Technical

TYNDP 2018

TYNDP Cost-Benefit Analysis
from assessment indicators to investment decisions

Final version after public consultation and ACER opinion - October 2019

What influences the TYNDP CBA indicators? How did CBA indicators evolve compared to previous TYNDP editions?

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Contents

ENTSO-E Reports 2018

As an improvement to the TYNDP 2018 package, the Insight Reports have been categorised in order to help readers navigate through the document and focus on what readers might find of interest. The category of reports are:

— Executive Report – Contains the key insights of the whole TYNDP package through its two-year cycle.

— Regional Reports – Based on the four projects of common interest (PCI) regions, the reports focus on the regional challenges of the energy transition.

— Communication – These reports communicate how we have interacted with our stakeholders and improved the TYNDP package from 2016 to 2018.

— Technical – These reports give a deeper insight into the technical subjects, including how we use our data, and the technical challenges of energy transition.

We hope this guide is of benefit to all stakeholders.

Main Report

Regional Reports

- North-South Interconnections East
- North-South Interconnections West
- Northern Seas Offshore Grid
- Nordic & Baltics

Communication

- Stakeholder Engagement
- Improvements to TYNDP 2018

Technical

- Data and Expertise
- Technologies for
- Transmission
- Viability of the Energy Mix
- CBA Technical

Adequacy

- Mid-Term Adequacy Forecast

Section 1

Executive summary

The energy system and energy market of the future are being built today by its participants. The investment decisions in the energy sector today should re lect a compromise between cost effectiveness and technical feasibility.

ENTSO-E is striving to outline the main parameters that should facilitate the investment decision process and provide consistent interpretation of the assessment results that are being produced in the TYNDP.

While the current report highlights the differences between the current TYNDP 2018 CBA results compared to TYNDP 2016, it is worth acknowledging that the CBA methodology applies a multi-criteria analysis, as many of the indicators cannot be monetized. Such non-monetized indicators (security of supply, flexibility, stability etc.) should not be underestimated as they are expected to play an increasingly significant role in the future of the energy transition in Europe and worldwide.

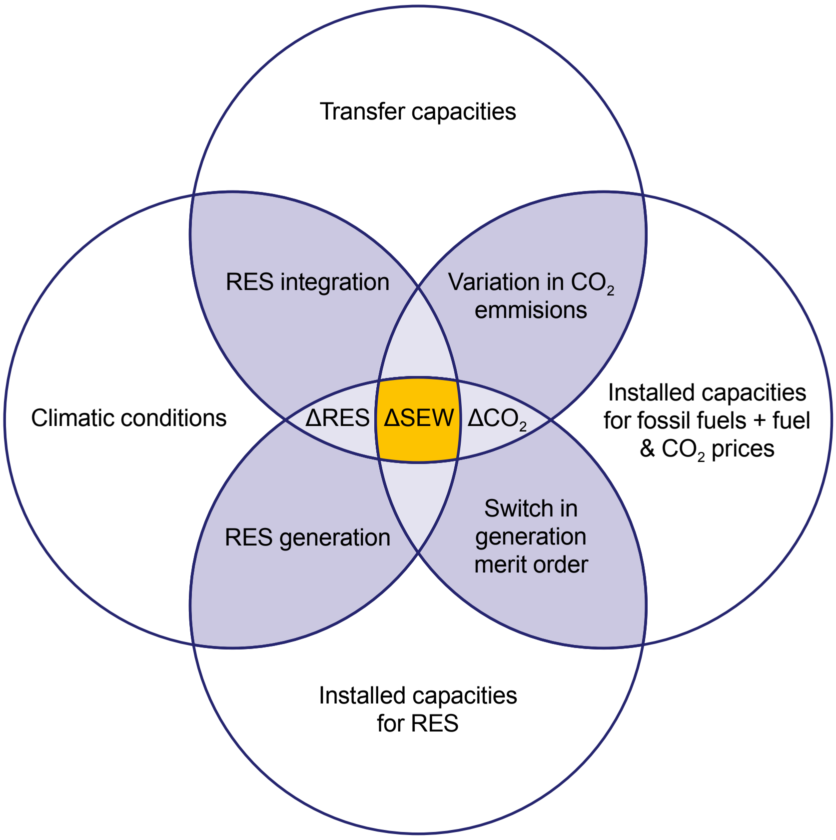
The system needs analyses performed by ENTSOE for the TYNDP 2018 showed the necessity for the construction of transmission projects, even with reduced monetized benefits during the CBA phase. Therefore, whilst this insight report concentrates on the overall comparison of the monetarised CBA analysis results between the TYNDP 2016 and 2018 and the reasons for this, the impact on the each individual transmission project CBA must consider the totality of the monetized and non-monetized indicators for any given project.

Overall the TYNDP 2018 showed a decline in the benefits of its projects as compared to the predecessors. This is caused by both Scenario assumptions, that have changed significantly for TYNDP 2018 compared to TYNDP 2016 and methodologies that have been improved and increased in complexity for the new release of this TYNDP.

In summary, the following parameters which influence the TYNDP CBA indicators:

— Climatic conditions
— RES installed capacities
— Fossil fuel installed capacities
— Fuel and CO_2 prices
— Transfer capacities
— Uncertainty ranges.

Figure 1.1 Drivers for change for 3 main monetarized CBA Indicators



Section 2

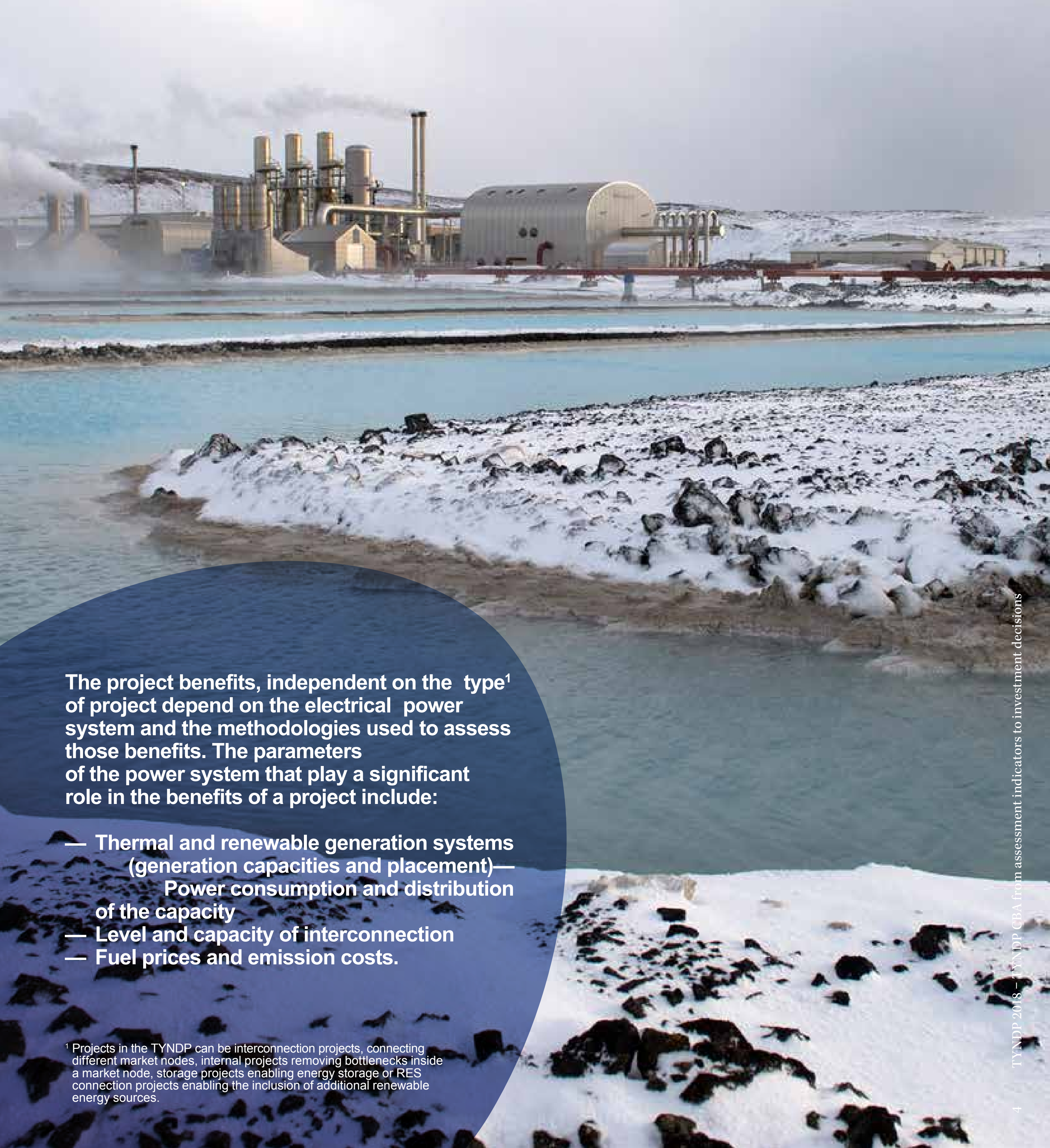
Introduction to the TYNDP Cost Benefit Analysis

The TYNDP CBA is conducted every 2 years by ENTSO-E and acts as reliable basis to define the benefits of potential candidate projects for the Projects of Common Interest (PCI) list and other electricity infrastructure within the ENTSO-E area. ENTSO-E improves with each TYNDP the quality of data used for the studies, the processes used to assess projects and to study other aspects of the expected future electricity system and the communication of results.

This insight report provides an overview of the TYNDP 2018 CBA results evolution as well as answers the question why TYNDP 2018 CBA results differ compared to the results of previous TYNDP 2016.

Section 3

Project benefits as result of the scenarios



The project benefits, independent on the type[1] of project depend on the electrical power system and the methodologies used to assess those benefits. The parameters of the power system that play a significant role in the benefits of a project include:

- **Thermal and renewable generation systems (generation capacities and placement)— Power consumption and distribution of the capacity**
- **Level and capacity of interconnection**
- **Fuel prices and emission costs.**

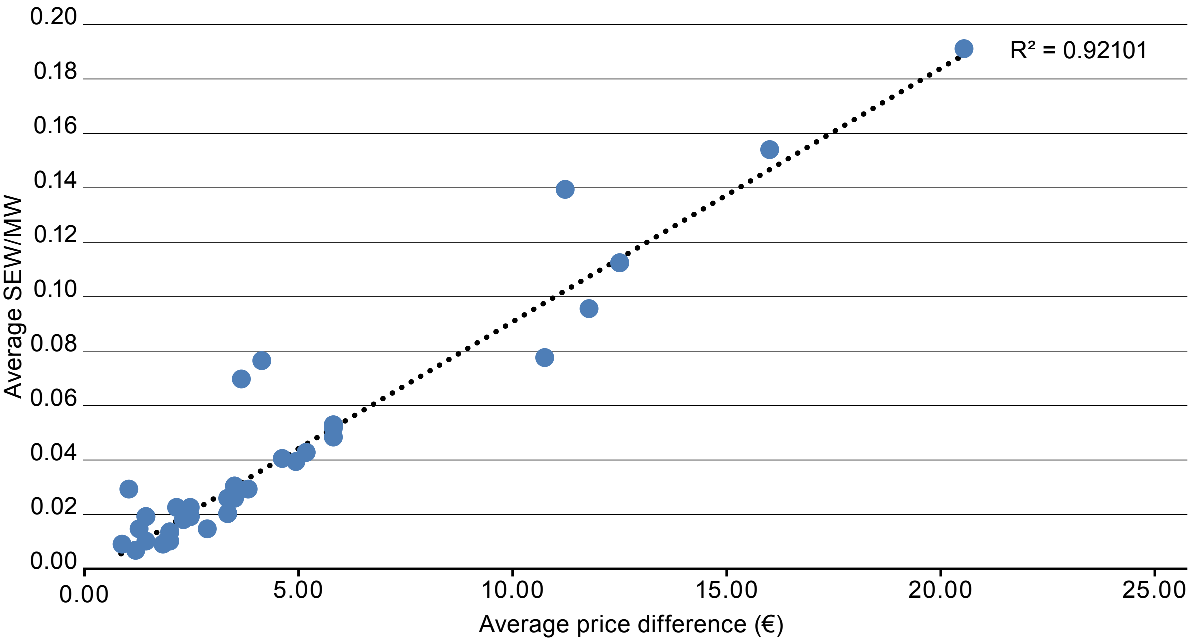
[1] Projects in the TYNDP can be interconnection projects, connecting different market nodes, internal projects removing bottlenecks inside a market node, storage projects enabling energy storage or RES connection projects enabling the inclusion of additional renewable energy sources.

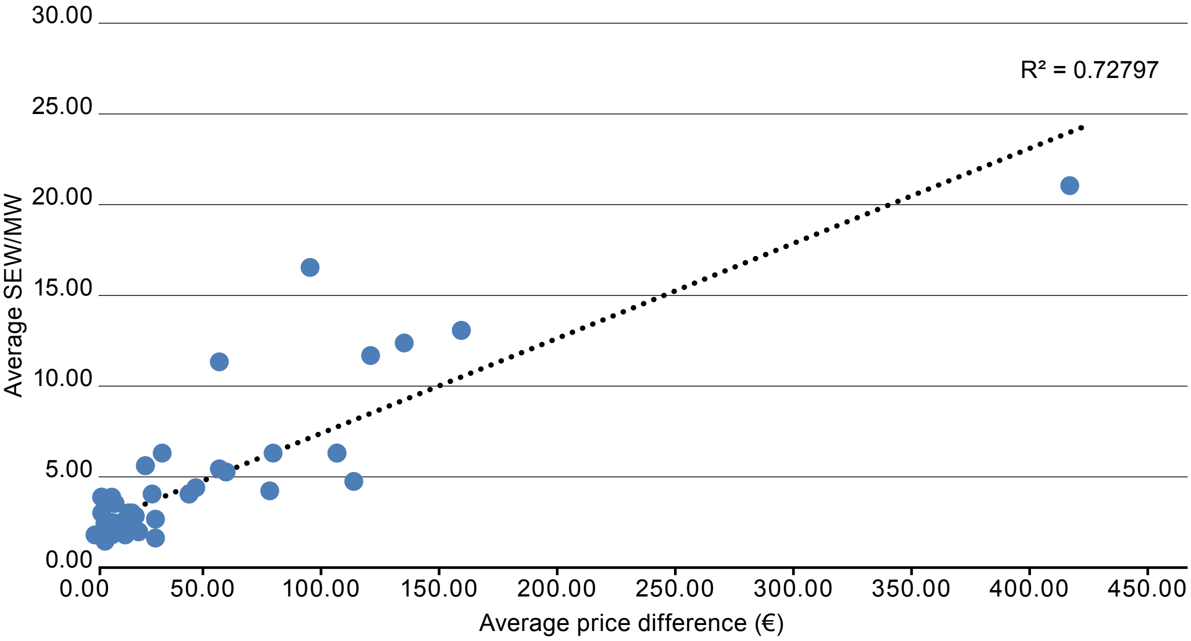
All these parameters are part of the ENTSO-E future electrical power system forecasts – the TYNDP2018 scenarios.

According to definition of the Socio-Economic Welfare, price spread between the markets is a direct driver for benefits that the project may indicate as a result of assessment.

The portfolio of assumptions characterized in each scenario, developed by ENTSO-E, directly impact on the results from the simulations performed. Therefore the price spreads are influenced simultaneously. Figure 3-1, below, shows the relationship between the average hourly price differences and the transmission project's socio-economic benefits (per MW) at the borders represented by particular projects submitted to TYNDP 2018.

Figure 3.1: Relationship between project socio-economic welfare and price differences at the borders – TOOT and PINT





The Figure 3.1 graphically confirms the interdependency between the yearly average price difference at the border between the market areas and the capacity at such border both for projects assessed according to TOOT and PINT methodologies.

Therefore, to further understand the drivers behind the change in the socio-economic welfare and other CBA indicators for each project assessed in TYNDP 2018 it is worth investigating in detail the drivers behind such change in the developed Scenarios and the methodologies used in the process.

The benefits of a project, independent of the type of project, depend on the electricity system as a whole. Information on, but not limited to, thermal and renewable generation systems (generation capacities and placement), consumption amounts and location, the interconnectivity of market nodes and both fuel prices and emission costs play an important role. All these factors are part of the description of the expected future electricity system – the TYNDP2018 scenarios.

Section 4

Differences between TYNDP16 and TYNDP18 project indicators

As concluded in the previous chapter, improvements to the methodology used as part of the CBA 2.1 methodology and change in the scenarios in the scope of TYNDP 2018 when compared to TYNDP 2016 have led to considerable changes in the CBA results for the TYNDP projects.

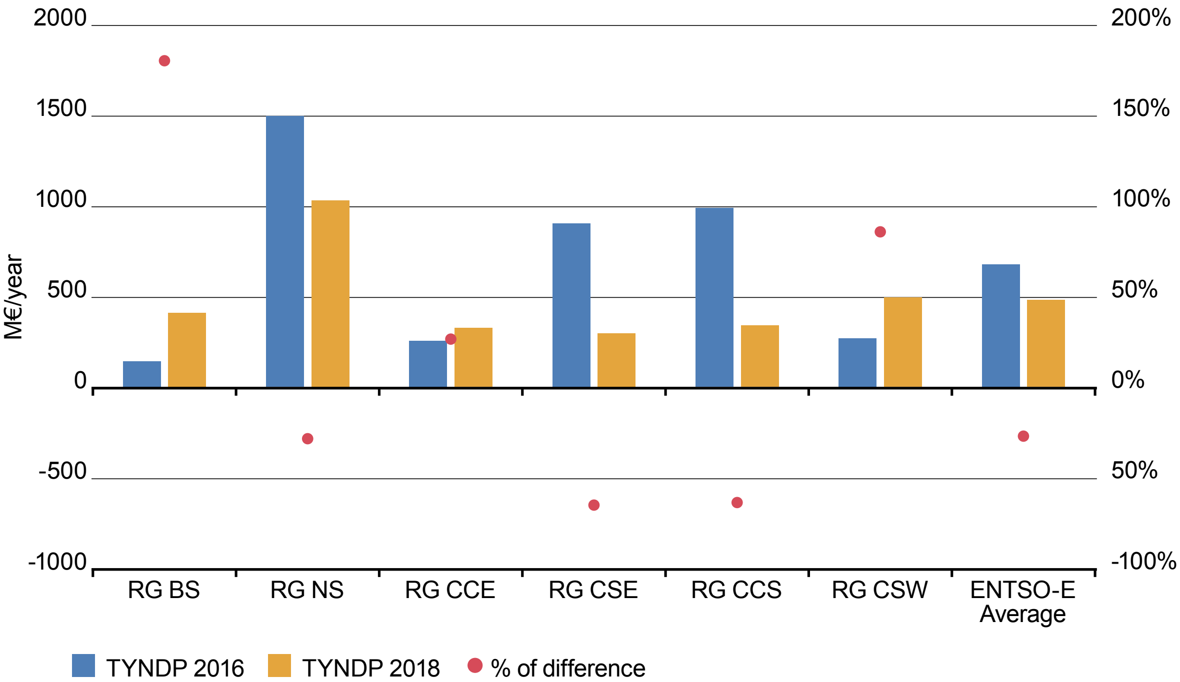
These effects are caused by multiple reasons, with factors interacting with each other. We have identified the main trends and drivers.

4.1
Evolution of ΔSEW indicator

As it has been observed during the TYNDP 2018 process, the ΔSEW indicator has faced considerable changes compared to the values reported in TYNDP 2016.

Figure 4.1, below, describes the differences in the total socioeconomic welfare of selected projects[2] for each of the six SDC ENTSO-E regions.

Figure 4.1: Comparison of average between all TYNDP 2016 and all TYNDP 2018 total ΔSEW for selected projects



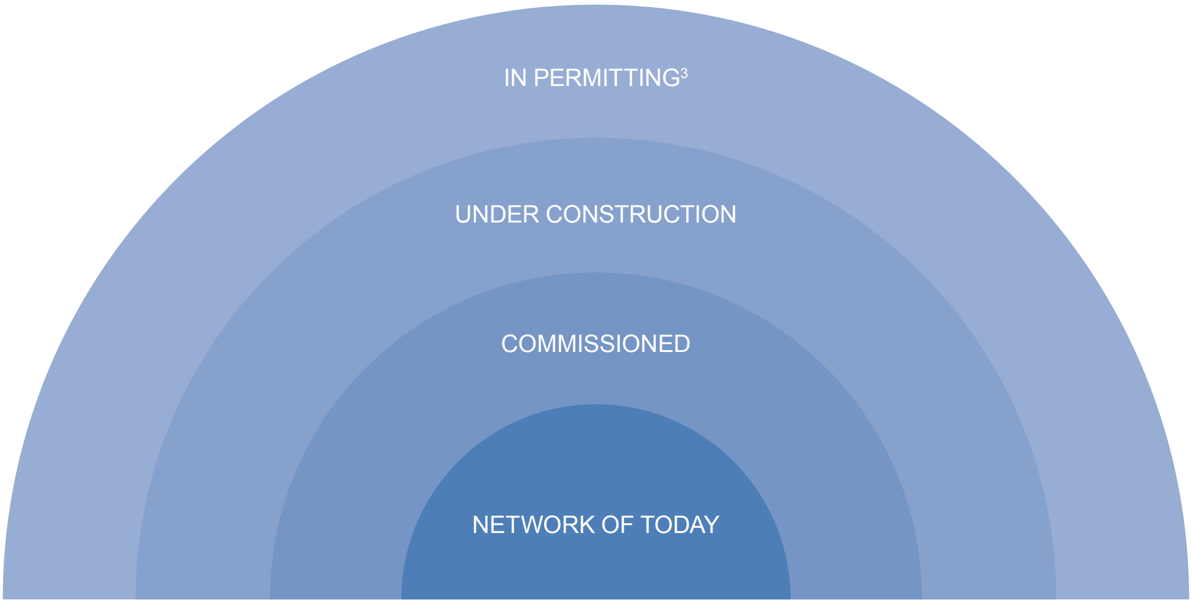
It should be noted that while three SDC Regions show higher cumulative ΔSEW results, the remaining three regions reported lower values compared to the 2016 TYNDP edition. This indicates that the changes are not a simple uniform reduction, but there are more complex interactions.

The key drivers leading to the changes of the benefits could be summarized as following:

Changed Reference Grid
For TYNDP18 edition, the reference grid composition guidelines have evolved, i.e. the reference grid has been composed as shown on the Figure 4 2 below:

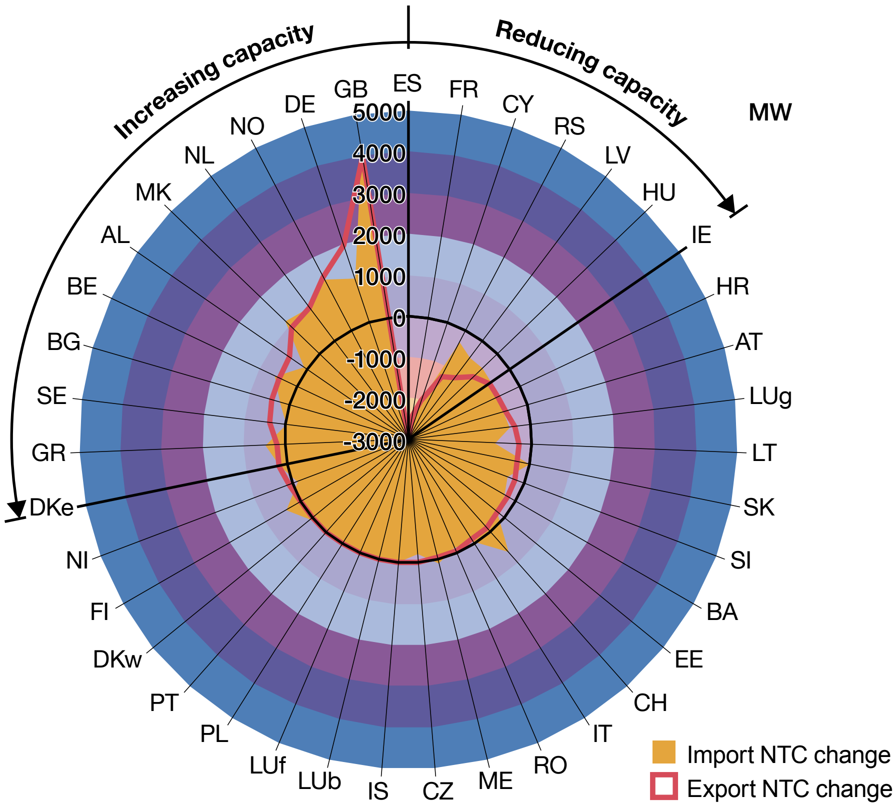
[2] Selected projects for comparison were such that do not vary for more than 50% in delta NTC parameter and have not changed substantially in terms of network topology between TYNDP 2016 and TYNDP 2018.

Figure 4.2: 2 TYNDP 2018 Reference Network Composition



Overall, the evolution of the interconnectivity (sum of the import and export Net Transfer Capacities) for the market areas in the TYNDP 2018 CBA reference network compared to 2030 CBA reference network in TYNDP 2016 are summarized in the Figure 4 3 below.

Figure 4.3: Change of Import and Export NTC sum in TYNDP 2018 CBA network compared to TYNDP 2016 2030 network



[3] In TYNDP 2018 "In permitting" project status is refered to planned projects able to prove by a written acknowledgement by a competent body that application to the permitting phase has started (similar to the pre-application phase defined for PCIs defined in TEN-E).

It may be derived from Figure 4.3, that despite a more restricted reference network in TYNDP 2018 as compared to TYNDP 2016, for some areas the status of some transmission infrastructure had evolved by the time of the project collection phase for TYNDP 2018, to increase the cross border or even cross boundary capacity, e.g. for 'boundary 2' which is strongly affected, (see more details in NSOG insight report).

As indicated by the SEW/ NTC study results in the appendix to the Executive report, the reference grid impacts the socio-economic benefits of the project. Through application of the CBA methodology, projects under assessment are always assumed to be the last project being built on top of a series of other projects assumed to be already in operation.
Thus, with an increased reference capacity across a particular boundary, the socioeconomic benefit margin decreases for the project being assessed, which is a careful and conservative approach.
This drives the SEW values down for all projects associated with the boundary.

Taking into account the large investments associated with HVDC cross border connections, the viability of all projects associated with a saturated border needs careful consideration. There might be competing projects included, which will not all materialize.

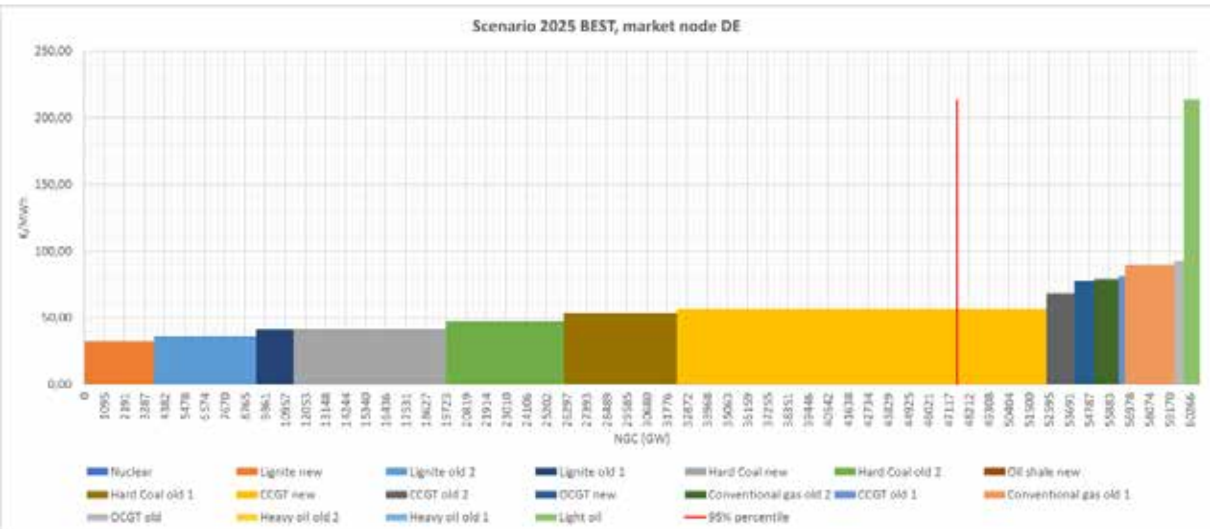
Particular attention should be paid to the borders connecting different synchronous areas as these may be highly impacted by the increased reference network topology. It should be mentioned, that the interconnectivity of GB market area has significantly increased (about 4000 MW), which has influenced the projects at the FR-GB border.

Changed merit order – driven by the change in CO_2 prices and technological distribution

Another reason for changed SEW values compared to TYNDP16 is attributed by a general change of the CO2, fuel prices and technological distribution. In general, the price differences between the key generation technologies represented in the merit order in TYNDP 2018 have decreased and the distribution of the technologies has shown to be more optimized. This has led to the lower potential for benefits from reduced price differences as a result of an increase in the transmission capacity at the border from a project.

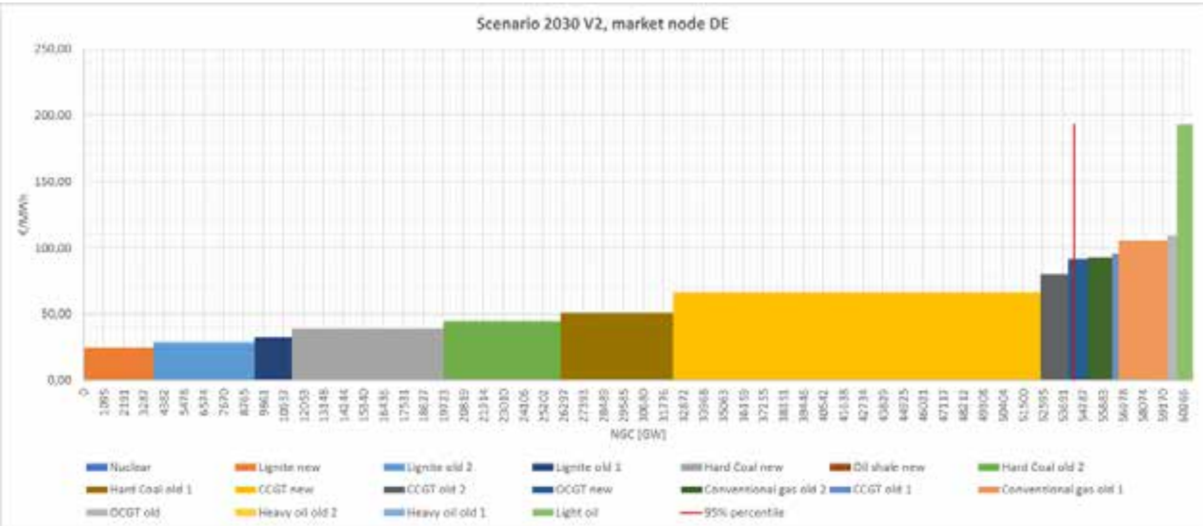
As an example in Figure 4-4, Germany for the Scenario 2025 Best Estimate in TYNDP 2018, we can see that the 95 percentile of the time the residual load in this Scenario is located at the end of the CCGT new technology margin in terms of net generating capacity. This means that a project increasing Net Transfer Capacity at a border, may results in unchanged marginal cost, without a switch in marginal technology and consequently no ΔSEW generated for most hours of the year.

Figure 4.4: NGC/Marginal cost per generation technology – DE market node – Scenario 2025 BEST



At the same time the same case for Germany for 2030 V2 Scenario from TYNDP 2016 already shows that for 95% percentile of the time that the residual load is located at the steep part of the Merit Order. This ensures that there is an clear marginal price difference even for transmission projects without extensive NTC increase at the border. This case is visualized in the figure 4-5 below.

Figure 4.5: NGC/Marginal cost per generation technology – DE market node – Scenario 2030 V2

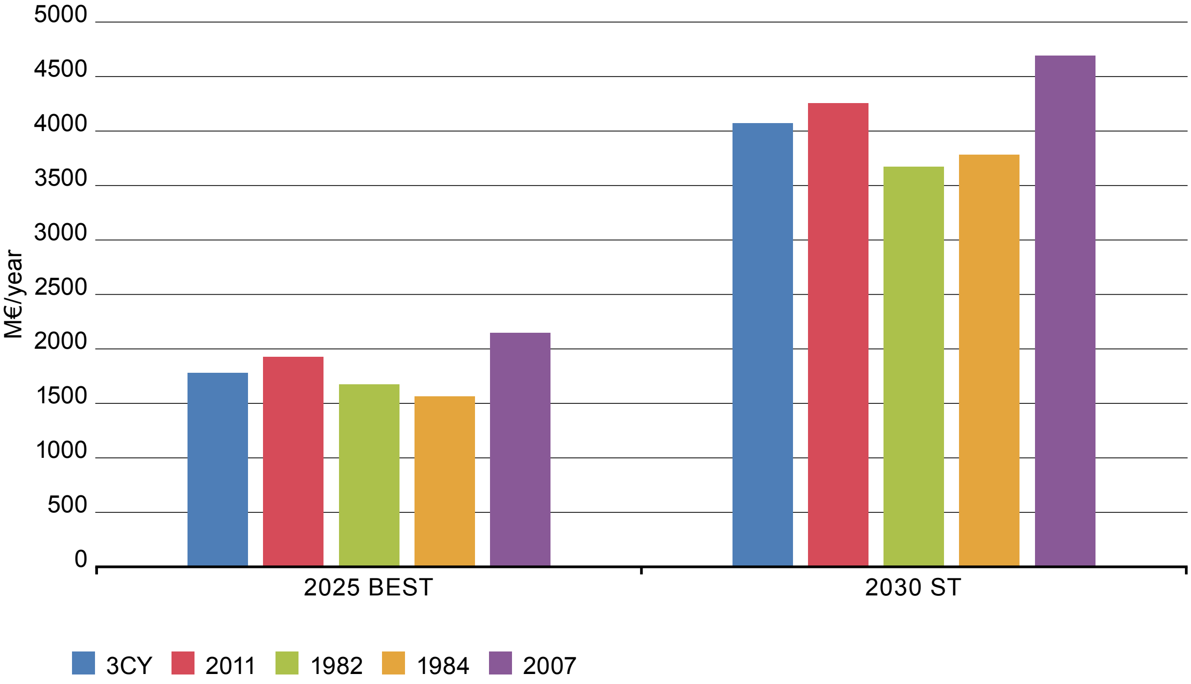


More details on merit orders in TYNDP 2018 could be found in the Annex 1 to this report.

Use of different and more Climatic Conditions in the simulations

In the TYNDP 2018 CBA process, 3 different climate conditions have been considered in electricity market simulations, each of which are represented by corresponding historical climatic year: 1982, 1984, 2007. In TYNDP 2016 process the 2011 historical year climate conditions were used as assumptions for the market analysis. This has led to an overall decrease of the ΔSEW indicator at the ENTSO-E perimeter. Based on an overall specific comparison of the cumulative ΔSEW indicator results for the limited number of projects under investigation. Historical years 1984 and 1982 showed negative impact on the overall ΔSEW, while 2007 increased the ΔSEW in the final weighted average result compared to 2011, preliminary used in TYNDP 2016. The described impact has been summarized in the Figure 4.6 below for selected number of projects.

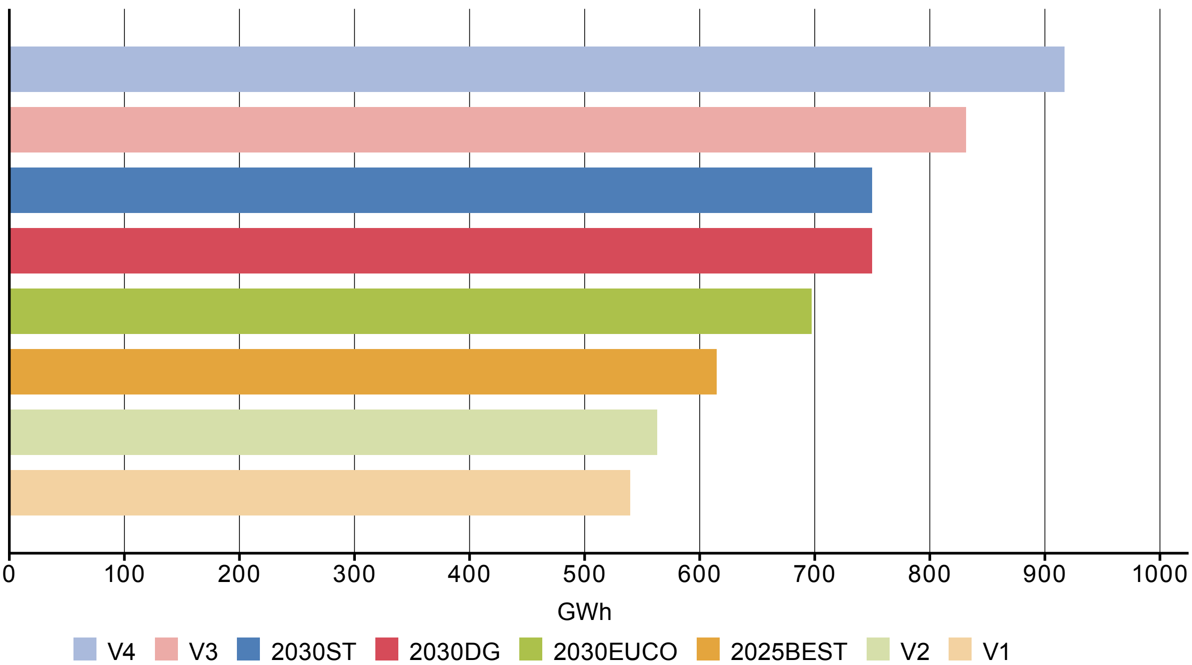
Figure 4.6: Influence of different climatic conditions on the cumulative ΔSEW results for selected projects



Marginal cost difference amplifier effect caused by increased wind generation
As it has already been concluded, benefits of transmission projects are driven by the generation cost differences between market areas. The uncorrelated wind infeed from the RES generation distributed around ENTSO-E based on the economic feasibility is leading to volatility of the marginal cost in one market area against the other thus causing the upward trend for the transmission infrastructure benefits in terms of Socio-Economic Welfare.

Increased volumes of wind generation amplify this effect.

Figure 4.7: Wind generation difference – TYNDP 2016 vs TYNDP 2018

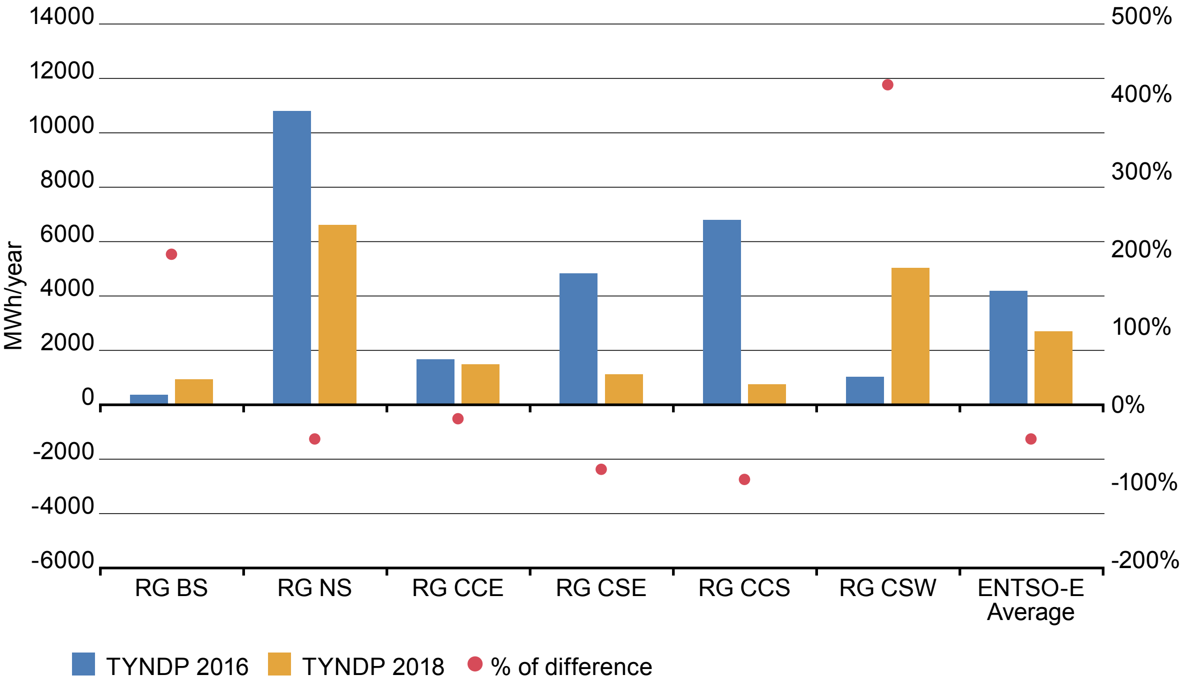


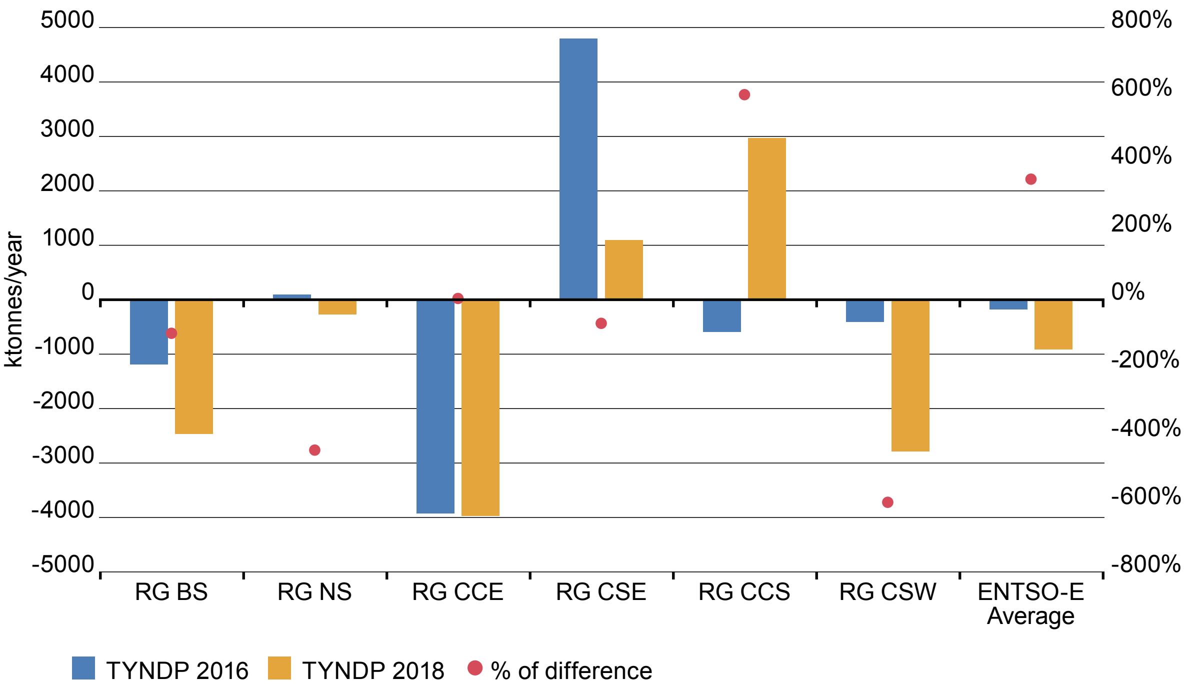
4.2

Changing ΔRES and ΔCO2 indicators

The ΔRES indicator has shown in overall a decreasing trend at the ENTSO-E perimeter in TYNDP 2018.

Figure 4.8: Comparison of average between all TYNDP 2016 and all TYNDP 2018 total ΔRES and ΔCO2 for selected projects



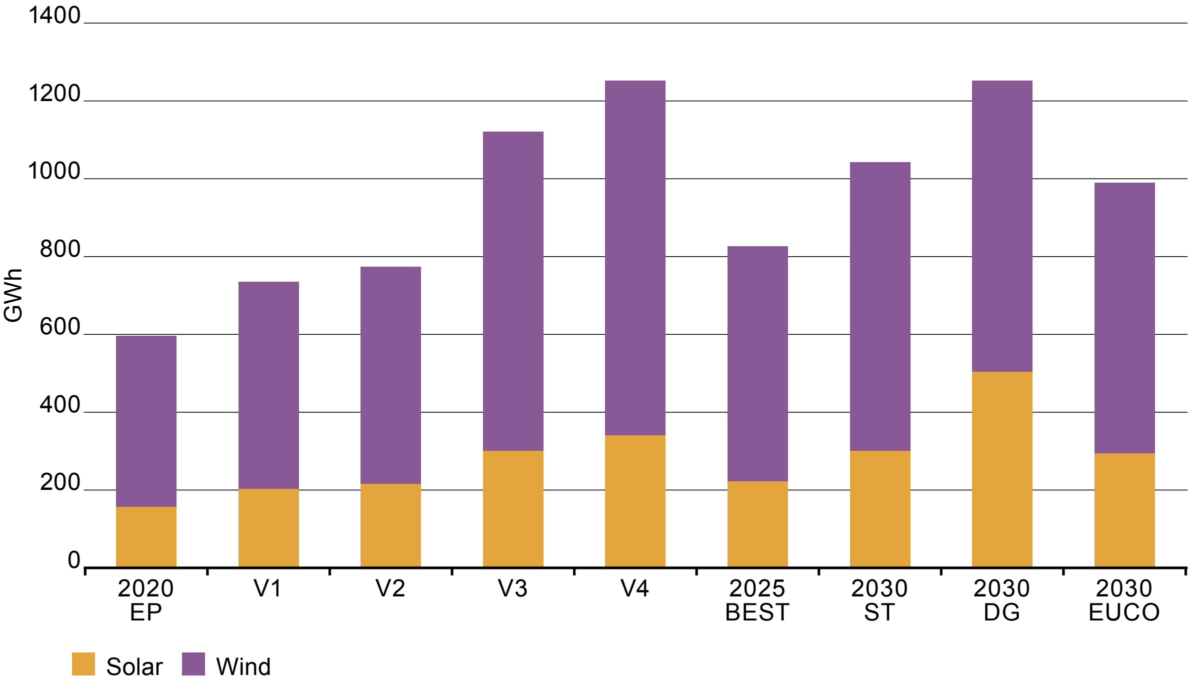


In general, according to the Figure 4-8,a reduction of up to 100% can be seen in the average ΔRES indicator for 4 SDC regions and an increase for 2 regions. The key drivers for this are described further below. Overall, the ΔCO_2 indicator has dropped significantly across the ENTSO-E area.

Changed assumptions on installed RES capacities

For TYNDP 2018, the scenarios have been built according to storylines, consulted with stakeholders, and in the case of the EUCO scenario, provided by a third party. Therefore, whilst the scenarios overall quantities are comparable to RES generation in TYNDP 2016, the distribution and location of this generation has changed.

Figure 4.9: Solar and Wind generation – ENTSO-E perimeter



The comparison of wind based energy produced is shown in Figure 4.9, indicating that the TYNDP18 generation figures are in the envelope of TYNDP16 Visions, but do not go to the extremities in their variation.

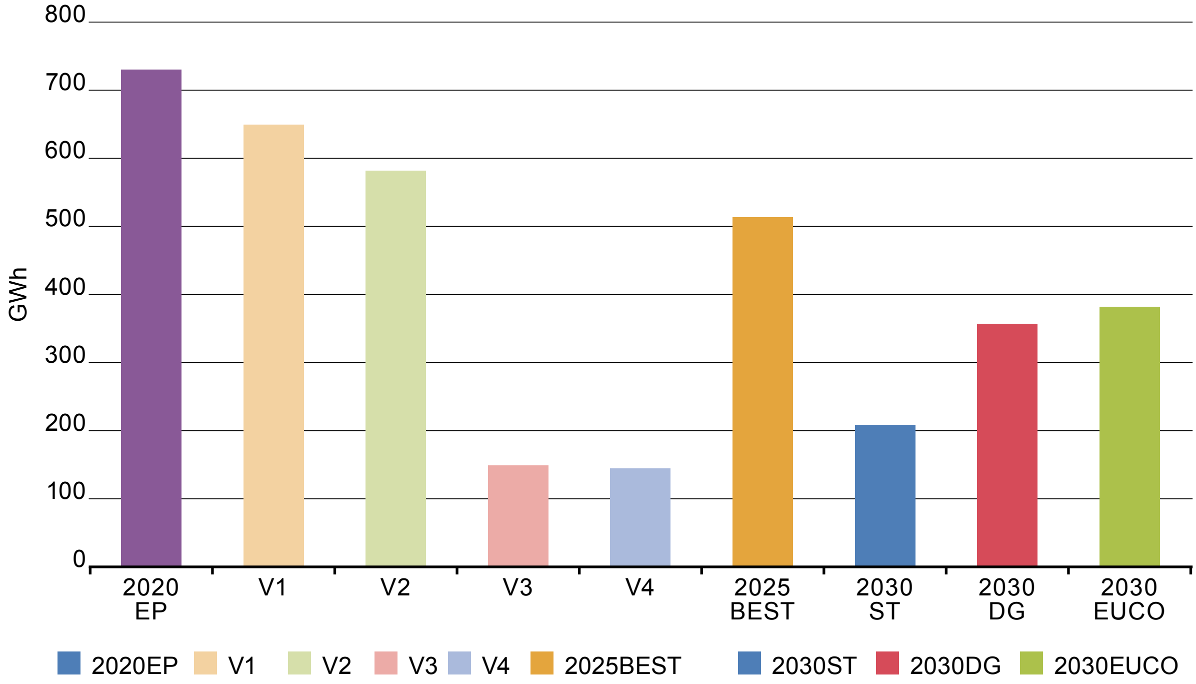
This differs for solar PV, which forms the envelope in TYNDP18 for the levels reached in TYNDP16. While solar energy sees higher local changes, requiring local flexibility, wind energy is less correlated on hourly resolution and can easier be shared across larger areas.

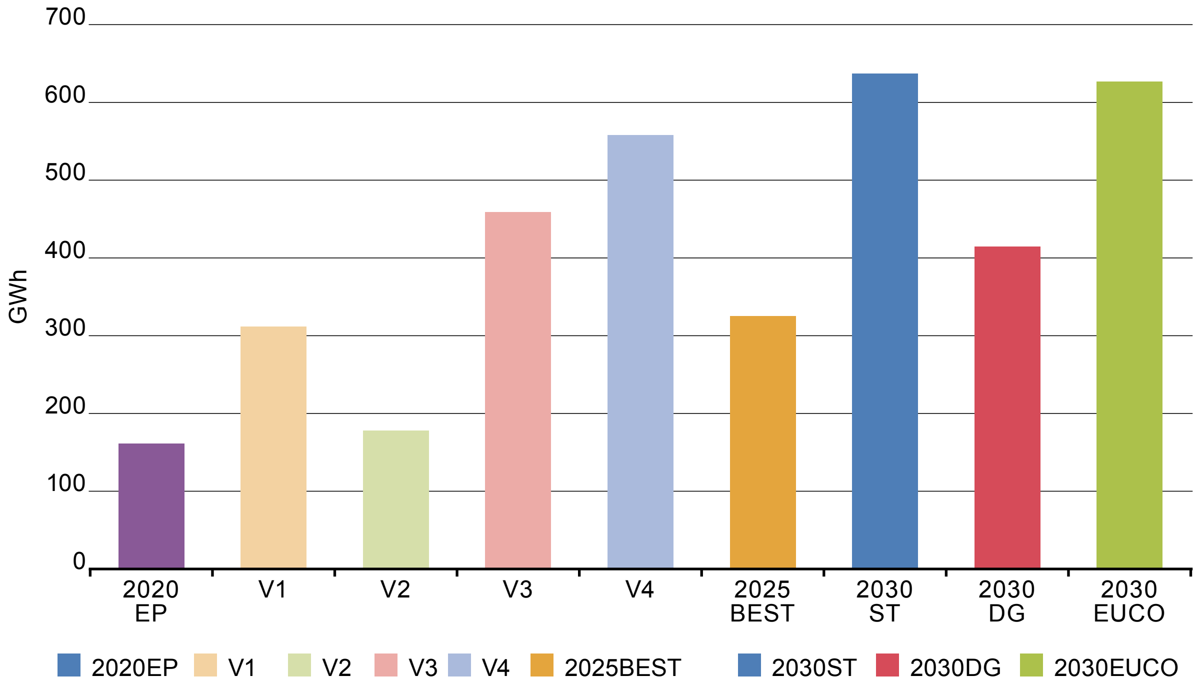
Changed assumptions on fossil based electricity production

Comparing the amount of energy produced by gas, the average across 2030 scenarios in TYNDP16 is a slightly lower compared to TYNDP18. The same comparison for coal and lignite sees less extreme variations in TYNDP18.

As a result, the RES and CO2 indicators are impacted. The above trends, especially concerning RES generation due to their variability, trigger an need for optimised interconnection amongst the scenarios, reflecting potential European collaboration on RES support schemes.

Figure 4.10: Gas, Coal and Lignite generation





Consideration of multiple Climate Years

For the current TYNDP, multiple climate years have been considered in the CBA assessment; among 34 climate years, 3 representative years have been selected and used during the CBA phase. For TYNDP 2016, one climate year was used in the analysis. The overall sensitivity to Climate years varies across Europe – while regions with a lot of hydro generation are affected by dry and wet years, other regions may see a bigger impact of changing wind conditions.

Figure 4.11: ENTSO-E Climate Year Sensitivity

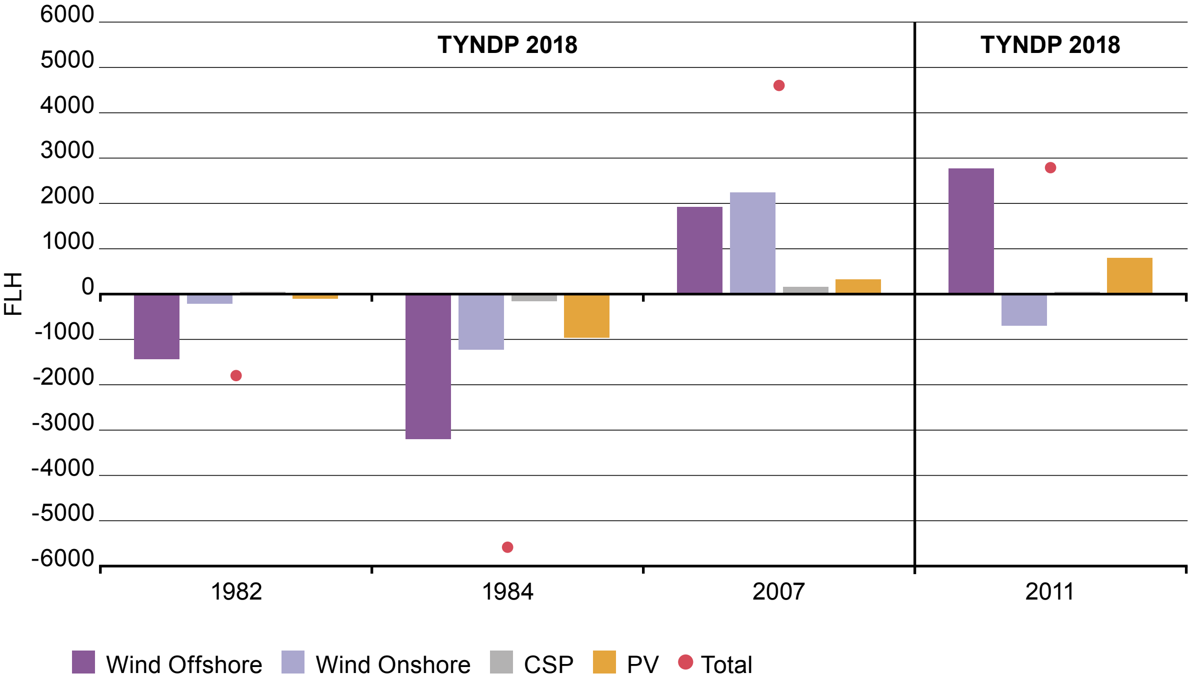


Figure 4.11 shows the variation of the full load hours in comparison to the average of 4 Climatic Years (1982, 1984, 2007, 2011) for different RES technologies as represented in Pan-European Climate Data Base (PECD) in ENTSO-E.

Overall, it can be seen in Figure 4.11 that the TYNDP 2016's climatic assumptions lie between the 3 climatic year conditions used in TYNDP 2018 in terms of full load hours of the different RES technologies. In the TYNDP 2018 calculations the weighted average of 3 Climatic Condition (1982, 1984, 2007) were used, which as a result show lower full load hours for the ENTSO-E region.

It is worth mentioning that in the long term prospective, climatic change may lead to more extreme weather conditions in Europe which potentially may imply higher energy generation from RES which may change the CBA results.

Switch to gas before coal merit order for the Scenarios after 2025 horizon

According to the TYNDP 2018 Scenario Storylines, reaching the RES penetration targets after 2025 requires more flexible low carbon technologies to be built. In this regard the gas generation plays a significant role. Gas fired technologies in turn placed in a large scale in the middle of the merit order scale, limiting the variation of the CO_2 emission factors from hour to hour, thus leading to lower CO_2 emission variation.

More optimized use of hydro generation

The ΔCO_2 results have partially dropped in the TYNDP 2018 CBA process due to the optimization of hydro generation in the Scenarios. Before the start of assessment phase of TYNDP 2018 the hydro generation patterns were checked by several large hydro producer countries to ensure optimal hydro dispatch and avoid undesirable generation spillage and possible non-optimal use of hydro resources.
This caused coverage of more demand by the hydro generation without considerable change in hydro generation and consequently less use of fossil fired technologies causing variation of CO_2 emissions.

4.3
Increased losses

The increase of interconnection capacity enables power to flow from one side of Europe to the other, in-line with political objectives. In many cases, these power transfers are accompanied by an increase in grid losses. Additionally, some projects facilitate entirely new flows which would not be possible without the project. These increased losses can be interpreted as the price to pay for fulfilling the European Energy targets. In general, the assessment of losses variations induced by new projects has been improved in TYNDP18 when compared to TYNDP16 especially for monetization.

A comprehensive all year round simulation and European-wide calculation has been applied to obtain a view on the regional losses. The monetisation of losses based on hourly data (TYNDP18) rather than yearly pan-European marginal cost (TYNDP18) has a significant impact, as no particular deviation could be noticed when considering results in volume, i.e. in MWh.

The results should be treated with caution, as losses have a very high sensitivity to generation assumptions, in particular the location of generation units.

4.4
Lower uncertainty ranges due to improved market modelling

Most of the CBA indicators of the project assessments are based on results of market studies, carried out with fundamental market models (i.e. software tools that try to simulate the electricity system as close to the reality as possible). Even if the complexity of the market simulations has been increased in TYNDP2018 (several climate years, multiple tools for every assessment, results-comparison and outlier-identification processes) – the confidence of the market model results has increased noticeably in TYNDP2018.

The reason for such evolution, despite the fact the results themselves have changed, is the fact that in TYNDP 2018 more sophisticated error checking methods were used ensuring higher precision. Also, the fact that 3 market modelling software tools were used.

Figure 4.12: Ranges of project assessments results (ΔSEW) across market models

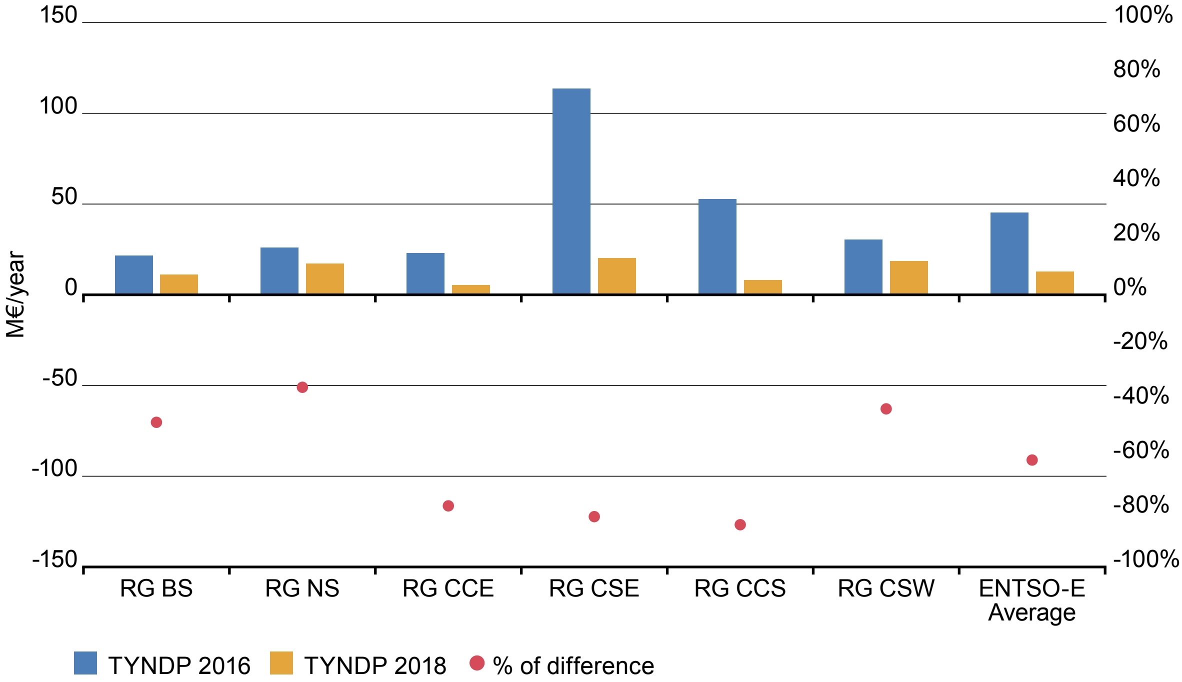
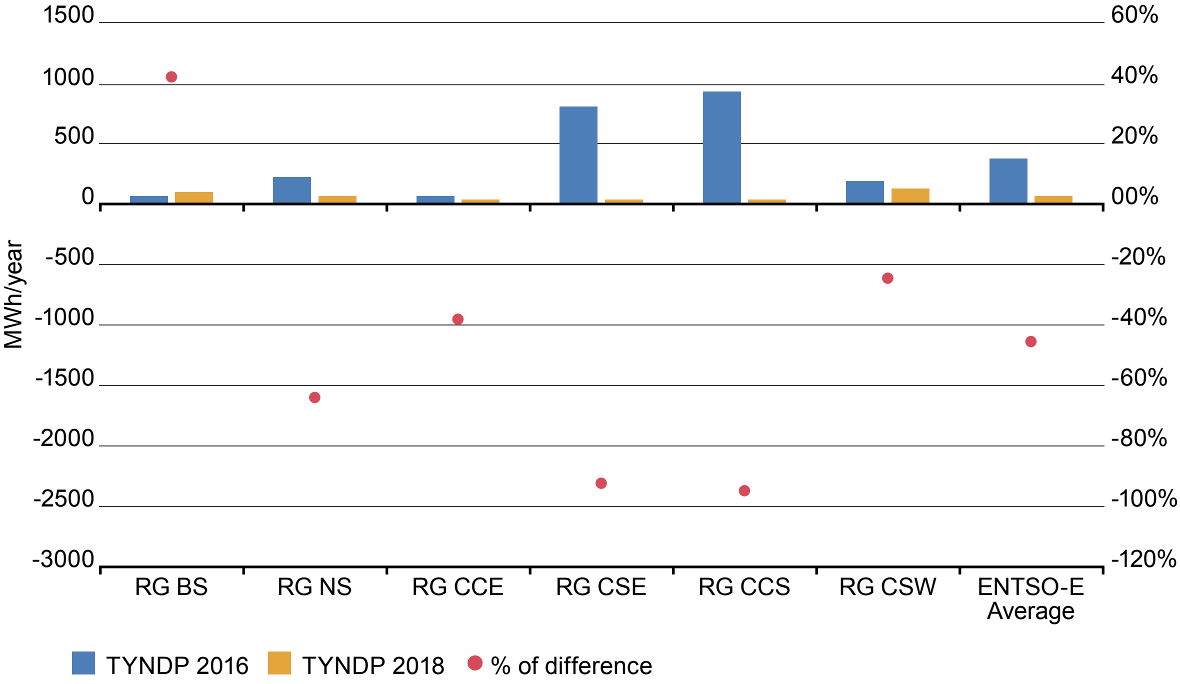
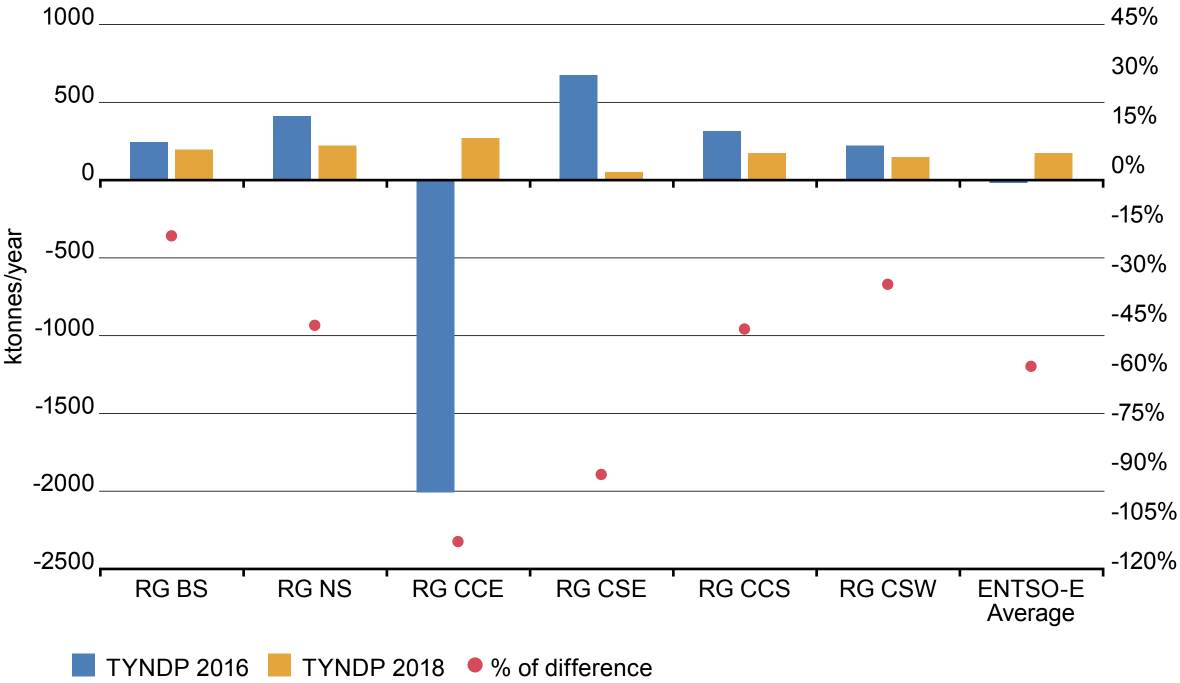


Figure 4.12 above shows the average range of results in TYNDP 2016 and TYNDP 2018. In all regions, these ranges could be narrowed down by several million € per year accounting for up to 80-90% decrease in relative terms in TYNDP 2018 compared to TYNDP 2016.

A similar case can be observed for the ΔRES indicator. As shown in Figure 4.13 the ranges for the RES integration results have decreased significantly. In the case of South East and Central South SDC regions it shows up to 97% drop. Only the Baltic Sea region shows an increase in the RES integration range which is mainly caused by the overall increase in absolute terms for this indicator.

Figure 4.13: Ranges of project assessments results (ΔRES, ΔCO2) across market models





For the ΔCO2 indicator, the pattern is even more distinct. In some cases (RG CCE), the ranges might reach a level 113 % decrease in relative terms compared to the results in TYNDP 2016 package.

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