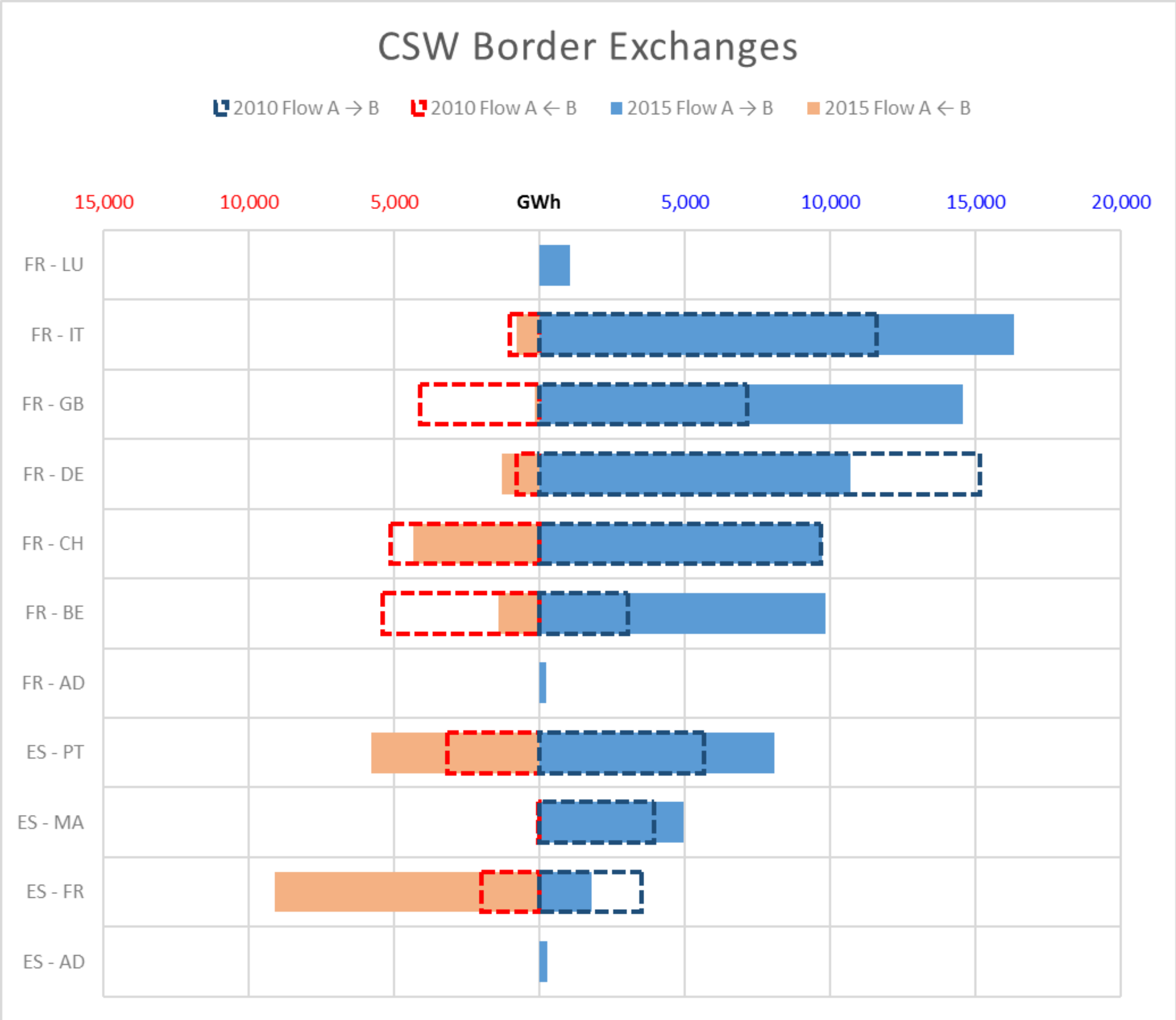

Figure 3-5: Cross-border physical flows (GWh) in the Continental South West Region in 2010 and 2015 years

Last, regarding adequacy, and the possibility suffer Energy Not Supplied situations, the ENTSO-E Winter Outlook 2007-2018[11] says that this winter January could be tense, especially in continental west Europe (including France) in case of a severe cold wave. During this period, remaining generation resources available in southern regions (Iberian Peninsula, Southern Italy, part of Balkans) could be not accessible to central and northern Europe due to cross border congestions. However, simulations show that adequacy issues could be fully mitigated by activation of strategic reserves across Europe. To summary, additional interconnection Iberian Peninsula-France could help France and central Europe to withstand this extreme climate situations, and avoid ENS.

3.1.3 Interconnection ratio in the region

The current interconnection capacity between Iberia and mainland Europe is too low to enable the Iberian Peninsula to fully participate in the internal electricity market.

[11] https://www.entsoe.eu/publications/system-development-reports/outlook-reports/Pages/default.aspx

The European Council established on 15 and 16 March 2002 the objective of reaching a minimum interconnection ratio of at least 10% of the installed generation capacity in every Member State[12]. In the European Commission's view, the EU energy policy goals and the 2020 and 2030 energy and climate targets will not be achievable without a fully interconnected European electricity grid with more cross-border interconnections, storage potential and smart grids to manage demand and ensure a secure energy supply in a system with higher shares of variable renewable energy. In this respect the gradual construction of the pan-European electricity highways will also be crucial.

In October 2014 the European Council called for speedy implementation of all the measures to meet the target of achieving by 2020 an interconnection level of at least 10 % of their installed electricity production capacity for all Member States.

At present, based on the EC "Communication on strengthening Europe's energy networks"[13] published on November 2017 the three countries in the CSW region are below the objective: Spain with a 6%, and France and Portugal with a 9%. In 2020 Portugal and France are expected to fulfil the 10% objective while Spain will still be in a range of 6-7%, still far away from the 10%.

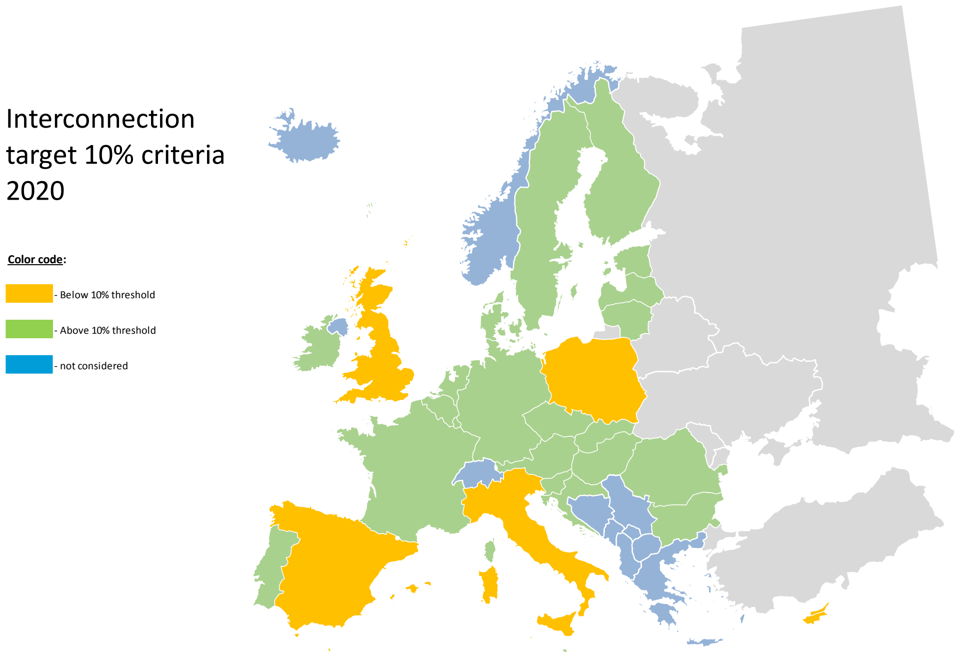

Figure3-6: Fulfilment of the 10% interconnection target in 2020 (source EC)

On the other hand, due to the peripheral situation of the region it is also relevant to report the interconnection ratio of the Iberian Peninsula as a whole, which is currently in the range of 2-3%, a very low value which will not improve for the 2020 horizon. The Iberian Peninsula will still be considered as an electric island.

[12] The COM (2001) 775 establishes that "all Member States should achieve a level of electricity interconnection equivalent to at least 10% of their installed generation capacity". This goal was confirmed at the European Council of March 2002 in Barcelona and chosen as an indicator the EU Regulation 347/2013 (annex IV 2.a) The interconnection ratio is obtained as the sum of importing GTCs/total installed generation capacity

13 COM(2017) 718 final https://ec.europa.eu/energy/sites/ener/files/documents/communication_on_infrastructure_17.pdf

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3.2 Description of the scenarios

The Figure 3-7 below gives an overview about the timely related classification and interdependencies of the scenarios in the TYNDP 2018 and shows the transition from the situation in 2020, including the time points 2025 and 2030, to the year 2040.

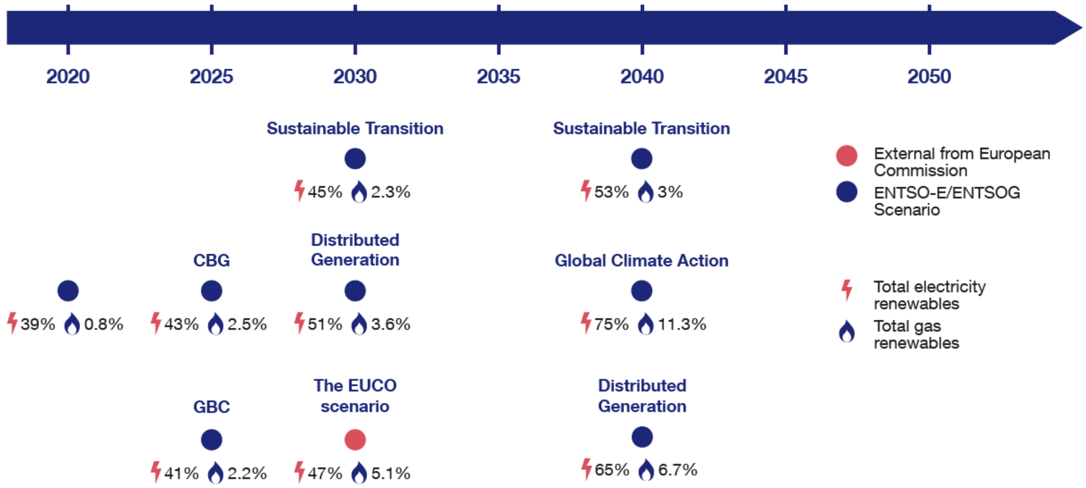

Figure 3-7: Scenario building framework indicating Bottom up and Top Down scenarios.

In 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 cost and benefit analysis. The methodology ensures a minimum adequacy of production capacity in the system giving a maximum of 3 hours energy not served per country (ENS).
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 TYNDP2016 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 was derived from the 2030 data base, as showed in the figure 3-7.

Scenario "Global climate action"

The "Global climate action" story line 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 Emission 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 best hydro, 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.

From a regional point of view the scenario "Global climate action" is based on a high growth of renewable energy sources (RES) and new technologies and with the goal to keep the global climate efforts on track with the EU 2050 target as shown in Figure 3-8. This scenario has the highest RES growth in the CSW region between 2025 and 2040, increasing overall solar capacity by 112 GW (of which 51% in Spain) and wind by 68 GW (of which 57% in France). In this scenario, some development of battery storage is expected along RES, although total installed capacity is below 8 GW in 2040.

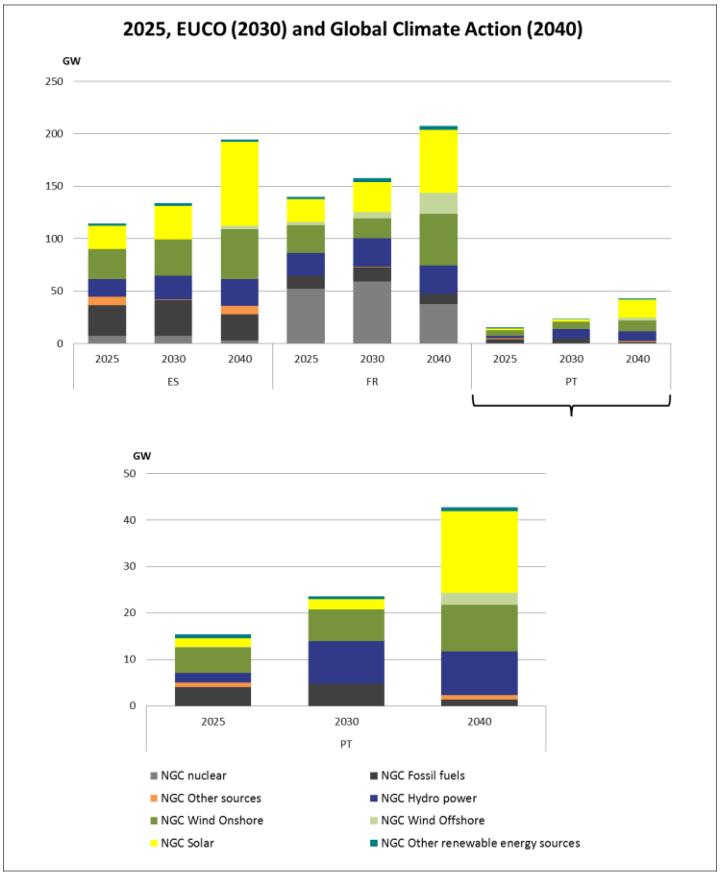

Figure 3-8: Installed net generation capacities at regional level in scenario “Global climate action”

Scenario “EUCO”

Additionally for the year 2030 there is a third scenario based on the European Commission’s (EC) 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 taking in to account current national policies, like 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 energy efficiency target of 30%.

Scenario “Sustainable Transition”

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

From a regional point of view the scenario “Sustainable Transition” is mainly assuming moderate increases of renewable energy sources and moderate growth of new technologies and in line with the EU 2030 target, but slightly behind the EU 2050 target (Figure 3-9). Nevertheless, in the CSW region, total solar capacity is to be increased between 2025 and 2040 by 55 GW (of which 59% in Spain) and wind power by nearly 49 GW (of which 65% in France).

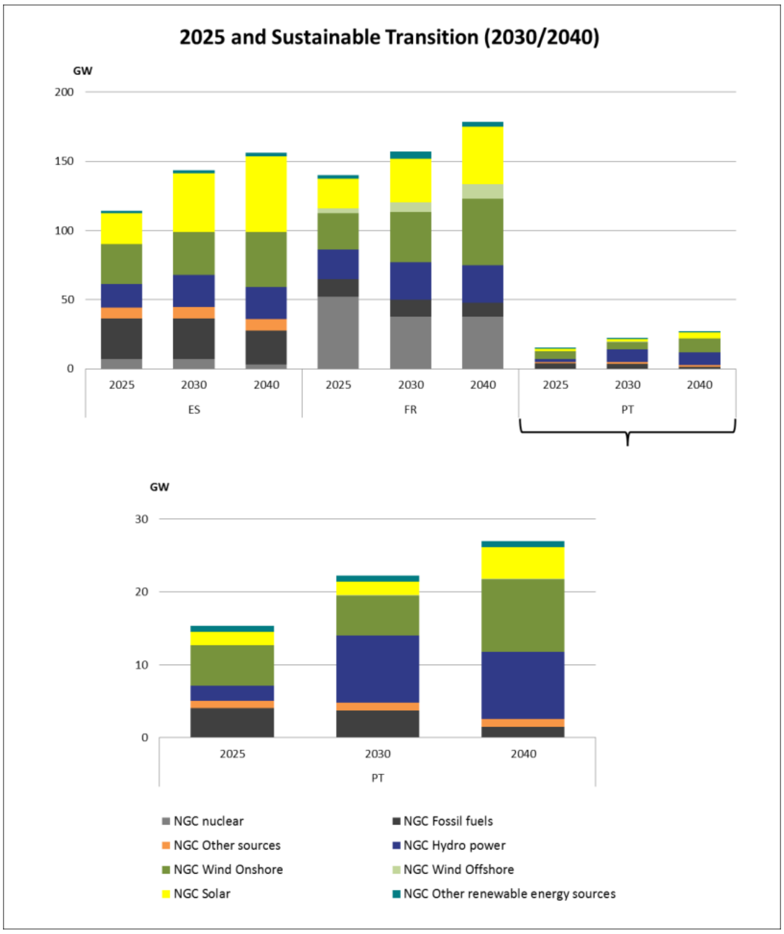

Figure 3-9: Installed net generation capacities at regional level in scenario “Sustainable transition”

Scenario “Distributed Generation”

In the "Distributed generation" story line, 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 EU on track to 2030 and 2050 targets. A “prosumer” rich society has brought into the energy markets, so society is engaged and empowered to help achieve a decarbonized place to live. As a result no significant investment in shale gas is expected.

From a regional point of view the scenario “Distributed Generation” covers a very high growth of small-size and decentralized 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, i.e. the EU 2030 and 2050 goals (Figure 3-10). This trajectory represents the second highest RES growth of the three between 2025 and 2040 in the region. While solar installed capacity is expected to be increased approximately by the same amount as in “Global Climate Action”, wind power growth is more moderate with 45 GW increase (of which 78% in France), meaning slightly lower than in “Sustainable Transition”. On the other hand, small-scale storage is expected to grow significantly along with RES, whereas total capacity reaches almost 39 GW in 2040 in the region.

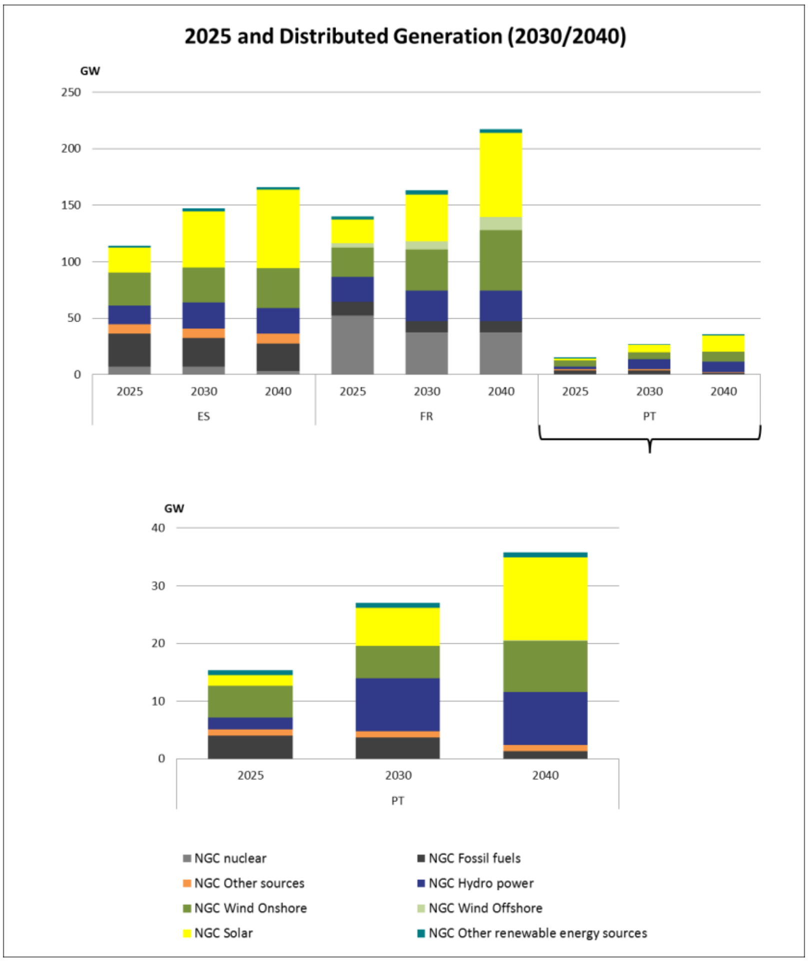

Figure 3-10: Installed net generation capacities at regional level in scenario "Distributed generation"

A more detailed description of the scenario creation is available in the TYNDP 2018 Scenario Report[14].

[14] TYNDP2018 Scenario Report: http://tyndp.entsoe.eu/tyndp2018/

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. 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 like:

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

3.3.1 Challenges from market studies approach

The figures 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 figures in chapter 4, showing the 2040 market data simulations combined with an appropriate 2040 scenario grid.

Additional future regional challenges are described as well.

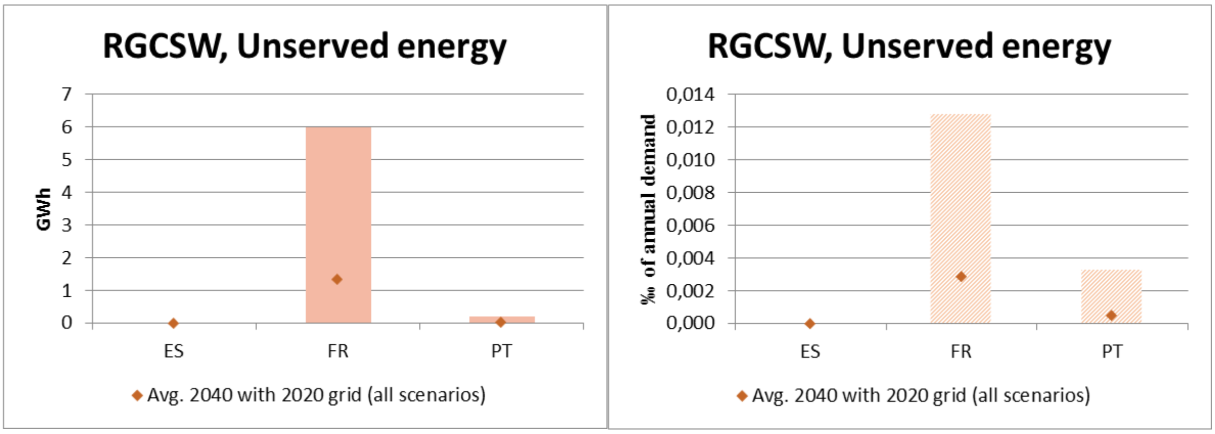

Figure 2-11: Unserved energy in the region for 2040 scenarios with 2020 grid

The previous Figure shows that with the 2040 scenarios in terms of load and generation, and the network expected for 2020, France could expect unserved energy due to the lack of projects expected to be commissioned in 2025-2030, such as; Celtic Interconnector (FR-IE), Biscay Gulf, FAB France-Alderney-Britain (FR-UK). No problem in the Iberian Peninsula is identified in this respect.

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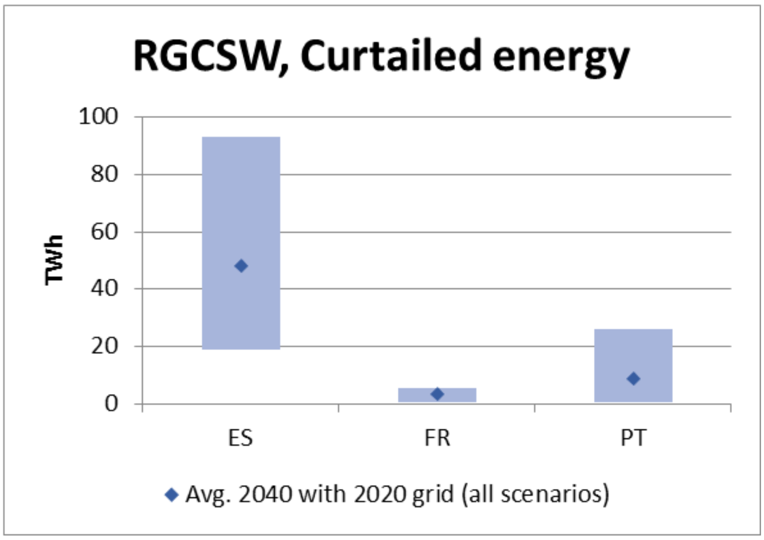

Figure 3-12: Curtailed energy in the region for 2040 scenarios with 2020 grid

Regarding RES integration, the previous Figure shows a high level of curtailed energy in the Iberian Peninsula, especially in Spain, with a background of 2020 network, for which the future projects (especially those to be commissioned 2025-2030) help to reduce the situation although are not yet helping solving all the spillage.

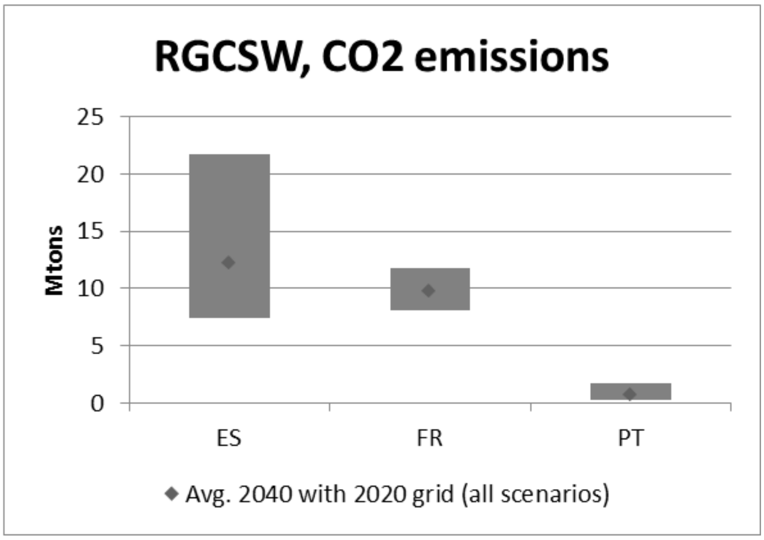

Figure 3-13: CO2 emissions in the region for 2040 scenarios with 2020 grid

Regarding emissions, with the scenarios 2040 in terms of load and generation, and the network 2020, the level of CO2 still reflects an imperfect level of RES integration. On the other hand, as a result of the scenarios themselves it is expected a very high reduction of CO2 specially in Spain and Portugal[15].

[15] Average CO2 emissions in the 2020 are expected to be 53,2 Mtons/y for ES, 9,6 Mtons/y for FR, and 11,5 Mtons/y for PT

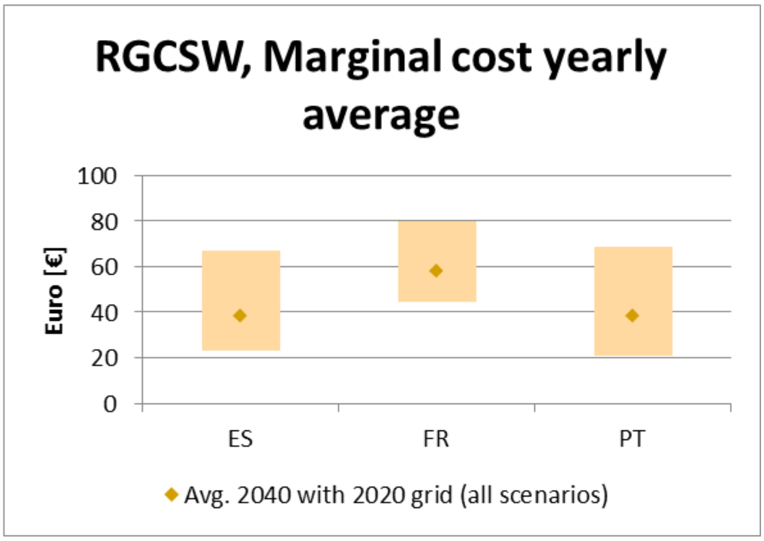

Figure 3-14: Marginal costs in the region for 2040 scenarios with 2020 grid

The previous Figure shows marginal cost yearly average with the 2040 scenarios in terms of load and generation, and the 2020 network. Values for Spain and Portugal are around 40 €/MWh while values for France are around 60 €/MWh. These values are coherent with the production considered in 2040 scenarios and with expectations of higher exports in long term future from the Iberian Peninsula to central Europe in order to integrate its high RES potential.

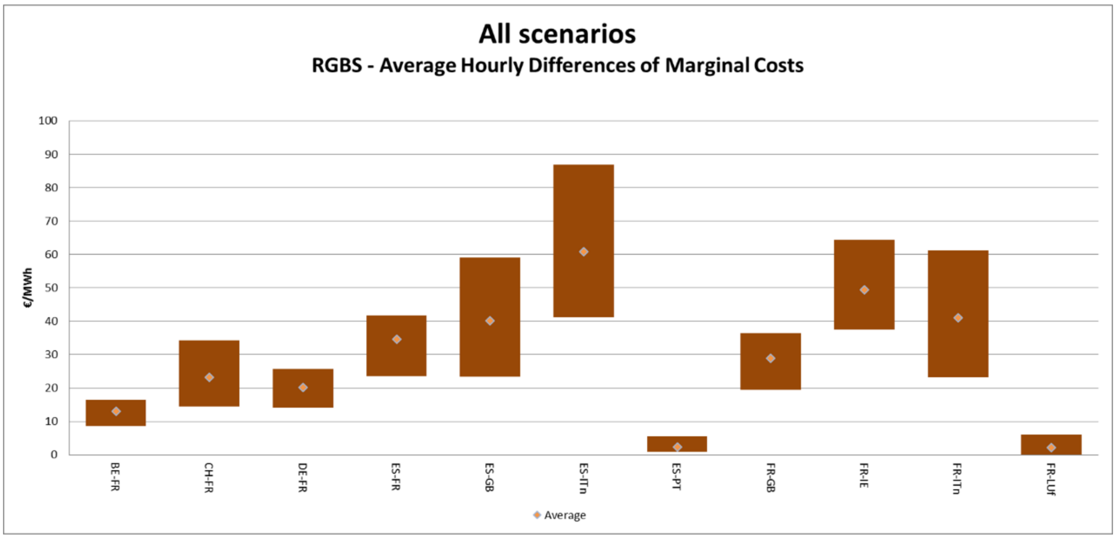

Figure 3-15: Average hourly price differences in the region for 2040 scenarios with 2020 grid

This Figure illustrates a low marginal cost spread in the Spanish-Portuguese border showing that MIBEL market will be quite well functioning, as the new Northern interconnection (to be commissioned around 2020/21) is already included in the 2020 network. However, the yearly average marginal cost spread[16] in the Spanish-French border is around 35 €/MWh, which illustrates the relevance of projects planned to be commissioned by 2025- 2030 and beyond in order to reduce the level of this spread and favour RES

[16] The yearly average marginal cost spreads is the yearly average of absolute values of costs spreads, then higher than the difference between yearly average marginal cost of two considered countries

integration in the Iberian Peninsula. On the other hand, the figure also shows that the spread Spain-Great Britain or Spain-Italy is higher than the Spain-France spread, at a level likely to trigger consideration of potential interconnection projects. However, as will be shown later in this report, the long distances between concerned countries and certain difficulties in the submarine routes especially in the Mediterranean sea are challenging to get economically justified projects as an outcome.

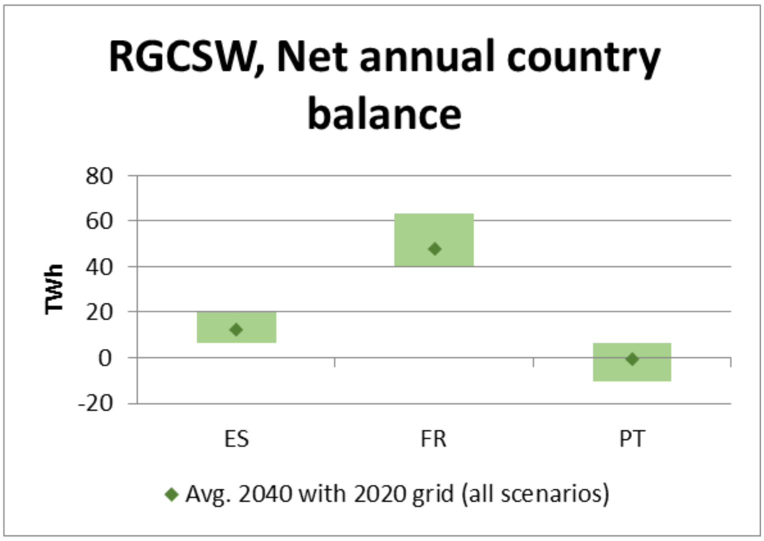

Figure 3-16: Net annual country balance in the region for 2040 scenarios with 2020 grid

The following figure 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 renewable energy sources (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.

The scenarios consider a high RES installed capacity that produces at zero marginal costs, and therefore tend to displace conventional generator units from the market. Unlike conventional generators with more expensive but controllable sources of primary energy, primary energy from RES has a variable and non dispatchable nature. The higher the RES, the higher the variations that can be considered as needs for flexibility in order to maintain the frequency equilibrium.

As the Figures show, the ramps in 2040 are much higher than today values, as their order of magnitude looks to be in the range of 4-5 times higher than current values, especially in Spain and France, which reflects the great challenge that these countries has to face related to system flexibility, bigger in case of non interconnection development.

Residual load ramps is an important issue in all studied scenarios and they will be further studied in TYNDP2018. One goal will be to guarantee the necessary volume of frequency reserves in all timescales for the cases of unforeseen generation and demand imbalances.

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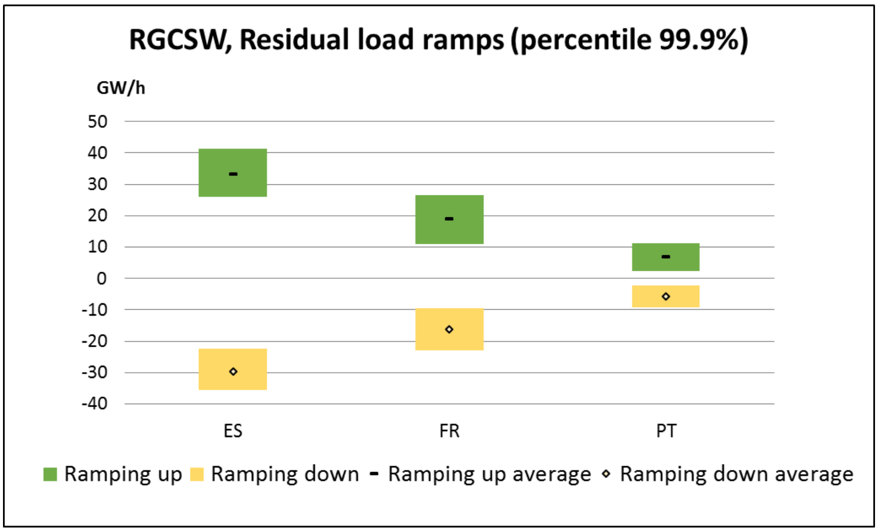

Figure 3-17: Residual ramp loads in the region for 2040 scenarios with 2020 grid

3.3.2 Challenges from network studies approach

The maps below show (Figure 3-18) network study results of the 2040 scenario market data implemented in a 2020 network model.

The upper left map first figure shows the level of 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. It highlights that actual cross border lines are inadequate. All cross-border lines between Spain and France would be congested in an N situation (except for the HVDC that as has controllability, it can limit the flows to a safe limit). In the case of the Portuguese-Spanish border some congestions would appear in contingency situation in the Tagus area and occasional congestions in Douro\Duero, Alentejo\Andalusia and Algarve\Andalusia areas.

The other maps show needs for internal reinforcements to make the scenarios feasible from the network point of view, that implies integrating the considerable amounts of additional renewable power generation, and accommodate not only new power flows profiles but also higher volumes, both internals and cross border.

As previously said, the high amount of RES (mainly solar) in Iberian Peninsula and south of France leads to many congestions on internal and cross-border lines in Spain, Portugal and France. Spanish and Portuguese solar generation will be probably mainly located in the south, so when solar generation production is high, the region experiences very high flows internally in the Iberian Peninsula from south to north and also to go through CSW region and towards Germany and Switzerland. The current network was not designed for these new power flows profiles. Therefore, a significant number of reinforcements are needed in order to alleviate those future congestions, being the Distributed Generation scenario the most critical input for the transmission network.

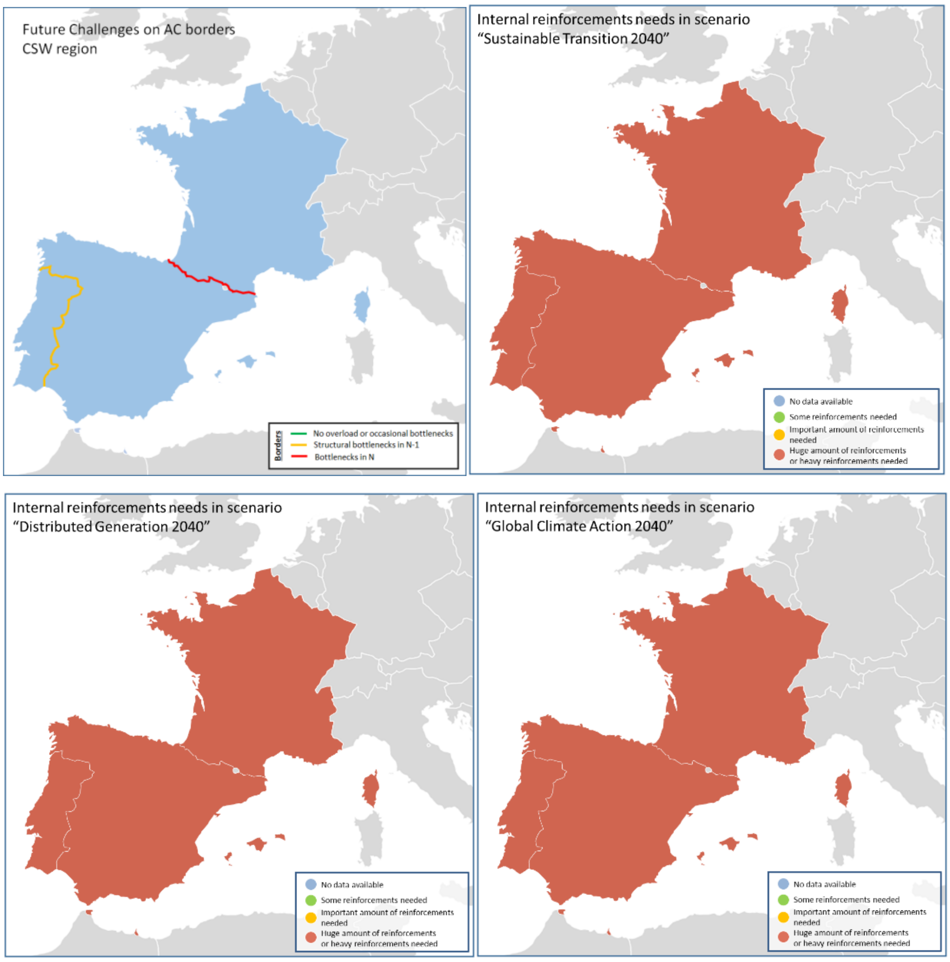

Figure 3-18: Future Challenges on borders and inside the countries

For the Portuguese system, the high solar generation mentioned previously leads to a change of the direction of the current predominant flows, changing from north to south to south to north. During day hours with high solar production, severe congestions may be found, and a significant number of network reinforcements are needed in order to alleviate those future congestions.

The following issues have been observed in the Spanish system:

- The high solar generation mentioned above leads to a change of the direction of the current flows, turning up from the south to the north.
- High flows appear from the south of Spain to the Douro area, causing severe bottlenecks in the Sevilla-Douro axis.
- There are also important congestions in the Spanish Douro axis, with flows heading from Portugal to the western Spanish-French border.
- The supply of big cities, especially Madrid and Barcelona implies harsh congestions in the feeding axis to this areas, as a result of a combined effect with the new long transit power flows.

For south west of France, lines between Toulouse and Montpellier are overloaded in case of high import from Spain and high RES generation. Moreover, in central France many lines are at a crossroads of many evolution of generation pattern.

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There are some projects included in chapter 7 as Regional projects that would allow to solve these future problems. However, it is too soon yet for defining with many details the reinforcements needed for 2040, as the volumes of RES and correct location of generation in the CSW region should be more certain.

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 process or in additional (bilateral or external) studies related to capacity needs. Subchapter 4.2 explains the regional market analysis results in detail, whereas subchapter 4.3 focusses on the network analysis results.

4.1 Future capacity needs

In preparation of the TYNDP2018, in order to ensure that project portfolio is sufficient to accommodate any of the TYNDP scenarios for 2040, ENTSO-E conducted a pan-European study in order to identify the system needs.

The aim of the joint study was to identify the needs for new cross-border capacity increases in the long-term time horizon triggered by market integration, RES integration, security of supply and interconnection targets, in a coordinated pan-European manner also building on the grid planners expertise of all TSOs.

For CSW region new cross border increases were tested according to the methodology for the borders Spain-France, Spain-Portugal, Spain-Italy and Spain-Great Britain. The outcome of the analysis is synthesized in the next figure and table.

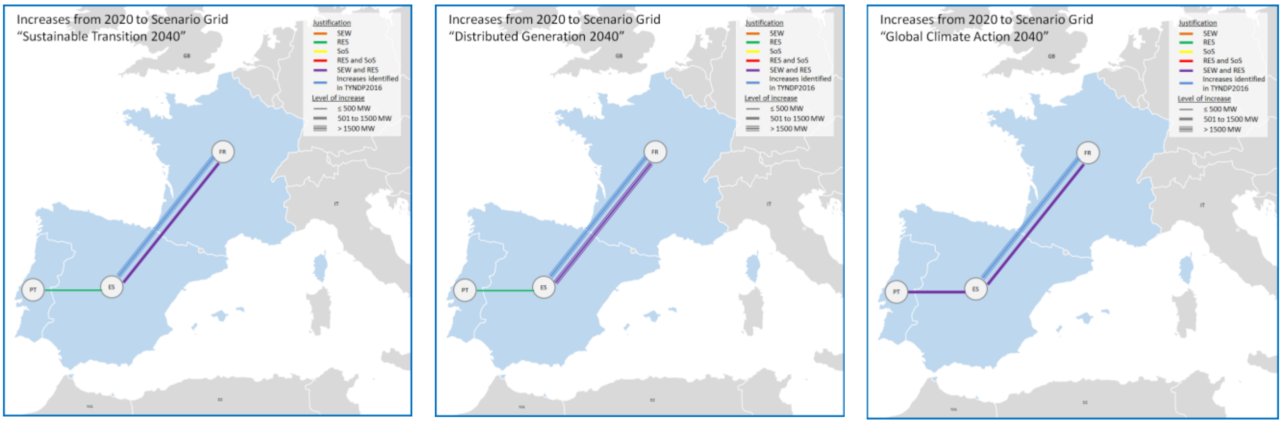


Figure 4-1: Identified capacity increase needs in the three studied 2040 scenarios in CSW region[17]

The maps above show the needs for cross-border capacity increases beyond the expected 2020 grid for every 2040 scenario. While mature projects from earlier TYNDP's have been added directly, other increases are shown with the need(s) they fulfil according to the "Identification of System Needs (IoSN) methodology": needs triggered by market integration (SEW) in first place and afterwards and in case not solved previously by security of supply (SoS) and/or renewable integration (RES) requirements.

The shown needs are based on simulations including standard cost estimates for every border investigated (ratio between costs and benefit can be decisive for choosing among potential reinforcements). An

[17] "Increases identified in TYNDP2016" refers to the reference capacities of TYNDP 2016 for 2030 which for some borders had been adjusted for the TYNDP18 purpose. Projects commissioned in 2020 are not included as increases.

overview of these standard costs can be found in appendix 8.1.4. Standard costs of the increases were assessed by expert view, taking as far as possible the specificity of the area (e.g. presence of mountain or sea), internal grid considerations as well as knowledge from previous projects at these borders (if any) into account.

From the market point of view, and considering the potential benefits of the NTC increases (only with a SEW approach[18]) and the estimated costs of those increases, the increase of capacities in the Spain-France border showed potential benefits if increased in the three 2040 scenarios in values from 5700 MW (ST and GCA) to 6900 MW (DG) from 2020 values. The increase of capacities in the Portugal-Spain border only showed potential benefits to be increased (1000 MW) in the 2040 GCA scenario from 2020 values, which included already the commissioning of the future Northern Interconnection. The estimated costs also affect results within the region, especially in Spain-France where it has been considered a cost of underground or submarine HVDC potential project to cross the border. The possibility of AC potential projects, although would give higher values although it could be unfeasible from the social point of view.

In addition, due to the high amounts of spillage in the region in all scenarios an increase of 500 MW in all borders was considered. However, it has to be noted that these increases do not solve the spillage in the region, but it is a way to communicate that interconnections would be an additional solution to this major challenge together with internal reinforcements, storage, etc.

The table below shows different cross-border capacities as identified during the TYNDP2018 process within the CSW region, and with the rest of Europe (i.e. French neighbours).

The first columns show the expected 2020 capacities. 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 "Identification of System Needs"-phase and are dependent on the scenario.

	NTC 2020		CBA Capacities		Scenario Capacities					
			NTC 2027 (reference grid)		NTC ST2040		NTC DG2040		NTC GCA2040	
Border	=>	<=	=>	<=	=>	<=	=>	<=	=>	<=
BE-FR	1800	3300	2800	4300	4300	5800	3800	5300	4300	5800
CH-FR	1300	3150	1300	3700	2800	5200	3800	6200	3800	6200
DE-FR	2300	1800	4500	4500	4800	4800	5800	5800	4800	4800
ES-FR	2600	2800	5000	5000	9000	9000	10000	10000	9000	9000
ES-PT	4200	3500	4200	3500	4700	4000	4700	4000	5700	5000
FR-GB	2000	2000	6800	6800	6900	6900	5900	5900	5900	5900
FR-IE	0	0	0	0	700	700	1200	1200	1200	1200
FR-ITn	4350	2160	4350	2160	4350	2160	4350	2160	5350	3160
FR-LUF	380	0	380	0	380	0	380	0	380	0
FRc-ITCO	50	150	150	200	150	200	150	200	150	200

[18] Other potential benefits included in the CBA methodology or beyond it are not considered. However, it is assumed that if the SEW benefit alone compensates the cost the capacity increases are economically viable

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

The reference grid is considered the starting grid for the CBA analysis in the TYNDP2018. It considers the most mature projects that are already under construction or have entered the permitting stage and are expected to be commissioned until 2027. It includes the Northern Interconnection between Spain and Portugal and the Biscay Gulf project between Spain and France.

From the table above it is possible to identify the gaps between the capacities from the current situation and reference grid and the scenario capacities resulting from the IoSN analysis.

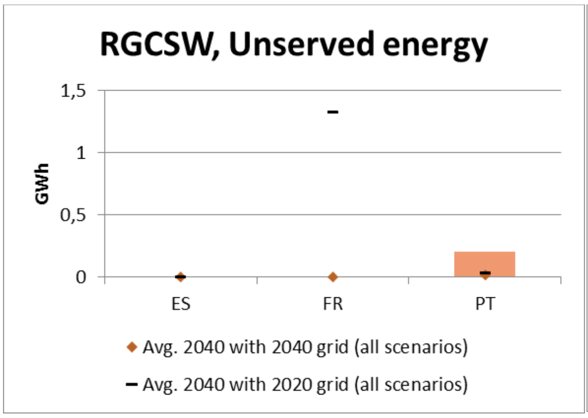
The border Spain-Portugal which considers the commissioning date of the future Northern Interconnection[19] by 2020/2021, has no additional project considered. There are some gaps with the 2040 scenario capacities that still need to be investigated in future releases of the TYNDPs, but up to now those analysis are not robust enough and so it seems too soon to propose any additional project in this border.

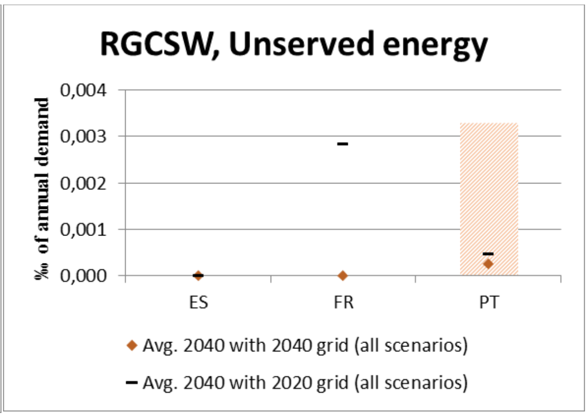
The border Spain-France considers the Biscay Gulf project in the reference grid on top of the 2020 situation. However, there is still a significant gap to fulfil the values identified for the 2040 scenario capacities. There are some projects already considered that are intended to reach a value of 8000 MW. The remaining gap still needs to be investigated in future releases of the TYNDPs, also looking for consistency with the evolution of already planned projects, so it seems too soon to propose any additional project in this border.

The borders Spain-Italy and Spain-Great Britain were considered as potential reinforcements in the Identification of system needs analysis but the cost considered for potential projects in those borders[20] did not compensate the SEW savings, so these borders were discarded. The long distances between concerned countries and certain difficulties in the submarine routes especially in the Mediterranean sea are challenging to get economically justified projects as an outcome.

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 cross-border exchange capacities.





[19] The expected value of NTC after the new northern interconnection is in the range 3600-4200 MW in the direction Spain to Portugal and in the range 3200-3500 MW in the direction Portugal to Spain. For the IoSN studies the upper limit was used.

[20] Additional information on cost in the Appendix 8.1.4

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

Figure 4-2 shows that there is no unserved energy in the CSW region across all 2040 scenarios with an improved interconnection network that reflects the scenario capacities values presented in the previous chapter. Therefore 2040 crossborder capacities in Europe allow up to 5 GWh reduction of Energy not served in CSW region.

On the other hand, curtailed energy resulting from high levels of renewable installed capacity is still expected, especially in Spain and Portugal. Average results show 30 TWh in Spain (ranging between 9-67 TWh), 5 TWh in Portugal (ranging between 0-17 TWh) and 2 TWh in France (ranging between 0-4 TWh). Network capacities increases in Europe from 2020 to 2040 (that is, already planned projects and additional identified interconnection needs in this analysis) allow to reduce the spillage in the region in a range of 9 to 39 TWh with an average of 15 TWh, especially in Spain (see Figures 4-3 and 3-12).

Long term copper plate simulation (that would represent no limit in interconnection capacity Europe wide) would show a level of spillage still relevant, which would mean that the spillage issue in a 2040 horizon cannot be solved only by interconnection reinforcements (due to the fact that spillage occurs in all countries at the same time). Therefore, further measures would be required in order to mitigate such energy spill, such as storage facilities, power to gas, etc ….

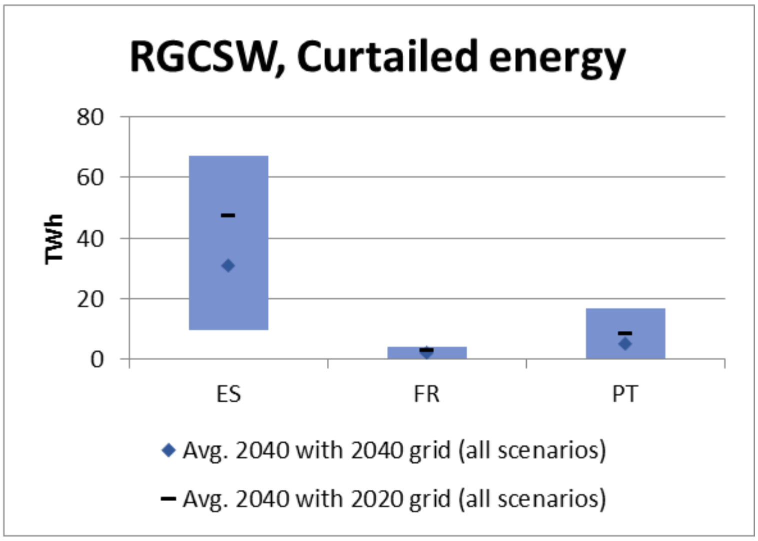


Figure 4-3: Curtailed energy in CSW region in the three studied 2040 scenarios with identified capacity increases

Regarding CO_2 emissions they greatly depend on scenarios, especially on RES share of capacity, whereas average results are 12 Mtons/y in Spain (ranging between 7-19 Mtons/y), 10 Mtons/y in France (ranging between 7-13 Mtons/y) and 0.5 Mtons/y in Portugal (ranging between 0-1 Mtons/y).). Cross-border exchange capacities increase Europe-wide from 2020 to 2040 allow to reduce the CO_2 emissions in the region in an average of 1.3 Mtons/y, especially in Spain.

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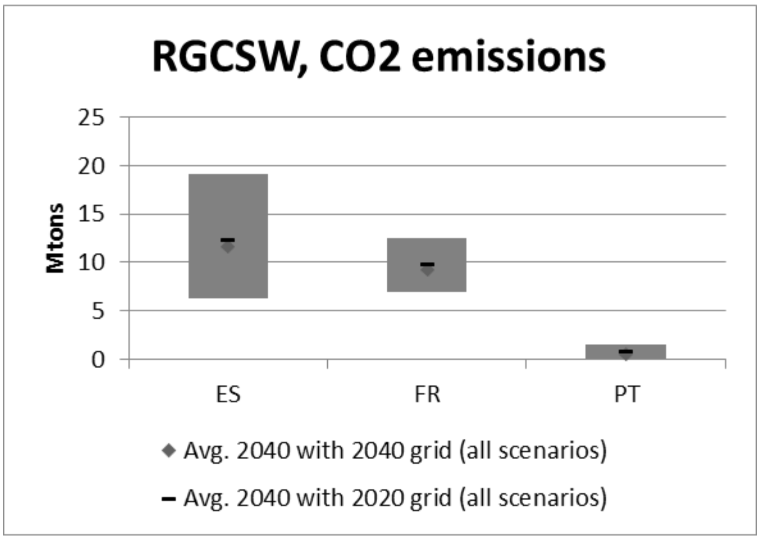

Figure 4-4: CO2 emissions in CSW region in the three studied 2040 scenarios with identified capacity increases

In terms of marginal costs, Spain and Portugal show approximate figures with average 43 €/MWh (ranging between 23-71 €/MWh), and generally lower than 55 €/MWh identified in France (ranging between 40-73 €/MWh). Again this reflects countries' generation portfolio, with Spain and Portugal showing higher RES levels. Cross-border exchange capacities Europe-wide increases from 2020 to 2040 enable an average reduction of marginal cost in France by 5 €/MWh (while in Spain and Portugal shows a slight increase).

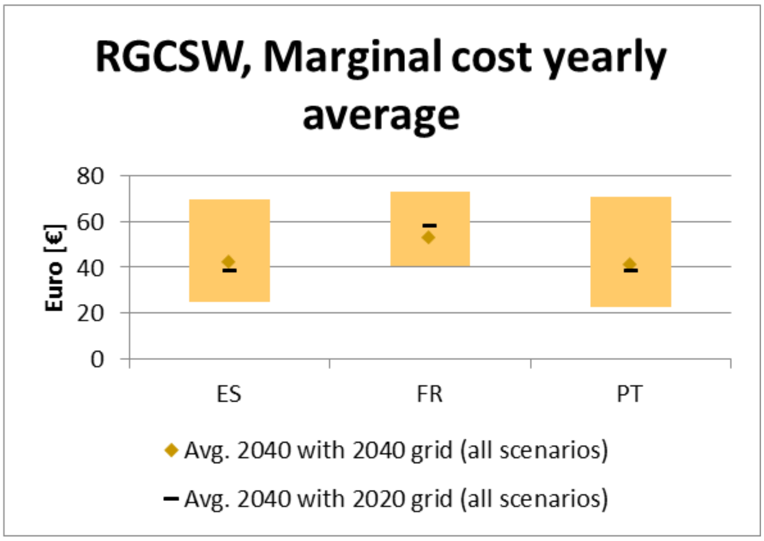

Figure 4-5: Yearly average of marginal cost in CSW region in the three studied 2040 scenarios with identified capacity increases

With foreseen 2040 grid, yearly averages Marginal Cost spreads [21] are expected to be reduced significantly in almost all borders in the region, by an average 26 €/MWh in comparison to a 2020

[21] The yearly average marginal cost spreads is the yearly average of absolute values of costs spreads, then higher than the difference between yearly average marginal cost of two considered countries

grid. The exception is the border between Spain-Portugal that generally maintain the same level of Marginal Costs. However, it should be noted that high differences are still expected within CSW and also between neighbours, as is the case of ES-FR (14 €/MWh), ES-GB (18 €/MWh), ES-ITn (29 €/MWh), FR-IE (15 €/MWh) and FR-ITn (19 €/MWh). Therefore, price convergence is still not reached.

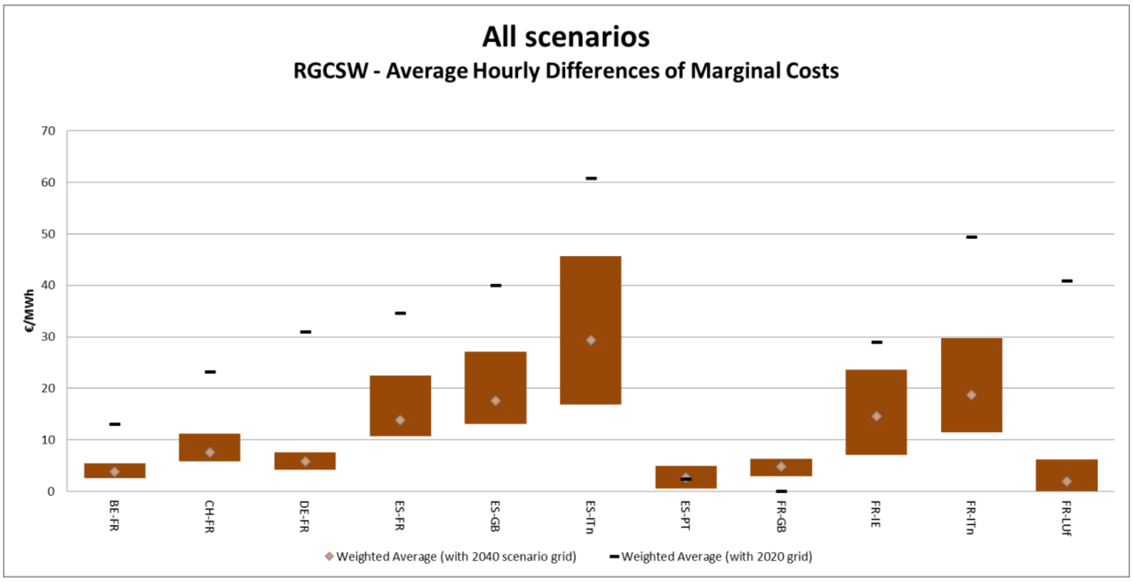

Figure 4-6: Average hourly price differences in CSW region in the three studied 2040 scenarios with identified capacity increases

Concerning country balances, Spain and France are always net exporters showing average exports of 25 TWh and 48 TWh, respectively. Portugal is slightly net exporter, but it can vary significantly depending on the scenario. Cross-border exchange increases from 2020 to 2040 are relevant to Spain in this matter as they enable the country to almost double its exports.

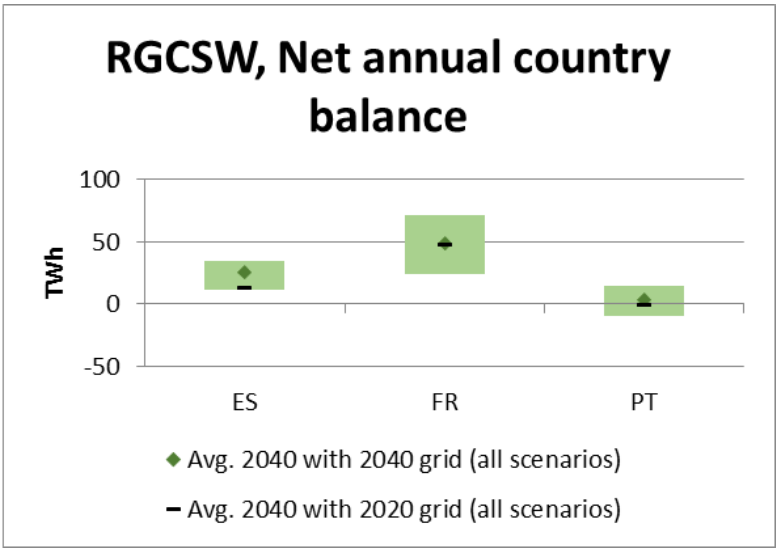

Figure 4-7: Net annual country balance in CSW region in the three 2040 scenarios with identified capacity increases

4.3 Network Results

Even with a grid including new projects expected between 2020 and 2030 as assessed in the TYNDP2016, the new TYNDP2018 scenarios for 2040 cause internal congestions. The maps below show the needs for additional internal grids reinforcements, beyond those identified to solve restrictions in chapter 3, for all three 2040 scenarios when combined with the identified 2040 cross-border capacity needs.

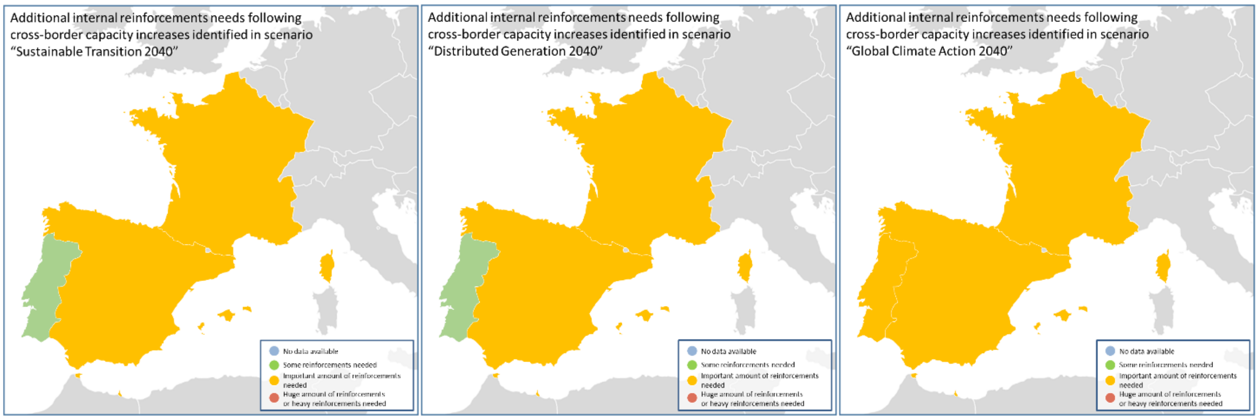

Figure 4-8: Impact of identified capacity increases on internal grid reinforcement needs in the three studied 2040 scenarios

For the Portuguese system, in the scenarios ST and DG no important reinforcements have been identified due to the identified 2040 cross-border capacity needs. For the GCA scenario a significant increase in the cross-border capacity was identified, resulting in additional congestions identified in the Douro region.

For the Spanish system, it is not trivial to separate the constraints that are due to the capacity increases in this exercise from those that are associated to RES integration, as many of them are very interrelated when the increase of cross border flows is due to higher RES production. However, there are three main congested areas in the three 2040 scenarios after the cross border capacity increases: the Sevilla-Douro axis, the Douro –France path and Southern Catalonia.

For the French system, in the scenario ST and GCA, there are less congestions than DG but the grid in south west and central France is often overloaded. In DG, a significant increase of cross border capacity was added, that results in additional congestions or deeper congestions.

However, it is too soon for defining in a detailed way the reinforcements needed due to the identified 2040 cross-border capacity needs, as the volumes of RES and correct location of generation in the CSW region should be more certain.

More detailed results from network studies (detailed map of congestions for the three scenarios) are presented in appendix 8.1.4.

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5 Additional Regional Studies

This chapter introduces not the only one but the most interesting regional study performed outside the ENTSO-E RGCSW cooperation.

Beyond the necessity to efficiently ensure balance between production and demand at any time, the future system will also need to be operable in real-time by TSOs. The changing environment radically transforms the way this will be done, leading to new technical needs for the system. It also increases both the interdependency of TSO processes to operate the system in a secure and efficient manner, and the need to take into account the challenges associated to the operation of the future system when designing the transmission network.
Individual characteristics and technology of the projects is a tool to face this operation challenge, and the reason of the importance of the following study.

5.1 Additional studies developed in the Spanish-French border

Biscay Gulf project consists on an HVDC corridor that will increase the capacity of French-Spanish electricity interconnection to 5GW import and export. Spanish and French TSOs are investigating the new dynamic behaviour of the power system when the Biscay Gulf project is in operation and the exchange capacity between France and Spain is increased.

REE and RTE have launched in 2017 common dynamic studies work, which aims to identify the issues related with dynamic performance of the network. Dynamic phenomena are very complex issues to detect so all these studies require many detailed data and a fully collaboration between RTE, REE, which is ensured under the Inelfe[22] umbrella.

This bilateral study has begun with an exchange of information of the networks, scenarios of study, modelling assumptions, and possible different hypothesis to consider in a future horizon beyond 2025, which is the expected commissioning date of the Biscay Gulf project. Taking into account the changing perspective of our power systems, it is important to consider a wide range of hypothesis for the possible development of the power system, in order the network models to be analysed are able to represent as much future possible situations as possible. Once the set of network models were agreed, RTE and REE have launched the work of simulation, results analysis and investigation on sensibilities, which has not yet concluded. These studies are being done separately by each TSO using the common models with specific software and data, and the results and conclusions are being shared, ensuring therefore robust and coherent results.

The main aim of these dynamic studies is to identify issues related with the dynamic response of the power systems, such as voltage and frequency instabilities, transient overloads, loss of synchronism of generators or network areas, and possible oscillation modes with a bad damping. One other issue is how to manage a peninsula with AC and DC links operated in parallel. working in paralell . The handling of the control conditionsmanagement of the existing HVDC Baixas- Santa lLlogaia and the future Biscay Gulf (together with the existing Phase Shift Transformers) and its interation have to be defined and be checked to ensure a safe system operation.

The common dynamic studies will be finished before the final releasing of the technical specification of the project as long as, if some dynamic issues are identified, some of them may be solved by means of setting requirements to the cable or HVDC converters in the specification of the project.

[22] https://www.inelfe.eu/

6 Links to national development plans

Portugal:

Complying with legislation, in March 2015, REN - Rede Eléctrica Nacional, S.A., submitted to the General Directorate of Energy and Geology (DGEG) a draft proposal for the Portuguese Ten-Year Development and Investment Plan for the Electricity Transmission Network for the period 2016-2025 (PDIRT 2016-2025).

Considering DGEG determinations, REN reviewed the PDIRT 2016-2025 and in June 2015 presented to DGEG a new PDIRT 2016-2025 proposal. This PDIRT 2016-202523 proposal was submitted to a public consultation promoted by the Energy Services Regulatory Authority (ERSE), between November 2015 and January 2016, with the purpose of gathering information and comments from different economic agents, consumers and other stakeholders.

After this public consultation period, in February 2016 ERSE issued its opinion on the PDIRT 2016-2025 proposal and after that, taking into consideration ERSE opinion, REN prepared a final PDIRT 2016-2025 proposal, which was sent to DGEG in April 2016.

In March 2017, REN submitted to DGEG a new draft proposal for the Ten-Year Development and Investment Plan, now for the period 2018-2027 (PDIRT 2018-2027).

Considering the DGEG determinations REN reviewed the PDIRT 2018-2027 proposal and in June 2017 sent to DGEG the new PDIRT 2018-2027 proposal.

Spain:

The current National Development Plan in Spain, named *"Planificación Energética. Plan de Desarrollo de la Red de Transporte de Energía Eléctrica 2015-2020*"[24] was published in October 2015 by the Spanish Government (Ministry of Industry, Energy and Tourism). In this process, the Spanish TSO (Red Eléctrica de España) acts as technical support for the Government.

The legal framework for this plan is the Law 24/2013 of the Electric Sector and the RD1047/2013 of remuneration of the transmission activity, where is it established the need to publish every 4 years a Master Plan which covers a period of 6 years, and an annual and a global investment limit. The 3-pillar objective for the National Development Plan is to ensure the Security of Supply, being sustainable, and do it at the minimum possible cost. Moreover, it allows Spain to fulfil the 2020 European energy objectives.

The Master Plan provides a list of binding transmission infrastructure for the next period 2015-2020 (f.i. substations including detail of new bays due to new connections of demand or generation, lines, transformers, reactive compensation, FACTs, etc.) and detailed cost benefit analysis for certain major projects. The Master Plan also includes in the Appendix 2 a list of projects that would be needed after 2020. These projects in Appendix 2 can start the permitting procedures although they should be confirmed in the next Master Plan.

[23] http://www.erse.pt/pt/consultaspublicas/consultas/Documents/53_Proposta%20PDIRT-E_2015/PDIRT%202016-2025%20-%20Junho%202015%20-%20Relat%C3%B3rio.pdf

[24] http://www.minetad.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

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France:

The French Schéma Décennal de Développement du Réseau (SDDR)[25] is published every year by RTE, in compliance with article L321-6 of the French Energy code, transposing the CE 2009-72 Directive. Along the lines of the energy code, "*SDDR is based on existing offer and demand as well as on reasonable mid-term assumptions concerning the evolutions of generation, demand, and cross-border electicity exchanges*". In addition, the SDDR has to mention "*main infrastructures planned in the 10 coming years*" and identify "*already decided investments due to be commissioned in the next three years*",

Furthermore, the Commission de Régulation de l'Energie (CRE, French Regulatory Energy Commission) has to check whether this SDDR covers all the investment needs and its consistency with the electricity TYNDP.

The latest SDDR, SDDR 2016, was published in January 2017 under its final version following a public consultation. It is consistent with the TYNDP 2016.

[25] http://www.rte-france.com/fr/article/transition-energetique-et-revolution-numerique-plus-de-10-milliards-d-euros-d

7 PROJECTS

The following projects were collected during the project call for TYNDP 2018. They represent the most important projects for the region. To include a project 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[26]. The chapter is divided in Pan-European and regional projects.

7.1 Pan-European projects

The map below shows all approved projects, submitted by project promoters during the TYNDP 2018 call for 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 Cost Benefit Analysis. A full table of all European projects submitted can be found at the TYNDP 2018 homepage.

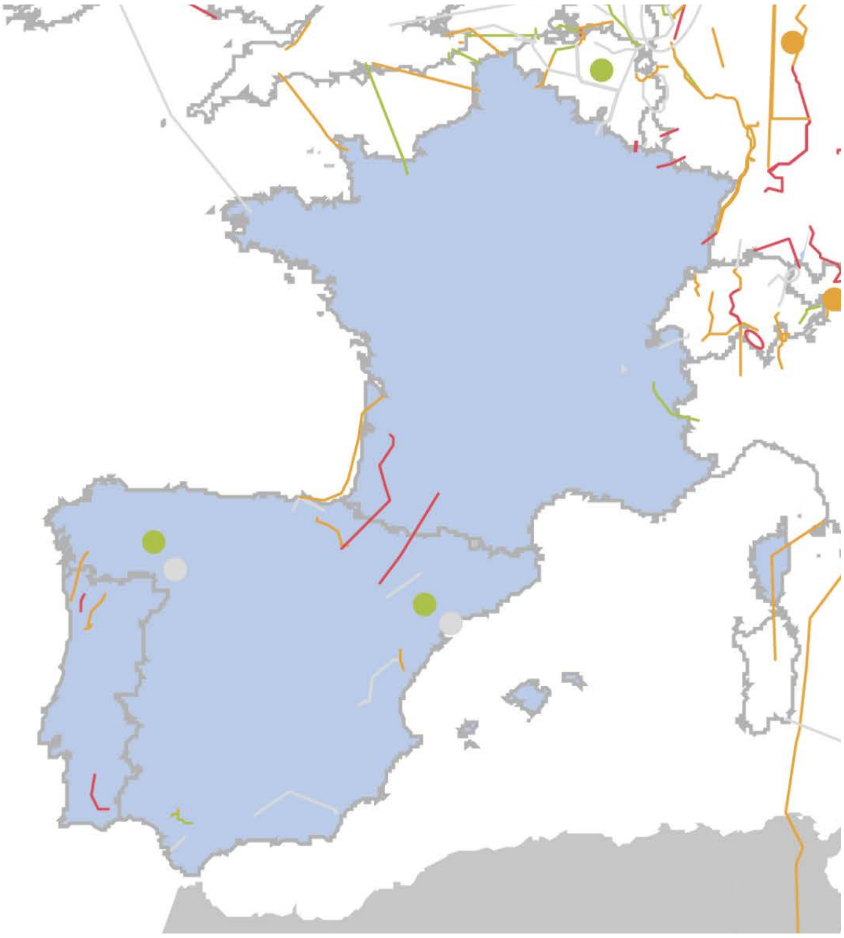


Figure 7-1 TYNDP 2018 Project: Regional Group CSW

[26] http://tyndp.entsoe.eu/tyndp2018/

7.2 Regional project

In this chapter the CSW projects of "regional" 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 appropriately description and the main driver, why they are designed to be realized in the future scenarios, together with the expected commissioning dates and evolution drivers in case they were introduced in the past Regional Investment Plans.

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 to be included.

In the table below projects of regional and national significance in CSW region are listed.

Country	Project Name	Investment		Expected Commissioning year	Description	Main drivers	Included in RgIP 2015?
		From	To				
FRANCE	Long Term perspective in Eastern France			>2027	Reconductoring or upgrade 220kV OHL as 400kV	Market and RES Integration	Yes
FRANCE	Lille-Arras	Avelin	Gavrelle	2021	An existing 30-km 400-kV single circuit OHL in Lille area will be substituted by a new double-circuit 400kV OHL.	SoS, RES integration The project aims at ensuring the security of supply taking into account RES generation volatility	Yes
FRANCE	Cergy – Persan	Cergy	Persan	2018	Upgrade of an existing 35-km 225 kV line to 400-kV between Cergy and Persan (north-western Paris area) and connection to Terrier via an existing 400kV line.	SoS, Market and RES integration	Yes
FRANCE	Havre - Rougemontier	Havre	Rougemontier	2019	Reconductoring of existing 54km double circuit 400kV OHL to increase its capacity.	Connection of new generation in Le Havre area	Yes
FRANCE	Sud Aveyron			2020	New substation on 400kV Gaudière-Rueyres for local RES integration. 2020 subject to its authorization	RES integration	Yes
FRANCE	Massif Central South	Gaudière	Rueyres	>2027	Upgrade of the existing 400 kV overhead line, under study	Security of supply, RES, Market integration	No*
FRANCE	Eguzon - Marmagne 400kV	Eguzon	Marmagne	2022	Reconductoring existing 400 kV OHL (maintenance), under study		No*
FRANCE	Façade Atlantique Upgrade of the North-South 400 kV corridor between Nouvelle-Aquitaine and Vallée de la Loire, under study			2030	Upgrade of the North-South 400 kV corridor between Nouvelle Aquitaine and Vallée de la Loire	RES, Market integration	No*
SPAIN	400 kV Madrid Ring (Moraleja-Segovia-Galapagar)	Moraleja	Galapagar	2025	Closure of the 400kV ring of Madrid	Security of supply	Yes

SPAIN	400 kV Asturias ring and Sama Velilla	Gozón	Velilla	2022-2027	This project consists of closing the 400kV Asturias Ring in the northern part of Spain, and comprises a new 400 kV OHL line between Gozón and Sama, with two new 400kV substations in Reboria and Sama (Spain) , which main purpose is support the distribution network. The connection Sama-Velilla intends to reinforce asturian connection with the centre of the country	Security of supply, market integration	Yes*
SPAIN	North Axis in Basque Country (Ichaso-Abanto/Gueñes)	Ichaso	Abanto and Gueñes	2020	New double circuit that consist on the lines Ichaso-Abanto and Ichaso-Gueñes	Market integration	Yes
SPAIN	Uprate of Transpireneean axis (Sabiñánigo-TEscalona-Escalona-TForadada – La Pobla)	Sabiñanigo	La Pobla	2019-2021	Uprate the OHL 220 kV axis Sabiñanigo-T- Escalona-Escalona-T-Foradada-La Pobla	Market integration	Yes
SPAIN	2nd link Spanish Mainland-Mallorca	Morvedre	Santa Ponsa	<2025	HVDC Subsea cable 2x500MW link from Valencia to Mallorca	Market integration, interconnection among asynchronous systems	Yes
SPAIN	Submarine connection Gran Canaria – Fuerteventura&Lanzarote			2025-2030	Subsea connection 2x100MW from Gran Canaria to Fuerteventura-Lanzarote	Market integration, interconnection among isolated systems	Yes
SPAIN	Submarine AC connection Spanish Mainland – Ceuta	Puerto de la Cruz		2022	Subsea AC connection 132kV link from Pto de la Cruz to Ceuta (in North Africa)	Market integration	Yes
SPAIN	Submarine connections in Balearic Islands	x	x	2022-2025	Several subsea AC connections at 132kV among the islands	SoS, market integration	Yes
SPAIN	Submarine connections in Canary Islands	x	x	2020-2022	Fuerteventura - Lanzarote 120MW132kV link and La Gomera - Tenerife 2x50MW 66kV link	Interconnection among isolated systems, SoS, market integration	Yes
SPAIN	RES integration in Canary Islands	x	x	2018-2020	Transmission network reinforcements (66kV, 132kV and 220kV)	RES integration	Yes
SPAIN	Reinforcement of southern Aragón-Cataluña axis	tbd	tbd	2025-2030	The detail of the reinforcement is not fully defined and it is pending of future National Development Plan	Market integration	
SPAIN	Reinforcement of the axis La Serna – Magallón 400 kV	La Serna	Magallón	2025-2030	The detail of the reinforcement is not fully defined and it is pending of future National Development Plan	Market integration	No
SPAIN	Reinforcement of the axis Guadaira – D.Rodrigo 400kV	Guadaira	D.Rodrigo	2025-2030	The detail of the reinforcement is not fully defined and it is pending of future National Development Plan	Market integration	No
SPAIN	Reinforcement of the axis Villaviciosa-Moraleja 400kV	Villaviciosa	Moraleja	2025-2030	The detail of the reinforcement is not fully defined and it is pending of future National Development Plan	Market integration	No
SPAIN	Reinforcement of the axis Aldeadávila – Villarino--Grijota-Herrera-Virtus (400kV)	Aldeadavila	Virtus	2025-2030	The detail of the reinforcement is not fully defined and it is pending of future National Development Plan	Market integration	No
SPAIN	TSCC in Pierola 400 kV	Pierola	Pierola	2024-2028	FACTS TTCC device in Pierola substation	SoS,	No
SPAIN	FACTs Statcom	x	x	2024-2028	FACTS Statcom devices in the substations of Vitoria, Carmona, Benahadux and Moraleja	SoS,	No
SPAIN	FACTs in northwestern Spain	x	x	2024-2028	FACTs in Mesón and Tibo	SoS,	No

SPAIN	Pumpings in Canary Islands	x	x	2025-2030	Pumping units in Soria-Chira (Gran Canaria) and Tenerife	RES integration, SoS	No
PORTUGAL	Falagueira-Fundão	Falagueira	Fundão	2018	New 400kV double OHL, with one 400 kV circuit installed between the existing substation of Falagueira and the future of Fundão.o	RES integration	No*
PORTUGAL	Falagueira-Estremoz-Divor-Pegões	Falagueira	Estremoz, Divor and Pegões	2019-2021	New 400kV OHL axis Falagueira-Estremoz-Divor–Pegões, including the new substations of Divor rand Pegões	SoS and RES integration	No

(*) These projects were in the TYNDP2016 list

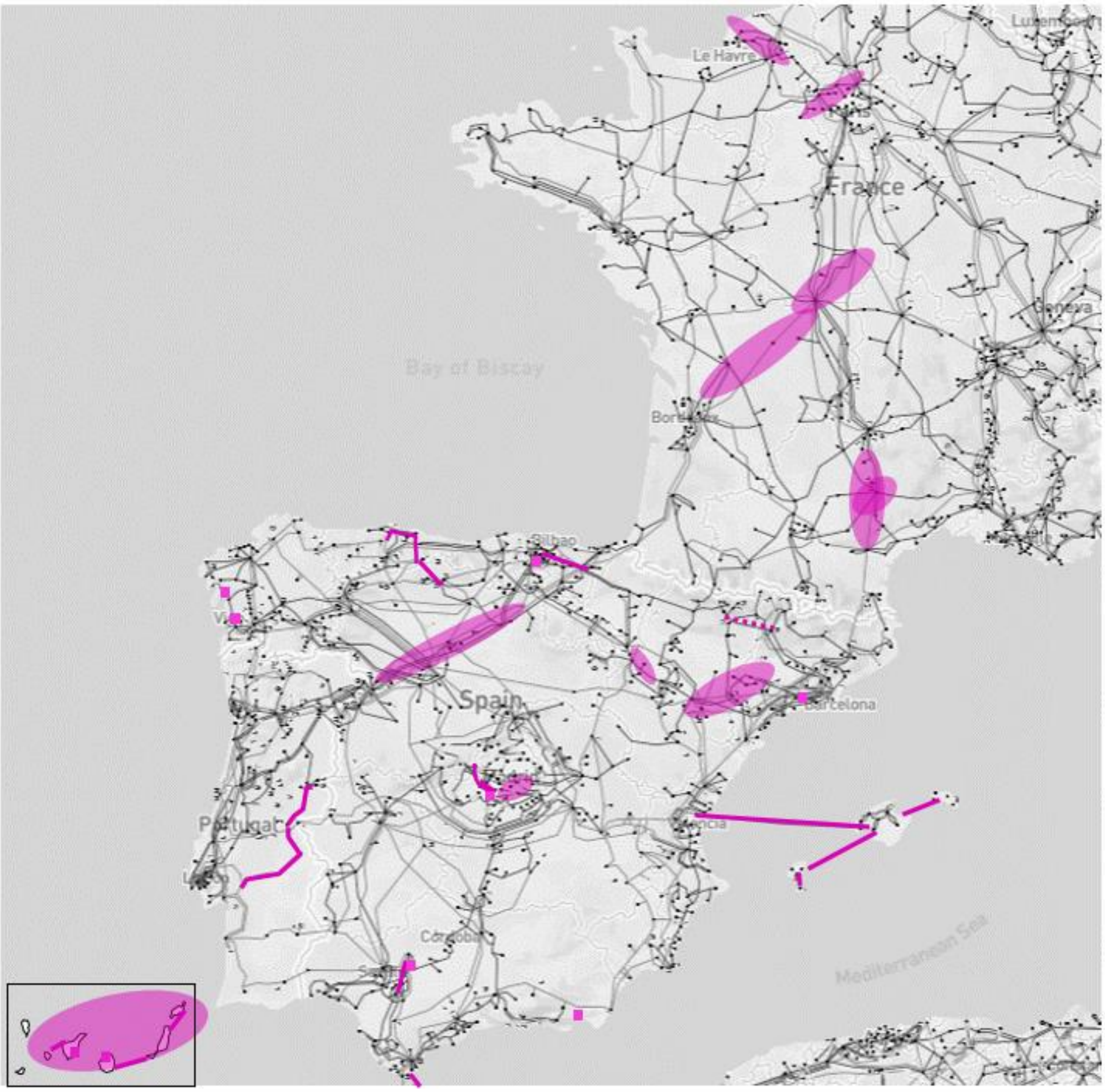
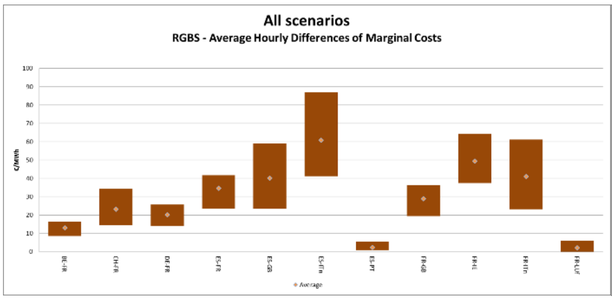


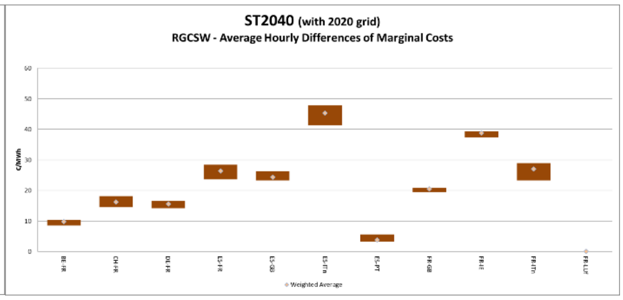
Figure 7-2: Additional Regional Projects

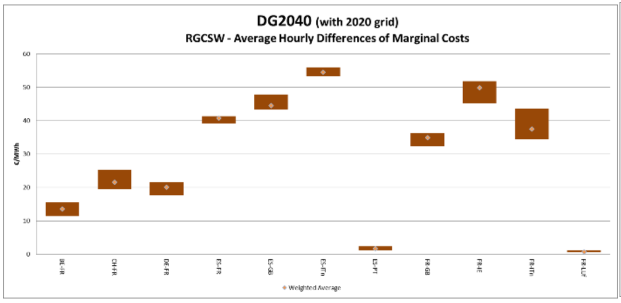
8 APPENDICES

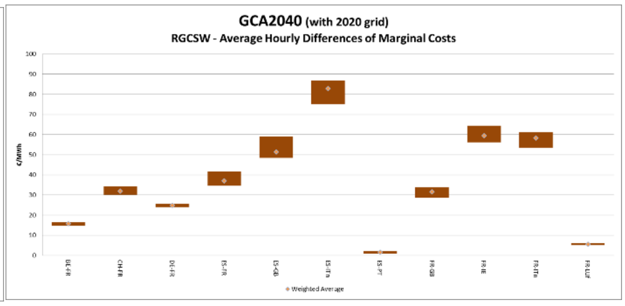
8.1 Additional Figures

8.1.1 Future challenges









8.1.2 Market study results

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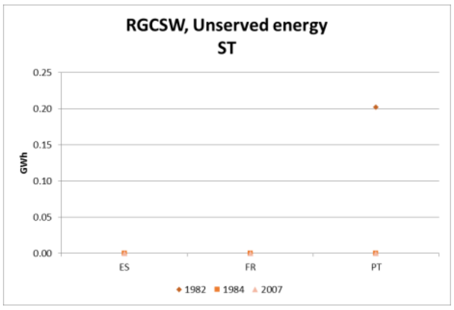
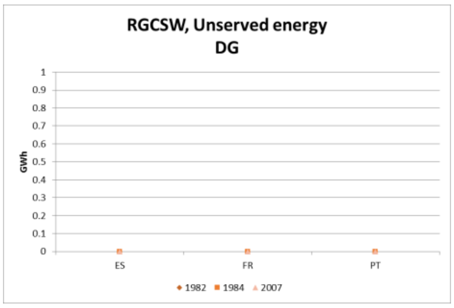
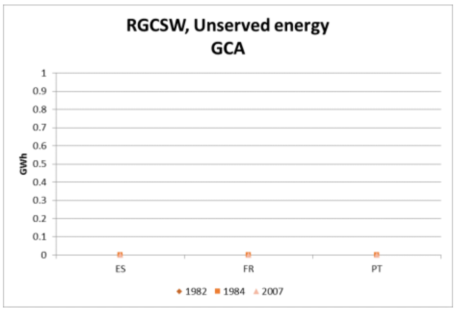
<tr><td>
</td><td>
</td><td>
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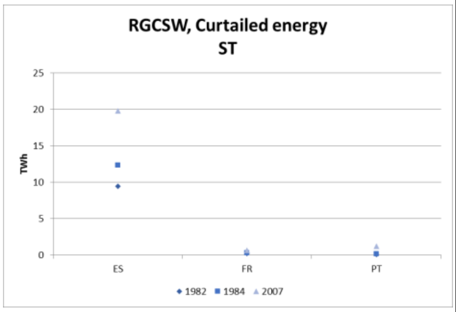
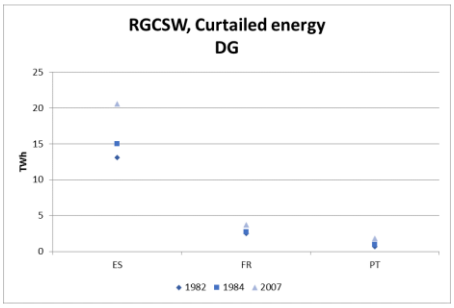
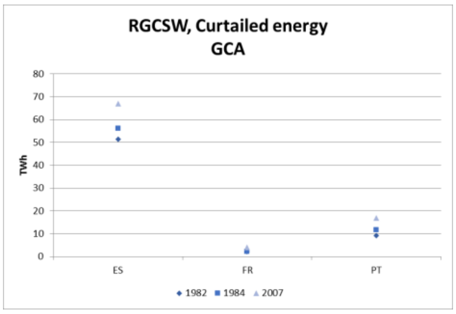
<tr><td>
</td><td>
</td><td>
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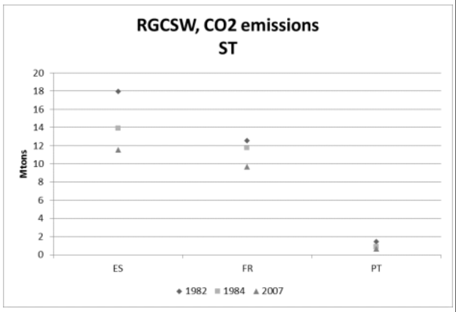
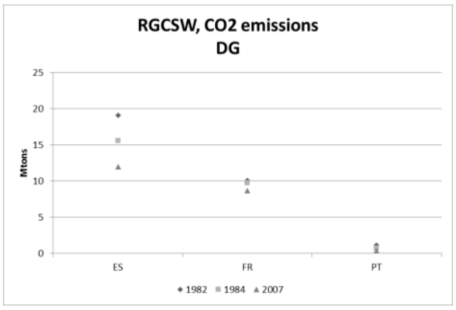
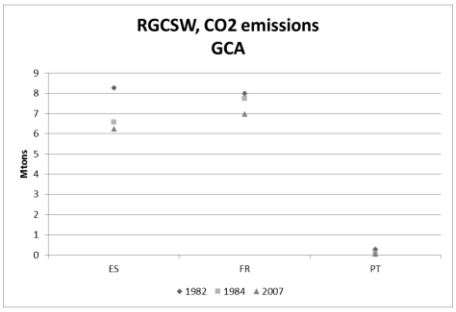
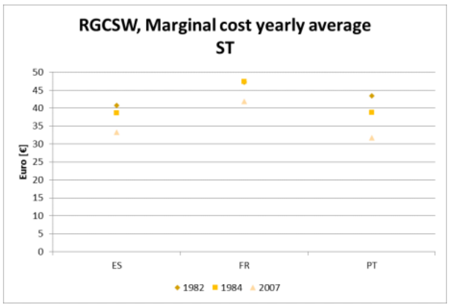
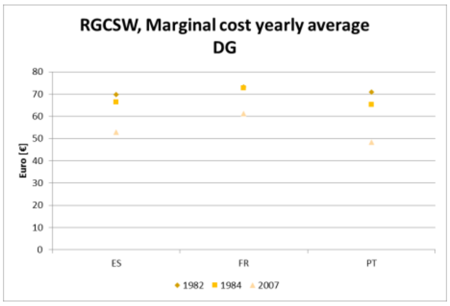
Sustainable Transition 2040	Distributed Generation 2040	Global Climate Action 2040

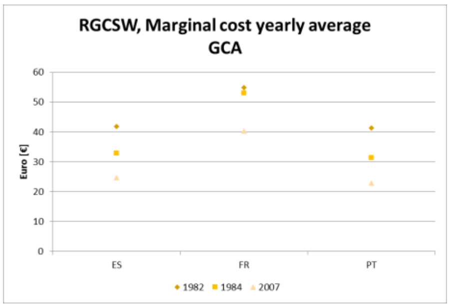


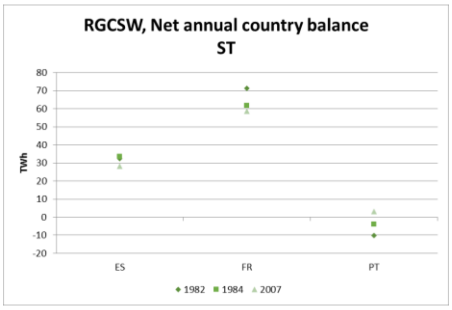


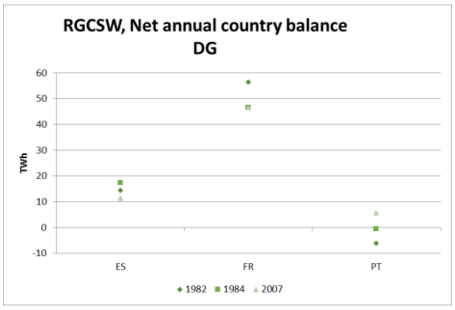


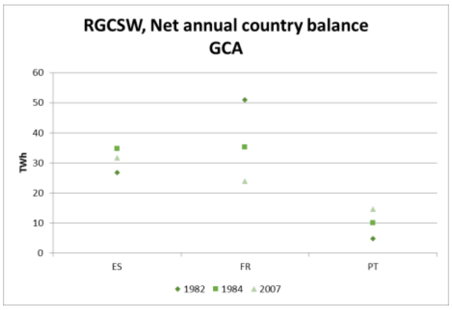


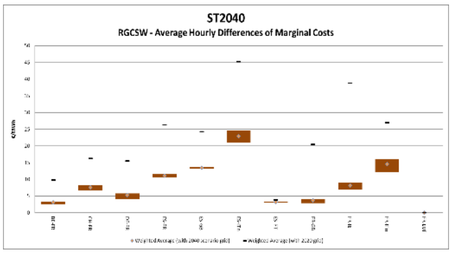


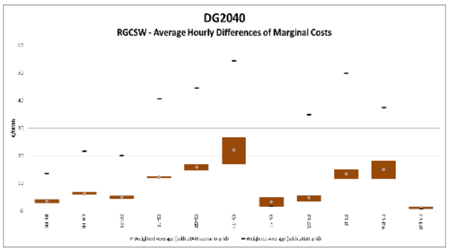


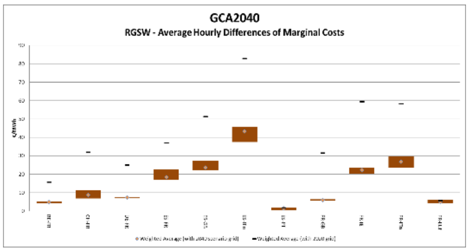






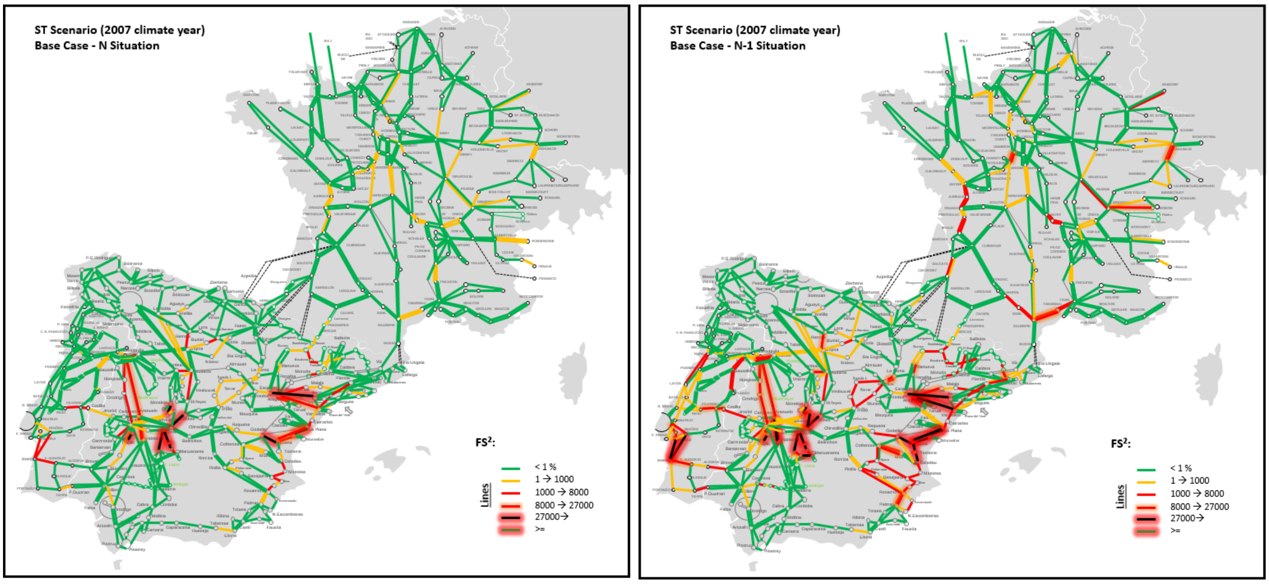




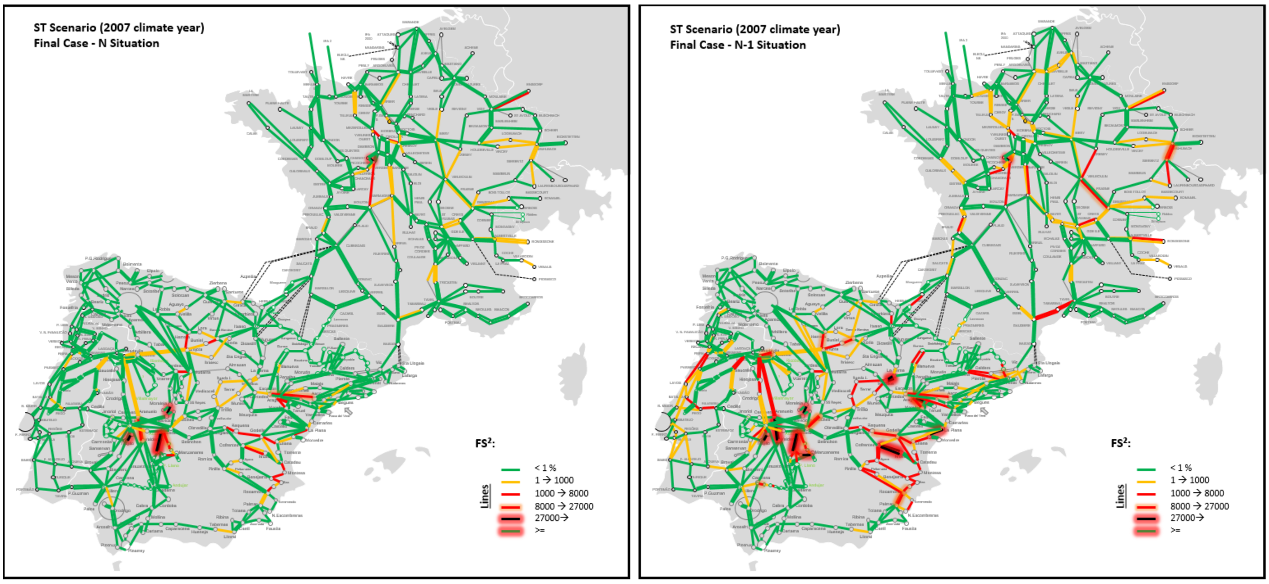


8.1.3 Network study results

Sustainable Transition Scenario

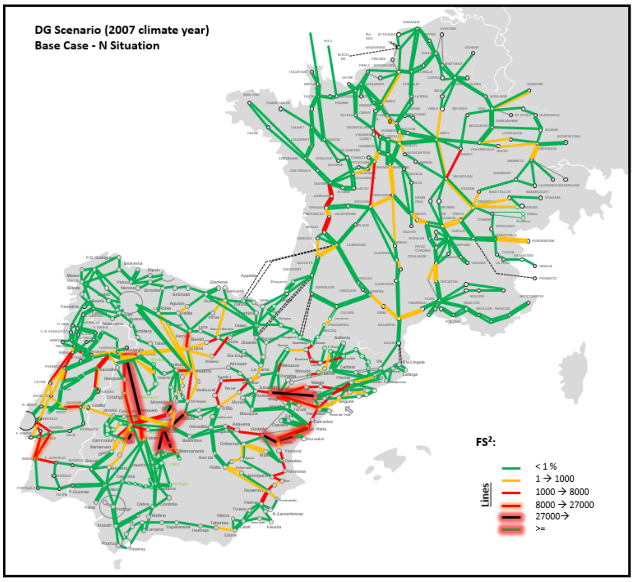


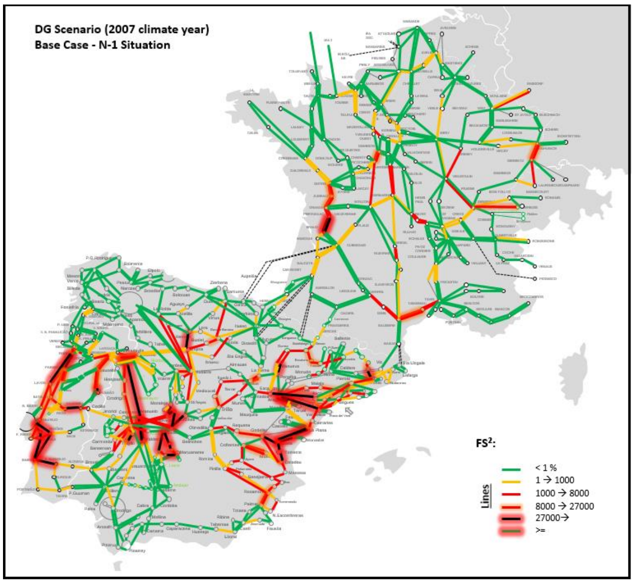
Base Case: N and N-1 condition



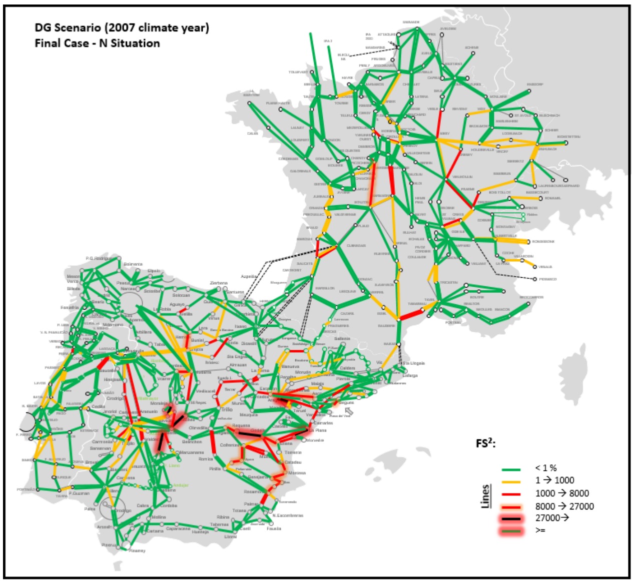
Final Case: N and N-1 condition

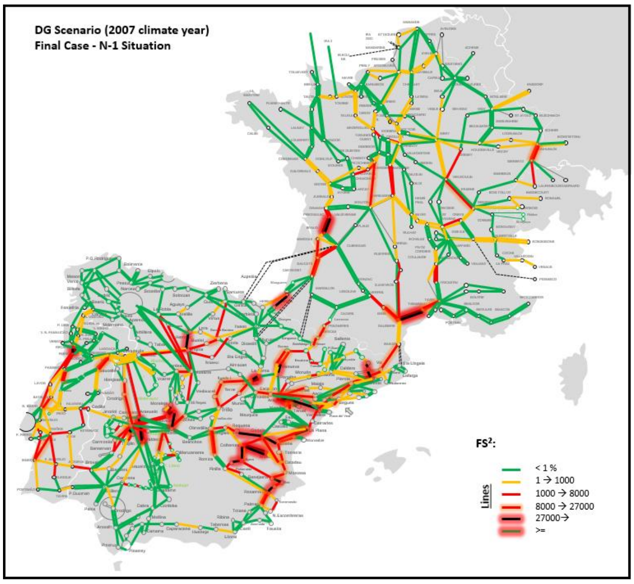
Distributed Generation Scenario





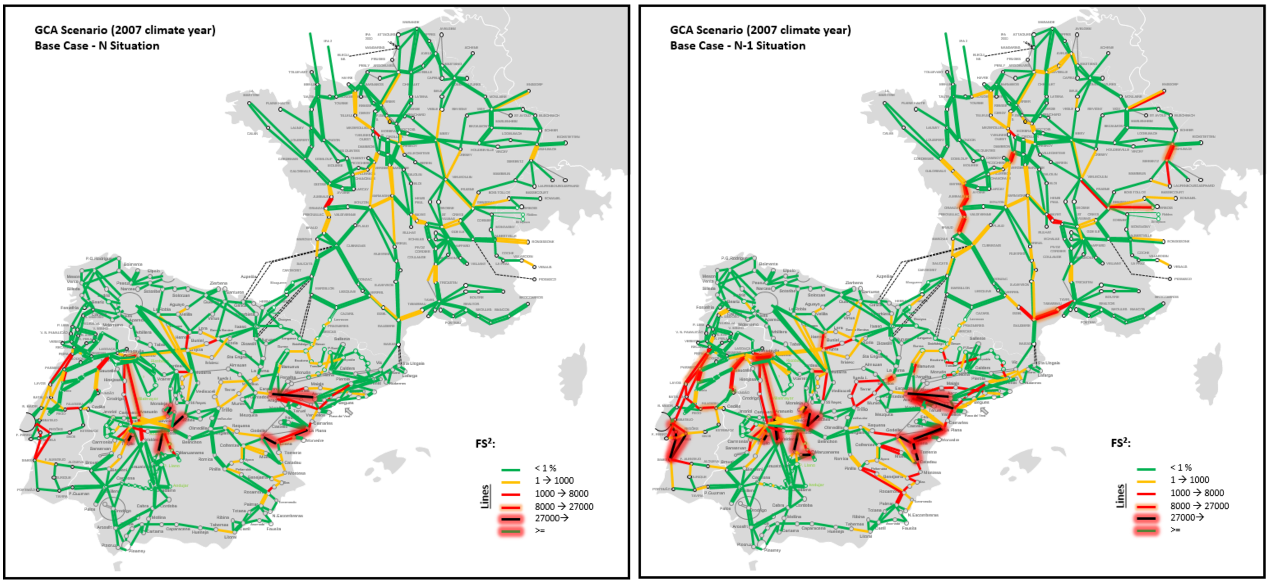
Base Case: N and N-1 condition



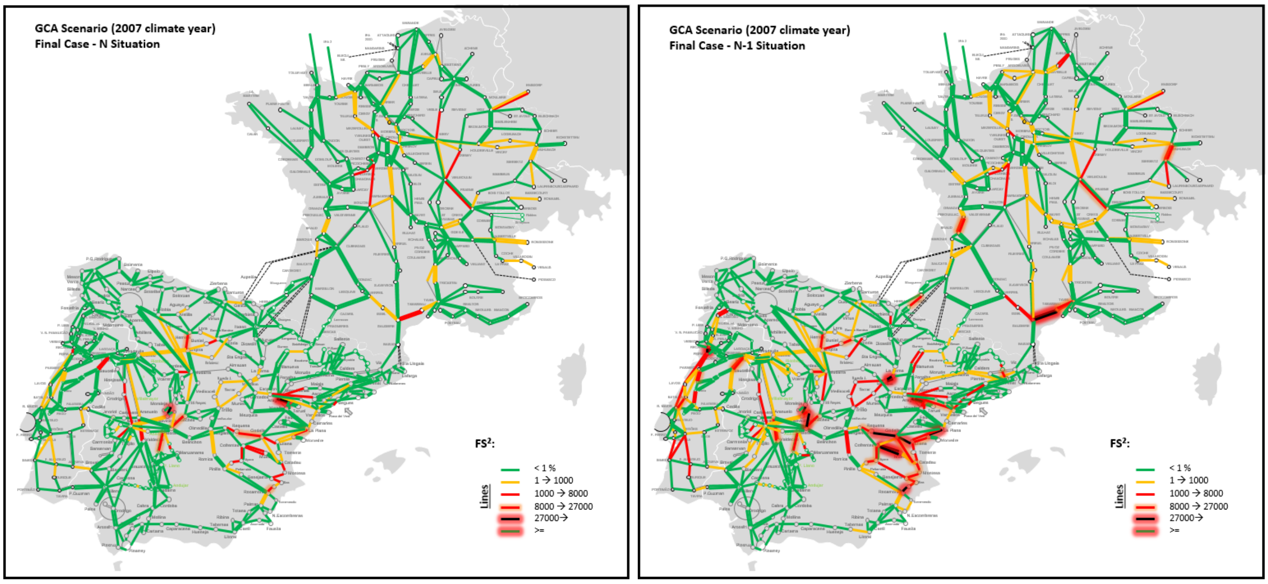


Final Case: N and N-1 condition

Global Climate Action Scenario

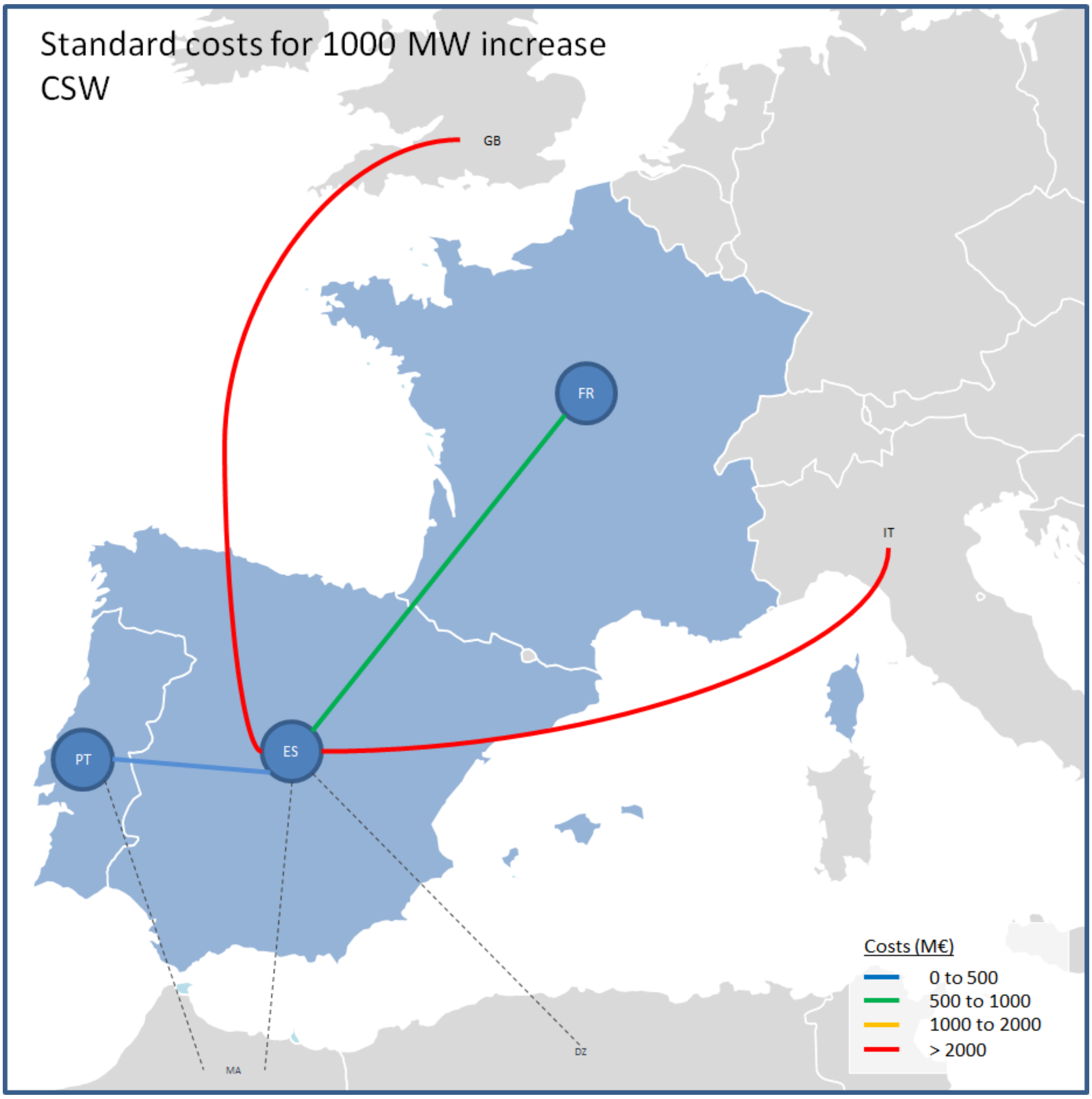


Base Case: N and N-1 condition



Final Case: N and N-1 condition

8.1.4 Standard cost map



8.2 Abbreviations

The following list shows abbreviations used in the Regional Investment Plans 2015.

- AC Alternating Current
- ACER Agency for the Cooperation of Energy Regulators
- CCS Carbon Capture and Storage
- CBA Cost-Benefit-Analysis
- CHP Combined Heat and Power Generation
- 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
- EU European Union
- GTC Grid Transfer Capability
- HV High Voltage
- HVAC High Voltage AC
- HVDC High Voltage DC
- IEA International Energy Agency
- KPI Key Performance Indicator
- IEM Internal Energy Market
- LCC Line Commutated Converter
- LOLE Loss of Load Expectation
- 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
- RgIP Regional investment plan
- RES Renewable Energy Sources

- RG BS Regional Group Baltic Sea
- RG CCE Regional Group Continental Central East
- RG CCS Regional Group Continental Central South
- RG CSE Regional Group Continental South East
- RG CSW Regional Group Continental South West
- RG NS Regional Group North Sea
- SEW Socio-Economic Welfare
- SOAF Scenario Outlook & Adequacy Forecast
- SoS Security of Supply
- TEN-E Trans-European Energy Networks
- TOOT Take Out One at the Time
- TSO Transmission System Operator
- TWh Terawatt hour
- TYNDP Ten-Year Network Development Plan
- 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 Regional Investment Plan.

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 - means 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 taken into account 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 take part as well (reserves, regulation up and down…) which introduce changes in the final electricity price.

Net Transfer Capacity (NTC) – the maximum total exchange program between two adjacent control areas compatible with security standards applicable in all control areas of the synchronous area, and taking into account 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 – 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.

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) – 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 to evaluate the load flows over the lines with and without the examined network reinforcement.

Ten-Year Network Development Plan – The Union-wide report carried out by ENTSO-E every other year as (TYNDP) 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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