CBA METHODOLOGIES FOR ELECTRICITY TRANSMISSION INFRASTRUCTURE AND SCENARIOS FOR ENERGY AND POWER SYSTEM PLANNING

Final Report

V1.2.1

FWC ACER/OP/DIR/08/2013/LOT 3
Req. no. ACER/OP/DIR/08/2013/LOT 3/RFS 02

May 2016

ENERGY & ENVIRONMENT CONSULTANTS

CONTENTS

ACRONYMS

ACER	Agency for the Co-operation of Energy Regulators
CBA	Cost Benefit Analysis
CBCA	Cross-Border Cost Allocation
CEER	Council of European Energy Regulators
EC	European Commission
EENS	Expected Energy Not Supplied
ENTSOE	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
GTC	Grid Transmission Capacity
KPI	Key Performance Indicator
MS	Member State
NDP	National Development Plan
LOLE	Loss of Load Expectation
PCI	Project of Common Interest
RES	Renewable Energy Sources
RG	Regional Group
RgIP	Regional Investment Plan
SoS	Security of Supply
ToR	Terms of Reference
TSO	Transmission System Operator
TYNDP	Ten Year Network Development Plan
VOLL	Value of Lost Load

1 INTRODUCTION

The current document comprises the Final Report of the project "CBA Methodologies for Electricity Transmission Infrastructure and Scenarios for Energy and Power System Planning" and presents the findings of the Consultant's work. The project was procured by the Agency for the Cooperation of the Energy Regulators (ACER), as a specific assignment under the Framework Contract – Lot 3 – "Assistance on Technical Issues".

In accordance with the ToR, the project aimed at:

- Describing, assessing and comparing the methodologies used by ENTSO-E and in EU Member States for CBA of investments in electricity transmission networks;
- Describing, assessing and comparing the methodologies using scenarios used by ENTSO-E and in EU Member States for energy and power system planning;
- Providing recommendations for improvements and consistency

  (i) between the national methodologies for CBA and the ENTSO-E CBA methodology,
  (ii) between the national methodologies using scenarios for energy and power system planning and the respective methodology developed and used by ENTSO-E;

The purpose of the study was to contribute to the Agency's activities in relation to the scenarios for energy and power system planning and the CBA for electricity transmission Infrastructure.

In particular, the Study required:

- A detailed assessment of the ENTSO-E CBA methodology and provision of recommendations for potential improvements
- A detailed assessment of the ENTSO-E scenario development methodology and provision of recommendations for potential improvements
- A description, assessment and comparison of methodologies used in EU Member States for CBA for investments in electricity transmission networks

Regulation (EU) No 347/2013 requests ENTSO-E (the European Network of Transmission System Operators for Electricity) to establish a "methodology, including on network and market modelling, for a harmonised energy system-wide cost-benefit analysis at Union-wide level for projects of common interest". Furthermore, the Regulation requires that the CBA methodology shall be based on a common input data set representing the European Union's electricity and gas systems and assigns to ENTSO-E the responsibility to prepare a CBA methodology for the assessment of transmission infrastructure projects in electricity. The methodology should be used to assesses all Ten-Year Network Development Plan (TYNDP) candidate projects against their value for society and aims to ensure that the selected projects are those that add the most value.

On February 2015 and after extensive consultation rounds, ENTSO-E published the CBA methodology which has been approved by the European Commission. Although this methodology marked a significant progress since 2012, when ENTSO-E started the preparatory work for the CBA methodology, further challenges and possible improvements have been identified by the Agency and were described in the Agency's Opinion on the ENTSO-E Guideline for CBA of Grid Development Projects and the Agency's position of 30/1/2013 on CBA.

Against this overall background and taking into account the Project ToR, the Consultant proceeded with a detailed review and assessment of the CBA methodology as published in February 2015 and of the TYNDP 2014 and 2014 and 2016 Scenario Development Reports for formulating recommendations for improvements.

In parallel, the Consultant proceeded with the collection of information from TSO and NRAs of 10 representative Member States with regard to national practices regarding potential performance of CBA on national transmission development plans, as well as on preparation and assessment of national transmission system development scenarios, with the purpose to identify potential consistencies and form relevant recommendations for harmonization of national practices with TYNDP development / CBA methodologies.

Accordingly, this Report is organized in three main sections, the first one dealing with the critical review of the scenario development methodology, the second with the assessment of the CBA methodology and the third with the review of the situation with scenario development and CBA assessments in selected MS countries. The Report is concluded with an overview of the proposed recommendation on all three of the above issues, as well as with a critical overview of the provided recommendations in terms of implementation priority, difficulty, effort, associated risks, etc.

2 ENTSO-E SCENARIO PLANNING FOR TYNDP

2.1 Scenarios and CBA: A Sole Basis for the TYNDP Process

The CBA methodology and scenario planning methodologies have been developed in the framework of the TYNDP process and comprise the basis on which the main results of the TYNDP are being grounded on. Due to the intrinsic relationships between TYNDP, scenario planning and CBA it is important to consider the TYNDP development framework in order to put in context the purpose and scope of the scenario planning and CBA processes. This will allow the more targeted and purposeful assessment of the two processes and formulation of relevant recommendations. It will also illustrate the importance of other supporting processes, i.e. the market and network studies which are also intrinsically linked to the CBA.

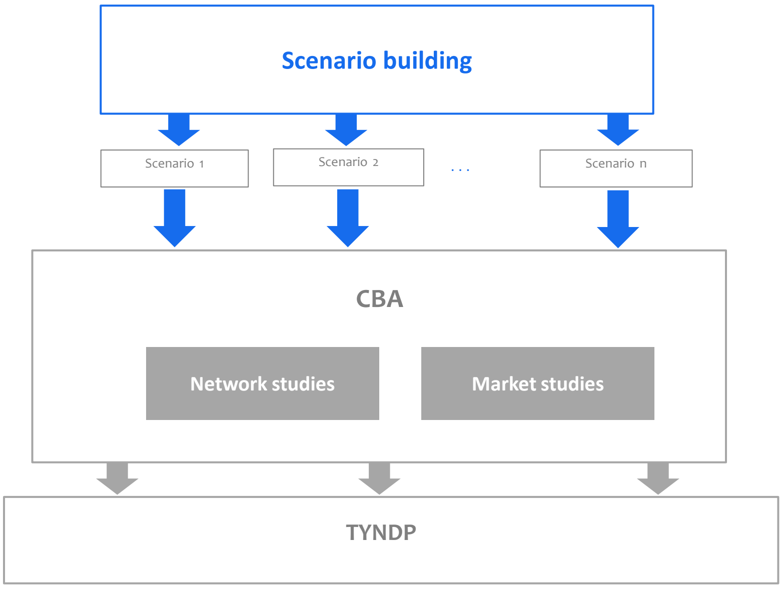
The TYNDP includes the transmission projects necessary to tackle with the future transmission needs of the electricity sector in Europe and therefore comprises a comprehensive overview of transmission projects that have a pan-European significance. The major objective of TYNDP is to demonstrate the future needs for new transmission grid infrastructure and inform properly the decision makers and the stakeholders.

The TYNDP is published every two years and is developed for the entire ENTSO-E area that includes the EU MS, as well as several non-EU countries. Despite the fact that non-EU ENTSO-E countries are in a process of aligning with the EU energy acquis, their legislative and regulatory incompatibilities (e.g. absence of NREAPs, non-binding targets etc.) increase the effort and complexity for obtaining ENTSO-E wide harmonised scenarios and perspective for the future.

The TYNDP 2014 was prepared assessing the period up to 2030, and the analysis was based on the system outlook in the year 2030. The forthcoming TYNDP for 2016, shall cover again the period up to 2030, and is expected to base the corresponding analysis and results on two time points, i.e. 2020 and 2030.

The TYNDP process, which is illustrated schematically in Figure 2.1, is carried out through the following steps:

Figure 2.1: TYNDP network planning phases



- The TSOs and third parties submit to ENTSO-E the cross-border transmission project investments which they are developing and/or consider for development. Third parties include non-ENTSO-E TSOs and other potential investors that are interested in electricity transmission business.
- The submitted transmission investments are validated / filtered by ENTSO-E against certain pre-conditions they need to fulfil, which however do not relate to any sort of evaluation or assessment of the investment. Subject to the fulfilment of these pre-conditions, the investments are registered for the next TYNDP.
- ENTSO-E proceeds with the development of a number of scenarios which describe possible future evolutions in load demand and generation mix, considering alternative developments of major factors affecting the European power system, e.g. RES development, decarbonisation, energy efficiency, etc.
- Each registered candidate investment (alone or clustered with other investments) is assessed against each of the alternative scenarios. Each such assessment comprises effectively the carrying out of a corresponding CBA in accordance with the approved relevant methodology. The CBA comprises the assessment of a series of impact and benefit indicators. It incorporates procedures for the detection of weak transmission corridors and definition of relevant transmission needs (referred as "boundaries") and grouping the transmission investments into "clusters" (called "projects") on the basis of certain criteria.

The Scenarios and the resulting TYNDP are subject to a wide consultation process, which is carried out during every TYNDP development cycle. The CBA methodology has been subject to a wide consultation process as well, which concluded with its approval by the European Commission in February 2015. It is noted that the application of the CBA methodology to TYNDP projects is based to a great extent on data which are derived through the so called Regional “Market Studies” and “Network Studies”, which are also carried out during the TYNDP development process. These studies are therefore important supporting components of the CBA methodology, and in this context they are reviewed and assessed in a corresponding relevant section of this Report.

The whole TYNDP development process is carried out under the responsibility of ENTSO-E. However, as ENTSO-E relies heavily on the work of its member TSOs, it is understood that certain tasks are carried out in a decentralised manner by member TSOs, or the relevant Regional Groups. It is also understood that, depending on the case, the work may be carried out on different subsets of data. Thus, the scenarios are developed on the basis of a pan-European global view at the ENTSO-E level, i.e. taking into account the power system of all ENTSO-E members, while the CBA of each project is performed by the ENTSO-E Regional Groups, principally on the basis of the corresponding regional part of the power system.

The TYNDP development process is concluded with the publication of the TYNDP package which provides a global description of the foreseen main attributes of the future electric system in Europe and relevant figures at the pan-European and national level. Such attributes include for example the load evolution, electric energy balances and RES capacity and generation levels, CO_2 emissions levels, estimations on electricity prices, new transmission costs, transfer capacities, estimated power flows, etc. for the years(s) that the power system has been analysed for. Thus, in the case of TYNDP 2014, these figures are presented for 2030 alone.

There is also specific information on each transmission project that is part of the TYNDP. This information comprises:

- A description of the main parameters of the project (length, voltage level, etc.)
- An approximate geographical representation
- The CBA indicators assessment results for each scenario, for the year of analysis (2030 in the case of TYNDP 2014)

The TYNDP package includes, as well, 6 Regional Investment Plans (RgIPs) providing similar information as above on projects of regional significance and a System Outlook and Adequacy Report (SOAF).

Beyond TYNDP, the CBA is further used in the context of the PCI selection process. During this process, it is understood that CBA results are among the criteria for ranking candidate PCIs and therefore for the selection of those that will be eventually introduced in the PCI list and receive EU co-funding.

Given the aforementioned context, the Consultant considers reasonable to assess first the scenario planning process and then the CBA methodology taking into account the overall framework these are carried in and the associated objectives, as well as to include in this assessment the supporting tools used, e.g. the network and market studies for which the CBA methodology makes a high level reference to the context of their use in the CBA process. The following sections discuss the respective findings.

2.2 Scenario overall build-up process

The scenario building methodology for the TYNDP 2014 was rather short, lacking explanations and justification on several scenario development aspects, and as such it received several remarks from the Agency and other stakeholders. In November 2015 and after a public consultation process, ENTSO-E published the “TYNDP 2016 Scenario Development Report” (onwards also called the “Report”), which was admittedly a significant step forward and addressed the major part of the comments and criticism that had been received with regard to TYNDP 2014.

Table 1 below summarises the comments made by ACER and the way that these comments have (or have not for that matter) been addressed in the latest TYNDP 2016 Scenario Development Report.

Table 1 The Agency's comments on scenarios and study results as included in Opinion 1/2015

Agency Comment	Assessment of comments with regard to 2016 scenarios
ENTSO-E to provide stakeholders with a comprehensive description of assumptions, documentation of data sources, data acquisition and processing methods;	Data sources, documentation and assumptions are presented to a considerably greater level of detail than in 2014 scenarios. Processing methods are presented in much more detail, but more elaboration is required at some points.
ENTSO-E to provide assumptions on hourly load, hourly generating available capacity, available interconnection capacities, fuel prices and CO2 prices in a transparent way in the future Scenario Development reports;	These assumptions have been provided
ENTSO-E to provide more information and clarity on the methodology used for the development of Visions 2 and 4, and on the reasons why these two Visions are characterised as 'top-down';	This information has been provided
ENTSO-E to more clearly identify the 'distance' between parameters used in the different Visions other than installed renewable energy sources (RES) capacity or load;	The distance between parameters used in scenarios is not clearly identified.
ENTSO-E to assess the TYNDP scenarios against their 'feasibility' related to factors such as system adequacy, economic viability of generation investments, flexibility embedded in the assumed system to cope with intermittent RES and dependence on gas-fired generation;	ENTSO-E should place more emphasis on assessing the feasibility of scenarios against these parameters.
ENTSO-E to explain the method used to deal with the recursive process of making assumptions on the level of generation capacities and of calculating the future interconnection capacities;	This issue has been addressed to a large extend, some more clarifications are needed though
ENTSO-E to consider a case of high energy prices and high RES development.	This issue has not been addressed by ENTSO-E
Finally, the Agency suggested that a stakeholder comment on using also a "best estimate" scenario deserves a broader discussion	ENTSO-E has elaborated a scenario reflecting the best estimates of TSOs on developments until 2020 but not until 2030.
ENTSO-E adopts a two-year period for issuing separately the reports relevant to scenario development and to adequacy assessment	ENTSO-E does not appear to have commented on this remark.

Overall, as derived by the above Table, the report on the TYNDP 2016 scenarios represents a significant improvement on the major part of the comments received for the scenarios developed for TYNDP 2014.

In accordance with the 2016 Scenarios report, **each scenario is defined as a set of data** referring to:

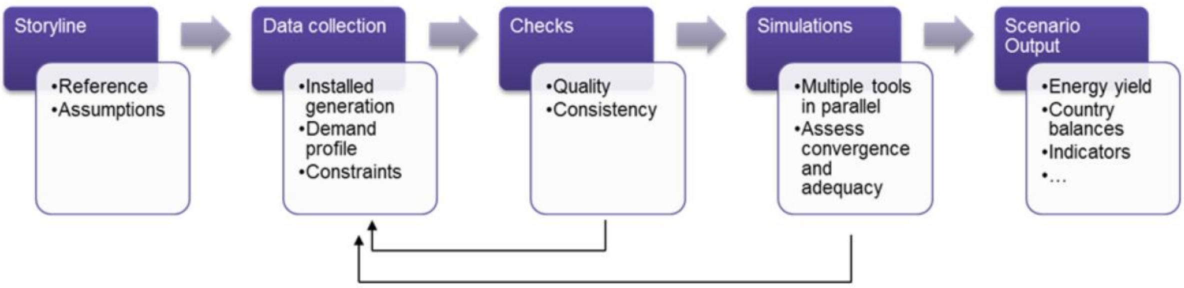
- The load demand level at national level for each ENTSO-E member country.
- The energy balances for each of these countries.
- The foreseen network developments within each ENTSO-E TSO control area.

The scenarios are developed based on a story-line, assumptions and hypotheses on future development, data on installed generation, demand profiles and technical constraints and following relevant quality and consistency checks. These storylines have been characterized as "Visions" and are based on some parameters affected by:

- the level of achieving the European targets to reduce greenhouse gas emissions by 2050 to 80-95% below 1990 levels and,
- the level of strength of pan-European governance in the energy sector.

For each scenario, ENTSO-E performs market studies which result to the quantification of country energy balances, indicators, etc. The whole process is schematically illustrated in Figure 2.2.

Figure 2.2 Scenario Development Process (source: ENTSO-E 2016 Scenario Development Report)



According to ENTSO-E, each scenario "combines the views of national plans provided via TSO correspondents, the expertise and large variety of tools of dozens of market modelling experts, and the pan-European perspective via elaborate scenario development methodologies". Moreover, each scenario is developed starting from a storyline that assumes and takes into account binding targets, long-term ambitions and available technology roadmaps. It is also stated that "the scenarios do not aspire to give a forecast of the future, nor is there any probability attached to any of the 2030 Visions. The Visions do not have the pretext to show what some would hope the future to be like, but rather give the full spectrum of what is considered realistic".

Scenarios are a fundamental component of the TYNDP development process. ENTSO-E scenarios or "visions" have been subject to a wide discussion on various consultations. ENTSO-E has adopted a bottom-up / top-down approach in order to reflect loose / strong European framework for the period studied. Furthermore, the 4 scenarios developed extend up to 2030 and they all share a common path up to 2020. Due to the proximity to 2020, this common path expresses the best estimate scenario up to that time point.

It is understood that this common path is based on the NREAPs of the Member States. However, the TYNDP 2016 Scenario document does not clarify what are the assumptions adopted by the TSOs for the development of the scenarios in the 2020-30 period, i.e. to what extent they are harmonised with the national energy policy / goals, or what assumptions are adopted for the projections to 2030. It is also not clear what guidelines are provided to the TSOs for the construction of the bottom up scenarios.

The scenario document provides an overview of the key parameters adopted for each scenario. However, several of these parameters are expressed in qualitative terms. Clarifications are required whether the interpretation of these parameters into the specific numeric figures which is necessary for scenario calculations is left with the TSOs or specific relevant guidelines are provided by ENTSO-E.

The clarifications on the development of the bottom up scenarios become more important, as due to the way that the top-down scenarios are developed, they are eventually based to a significant extent on the structural characteristics of the bottom up scenarios. Subject to any relevant clarifications, it can be argued that a more co-ordinated approach to bottom up scenario building by the TSOs would enlarge the value of the scenarios. Such an approach should consider consistency to other national energy planning documents (e.g. NREAPs, Adequacy studies and provisions, energy efficiency programs, others, if any), regional cooperation to assess realistic intra-area transfer capacities and cross-border regulation possibilities, and common assessment of technical evolutions at the regional level. A coordinated approach could lead to a “best estimate” scenario at regional level and consequently at the pan-European level.

On the other hand, determining the detailed scenarios and parameters entails a strong policy dimension as far as targets and interaction with other energy sectors is concerned. There is quite a number of other studies developing future scenarios, some of them officially endorsed by EC, performed by entities such as EC-DG Energy, IEA and other institutions and organisations, which are more extensively involved with building of policy scenarios due to their role. In this context, in the Consultant’s opinion, the development of scenarios should be subject for a broader collaboration and not of consultation alone, especially for the longer term time periods.

Such collaboration could refer to a range of alternative options, i.e. from the definition of visions and key scenario parameters to the use of the modelling tools. The Consultant would recommend that the EC and Member States are more actively involved in the process of scenarios / visions development and potentially even undertake the overall exercise in broader collaboration with stakeholders. This approach would allow for more consistency with policy directions in one hand but it would also take into account the most up-to-date evolution of technologies. Such a procedure would also increase significantly the transparency and acceptability of the scenarios among stakeholders and facilitate the effective distribution and communication of both the approaches and methodologies utilized and the results.

The Agency and NRAs should keep having a key consulting role by providing opinions and assessments on the scenarios in the framework of this process. It is also considered that ENTSO-E could focus in assessing the technical aspects of the scenarios implementation from the transmission infrastructure point of view, an activity which is also closer to its fundamental role. This approach would release as well ENTSO-E resources to be used in other activities related to the CBA assessment.

Independently of the above, in the Consultant's opinion, due consideration should be paid on the overall approach of defining 4 visions, considered to 'provide the envelope within which the future is likely to occur'[1], which raises reasonable question marks whether this 'envelope' contains all or the major part of the possible future system evolution states in the long term. In the Consultant's opinion, an approach based on the development of a 'best estimate' long term scenario, accompanied by a sensitivity analysis could be potentially less effort intensive compared to the current approach of the 4 visions, while providing clearer results. The best estimate scenario assumptions could be adopted through the collaborative process mentioned above. Through the same process, potential 'extreme' values of the key assumptions could be also defined and used as the basis of the sensitivity analysis during the CBA process. In this way, CBA indicators could be more illustrative, as they would provide a 'main' set of values, and a range for each these values, instead of a set of 4 distinct values which is the case with the 4 visions approach.

Another general aspect of the scenario development/assessment methodology with power based models used by ENTSO-E, is that they focus on the electricity sector, with limited, if any, consideration of the energy sector as a whole, thus ignoring significant interactions and substitution effects among energy sub-sectors and more specifically between electricity versus coal and gas, as well of other more general aspects, e.g. elasticity of demand, etc. This is acknowledged by ENTSO-E in the TYNDP 2016 Scenario Development Report which states that "*on one hand pure energy-models (such as the PRIMES model used in the EC trends) allow to look forward based on an optimization of all energy components, not purely electricity but also gas and oil which all interact. On the other hand, power-based models (such as the ones used by ENTSO-E in this report) are based on electricity market simulations which take into account full-year hourly based profiles of load and climate data, as well as grid constraints. Such power-based model allows to assess price zone differentials, RES spillage, country balances, etc.*" Although this is a rational claim, in the Consultant's opinion, an approach based on a combination of modelling methodologies could provide more appropriate results. For example, the data (e.g. electricity energy balances and power generation capacity data) used as input for the market studies performed by ENTSO-E in the course of CBA assessments could be obtained by those that have resulted through energy/economy models, which address the complete energy sector (including gas) and, ideally, have been endorsed by the EC and the MS. In such a case, ENTSO-E would then undertake to make the required further breakdown to the appropriate level of detail in order to run the power models it uses and perform analyses at the level of detail pursued by ENTSO-E. for the market studies. The above approach would have the advantages of relieving ENTSO-E from a major part of the scenario planning process, and make

[1] TYNDP 2016 Scenario Development Report

the detailed market studies within an already defined overall framework, which has taken into account the interactions among energy sub-sectors in a more comprehensive manner.

Notwithstanding the above opinion of the Consultant, special care should be given to the gas sector as being the one with the highest interaction with electricity in several aspects, such as gas prices and availability, spatial distribution of future gas power plants, economic viability of gas fired power plants vs RES exploitation, impact on greenhouse emissions by replacing coal by gas, heat and power cogeneration, viability of future gas power plants under high RES penetration, technical issues related to future thermal generation mix to achieve required flexibility to accommodate intermittent RES, etc.

A high level review of the respective TYNDP for the gas sector issued by ENTSO-G on 2015 indicates deviations in many aspects, such as the date of issue (ENTSO-E releases TYNDP on odd years - ENTSO-G releases TYNDP on even years), the planning horizon (until 2030 for ENTSO-E, while until 2035 for ENTSO-G), the initial hypotheses, the number of scenarios considered (two visions for ENTSO-G for 2030 versus four visions for ENTSO-E). It is also noted that it is difficult to reconcile the gas demand for electricity generation between the gas and electricity TYNDPs, as the figures in the respective reports are presented only as graphs. These inconsistencies and non-harmonized practices impact the credibility of both TYNDPs, thus reducing the acceptability of both documents among stakeholders. It is therefore evident that there is a need for harmonization of views and consistency of assumptions across electricity and gas TYNDPs. To the Consultant's view, a process should be adopted so as to achieve consistent methodologies and assumptions with respect to all the factors and parameters affecting the electricity and gas sector interdependence, as well as similar study horizons across electricity and gas TYNDPs. This harmonization process between the two sectors is a crucial topic that should be discussed intensively among national electricity and gas TSOs, ENTSO-E, ENTSO-G, NRAs and ACER.

2.3 Story-line Definition and relevant inputs

Each storyline is defined so as to construct contrasting Visions for 2030 in terms of various factors that reflect possible evolutions. These factors can be classified to:

- **Economy and Market**
  - Economic and financial conditions
  - New market designs
  - National schemes regarding R&D expenses
  - Dispatch merit order: primary fuel pricing – carbon pricing
- **Demand**
  - Energy efficiency developments
  - New usages (heat pumps, Electric vehicles)
  - Demand response potential
  - Smart grid and impact on load & generation patterns
- **Generation**

- RES (wind, solar, hydro (Run of River), biomass)
- Back up capacity, nuclear, etc.
- Decentralized and centralized storage

In order to build the 2030 visions a set of parameters has been used to reflect long-term future conditions. These parameters constitute the basis for the quantification of future demand and generation conditions within each TSO area. Relevant data are provided by TSOs for the construction of the so called "bottom-up" scenarios and this issue has been discussed in the previous section. The parameters are differentiated mainly with regard to the progress along the Energy Road Map 2050 and the harmonization level across Europe (loose to strong European framework). These parameters reflect a number of possible future evolutions. The 2016 TYNDP scenarios document includes the following Table 2 for presenting a "summary of characteristic elements of 4 visions".

Table 2 Summary of characteristic elements of 4 visions (source: 2016 TYNDP scenarios report)

	Slowest Progress	Constrained green progress	National green transition	European Green revolution
	Vision 1	Vision 2	Vision 3	Vision 4
Economic and financial conditions	Least favourable	Less favourable	More favourable	Most favourable
Focus of energy policies	National	European	National	European
Focus of R&D	National	European	National	European
CO_2 and primary fuel prices	low CO_2 price, high fuel price	low CO_2 price, high fuel price	high CO_2 price, low fuel price	high CO_2 price, low fuel price
RES	Low national RES (>= 2020 target)	Between V1 and V3	High national RES	On track to 2050
Electricity demand	Increase (stagnation to small growth)	Decrease compared to 2020 (small growth but higher energy efficiency)	stagnation compared to 2020	Increase (growth demand)
Demand response (and smart grids)	As today	Partially used	Partially used	Fully used
	0%	5%	5%	20%
Electric vehicles	No commercial break through of electric plug-vehicles	Electric plug-in vehicles (flexible charging)	Electric plug-in vehicles (flexible charging)	Electric plug-in vehicles (flexible charging and generating)
	0%	5%	5%	10%
Heat pumps	Minimum level	Intermediate level	Intermediate level	Maximum level
	1%	5%	5%	9%
Adequacy	National - not autonomous limited back-up capacity	European - less back-up capacity than V1	National - autonomous high back-up capacity	European - less back-up capacity than V3
Merit order	Coal before gas	Coal before gas	Gas before coal	Gas before coal
Storage	As planned today	As planned today	Decentralized	Centralized

As a general comment it is noted that the full disclosure of the scenario building methodology and assumptions would also allow stakeholders to fully understand the relative position of scenarios thus increasing both the value of the scenarios and transparency. Additionally, the detailed explanation of the methodology would allow to fully understand how the inputs/parameters are related to the outputs, which is currently a "black box" to the reader. Specific comments on the information provided in the above Table 2 are presented below:

- **Inputs and results.** It is understood that most of the above characteristics are inputs to the models, while certain refer to the scenario results (e.g. demand, etc.) The table seems therefore to present a high level view on the scenarios trying to illustrate the aspects considered as key by the authors. However, we consider that the table should become clearer and eventually more detailed and informative on the scenario input assumptions.
- **Choice of parameters.** Under the aforementioned remark and in the absence of a clear list of input assumptions, it is assumed that key input assumptions have been chosen as a result of intensive consultation and consideration. Nonetheless, the rationale for choosing these parameters and not others is not explained in detail by the authors of the report, especially so, when eventually they reflect policy options. On the other hand, it

remains unclear if and to what extend other parameters, e.g. the flexibility and ability of the power grid to integrate more renewables through the provision of the necessary ancillary services are considered in the scenarios.

- **Quantification of parameters.** A major issue that reduces the clarity and transparency of the above table and eventually of the methodology is that most of the parameters are not quantified, but presented in qualitative terms (e.g. electricity demand, RES, etc.). As already discussed, this leaves unclear the mechanism for interpreting these terms in numeric figures, the role and approach of each TSO on this and the potential relevant co-ordination. On the other side, the impact of the interpretation of descriptive values by each TSO cannot be justified. The Consultant recommends a more robust, comprehensive and quantifiable description of the story line behind each scenario. This would also allow for a better assessment of the relative distance among the scenarios and will increase transparency in line with ACER's request.
- **Distance between parameters**. Due to the poor quantification the "distance" among the parameters used to build the different Visions (other than installed thermal and RES capacity or load) is not clearly defined. Practically, it is difficult to justify how feasible and realistic or how extreme the visions are and what is the relative distance among them. Therefore, a more concrete and quantified set of initial hypotheses is needed.
- **Uniform application of parameters.** The values presented in the above table for some quantified parameters (such as demand response and smart grids, electric vehicles and heat pump) appear to be uniformly applied throughout the entire ENTSO-E area which seems not realistic (just note the different level of developments across EU and the participation of non-EU countries). This hypothesis should be further discussed and justified.

2.4 Study horizon and Visions in TYNDP 2016

The TYNDP 2016 Visions represent 4 different scenarios to capture contrasting or "extreme" evolutions in the electricity sector. Each vision reflects similar boundary conditions for every country so as to capture a realistic range of possible future pathways. Visions differ from each other on a series of parameters and policy choices as described above. The goal of the scenarios is to eventually allow TYNDP projects to be assessed across the same range of possible evolutions. The TYNDP focuses on the long term horizon for the year 2030. Targets set for renewables, energy efficiency, de-carbonization and interconnections, frame the direction of the studies and resulting recommendations for grid development up to 2030. Nonetheless, the absence of a time series of 'snapshots' of the generation mix foreseen until the one of 2030 (e.g. annually, every two or five years) does not provide a clear picture of the evolution of the EU power system.

ENTSO-E has acknowledged this need as a number of stakeholders have expressed the requirement for shorter timeframes than the single 2030 view. To meet this requirement, for the TYNDP 2016 a new scenario called "Expected Progress" provides an outlook for 2020 as a bridge to 2030, and is common to all 4 visions / scenarios for the period 2020-30.

In Consultant's view, even though the development of the 2020 scenario is towards a positive direction, still the disclosure of the energy outlook for more time points time until 2030 remains a prerequisite to allow for a more comprehensive CBA, as well as for allowing stakeholders and NRAs to obtain a better insight of each view and relevant justification. Therefore, a full specification of the location, commissioning date and evolution of new generation capacity over time is recommended. A corresponding recommendation is also provided in the CBA part with regard to the provision of a time series of CBA results.

Furthermore, according to Consultant's assessment there is need for a different treatment of the long term horizon (> 10 years) than the medium term. In this context, the role of stakeholders could be much more useful in developing long term views as TSOs typically utilise future data for no more than 10 years ahead and they have no data on very long term developments. The example of the e-Highways project is a good basis for the involvement of more participants, other than TSOs, such as universities, agencies, research centers, technology companies, consultants etc. in the scenario building for long and very long term horizons.

2.5 Data references

The data references have improved significantly compared to the TYNDP 2014 case and reach a satisfactory level of transparency. The main source of data for the main cost parameters is IEA (following a recommendation by stakeholders). Other general accepted sources of data have been used as a reference.

A major issue related to the development of visions is the non-disclosure of data for a list of parameters and assumptions. ENTSO-E acknowledges the fact that the important assumptions at ENTSO-E level might differ from those at the national level, which in turn may lead to different results from the TSO's best estimates. Thus, the publication of key data is essential in order to enhance transparency and accountability of the scenario building and planning process.

There are some unclear points concerning the data sources (especially at the TSO level) though. A full specification/description of inputs referring to future development of internal networks is required as well as the distinction between data that are confidential and those that are or could be publicly available.

2.6 Reporting

The TYNDP 2016 Scenario Development Report provides draft results per vision and country: the estimated future demand (MWh), installed capacities per technology (MW) and relevant energy balances (MWh). The reporting part could be significantly improved by adding more information especially on:

- Peak loads

- Result of demand side measures
- Impact of new technologies in electricity share (e.g. electric vehicles, heat pumps)
- Equivalent operation hours of thermal units; the latter is of high importance to justify the economic viability of thermal power plants and impacts severely on the credibility of each scenario
- Imports/exports between countries

Such enrichment of the report would increase transparency and eventually its value for the stakeholders as they could have a clearer picture of the evolution of the power system. Apart from public sector stakeholders (NRAs and TSOs) this type of information could also help private sector stakeholders, particularly transmission project developers better plan their future investments.

2.7 Bottom-up and top-down approaches

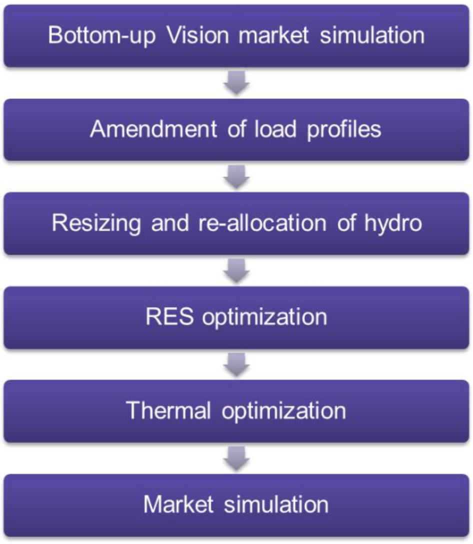
As stated in the TYNDP 2016 Scenario Development Report the set of scenarios (4 visions) for year 2030 to be considered are classified into bottom-up and top-down scenarios. Bottom-up scenarios (i.e. 2020 Expected Progress and Visions 1 and 3 for 2030) are created by a straight forward process as already depicted in Figure 2.2.

The "bottom-up" scenarios have been constructed based on the collection of national figures that are "combined" so as to produce a pan-European scenario. These data have been provided by TSOs to the best of their estimations and expertise. The methodology is clear in general with the exception of the following points:

- Data collected by the corresponding TSOs and used for the elaboration of the bottom-up scenario at the national level follow national methodologies. These data are crucial as they refer to the most crucial parameters for vision construction (expected installed generation, demand profiles, transmission constraints etc.). The adoption of a harmonized procedure and concept would greatly increase the alignment between ENTSO-E members with regards to the building of the top down scenario.
- The extent at which the transmission capacities foreseen for 2030 fit to the individual transmission National Development Plans (if any).
- Some data concerning the level of demand side measures and relevant data on the impact of electric vehicles and heat pumps per country are not reported at all.

Top-down scenarios (2030 Visions 2 and 4) are developed considering bottom-up scenarios as a starting point: Vision 1 is used as the basis for Vision 2 and Vision 3 for Vision 4. Top down scenarios aim to present a future case of the EU energy sector under strong European governance. The scenario is adapted using a step-by-step procedure starting from capacities and load profiles and network models so as to reach a pan-European scenario incorporating European governance and MS coordination. More specifically, this procedure includes algorithms for the amendment of load profiles, resizing and reallocation of hydro, RES and thermal generation optimization as shown in Figure 2.3.

Figure 2.3 Establishment of top-down TYNDP scenarios



The concepts behind the individual methodologies to carry out the steps mentioned above (shown in Figure 2.3) are well explained and justified. However, there are certain unclear points on both the data and the specific methodologies used to implement the reported concepts, e.g.:

- There is a need to further clarify the assumptions regarding interconnection capacities assumed in the top-down scenarios.
- The re-sizing and re-allocation of hydros seems to be done in an arbitrary manner; How reported percentages have been decided? Where is the excess hydro capacity located? Which is the main source of data?
- There is no information on the methodology used to calculate the future Locational Marginal costs of Production (LMPs). Also the relevant results on LMPs evolution (crucial for the re-allocation of RES) are not reported.

It is suggested to report more specifically and in more detail the methodologies used within each process. It will increase the transparency of the entire process and the value of the scenarios. More information is also needed on the practical details of the implementation including data used and algorithms, the perimeter of application (e.g. ENTSO-E wide/regional/National level, consideration of transmission constraints etc.).

Another unclear point is the temporal and spatial allocation of the new conventional and RES generation within each country. The top-down scenario foresee, in general, more RES and less thermal, but there is no description of how this new generation (or decommissioned thermal generation) is allocated within the geographic territory of each TSO. More specifically, the following questions arise:

- Is there a concrete methodology or is this allocation based on each TSOs expertise?
- Are there any specific criteria applied?
- How is it related to the gas system?

The above issues should be described in the CBA methodology in order to increase credibility of visions and a harmonized methodology on the geographical allocation of future generation is recommended to be applied by all TSOs.

2.8 Consistency of visions with National views and EC expectations

The visions scenario planning methodology has been developed by utilizing data from various sources including data provided by TSOs. Nevertheless, the methodology pays little attention on the consistency of visions with national/regional planning scenarios and respective results. These are by definition closer to reality for the short and medium horizon as they use more reliable assumptions and data projections focusing exclusively on a country level.

ENTSO-E acknowledges the fact that the final values of these scenarios might not correspond to the best estimates from the national TSOs, because the important assumptions at ENTSO-E level might differ from those at the national level. Therefore, it is strongly suggested that the consistency and alignment between the scenarios developed by ENTSO-E and those on national level is more thoroughly assessed (especially for the top-down scenarios assuming strong European governance). It is always possible that the national prospects and relevant scenarios do not fall within the "Vision square". Therefore, in order to better inform the stakeholders, the ENTSO-E scenarios (especially the top-down) should be compared to the national ones; differences - when they exist – among the national scenarios and the ENTSO-E visions should be reported and explained, especially if the National scenarios are outside the "Visions square".

Independently of the above, we consider that there is a need for a comparison of the 2016 TYNDP scenarios with scenarios developed by other organisations in order to assess whether there is convergence. Currently, the 2016 Scenario document includes a rough comparison to IEA scenarios scaling the ENTSO-E scenarios to the EU-28 perimeter. This is a valuable overall comparison, however, in the Consultant's opinion, this should be complemented with a comparison of planned scenarios with the EC approved scenarios. Such comparison should address both the assumptions used, as well as the resulting energy outlooks, at least in terms at least of high level energy balance figures. The need for the latter comparison becomes more obvious when someone considers that PCIs are selected and potentially co-financed on the basis, among others, of CBA results which in turn are linked TYNDP scenarios.

2.9 Engagement of stakeholders

ENTSO-E has established the "long term network development stakeholders' group" aiming to enhance communication between ENTSO-E and stakeholders in order to improve the quality and robustness of the TYNDP. The specific group aims to contribute towards more productive information exchanges and the creation of a shared understanding of different views on relevant development/research/assessment topics. Furthermore, the stakeholder's group according to ENTSO shall "facilitate greater stakeholder involvement in the TYNDP process, and enable the stakeholders to play an active role in the TYNDP deliverables, as well as increase acceptability of ENTSO-E development plans".

The role and impact of stakeholders in the development of the scenarios remains largely unclear. The consultation with stakeholders includes a series of public workshops and "Stakeholders group" meetings. The aim of the process is to build up the relevant storylines and assumptions and to test the acceptance of the scenarios by the stakeholders.

In general, the level of consultations seems adequate, but it remains unclear which input from the 2030 Visions questionnaire and from the 2030 Visions data consultation has been taken into account by ENTSO-E. Therefore, it is proposed that ENTSO-E issues an explanatory document at the beginning of the TYNDP building process dealing with the following issues:

- ENTSO-E should address in a proactive manner the "inconsistencies" in forecasts among the various stakeholders that are coming out as a result of conflicting interests and explain how these are taken into consideration.
- The decision-making process for each building step should be clearly defined, as well as a methodology to consider stakeholders input in a productive manner.
- An explanation of what data will be shared with stakeholders and what data will remain confidential and why. The provision of a preliminary set of all public data referencing their source and justifying their selection would greatly improve the consultation process.

2.10 Techno-economic feasibility and reliability of visions

In order to increase the techno-economic feasibility and reliability of forecasts various aspects need to be assessed:

- **Generation adequacy assessment.** First of all, a more robust assessment of the generation adequacy is required for all ENTSO-E countries that would allow for an ex post validation of the reliability of results. A denser description of the scenarios for the first 10 years (e.g. per 2 years) and less "snapshots" for the long-term (10 years – 20 years) could provide a more detailed forecast. In this process the TSOs could play a more increased for the mid-term horizon (5 – 10 years), while the role of public institutions and stakeholders (as proposed in 2.2.1) should increase for the long term horizon. For these representative years, simulations could be performed for the assessment of indicators (LOLP, LOLE, etc.) to justify generation adequacy and available reserves.
- **System flexibility for RES integration.** As a continuation of the previous remark, a technical assessment is required in order to ensure that there is sufficient flexibility of conventional generators to meet the forecasted load. Furthermore, consistency is required between ENTSO-E and ENTSO-G visions due to the high degree of replacing coal by gas. In order to address these needs, the dependence on gas-fuelled generation needs

to be assessed, supported by a sensitivity analysis through a “shortage” in gas scenarios and taking into account cross-border regulation issues.

- **RES spatial allocation and meteo/hydro assumptions**. Another significant issue that could largely improve the reliability of visions is the thorough allocation of future RES plants in Europe and the better consideration of meteorological and hydrological data in order to ensure compatibility with NREAPs and justification of to what extend the plan is realistic. For instance, various stakeholders during the consultation process (of the TYNDP 2014) have commented on solar, hydro and pumping assumptions as being too pessimistic or optimistic. Therefore, RES scenarios should be coordinated with forecasts of Member States so as to comply with NREAPs and be optimized across Europe based on the RES potential.
- **Economic viability of results.** The assessment of the economic viability of forecasted generation (especially thermal) in the study period is essential, as well the assessment of the resulting electricity cost for the consumers. In addition, the calculation of the average values to estimate economics per type of thermal generation and RES (taking into account any policy-driven incentives) seems essential. Furthermore, the assessment of the cost of ancillary services (and capacity payments) is a key economic consideration that should be better assessed as these will increase considerably over time.

As a general recommendation is it highly advised that ACER and/or ENTSO-E set techno-economic criteria for “Vision acceptance”, which are consulted among the stakeholders and being published. Such criteria should take into account all parameters concerning generation adequacy, viability of thermal and RES power plants, RES potential across Europe, compatibility with ENTSO-G TYNDP, etc.

2.11 Evolution of Technologies

Each scenario includes specific assumptions regarding the basic characteristics of certain technologies such as Electric Vehicles, smart grids, renewables, heat pumps, storage solutions etc. These assumptions regard specific capital and operational costs, technical efficiencies, equivalent full load hours for intermittent (RES) of the various technologies which are assumed by ENTSO-E but not explicitly provided. The involvement of stakeholders in the context of the stakeholder group must be increased in order to provide more detailed data.

In order to systematize the TYNDP process and address this issue a common pan-European database publicly available including key data for RES technologies, Electric vehicles, smart grids, heat pumps, etc. could be created. These data could be provided by relevant stakeholders (i.e. mainly associations) and also approved by ACER (average/acceptable values) in order to increase the acceptability of the TYNDP.

Also, this would allow for a better understanding and assessment of the impact of certain technological evolutions (demand response including “smart grid” impact, electric vehicles and heat pumps) on scenario outlook that will transform the future electricity grids in the future.

3 REVIEW OF THE ENTSO-E CBA METHODOLOGY

3.1 Background

As per Article 11 of the Regulation 347/2013[2] of the European Parliament and of the Council on guidelines for trans-European energy infrastructure, ENTSO-E was requested to elaborate a methodology aiming at defining the framework for (a) a harmonised energy system-wide cost-benefit analysis at Union level and (b) the assessment of Candidate PCIs which contribute to market integration, sustainability and security of supply. The methodology should comply with the principles laid down in Article 11 and Annexes IV ("Rules and indicators concerning criteria for projects of common interest") and V ("Energy system wide cost-benefit analysis").

The CBA methodology was designed by ENTSO-E with a view to fulfil the above objective and describe the procedures proposed to be used in order to establish a harmonized methodology at EU level for assessing transmission and storage projects included in the TYNDP. The ENTSO-E CBA methodology has been developed following an extensive and long public stakeholder consultation process.

The assessment presented in this report is based on the latest edition of the methodology that was issued by ENTSO-E in February 2015 and has been approved by the European Commission. It is understood that a new edition of the methodology is under preparation by ENTSO-E and is expected to be released by mid 2016 (currently under Public Consultation).

Overall, the CBA methodology has gone at great lengths towards the fulfilling of the challenging requirement of establishing a framework for the assessment of transmission projects taking into account almost all the meaningful/significant cost and benefit indicators considering both the economic impact but also externalities (social, environmental) and technical impact. The assessment presented in the following aims at identifying potential for future improvements.

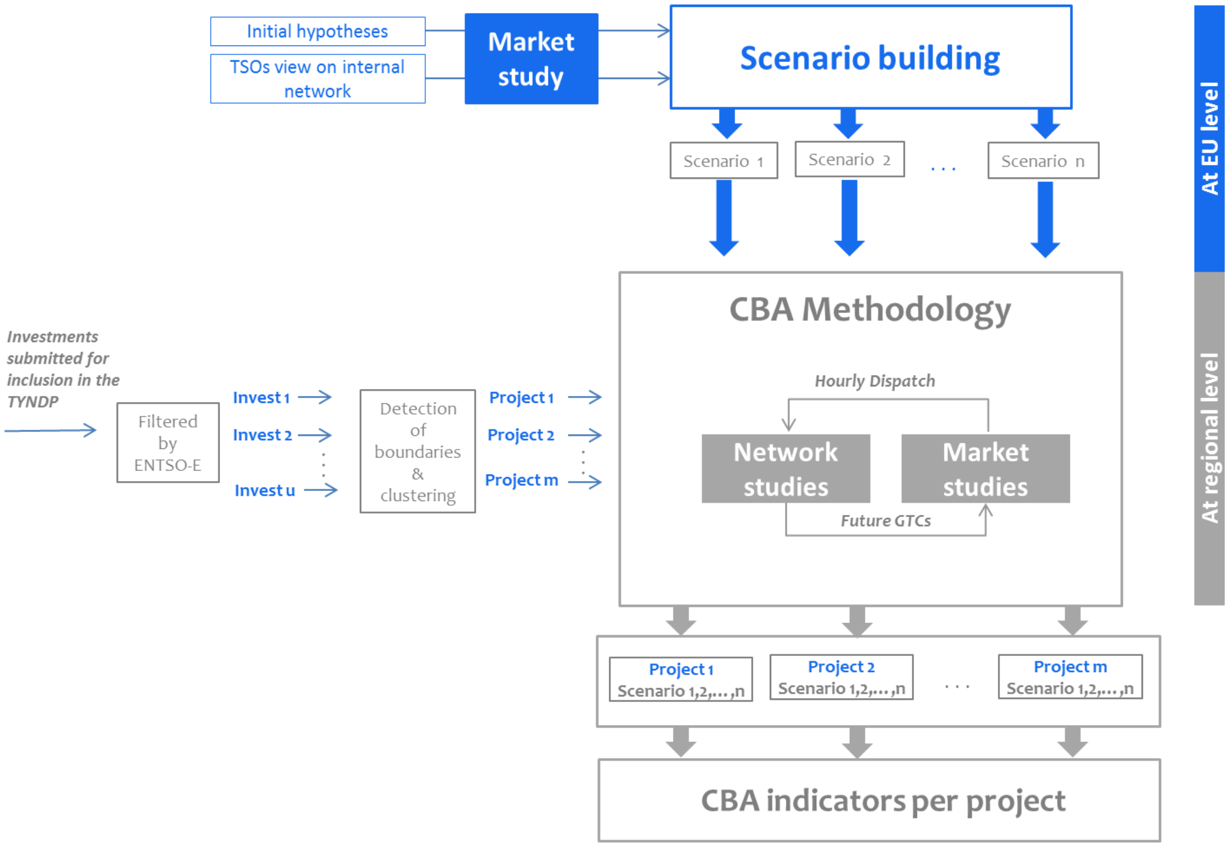
As already discussed in Chapter 2, the CBA assessment is one fundamental step in the course of the development of the TYNDP and the PCI selection processes. As depicted in Figure 2.1, its main components comprise the CBA indicators and the Market and Network studies which are the main sources for the data for the calculation of the CBA indicators. Therefore, the assessment of the CBA methodology, which is presented in the following, is addressing all these components.

[2] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0347&from=EN

3.2 The CBA implementation process

The process for CBA assessment of transmission projects in the framework of the TYNDP is illustrated schematically in the following Figure 3.1.

Figure 3.1 CBA implementation process



The CBA implementation process includes the following steps:

- Following filtering of the investments by ENTSO-E, procedures to detect transmission boundaries and rules to group individual investments into clusters are applied.
- The resulting clusters (referred as 'projects' in the ENTSO-E terminology) are assessed using the CBA methodology. The most important sources of calculation of the CBA indicators are the Regional Market Studies and Network Studies. These tools interact with each other: the available future GTC through a boundary is calculated by performing Network studies and is subsequently used as input in the Market study. On the other hand, the hourly dispatch of available generators is determined using the Market studies tool and is fed back as input in the Network studies.
- The CBA methodology is applied for each TYNDP project and against each scenario (as analysed in previous Chapter 2). The CBA process comprises the assessment of 9 indicators, two impact indicators (S1, S2) and seven benefit indicators B1 to B7). Some indicators e.g. B1 to B5 are scenario dependent, while indicators S1, S2, B6 and B7 are not. On the other hand, five indicators are quantified using physical units such as MW/MWh, hours, km, tons (S1, S2, B1, B3, B5), two are monetised (B2, B4) and two are qualitatively

assessed (B6, B7). It is noted that B3 and B5 are internalised in B2. Further information on the indicators and assessment process is provided in Chapter 3.5 .

- The indicators, calculated per project and scenario, are ultimately presented in the TYNDP.

The CBA assessment of TYNDP projects is a lengthy and resource-intensive process even only taking into account the sheer number of analyses that need to be performed. As illustrated above, each project is assessed again each scenario and therefore, market and network studies that are used as sources for the calculation of indicators, are also carried out for each project / scenario combination. In general, the methodology foresees that each project is assessed against the reference network which is defined for each vision. It is possible that the reference network may be different depending on the vision. It is estimated that the CBA methodology was applied over 400 times in the framework of the last TYNDP 2014. This process results into a heavy work load which is undertaken by ENTSO-E Regional Groups (RGs) every two years. It is understood that sometimes the number of market studies carried out is greater as in many RG more than one market study tools are applied by different TSOs (as analysed in Chapter 3.6.2). On the other hand, it is understood that network studies comprise a series of load flow analyses for each project / scenario case, as explained in Chapter 3.6.1 on network studies, thus increasing even further the work load.

3.2.1 Overall assessment methodology: TOOT vs PINT approach

The estimation of CBA indicators requires the calculation of the impacts resulting and benefits achieved by the commissioning of each project under assessment. To assign impacts and benefits to each project, the power system behaviour with and without the project is simulated and relevant system operation and performance parameters (such as operational costs, CO_2 emissions, RES generation, transmission losses etc.) are calculated and compared. These parameters are calculated based on the results of the Market and Network studies. For each project/scenario combination, two cases are simulated: with and without the project under assessment starting from the “reference network”. ENTSO-E proposes two alternative methodologies which are differentiated as far as the reference network is concerned, i.e.:

- the **TOOT (Take Out One at the Time)** method. There is no explicit reference in the CBA methodology regarding which is the reference network considered for the application of the TOOT method, however it can be reasonably assumed that this is the whole forecasted network (including all future investments which are foreseen to have been commissioned by 2030 since the CBA analysis is performed for the system only at year 2030. Therefore, the project in question is assessed against the whole forecasted network, as if it was the last investment to be commissioned. According to ENTSO-E, the application of TOOT method is suggested for the CBA analysis of transmission investments for the 2030 horizon in the TYNDP process.
- **the PINT (Put IN one at the Time)** method. In this case, the project is evaluated against a reference network which is the currently existing network without any of the future TYNDP and internal projects i.e. the baseline network.

The assessment using TOOT approach implies the existence of a stronger reference network (i.e. a network "closer" to a "copper plate") as it includes all TYNDP projects and all the forecasted network enhancements at TSO level. According to the TOOT approach, the project under assessment is considered as the last one to be commissioned and is assessed against the whole forecasted network. This consideration evidently tends to moderate the results as far as benefits indicators are concerned, since each project is assessed against a network which is already significantly reinforced.

In contrast, according to the PINT approach, the project under assessment is evaluated against a reference network which is the existing network without any of the future TYNDP projects. Evidently, this approach results to an estimation of larger benefits (in relation to those estimated in the TOOT case) as each new project is added to a weaker reference network. The PINT method is recommended for individual project's assessment outside the TYNDP process.

In conclusion, the TOOT methodology tends to downsize the project's benefits while PINT approach tends to oversize them. Although the TOOT method tends to downsize the benefit indicators it is more appropriate to be used for projects that are foreseen to be commissioned in the long term timeframe (towards the end of the analysis period), as is the case of the opted target year (2030). For projects commissioned in the short to medium term timeframe the PINT approach gives more realistic results. In any case the methodology opted for the assessment of the projects (either TOOT or PINT) should be the same to allow rational comparisons.

According to the ENTSO-E CBA methodology, the application of TOOT approach is suggested for the CBA analysis for all transmission investment projects. As mentioned above, since, as understood by the Consultant, the CBA analysis is performed only for 2030, the method the TOOT method is applied for each transmission project regardless of its commissioning date. This seems rational considering the selection of 2030 to assess CBA indicators (2030), as by that year, it could be assumed that all projects are in place.

Nevertheless, the more forward in time from a project's commissioning date the reference network is considered, the higher the aforementioned underestimation effect of the TOOT method shall be for the specific project. Several of the TYNDP projects commissioning dates fall within the short and medium term horizon, i.e. they are far from 2030, (i.e. of which year's reference network they are assessed with). Thus, for such projects, the use of TOOT method for their assessment may lead to severe underestimation of CBA indicators (as far as benefits indicators are concerned).

Since the assessment of the CBA indicators for the TYNDP-2016 projects is referenced to year 2030 conditions, the Consultant would recommend that projects which are planned to be commissioned in the short to medium term horizon are evaluated using not only the TOOT but the PINT method as well. The reference network to be applied for the application of the PINT method could be the existing network of today or the one considered in the "2020 Expected Progress" scenario (if this is different from the former, depending on the project's commissioning date. Such additional results will allow relative comparisons of benefits under the two extreme network conditions concerning the reference network. In the case of candidate PCI projects which are planned to be commissioned in the short to medium term, such a comparison could potentially allow more informed decisions for the final PCI selection.

3.2.2 Clustering of individual investments

The objective of the TYNDP is to define the needs in transmission infrastructure so as to alleviate the existing bottlenecks in the transmission network and increase the transfer capacities within the ENTSO-E system. Special care is given to increase the cross-border transmission capacities (represented by the so called "Grid Transmission Capacity – GTC") among countries in order to increase the cross-border exchanges towards an integrated European market. In many cases the alleviation of transmission constraints in specific transmission corridors, requires the enhancement of several parts of the network i.e. the materialization of more than one transmission investments located in different TSOs areas and being implemented by different promoters. Thus a transmission infrastructure project can in practice comprise more than one investment items. To avoid confusion, ENTSO-E uses the following terminology:

- **Investment** which refers to an individual transmission element, i.e. overhead line, cable, substation, transformer, etc.
- **Project** which refers to a set of transmission investments which comprise a "group" of investments complementary to each other to achieve a common goal

Complementary investments / projects that are located in the same area or along the same transmission corridor and contribute to achieve a common measurable goal, are further clustered together in order to allow for an appraisal of their interactions and linked benefits under a "common project" framework. Pursuant to the ENTSO-E CBA methodology, two quantitative clustering rules exist for an investment to be considered as a part of the project:

- Substantial influence of the investment on the project, i.e. the investment contributes by more than 20% on the total GTC increase obtained by the main investment defined as the investment that "*is intended to bring a highest value of GTC increase across a certain boundary*"
- Commissioning dates of the investments which are clustered together are within a period of maximum 5 years long

According to ENTSO-E, the above clustering rules were deemed significant in order to avoid excessive clustering. The thresholds were introduced by ENTSO-E experts during the consultation procedure for the development of the ENTSO-E CBA methodology and are currently subject to review.

Although clustering of investment is a rational simplification to reduce the work load and avoid complexity (without jeopardizing the level of accuracy), we consider that it needs some more clarification and justification. The rules applied (i.e. time gap and 20% of difference in load flows, with and without the project) are not currently justified and seem to have been established rather arbitrarily. A brief presentation of the concept that led to these rules would be needed in order to understand the underlying rationale.

Further to the above, the Consultant understands that the clustering of investments is performed, as well, in order to avoid underestimation of the potential net benefits as these benefits are reached only if complementary investments are materialized as well, while it has the side benefit to reduce the number of projects/ scenario combinations that need to be assessed.

Notwithstanding the above, the Consultant would recommend that the clustering rules could be used as a means to promote better time alignment of the commissioning dates of the cluster components. To this end, a shorter time gap in commissioning dates could be adopted as threshold for a 'no-questions-asked' clustering.

Independently of the value of the time gap threshold however, it is recommended that this threshold is not applied "literally". Instead, promoters wishing to have their projects clustered, in case the time gap rule is violated by a short margin could be required to provide justified arguments for the reasons not allowing their projects to be better aligned. Regarding the aforementioned margin, the shorter the adopted time gap the broader this threshold should be.

The CBA methodology introduces as well[3] the term "competing projects" which are defined as "projects delivering the same service to the grid"[4] (pg. 32). ENTSO-E proposes an elaborate methodology to assess the level of the transfer capacity needed in cases of competing projects. However, the definition and determination of competing projects is not clear. For example, the concept of 'competition' is well understood in case of parallel lines connecting two areas, but it is not obvious if there are other such clear cases of 'competition'. Generally, there are no specific rules for identifying competing projects.

Therefore, is recommended that the term "competing projects" is more clearly defined in the CBA Methodology. Further, it is suggested that the sensitivity of the change of commissioning date of competing projects is investigated, as it could give useful information on the "flexibility" of the project as defined by the B7 indicator.

3.2.3 Impact of future connectees

Future extensions of the EU transmission system (North Africa, UA/MD, Turkey, Cyprus etc.) could have severe impact on the volume of the exchanges and electricity prices. They should be therefore taken into account on a "realistic" way especially for the long-term horizon.

This impact could be assessed by considering the power system of the future connectee during the reference network definition, if available information on this system allows such a consideration, and therefore assessing the impact as part of the overall CBA process. If such

[3] Page 23 of CBA Methodology document
[4] Page 32 as above

information is not available, would be **recommended** to investigate the possibility of analysing the most likely exchange scenarios with the candidate future connectees under a sensitivity analysis approach.

3.3 Time-horizons

As per Annex V of the Regulation 347/2013, "*the methodology for a harmonised energy system-wide cost-benefit analysis for PCIs shall be based on a common input data set representing the Union's electricity and gas systems in the years n+5, n+10, n+15, and n+20, where n is the year in which the analysis is performed*".

As per ENTSO-E CBA methodology, "The scenarios will be representative of at least two time horizons based on the following:

- **Long-term horizon** (typically 10 to 20 years). Long-term analyses will be systematically assessed and should be based on common ENTSO-E scenarios.
- **Mid-term horizon** (typically 5 to 10 years). Mid-term analyses should be based on a forecast for this time horizon. ENTSO-E's Regional groups and project promoters will have to consider whether a new analysis has to be made or analysis from last TYNDP (i.e. former long term analysis) can be re-used.
- **Very long-term horizon** (typically 30 to 40 years). Analysis or qualitative considerations could be based on the 2050 outlooks (EC trends, IEA, etc.)-.
- Horizons not covered by separate data sets which will be described through interpolation techniques."

In addition, as per ENTSO-E CBA methodology, "*it is generally recommended to study two horizons, one mid-term and one long term*".

On the other hand, Regulation (347/2013 requires 4 input data sets that cover the horizon up to 20 years ahead in 5 years' periods. TYNDP-2016 is focusing on years 2020 (mid-term horizon) and 2030 (long-term horizon), thus partially following the approach stated in the CBA Methodology. The CBA results are subsequently presented only for the specific time points focused as above.

Providing time series results for the CBA indicators which are monetised, would allow the assessment of the accumulated benefit of a project using an appropriate discount rate. In the opinion of the Consultant, this accumulated benefit would allow the consideration of the effect of the timing of completion of a project within the period studied, as projects completed earlier may have a higher accumulated benefit compared to others which are completed further away in time, and thus a more representative comparative assessment would be possible.

As mentioned above, the CBA Methodology considers using interpolation techniques, although this does not seem to have been applied so far. In any case, the benefits of the projects are strongly interdependent and therefore the commissioning dates of other (especially neighbouring) transmission or generation investments might impact significantly on the CBA results. Another important aspect is that the electricity sector in Europe is under transition and the sector may experience significant changes due to technological, regulatory and economic evolutions. Such changes typically cannot be captured using interpolation techniques. Therefore, interpolation techniques, if used, should be limited to the shortest possible time periods.

It is fully understood that the assessment of time series of CBA results would entail a significant additional workload for ENTSO-E, considering the effort required for a single year assessment as discussed in the previous section. However, this should be in any case counterweighted against the resulting increase in the credibility and transparency of results.

It is recommended therefore, that ENTSO-E provides input data sets and performs relevant network and market analysis results for four time horizons. Such additional analyses would enable higher compliance with the requirements of the Regulation (EU) No 347/2013 calls for an analysis at (n+5, n+10, n+15 and n+20 time points. Evidently, it will be more practical selecting discrete time points for the analyses e.g. 2020, 2025, etc. instead of strictly following the “n+” rule.

3.4 The CBA and Multi-Criteria Approach

ENTSO-E has adopted a combined **cost-benefit** (Cost-Benefit Analysis-CBA) and **multi-criteria assessment** framework for the analysis of electricity transmission projects within the TYNDP process in order to comply with the requirements of Article 11 (“Energy system wide cost-benefit analysis”) and Annexes IV (“Rules and indicators concerning criteria for projects of common interest”) and V (“Energy system wide cost-benefit analysis”) of the EU Regulation 347/2013. The ENTSO-E CBA methodology is not intended to provide a fully monetized approach that will rank projects at a European-wide scale; it rather aims to allow for informed decision-making and improve transparency in displaying costs and benefits in a homogenous way.

The CBA methodology states in particular that “*The multi-criteria approach shows the characteristics of a project and gives sufficient information to the decision makers. A fully monetized approach would entail one single monetary value, but because all results of the CBA are very dependent on the scenarios and horizons, this would lead to a perceived exactness that does not exist*.”

We consider the need for a combined CBA and multi-criteria approach is a valid point, especially considering that certain of the CBA methodology indicators cannot be monetized and some can be only expressed on a qualitative scale. Nevertheless, it is understood from the results provided for the CBA of TYNDP 2014 and the available information on the scenarios for TYNDP 2016, that the relevant network and market studies are performed for one specific year which is determined by the time horizon (e.g. 2020 and 2030 for the two time horizons of the TYNDP 2016) and not for the whole time-series of the period of analysis.

On the other hand, a CBA typically entails the assessment of a time series of benefits and costs over the time period that the CBA is performed on, and the use of an appropriate discount factor for calculating the Present Value of the overall net benefit. Independently of any multi-criteria approach, the assessment of time series of impacts and benefits, despite being hinted on in the CBA methodology (as already mentioned in the previous section) does not seem to be applied, even for the CBA indicators which are monetized or quantified. Thus, for example in TYNDP 2015, the CBA indicators are presented only for 2030 for each TYNDP project.

The assessment of such time series however, is necessary in order to have a more complete assessment of the overall benefit of a project, as by assessing the net benefit only for a single time point the cumulative net benefit of a project over time is ignored. Thus a project commissioned on 2025 and one commissioned on 2030 and having the same net benefit on 2030, appear to be equivalent, while they are not. Furthermore, without using an appropriate discount factor, it is not possible to compare the cost of a project with the net benefit, as these occur in different points in time.

As per the CBA methodology, "The scenarios will be representative of at least two time horizons based ……" and "…. Horizons not covered by separate data sets which will be described through interpolation techniques". However, interpolating data sets over a 10 or even longer time period, would be of highly questionable accuracy. On the other hand, it is understood that performing analyses for each year of the TYNDP period would result in an unfeasible work load for the CBA of TYNDP. To this end, the assessment of data sets referring to the number of data points as recommended in the previous section, would allow for shorter interpolations and thus comparatively better approximation of the values for the in-between years.

On the other hand, in relation to the indicators that would be considered only under a multi-criteria point of view, the provision of indicator results which are representative of the whole period of analysis of the projects rather than for a single time point, would be of much greater value. Potential solutions in this direction, should be identified and used to the extent possible, so that eventually, all indicators' results refer to whole period of analysis. A specific suggestion to this end is provided in Section 3.5.2 in relation to the CBA indicator (B7) on a project's flexibility with regard to different scenarios.

3.5 CBA Indicators

3.5.1 Overview of CBA indicators

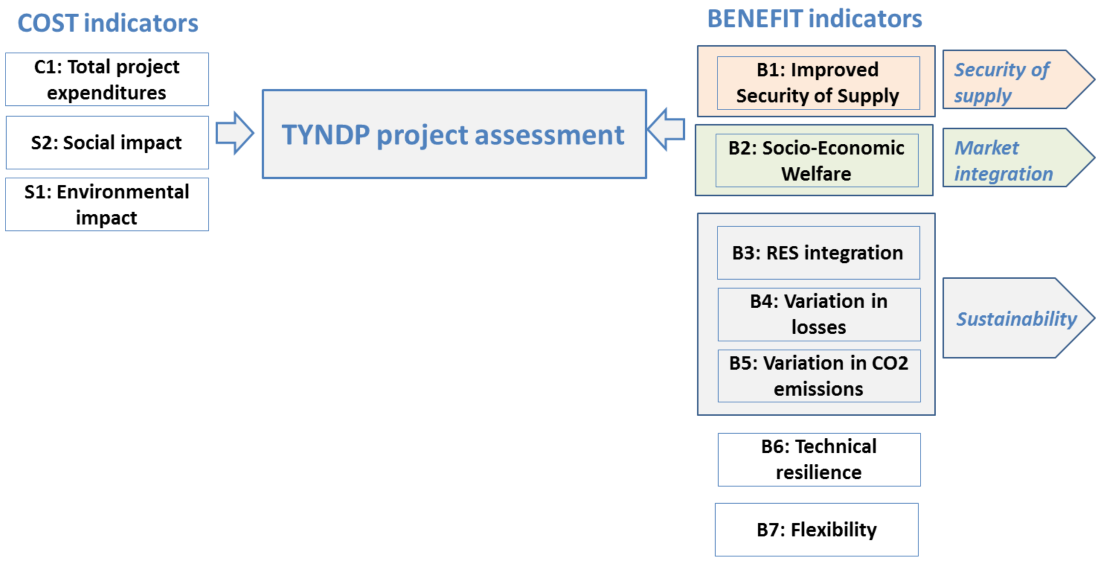
The ENTSO-E CBA methodology aims to assess the potential investment costs and the impacts of electricity transmission projects on the European electricity market, especially in regard with market integration, competition, system flexibility, security of supply and sustainability. The impact of each project is assessed through a number of indicators tracing the project's impact from different points of view: technical, economic, environmental and social.

The methodology employs in total the following nine indicators.

- **S1:** Environmental impact
- **S2:** Social impact
- **B1:** Improved Security of Supply (SoS)
- **B2:** Socio-Economic Welfare (SEW)
- **B3:** RES integration
- **B4:** Variation in losses
- **B5:** Variation in CO_2 emissions
- **B6:** Technical resilience/system safety
- **B7:** Flexibility

As depicted in Figure 3.2, two of the above indicators comprise 'cost element' indicators (S1 and S2) and seven comprise 'benefit' indicators (B1 to B7). Also, in addition to the nine indicators, the total project expenditures (C1) are calculated. It is noted that the specific criteria applied to the selection of PCIs, i.e. contribution to security of supply, market integration and sustainability are addressed through indicators B1, B2 and B3-B5 respectively; B2 includes also sustainability effects.

Figure 3.2 Cost and benefit indicators considered for the TYNDP project assessment by the ENTSO-E CBA methodology



A brief description of the nine indicators and their attributes with regard to quantification and monetisation is provided in Table 3.

Table 3.1: Overview of CBA indicators

Impact Indicators		Brief description	Monetization	Quantification
1.	**S1:** Environmental impact	Characterises the local impact of the project on nature and biodiversity.	No	Kilometres
2.	**S2:** Social impact	Characterises the impact of the project on the (local) population, giving a measure of social sensitivity.	No	Kilometres
Benefits Indicators		**Brief description**	**Monetization**	**Quantification**
1.	**B1:** Improved Security of Supply	Ability of a power system to provide an adequate and secure supply of electricity under ordinary conditions, in a specific area.	No	Hours or MWh
2.	**B2:** Socio-Economic Welfare	Ability of a power system to reduce congestion and thus provide an adequate Grid Transfer Capability (GTC) so that electricity markets can trade power in an economically efficient manner.	Yes	EUR
3.	**B3:** RES integration	Ability of the system to allow the connection of new RES plants and unlock existing and future "green" generation, while minimising RES plants' curtailments.	No	MW or MWh
4.	**B4:** Variation in losses	Characterisation of the evolution of thermal losses in the power system (energy efficiency).	Yes	
5.	**B5:** Variation in CO_2 emissions	Characterisation of the evolution of CO2 emissions in the power system.	No	tons
6.	**B6:** Technical resilience/ system safety	Ability of the system to withstand increasingly extreme system conditions (exceptional contingencies).	No	scored in ++/+/0
7.	**B7:** Flexibility	Ability of the proposed reinforcement to be adequate in different possible future development paths or scenarios, including trade of balancing service.	No	scored in ++/+/0

The two benefit indicators, i.e. *B3: RES integration* and *B5: Variation in CO2 emissions* (highlighted in "grey" in Table 3), are internalised in the benefit indicator B2: Socio-Economic Welfare (SEW). Thus, they are quantified and presented principally in order to provide more complete information but they are not accounted twice. The rest of the benefit indicators, i.e. B1, B4, B6 and B7 do not overlap with the exception of a certain overlapping between indicators *B1: Improved Security of Supply* and *B6: Technical resilience/system safety*. This is due to the fact that, in theory, failures and maintenance periods - although very short - have an effect on security of supply. However, in the Consultant's opinion, this overlap is practically negligible.

Concerning the impact indicator, *S1: Environmental Impact,* ENTSO-E states that it is also partially internalised in the total project expenditures (C1) through the compensation for environmental costs avoided/ mitigated. Thus, the impact indicators S1 and S2 consider only the residual impact of the project, i.e. the portion of impact remaining after potential mitigation measures and their associated costs have been considered under the total project expenditures (C1). S1 and S2 cannot be expressed in monetary terms, otherwise they would be considered under C1. They are presented separately and are quantified in terms of the number of kilometers, an overhead line or underground/ submarine cable (may) run through, environmentally "sensitive" areas.

ENTSO-E has placed great emphasis on defining transparent, objective and, to the extent possible, quantifiable criteria, which in addition reflect the assessment aspects required by the regulatory framework. Indeed, considerable progress has been made on the elaboration of the CBA methodology. Nonetheless, there are certain issues requiring further clarification and methodological issues that need to be further defined as it is discussed in the following Section. It is noted that CBA indicators are of great importance not only for the development of the TYNDP but, on the subsequent selection of TYNDP projects for being included in the PCI list and associated issues as provided by the Regulation 347 such as CBCA assessment, incentives, grants for works, information and publicity on PCIs costs and benefits. We consider that the developed methodology quite rightly puts special attention on and actually avoids double counting of costs and benefits indicators as discussed in the previous section.

3.5.2 Monetization and other issues of indicators

Benefit Indicator B1: *Improved Security of Supply (So S)*

The benefit indicator "*B1: Improved Security of Supply (SoS)*" is quantified through LOLE or EENS and is expressed in MWh not served, but is not ultimately monetized.

According to ENTSO-E, the SoS will be monetised through the VOLL, when the methodology suggested by CEER entitled "Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances" is applied at national level throughout Europe in a homogenous way.

As an intermediary solution, until the calculation of VOLL at national level based on the CEER methodology, it is recommended that ENNS and/or LOLE are calculated at pan European level treating the TYNDP as a whole and not for each individual TYNDP project. Similar indicators could be calculated as well at a regional level considering an agreed, among all involved TSOs in each region, VOLL per region. It is noted that "ENTSO-E Guideline for Cost Benefit Analysis of Grid Development Projects" (Draft 12 June 2013), includes in Annex 4 the following table with VOLL figures for certain MS. These figures were sourced from a variety of sources and reports. As reported therein however, these figures were not assessed from the compatibility of calculation methodologies point of view. Indeed, there seems to be room for extensive questioning of the compatibility of these values which are not always referring to the same economic sectors, some have been estimated with an almost 10 years' time difference, and the VOLL for the same sector appears to differ by more than one order of magnitude between 2 MS.

Country	VOLL (€/kWh)	Date	Used in planning?	Method/reference	Reference
Austria (E control)	WTP: Industry 13,2, Households, 5,3 Direct worth: Households: 73,5 Industry : 203,93	2009	No	R&D for incentive regulation, Surveys using both WTP and Direct Worth	(4)
France (RTE)	26. Sectorial values for large industry, small industry, service sector, infrastructures, households and agriculture available	2011	Yes (mean value)	CEER: surveys for transmission planning using WTP, Direct Worth and case studies.	(12)
Great Britain	19,75	2012	No	Incentive regulation, initial value proposed by Ofgem	(13)
Ireland	Households : 68 Industry : 8 Mean : 40	2005	No	R&D, production function approach	(6)
Italy (AEEG)	10,8 (Households) 21,6 (Business)[60]	2003	No	Surveys for incentive regulation, using both WTP and Direct Worth (SINTEF)	(3) & (5)
Netherlands (Tennet)	Households 16,4 Industry : 6,0 Mean : 8,6	2003	No	R&D, production function approach	(7)
Norway (NVE)	Industry: 10,4 Service sector: 15,4 Agriculture: 2,2 Public sector: 2 Large industry: 2,1	2008	Yes (sectorial values)	Surveys for incentive regulation, using both WTP and Direct Worth (SINTEF)	(9) and (10)
Portugal (ERSE)	1,5	2011	Yes (mean value)	Portuguese Tariff Code	(14)
Spain	6,35	2008	No	R&D, production function	(8)

The quantification of SoS indicator at the project level is a difficult task. The relevant results are usually negligible for new projects integrated into well meshed networks, as is the case for the majority of the TYNDP projects. This is probably the reason of zero contribution to SoS reported for a lot of projects in TYNDP-2014. However, it is not certain that their aggregated impact on security of supply is also negligible. In any case, the Consultant considers that an assessment of LOLE for the whole TYNDP could provide a useful indication of the overall impact of TYNDP on SoS, while a comparative review of LOLE of successive TYNDPs could also provide an index of the development of SoS over time, should the complete TYNDPs were implemented SoS impact for the TYNDP as a whole can be estimated by comparing the LOLE in the target network (i.e. the network with all future projects included) to the LOLE calculated with regard to the network of today. This is a useful piece of information that could increase the value of the TYNDP results.

On the other hand, the value of SoS indicator is considerable for projects affecting severely the network structure and therefore the SoS, e.g. radial new connections of isolated systems or areas weakly connected. Assessment of SoS indicator for individual projects is thus recommended to be restricted to such selected cases that should de described and defined in the ENTSO-E CBA methodology. This would reduce the relevant work load of ENTSO-E, without practically reducing the accuracy of the estimation. In the opinion of the Consultant, this recommendation does not result in compromising the evaluation of network reliability targeted projects, as it does not imply elimination of SoS indicator, but rather to focus the assessment of this indicator to those projects which are expected to have such effect and avoid spending resources for assessing SoS indicators in cases where it will have practically negligible, or even zero value, which seems that was the case in TYNDP 2014, where several projects have zero value for the SoS indicator.

Benefit Indicator B2: Social Welfare

The benefit indicators *B2: Socio-Economic Welfare* and B4: Variation in losses are the two indicators currently monetized. More importantly it is noted that B2 is the benefit indicator with the highest significance as it internalises "*B3: RES integration*" and "*B5: Variation in* CO_2 *emissions*", and it usually represents the major portion of the benefits achieved by a project.

Benefit indicator B6: Technical resilience / system safety

The proposed assessment of benefit indicator B6: Technical resilience / system safety is assessed through the key performance indicators (KPIs). In the opinion of the Consultant this is reasonable in the sense that it provides a broad idea of a project's contribution to future system security. This type of analysis is within the main field of interest and expertise of the TSOs and is justified in the framework of the TYNDP development. A better quantification of the criteria set (steady-state, distance to voltage collapse, etc.), although possible, requires a huge work load. However, the result of such improved quantification (and potential subsequent monetization of B6), in the Consultant's opinion would have negligible impact on the CBA results and it is not proposed, even more so as the monetization of the indicator is practically very difficult. It is also noted that indicator B6 has a certain contribution to B1 but this is still very small and difficult to calculate.

Benefit Indicator B7: Flexibility

The CBA methodology (pg. 26) states that indicator B7 assesses the ability of a proposed project to be adequate in different possible future development paths or scenarios, including trade of balancing service, through 3 KPIs. However, in the opinion of the Consultant, the B7 indicator attempts to capture a diverse range of issues, which are quite complex while the detailed methodology for the assessment of B7 as presented in the CBA methodology document (pg. 45) is not clear. Specifically, the only guidance provided therein states that by professional power engineering judgement based on the analysed new project's ability to address the issue, the project should be evaluated with a KPI that varies between a score of 0, a single or a double '+' (i.e. 0/+/++). Given the complexity of the issues which are stated to be addressed the above guidance does not seem adequate and therefore more methodological details are needed, including at least the principles for assessing each KPI.

It is noted that the impact of a project on trading of balancing services and more generally on the flexibility of the system to deal with the increased share of renewable generation is of high importance, as recognized in the same section of the CBA methodology. In the opinion of the Consultant, the assessment of this flexibility should become the subject of a more extensive methodological investigation and subsequent provision of guidance, and potentially subject of a new specific indicator, as also discussed in Section 3.5.4.

Notwithstanding the above, in the Consultant's opinion the main purpose of B7 indicator is to evaluate the adaptability of each project into different future system conditions, which to a significant extend may be considered to be represented by the 4 alternative scenarios. On this basis, we consider that the B7 indicator could be assessed in a more concrete manner, under certain conditions. Specifically, it could be considered that the project which is flexible and fits well with more scenarios, is the project presenting low variation of its calculated benefits across the different scenarios.

Under this assumption, a single quantifiable indicator of the flexibility of a project could be the relative variation of its benefits across the scenarios, which can be calculated as the root mean square deviation from the mean value of these indicators. Projects with the lowest such deviation are arguably the ones best fitting with most scenarios. In case that a probability is assigned to each scenario, the same probability could be introduced as weight coefficient in the aforementioned calculation, so that the overall index calculates internalizes the scenario probability impact too.

Impact Indicator S1: Environmental impact

The indicators for assessing the two impact indicators, "S1: Environmental impact" and "S2: Social impact" represent residual environmental and social costs, as already mentioned. We consider that the approach adopted by ENTSO-E is reasonable, as currently stated. Monetisation for these indicators is difficult as there are not yet reliable and widely accepted studies assessing with reliability the external costs of electricity generation and construction of transmission infrastructures

However, considering the definitions of indicators in CBA methodology, it is understood that the environmental impact is assessed on the basis of:

- Costs for environmental impact mitigation, which is included in the investment cost of the project (this captures the major environmental impact of the transmission line itself)
- Residual environmental impact (measured in S1) which is expressed as km of line length for which it not possible to apply mitigation measures (this captures the environmental impact of the transmission line itself as well), and the

- Avoided CO_2 cost, which is quantified as the amount of avoided tons of CO_2 emissions and monetized using the projected price per ton of CO_2 (this is used to capture the impact of avoided thermal electricity generation).

The external cost of thermal electricity generation comprises two main components: cost from greenhouse gases, and cost from the impact on health population of other emissions. The monetisation of the above costs (which are avoided in the case of avoided thermal generation) is different and likely higher than the cost of CO_2 as currently considered by the CBA methodology.

In the opinion of the Consultant the above components of environmental cost are not captured by the current methodology and therefore there is miscalculation and mismonetisation of the environmental benefit of transmission projects. It is recommended therefore that the complete external cost of thermal electricity generation is taken into account for assessing B2

3.5.3 Transmission capacity (GTC)

According to the ENTSO-E definition *“the GTC reflects the ability of a grid to transport electricity across a boundary”*. A boundary is described as a bottleneck in the system that restricts power transfers (i.e. the physical power flows) resulting by the engagement of generators according to the market rules. Although the meaning of a boundary is in principle described and comprehensible, it is not clear if a specific methodology is applied to detect the boundaries or the selection is done on an “expert opinion” level.

GTC across every boundary is calculated in both directions and it is independent of the scenario, depending mainly on the network topology. GTC increase within the European network is one major objective for the EU policy and a very important finding/result of the TYNDP as it is directly related to the interconnection targets, which in accordance to the recent European Parliament resolution of 15 December 2015, “on Towards a European Energy Union” are considered to be set to at least 10% of the installed generation capacity for 2020 and potentially increased to 15% for 2030.

The methodology used for the calculation of GTCs is described very briefly and should be further described and explained. For example, it is stated (textbox in page 28 of CBA Methodology) that *“the GTC value that is displayed and used as a basis for benefit calculation must be valid for at least 30% of the time”, a criterion which seems obscure*.

On the other hand, it seems that the GTCs used in the market studies do not take into consideration realistic power flows, while it is also not clear if any transmission margins are considered (i.e. margins allocated for regulation or other system security issues). These points need further clarification.

It also noted that the nodal representation of control areas in Market studies is questionable since it may ignore crucial internal congestions within each TSO area. Specifically, it is noted that several MS are represented as single nodes in the market model, with a few more nodes being used in the case of larger MS. It is therefore proposed the gradual application of flow-based methodologies so as to take into account internal congestions within each TSO area.

In any case, due to the high uncertainties resulting due to the high RES penetration and the markets' volatility, special attention should be given to the realistic representation of the power flows across the European network and the calculation of the relevant transfer capacities.

Therefore, the consultant suggests that ENTSO-E provides more information on the above mentioned implementation issues. In order to simulate the load flows across the European network and therefore account for the impact of transmission constraints in a more realistic manner, the utilization of "flow-based" methodologies is proposed. Such methodologies should be applied at least for the calculation of the GTCs. Consideration of more realistic power flows in the market studies would increase the accuracy of the results. The application of flow-based methodologies, although not an easy task, will increase considerably the value of results.

3.5.4 Issues for consideration of additional impacts of transmission projects

The CBA Methodology (Annex 5) does not clearly state if ancillary services (regulation/load following, generation flexibility, voltage regulation etc.) are taken into account and to what extent. On the basis of the available documentation it is unclear whether such issues are taken into account and in what way remains unclear.

It should be noted that the cost of ancillary services could be very high especially for scenarios with high intermittent generation (mainly RES). Special attention should be given on the flexibility of the future generation mix (affected highly by start-up and shut down times, ramp-up and ramp-down rates, use of reservoirs and pump-storage hydro etc.). Both the quantification and monetisation of ancillary services is indeed of high difficulty (due to the complexity of power system operation and the differences among markets in Europe) but some rough estimation on future ancillary costs should be given.

It is recommended that the implementation of such calculation be a future task for ENTSO-E. A methodology for the calculation of ancillary services should be provided within the framework of the "target model" as defined by Directive (3^{rd} package) on an ENTSO-E-wide base. On the basis of this methodology, an additional benefit indicator (B8) reflecting the benefits related to ancillary services could potentially added in the current CBA methodology.

3.5.5 Assessment of storage projects

In its CBA methodology (Annex 6), ENTSO-E explains the reasons why he proposes to assess electricity storage projects in the same way as transmission ones.

According to the Regulation (EU) No 347/2013 (Annex IV), "project with significant cross-border impact is a project on the territory of a Member State, which fulfils the following conditions:…… (b) for electricity storage, the project provides at least 225 MW installed capacity and has a storage capacity that allows a net annual electricity generation of 250 Gigawatt-hours/year. In addition, as per the same Regulation, *a storage project is an electricity storage facility used for storing electricity on a permanent or temporary basis in aboveground or underground infrastructure or geological sites, provided it is directly connected to high voltage transmission lines designed for a voltage of 110 kV or more*.

The same definition about the storage project and the minimum capacity criteria are applied in the ENTSO-E CBA methodology resulting to the consideration of only large-scale storage projects.

Storage projects will be of high and increasing importance as RES penetration increases. According to the criteria described above and the currently available technologies, the vast majority of the storage projects included in the PCI list refer to pump hydros. It is evident that in the TYNDP 2014 ENTSO-E has used the same cost and benefit indicators for assessing both transmission projects and storage projects. We consider this approach to be rational because it allows the comparative assessment of transmission and storage projects.

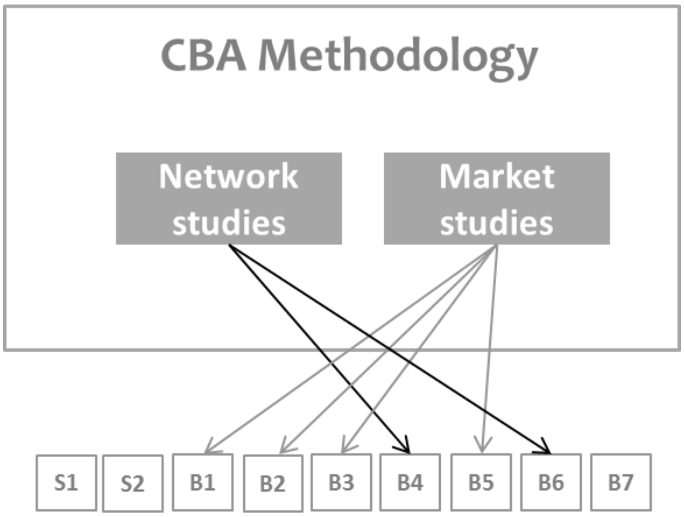
However, the CBA methodology does not seem able to capture the capacity / ancillary / flexibility benefits of storage or at least it does not provide any relevant information. More information is thus needed on the modelling and simulation of storage projects. Storage projects operation is affected by various factors such as operational practices followed, the pumping/generation cycles, the size of the reservoirs, etc. The investment driver for each specific project should be considered (i.e. market opportunities, system security, overall system cost optimization, RES accommodation to mitigate spillage and curtailments or other additional benefits such as contribution to ancillary services, increased flexibility etc.).

A concrete methodology on the modelling and simulation of storage projects and the relevant incorporation in the market studies is recommended to be prepared by ENTSO-E and adopted after consultation with the stakeholders. Some critical details (already commented by various stakeholders) such as application of TOOT method on cascading pump hydros, optimization objectives, etc. should be described.

3.6 Market and Network Studies

The main sources of calculation of the benefit indicators are the European Network studies and the Market studies that are developed by the ENTSO-E RGs at regional level. The importance of these studies is reflected by the dependence of the CBA indicators to the studies' results, as depicted in the Figure 3.3.

Figure 3.3 Dependence of CBA indicators to the results of the regional market and network studies



3.6.1 Network study

Network studies are performed in order to calculate the GTCs across network boundaries and assess the benefit indicator "B4: Variation in losses" as well as the scores of the KPIs for the assessment of "B6: Technical resilience/ system safety". Network studies are performed for the same system snapshots with and without the project under assessment and the results are compared. "B4 indicator is calculated in terms of annual energy losses by integrating differences in losses over the yearly period (applying the TOOT approach). The relevant methodology is described sufficiently and comprises steady state analysis through load flow studies along with the consideration of technical criteria related to system safety.

On the other hand, it is understood that extensive steady-state network analyses are performed and the respective work effort utilized, for assessing the Technical Resilience Indicators (B6) of the future network. Although useful, the relevance of this analysis in the framework of the CBA is recommended to be reassessed. Due to the distance in time of the year of study (2030), such a detailed analysis seems to be of limited relevance to the purposes of the TYNDP. More specifically, the proposed calculations (e.g. by distance to voltage collapse) require very specific studies, more data and huge work load. Furthermore, any such results would be highly debatable due to uncertainties with respect to hypotheses necessary for making the respective calculations. In addition, voltage collapse phenomena are highly network topology dependent and have a local character. Steady state analysis performed is insufficient to consider such dynamic phenomena. In Consultant's view, such an analysis is out of the scope of planning purposes as the ones considered for TYNDP. Also, the impact of such consideration will be definitely of low importance for the CBA.

3.6.2 Market study issues

Market studies provide the main results to support the calculation of the benefit indicators for each project. The methodology used in the market studies is not discussed in the CBA methodology; it has been shortly and poorly presented in TYNDP-2014. More information on the methodologies applied to carry out market studies by the various RGs of ENTSO-E is found in the Regional Investment Plans (RgIPs). Although the concepts followed by ENTSO-E RGs in market studies methodologies are very similar, it seems that there are differences among the methodologies used by the various RGs around Europe. Several different relevant tools are reported, such as ANTARES, Powrsym, or even in-house S/W tools). This could lead to inconsistencies of the results among ENTSO-E regions. Also, the utilization of different market tools is likely to lead to internal (i.e. within the RG) inconsistencies that normally take time to be resolved. The lack of uniformity of either the methodology or the tools utilized for market studies among RGs is understood to impose a heavier work load and additional effort for resolving any kind of inconsistencies. This is usually a difficult task as it requires the detection of the root of inconsistencies and procedures for convergence of results and therefore it consumes considerable resources.

The consultant recommends that ENTSO-E after consultation with the stakeholders proposes a common methodology to be applied Europe wide, by all regional groups. Preferably, a commercial widely used market studies S/W tool should be used. This could save a lot of the effort currently undertaken to check and modify the consistency of the results provided by different RGs. Furthermore, the adoption of a common market tool would allow the ENTSO-E to perform all the market studies with reference to the whole ENTSO-E region and not just at the regional level of the respective RGs. This step is expected to drastically decrease the overall work load and enable much higher consistency level of the results. It will also increase the transparency and consistency of the results.

Also, to our understanding, the utilization of GTCs in the market studies process is not clear. For example, it is unclear if the transfer capacity assumed between two TSOs (representing the secure maximum power transfer in MW between the TSOs) equals to the corresponding GTC or it is reduced by some quantities to represent any transmission margins kept to guarantee system security. It is recommended that market study methodology accounts for transmission margins required (e.g. for security reasons, for cross border frequency regulation, etc.). Also, rational assumptions for the allocation of cross-border reserves should be also proposed and agreed among TSOs in a transparent manner.

As mentioned in Section 3.5.4, an additional issue that needs special attention is the consideration of ancillary services cost and especially the required flexibility of conventional generators to ensure adequate load following capability (and therefore system security) in case of high penetration of intermittent RES. Although the relevant intertemporal characteristic parameters of the generators (such as start-up and shut-down times, ramping (up and down) rates) are mentioned in the document, it is not clear if they are taken into account and in what manner. The flexibility of the generation system is crucial for both the secure integration of RES and the future estimation of ancillary services costs.

The Consultant recommends that ENTSO-E puts effort in assessing the adequacy of conventional generation flexibility to accommodate high intermittent RES penetration (especially wind). Although premature, estimation of ancillary services cost and especially costs associated to the required system flexibility to accommodate intermittent RES should be put in the pipeline of the issues to be addressed soon.

Another important fact that should be taken into account in the market studies when calculating the overall system cost is the possible need for additional remunerations (on top of the market profit) to thermal generation in cases of high RES penetration (see relevant discussion in Section 2.7). As the RES contribution increases, the operating hours of thermal generation decrease. This puts in doubt the economic viability of thermal power plants since the income they can get from the market may be not enough to remunerate these plants for their fixed and variable costs. This is an emerging problem (already present in some countries e.g. GB, GR, ES etc.) and the impacts of this phenomenon should be carefully analysed and considered in the total system cost estimations.

3.7 Availability and transparency of CBA background data

As derived by the Regulation (EU) No 347/2013, the ENTSO-E CBA methodology is the main tool for a Union wide comparative assessment of the TYNDP projects. Since TYNDP is the main source of information available to stakeholders on the future grid in Europe, harmonised CBA results on Pan-European level is a valuable source of information.

Furthermore, according to the PCIs selection process, the inclusion of a candidate PCI project in the TYNDP list is a prerequisite for being considered for further assessment and evaluation. The CBA assessment is performed by the relevant ENTSO-E Regional Groups and, subject to the opinion of ACER and relevant results are provided to the EC to decide on the EU-wide PCI list. It is therefore clear that CBA has a crucial role in this process, being the main source of harmonised information on project's economic, technical and social performance for further use by the EC in the PCI selection process.

Having in mind that TYNDP includes not only projects planned and promoted by the ENTSO-E members (European TSOs) but also projects promoted by 3rd parties (i.e. projects promoted by TSOs that hold a transmission operating license but are not ENTSO-E members and entities that do not hold a transmission license, e.g. merchant lines, promoters of storage projects, etc.), the importance of CBA results in the PCI selection process is very high and therefore the results must be easily consulted not only among ENTSO-E TSOs but the stakeholders as well. A lot of 3rd party projects have applied to be included in the PCI list as most of them have a cross-border character and relevant impact.

Considering the importance of the CBA results, the transparency of the CBA methodology is of high importance as well. The "re-production" and verification of the results of the CBA performed by ENTSO-E should be potentially possible to be carried out by any stakeholder (e.g. a PCI promoter). However, the necessary data for performing the CBA, e.g. estimated load evolution, future generation mix, network topology evolution etc., are not presented in details in the document. It would be very helpful to the readers and the stakeholders an ANNEXED detailed description of the data required in the TYNDP building process. From a practical point of view, the possibility that ENTSO-E provides those data to the public should be investigated. Arguably, making public the necessary detailed data is a challenging task and it may also raise issues of confidentiality. Nonetheless, a road map towards the public availability of all necessary data for CBA should be established in order to promote conditions for increased transparency.

For increasing the transparency towards stakeholders, it is therefore recommended that ENTSO-E establishes a roadmap for making publically available all the necessary data for the CBA. The data and background material (e.g. market and network studies results) used for performing CBA, should eventually become publicly available, so that they can be used by stakeholders, project promoters, etc. It is noted that the availability and transparency of CBA data is an issue that reflects as well to the scenario data and the reference models which are used as background of the CBA process.

3.8 Clarifications related to Third party projects

A fundamental provision of the Regulation (EU) No 347/2013 is that Third party projects should be equally treated with the ENTSO-E TSOs' projects to avoid any kind of discrimination. More specifically, according to Annex III.2(5) *"By 16 January 2014, the Commission shall issue Guidelines on criteria to be applied by the ENTSO for electricity and the ENTSO for gas when developing their respective 10-year network development plans referred to in points (3) and (4), in order to ensure equal treatment and transparency of the process."*

The process followed by ENTSO-E to build the TYNDP-2016 is significantly improved compared to the TYNDP-2014 case. A major improvement is the adoption of a common application window for all candidate 2016 TYNDP projects submitted by both the ENTSO-E TSOs and third parties. This increases transparency. It is noted that still nonetheless, the TYNDP / CBA development cycle occupies approximately a whole year. Evidently, any new developments with regard to interconnection project of EU-wide importance during this period, cannot be taken into account, as changes in the reference model would require repetition of a potentially large amount of work already carried out.

Further to the above, the ENTSO-E CBA methodology does not clarify to what extent and in what manner third party projects are taken into consideration in the TYNDP development process. More specifically, more clarity is required on:

- The consideration of third party projects in the definition and construction of the "Reference Network"?
- The consideration of third party projects in the clustering process.

It is recommended that third party projects are taken into consideration in both the definition of the Reference Network and the clustering process in a similar manner as the ENTSO-E TSOs' projects and that the relevant process is documented.

3.9 Treating of uncertainties

The uncertainties in forecasts, assumptions and considerations for the future increase, sometimes significantly, with time. This means that uncertainties in the assessment of costs and benefits indicators increase as the time horizon of the project assessment increases.

It is recommended that a confidence interval of the CBA results should be provided to allow decision makers to take into consideration the continuously increasing uncertainties as the time horizon increases. Although not an easy task, the gradual incorporation of probabilistic methodologies in the market studies seems necessary to tackle uncertainties and will increase considerably the CBA results credibility and it is recommended to be considered in a later stage.

4 INTERNATIONAL (NON-EU) EXPERIENCE – THE CASE OF USA

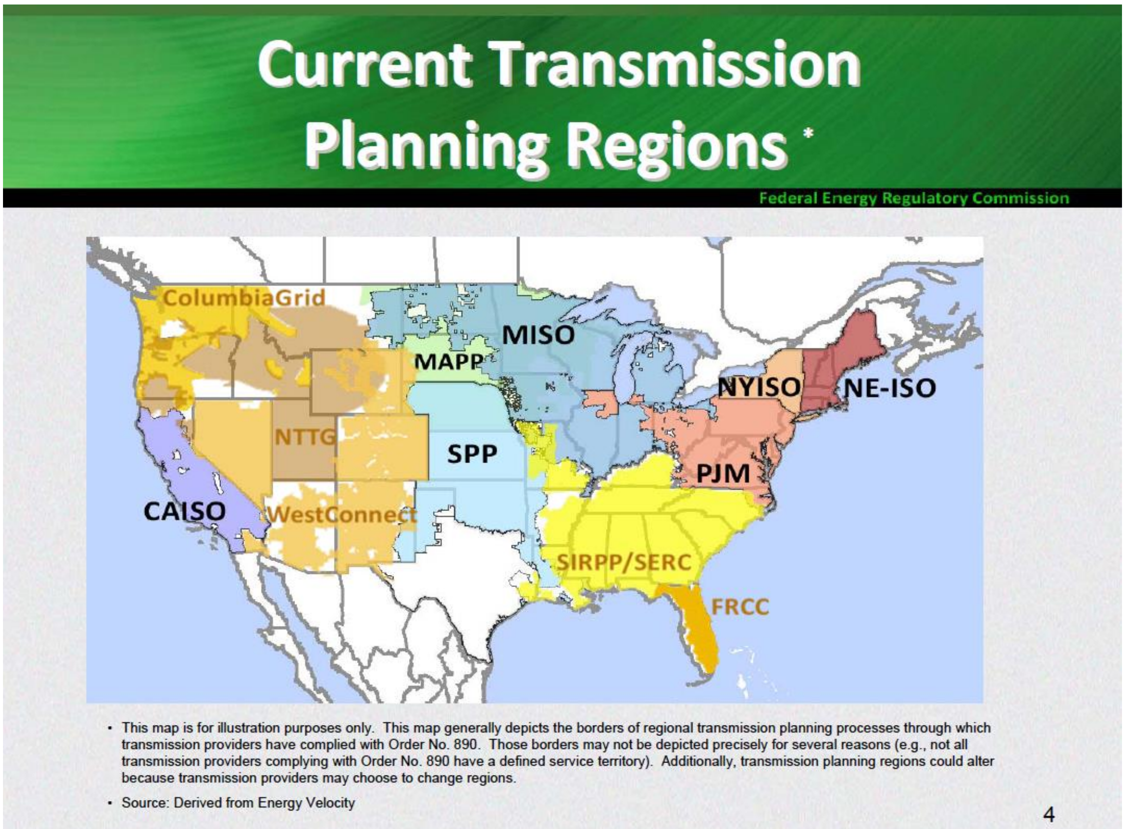
The Federal Energy Regulatory Commission (FERC) regulates interstate electricity commerce over long-distance transmission lines. One of the roadblocks to more competitive wholesale electricity markets is the difficulty in building new transmission lines. Policies to ensure adequate development of new transmission, such as removing barriers to building new interstate transmission lines, are increasingly relevant when integrating renewable energy resources located in remote areas are needed to meet RE standards. US transmission investments by FERC-jurisdictional transmission providers increased from $2 billion/year in the 1990s to $10-13 billion/year in last several years.

The Brattle Group projects $120-160 billion of investments over the next decade (for system reliability, to integrate new resources, upgrade / replace aging existing facilities built in 1950-70s)[5] Electricity networks and markets in the US are fragmented, the networks not being tightly meshed as in Europe nor interconnected across the Regions (see the map herein below), and there is not a target to create an integrated electricity (or gas) market across the whole of the US territory, as for the EU. It is worthy for example to note that the New York Independent System Operator (NYISO), which began operating in 1999, is a not-for-profit corporation primarily regulated by the FERC. The NYISO has signed with two other regional ISOs, i.e. the ISO New England (ISO-NE), and PJM a planning protocol to enhance inter-regional planning coordination and limit any seams issues that may arise between the three jurisdictions. The NYISO strategic Plan 2015-2019 stresses the effort to assume a leadership role in working with neighboring Regional Transmission Organizations (RTOs) / Independent System Operators (ISOs) to establish a broader regional market, to enhance inter-regional coordinated planning through the Eastern Interconnection Planning Collaborative (EIPC) structure which is seen as a topic of increasing urgency and importance to include also gas pipeline contingency analysis and evaluation of new EPA regulations Transmission Expansion, and Public Policy.

On the other side, Texas (ERCOT) Electric Regions, formed in 1970, (covers 85% of Texas load and serves a growing population of 23 million consumers), is the not-for-profit ISO for the Texas area and has been overseeing the region-wide planning since 2001. The Texas area is effectively isolated from the rest of the US, with only two interconnectors to other systems. As a result, ERCOT can be seen as an electrical island with some limited connection facilities to the eastern/western US and Mexico. Therefore, the FERC has no jurisdiction over the Texas electricity sector; regulation is exercised by the Public Utility Commission of Texas. However, ERCOT is a constituent council of the North American Reliability Council and as such follows the same reliability codes as most other US States.

[5] Pfeifenberger Johannes et al, The Brattle group: "Competition in transmission planning and development, Current Status and international

Figure 4.1: Current transmission planning regions in US (source: FERC presentation on Order 1000[6])



The basic regulatory instrument has been FERC's "Order 1000," of 2011[7] , which enacts a series of measures, that require large-scale regional planning of the nation's electric grid designed to create more competitive wholesale electricity markets by removing barriers to building new interstate transmission lines, and in part aimed also to enable investments necessary to provide greater access to renewable energy, necessary for effective implementation of regional RES policies, since most states have legislated Renewable Energy standards. It also requires fair allocation to regional beneficiaries of the cost of interregional transmission solutions chosen to meet regional transmission needs.

With respect to transmission planning, Order 1000:

- requires that each public utility transmission provider participate in a regional transmission planning process that produces a regional transmission plan;
- requires that each public utility transmission provider amend its Open Access Transmission Tariff (OATT) to describe procedures that provide for the consideration of transmission needs driven by public policy requirements in the local and regional transmission planning processes;

[6] FERC18 CFR Part 35 [Docket No. RM10-23-000; Order No. 1000] Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities, (Issued July 21, 2011). / Competition in Transmission Planning and Development: Current Status and International Experience
[7] https://www.ferc.gov/media/news-releases/2011/2011-3/07-21-11-E-6-presentation.pdf

- removes from Commission-approved tariffs and agreements a federal right of first refusal for certain new transmission facilities; and
- improves coordination between neighbouring transmission planning regions (see Figure 4.1) for new interregional transmission facilities (i.e. Public utility transmission providers in each pair of neighbouring transmission planning regions must coordinate to determine if more efficient or cost-effective solutions are available).

The regional transmission planning process must have in place:

- a regional cost allocation method for the cost of new transmission facilities selected in a regional transmission plan for purposes of cost allocation; and
- an interregional cost allocation method for the cost of certain new transmission facilities that are located in two or more neighbouring transmission planning regions and are jointly evaluated by the regions in the interregional transmission coordination procedures required by this Final Rule.

Each region develops its own proposed cost allocation method(s) that must satisfy the following six cost allocation principles:

- Costs allocated "roughly commensurate" with estimated benefits,
- Those who do not benefit from transmission do not have to pay for it,
- Benefit-to-cost thresholds must not exclude projects with significant net benefits,
- No allocation of costs outside a region unless other region agrees,
- Transparency for Cost allocation methods and identification of beneficiaries,
- Different allocation methods could apply to different types of transmission facilities

If a certain region cannot decide on a cost allocation method, then FERC would decide based on the record. There is no interconnection-wide cost allocation method and principles agreed and applied at interregional level.

An important aspect of US evolving electric power infrastructure, which the FERC refers to in its Order No.1000 as "non-transmission alternatives (programs and technologies that complement and improve operation of existing transmission systems that individually or in combination defer or eliminate the need for upgrades to the transmission system)", the appropriate label being "Market Resource Alternatives" or "MRAs," is how developments like MRAs affect the need for, and planning of, high voltage electric transmission[8], as MRAs refer to both supply-side and demand-side solutions that include distributed generation ("DG"), energy efficiency ("EE"), demand response ("DR"), utility-scale generation, and storage. An MRA generally is able to provide only a partial suite of services that transmission provides. Hence, MRAs may provide some of the services that transmission can provide, but they cannot perfectly replace transmission. Furthermore, the services each MRA can provide vary. Understanding the types of services and benefits transmission can provide is also necessary, as the relative merits of transmission and MRAs will be evaluated in the transmission planning

[8] London Economics, "MRA, An examination of new technologies in the electricity transmission planning process", Oct 2014

processes in terms of the services and benefits they can provide when compared to transmission, in order to ensure that investment in MRAs and/or transmission yield the optimal benefits for the money invested in each case.

The FERC considered that the regional participation transmission planning principle under the previous Order No. 890[9] may not be sufficient, in and of itself, to ensure an open, transparent, inclusive, and comprehensive regional transmission planning process. Order No.890 did not require development of a transmission plan by each transmission planning region, nor did it require compliance of regional transmission planning activities with the transmission planning principles it established. In particular, while Order No. 890 intended the transmission planning principle it required for the economic planning studies to be sufficiently broad, there was confusion whether Public Policy Requirements may be considered in the transmission planning process. As a result, the FERC comments, certain regions were struggling with how to adequately address transmission expansion necessary to, for example, comply with renewable portfolio standards. In contrast the new Order 1000, explicitly provides that both local and regional transmission planning processes must consider Public Policy Requirements.

Furthermore, in certain transmission planning regions, as permitted by Order No. 890, public utility transmission providers used the regional transmission planning process as a forum to confirm the simultaneous feasibility of transmission facilities contained in their local transmission plans, and do not develop, consider and evaluate alternatives that may meet the needs of the region more efficiently or cost-effectively. While, in particular in each of the existing RTO and ISO regions, which as the FERC notes serve over two-thirds of USA's consumers, the public utility transmission providers, analyse alternatives available for the regional level, hence the respective regional transmission plan identifies those transmission facilities that are needed to meet the needs of stakeholders in the region. The Order 1000 imposes an affirmative obligation for transmission planning regions to evaluate alternatives that may meet the needs of the region more efficiently or cost-effectively.

As stated by FERC, "while transmission planning processes have improved since the issuance of Order No. 890 we (i.e. FERC) are concerned that the existing Order No. 890 requirements regarding transmission planning, as well as cost allocation, are insufficient to ensure that the evolution of transmission planning processes will occur in a manner that ensures that the rate and conditions of jurisdictional services are just and reasonable and not unduly discriminatory or preferential".

It is noted that there have been, mostly, positive but also negative comments / reactions by stakeholders submitted in the relevant public consultations the FERC has been engaged prior to its final decision, while the Order 1000 has been challenged also in the Courts. Those that submitted negative comments argued that:

---

[9] Order No. 888 of 1996, provided for open access to transmission facilities to address undue discrimination and to bring more efficient, lower cost power to the Nation's electricity consumers. Order No. 890 of 2007, provided for coordinated, open and transparent regional transmission planning processes to address undue discrimination

- any problems with existing transmission planning are local in nature and that the Commission should not undertake comprehensive, generic reform.
- the Commission should allow existing regional transmission planning processes to mature before acting,
- transmission planning must be initiated at the local and regional levels subject to state-level authority and based on the needs of customers who bear the burdens and benefits of the decisions resulting from the planning process,
- transmission developers who offer transmission projects as an alternative to locally planned solutions must be required to participate in and have their proposals considered as part of the relevant state planning process.
- there would be potential confusion for a certain region and that the creation of a new regional transmission planning authority would impede, not hasten, transmission development.

The US Court of Appeals for the District of Columbia Circuit affirmed[10] , by a 97-page unanimous ruling, FERC's Order 1000. In particular dozens of state regulatory agencies, public and private utilities, regional transmission organizations and electric industry trade associations have challenged the Order arguing that states could not be forced to coordinate on transmission planning, carbon standards and paying for actions to create new transmission capacity, as Congress had "expressly" allowed such coordination among utilities to be voluntary. They also opposed the costs involved, arguing that it would be a departure from the usual process of passing costs onto consumers. The three-judge panel wrote that "The Commission reasonably determined that regional planning must include consideration of transmission needs driven by public policy requirements".

A great deal has already been said by the FERC and the courts about matching cost responsibility for transmission infrastructure and the receipt of identifiable benefits from such regulated investments. But, remarkably, there has been no common standard (in theory or practice) for the range of transmission benefits by which the merits of any proposed transmission project or a portfolio of projects should be judged11. There are serious shortfalls in the analytical processes by which planners assess the need for transmission which entail enormous potential costs and risks – to consumers, to the economy, and to society overall12. On the other hand, in evaluating the benefits of alternatives the risks and costs of inadequate infrastructure, that may be much greater than the costs of the necessary transmission investments, must be also assessed and documented to ensure that planners' decisions also adequately protect stakeholders against these risks.

[10] Reuters, 'U.S. court upholds FERC rules on electric grid planning', Fri Aug 15, 2014

[11] The Brattle Group, "A WIRES Report, on The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments" June 2013. The study tried to inaugurate that kind of analysis, ("Catalogue all the potential benefits2 of transmission that can, and arguably should, be identified, considered, and estimated in planning the expansion or upgrade of the grid, based on the growing experience of transmission planners across the US, and document the evolving experience and practice of regional transmission organizations (RTOs) and non-RTO regions in determining the economic, reliability, operational, and public policy benefits of transmission investments based on their physical and operational characteristics, location, technology, surrounding markets, prevailing regulation, and environmental and economic impacts) but the planning practices it advocated have not materialized

[12] The Brattle Group, "Toward More Effective Transmission Planning: Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid " April 2015

In assessing the transport infrastructure projects, it is essential to clearly specify the goals they are designed to achieve. Comparing the drivers for transmission development planning in Europe and the US, we may consider that both have two common goals, (a) to improve through grid development market efficiency and economics, and (b) to secure the electricity supply by increasing the reliability of the grid. These two purposes often cannot be separated clearly from each other; achieving one will frequently accomplish the other. However, in Europe, it has become progressively more important and constitutes the top policy priority, to create functioning and efficient integrated EU electricity, and gas, markets, comparable in size to that of the US, considering economic efficiency improvement as the first purpose of a grid development plan and its related analysis.

While the US priority of grid development, following the California Energy Crisis 2000-2001, as well as the massive blackout of the Eastern US in the summer of 2003, is to increase grid reliability and improve the SoS. Therefore, grid development planning and analysis process primarily focuses on measures to observe the federal reliability standards. After these analyses are done and the relevant measures are planned, economic improvement measures are analyzed. As an example[13], NYISO's market-based planning framework is the Comprehensive System Planning Process (CSPP) by which the NYISO evaluates resource adequacy and transmission system security for the next 10 years and evaluates solutions to meet the reliability standards. It takes place every two years and is comprised of three major components carried out sequentially:

- Local Transmission Planning
- Comprehensive Reliability Planning
- Economic Planning

In Europe the CBA for cross-border Interconnections focuses on increasing existing interconnection capacity and at national corridors rather than at the addition of EHV overlay to backbones. Reliability driven expansion projects in US are extremely difficult to quantify in a cost-benefit analysis because it is not easy to enumerate in monetary terms changes in frequency or duration of service interruptions. However, in both cases the key to achieve optimal economic, reliability, and public policy outcomes is to provide a comprehensive analysis of the full range of benefits that can be derived from a proposed transmission project as well as the available alternatives, including evaluation of the so-called "non-transmission alternatives" and means to more efficiently utilize existing infrastructure. It must be borne in mind that transmission provides a variety of services and offers a broad range of potential benefits. In addition to facilitating the delivery of energy and capacity, transmission can provide other benefits[14]. As Deloitte also confirms in its research report on behalf of the Japanese

[13] Strbac G. et al, Integrated Transmission Planning and Regulation Project: Review of System Planning and Delivery, Final Report , June 2013

[14] For example, transmission system reinforcements can reduce system losses and improve overall system efficiency. Transmission can also provide support to the electric power grid through the provision of certain ancillary services, which are used to keep the grid operating smoothly. Transmission can provide insurance against uncertain future market events and the costs of such unforeseen events on customers. For example, if in the future a generator were to unexpectedly go off line, transmission lines

Government[15] "all the countries and regions they studied, the principle of cost allocation is that citizens and users of the grid pay for the costs incurred by grid development since such infrastructure benefits all. However, there is also the clear principle that beneficiaries bear the cost according to the amount of benefits they receive, which often differ from location to location".

In all jurisdictions considered by Deloitte, the EU, UK, Germany, California ISO (US), PJM (US), ERCOT CREZ (US)[16] the plan-making process largely follows four steps, described below:

- Responsible TSO(s) or an ISO/RTO forecasts power generation and demand/load in a certain time frame and creates several future energy scenarios;
- TSO(s) or an ISO/RTO conducts a power flow calculation based on each scenario, and identifies when and where bottlenecks due to congestion and/or difficulty of observing reliability standards will occur;
- Solution options through grid development against each bottleneck are provided; and,
- A transmission development plan is created based on optimal solutions chosen through a comprehensive assessment of all options, performed by utilizing various socioeconomic, technological, and environmental methodologies, including cost–benefit analysis.

The selection of the most-likely scenario usually occurs at a later stage of the process, and the final plan is created based on the chosen scenario. Although detailed process and evaluation criteria are different among the countries and regions, they all perform sensitivity analyses according to their prioritized criteria and objectives, and engage in multiple consultations, requirement provided by respective national or regional legislation/regulations, performed in different phases with various stakeholders throughout the planning process to form a high-level of social acceptance, of the planning process. These consultations are repeated and efforts are made to create the final plan that reflects various opinions and concerns well.

The following Table 4.1 compares the main features of grid development planning and regulatory/investment schemes among the studied regions and countries.

---

could allow other generators on the system to serve customers. Transmission can also reduce production costs of energy through expansion of a market (and increased competition from other existing resources) as well as provision of market access to new resources. As a consequence of expanding access to market for existing and new resources, transmission can also help to reduce the emissions footprint of the market as a whole and curb harmful pollutants such as carbon dioxide and other greenhouse gases. London Economics: Study on Market Resource Alternatives, 2015

[15] Deloitte Tomachu, "Executive Summary Basic Research Project on Accelerating Deployment of New Energy", METI Japan,2015

[15] ERCOT CREZ identifies the Competitive Renewable Energy Zone (CREZ) process; an ad-hoc' transmission planning and delivery regime instituted in ERCOT to facilitate connection of large-scale renewables. As part of its long-term strategy Texas has adopted proactive transmission planning for selected Renewable Energy Zones, involving also a competitive bidding process for the construction of the selected transmission infrastructure (approach similar to that of the UK for Off shore wind connections).

Table 4.1: Comparison Table (source: Deloitte Tomachu, "Executive Summary Basic CBA and power system planning for selected countries Research Project on Accelerating Deployment of New Energy", METI Japan,2015

	European Union	United Kingdom	Germany	United States			
				Federal Government	PJM	CAISO	ERCOT CREZ
Grid Development Planning							
Resp onsibl	ENTSO-E	National Grid as an SO	4 TSOs and BNetzA	N/A	PJM	CAISO	PUCT and ERCOT
Legally Binding	No	No	Yes (legislated every3years)	N/A	No	No	No
Update	Every 2 years	Every year	Every year	N/A	Every year (5–yr plan) Every 2 years	Every 2 years	N/A
Planning Horizon	10 years	10 years	10 years	N/A	15 years	10 years	Began in 2005 and completed in 2014
Cost Allocation Principles	**Domestic lines** ■ Users pay more than generators ■ Reflect locational differences **Interconnectors** ■ Decided by those countries that will be interconnected ■ Allocate among the states based on a rule that states the beneficiaries pay according to benefits by using CBA method used to choose PCI	**Domestic lines** ■ Citizens/users pay for grid developed under the regulated schemes **Interconnectors** ■ Cost allocated among the countries based on the beneficiaries pay rule of the EU ■ Recover cost by congestion revenues	**Domestic lines** ■ Citizens pay equally for domestic grid developments **Interconnectors** ■ Cost allocated among the countries based on the beneficiaries	**Regional Interconnecting lines** ■ Beneficiaries pay according to benefits received	■ Beneficiaries pay according to benefits received ■ Hybrid methods of cost allocation, based on equipment features and sizes ■ Merchant lines recover	■ Cost recovered from all users through transmission access tariffs ■ Merchant lines recover cost through congestion revenues	All grid users equally pay in the ERCOT area (Postage Stamp method)
Transmission Investment							
Public Assistance	Available for PCI (EU Grants EU-related financial institutions investment/ finance)	EU supports for OFTO and PCI projects	EU supports for PCI projects	No	No	No	No
Investment/Cost Recovery Schemers	Member states decide	■ Categorize transmission assets into 3 groups and regulate each with separate schemes ■ Interconnectors can take either merchant scheme or regulated scheme	Incentive regulation scheme for all asset classes (Revenue Cap)	■ Obey FERC rules for regional interconnecting lines ■ Any developers can apply for FERC Order 679 incentives	■ Regulated scheme and merchant scheme co-exist	■ Regulated scheme and merchant scheme co-exist	N/A

Abbreviations: **BNetzA:** German Federal Network Agency, **CAISO:** California ISO, **ERCOT:** Electricity Reliability Council of Texas, **FERC:** Federal Energy Regulatory Comission, **OFTO:** Offshore Transmission Owner, **SO:** System Operator, **PUCT:** Public Utility Commission of Texas

5 SCENARIO-BASED AND CBA METHODOLOGIES REVIEW FOR SELECTED EU MEMBER STATES

The current section presents a short overview of the practices for scenario development and CBA assessment of transmission projects in ten selected MS, i.e. Spain, Italy, Austria, Belgium, Latvia, United Kingdom, France, Germany, Poland and Slovakia. The aforementioned MS have been selected in accordance with the ToR of the project which required the review of the six largest MS and one representative MS from the following regions (as per the ENTSO-E TYNDP 2014): North Sea, Baltic Sea, Continental Central East Europe and Continental Central South Europe. The information presented in the following sections is based on a questionnaire that was filled in by TSOs and NRAs of these MS.

5.1 Spain

5.1.1 Power system planning

The main transmission planning document in Spain is the National Electricity Transmission System Development Plan[17]. It is required by national legislation and is prepared by the Ministry of Industry (IDAE) every 4 years with a study horizon until 2020. Three scenarios are considered in the Development Plan while, the scenario building concept is based on an econometric and top down approach. The stakeholder's involvement is active, while the main sources of data used are Red Electrica de Espana's (REE) and stakeholder's data. The assumptions that are used for the scenario building are officially approved. Finally, the computer models/tools that are used are PSSE, UPLAN and EVIEW.

The Ministry of Industry prepares also the National Renewable Energy Action Plan (NREAP)[18] and the National Energy Efficiency Action Plan (NEEAP)[19]. Both documents are legally required, publicly available and have a time horizon until 2020.

Each of the above three scenarios used in the National Electricity Transmission System Development Plan represents a possible evolution of the main variables i.e. demand growth, generation mix, fuel prices, economic indicators, etc. In each scenario, different planning cases are analyzed. The cases represent different situations including but not limited to: summer/winter, peak/off-peak, weather conditions (wind, sun, water, and temperature), generation dispatch, energy flow between countries, etc. These scenarios are evaluated by

[17] http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Documents/Planificaci%C3%B3n%202015_2020%20%202015_10_22%20VPublicaci%C3%B3n.pdf
[18] http://www.idae.es/uploads/documentos/documentos_11227_PER_2011-2020_def_93c624ab.pdf
[19] http://www.idae.es/uploads/documentos/documentos_11905_PAEE_2011_2020._A2011_A_a1e6383b.pdf

REE and approved officially by the Ministry of Industry. The scenarios developed in the context of the National Transmission Development Plan are compatible with the energy planning scenarios included in the NREAP and NEEAP. The major difference between the Transmission Development Plan and the NREAP/NEEAP with respect to scenarios are the different sensitivities of the modelling parameters.

5.1.2 Cost Benefit Analysis

The Transmission System Operator (REE) performs Cost Benefit Analyses for certain electricity transmission projects and specifically for those related to structural reinforcement of the transmission grid (400 kV and 220 kV). The outputs of the study are included in Annex III of the National Transmission Development Plan. These infrastructures aim at ensuring security of supply, economic and energy efficiency and environmental sustainability and are justified by the compliance with the National Network Codes and their contribution to economic efficiency. The CBA methodology implemented by REE follows in general the "ENTSO-E Guideline for Cost Benefit Analysis of Grid Development Projects" approved by EC on 4.2.2015" and it is not approved by the Regulator.

The scenarios used in the CBA are the same as those described in the National Development Plan. The deterministic tool that is used for CBA is UPLAN. In order to conduct the Study both market simulations and network studies are performed based on own data and stakeholders' data which are compatible with data on common study horizons (e.g. 2020).

5.2 Italy

5.2.1 Power system planning

The power system planning document in Italy is the Ten Year Network Development Plan which is published annually by TERNA. The Plan is required by pertinent legislation, is subject to consultation and then an opinion by the NRA, is approved by the Ministry for Economic Development and is publicly available[20]. The Plan also includes a generation adequacy study with a horizon of 5-10 years. The generation adequacy is evaluated as part of the yearly demand forecast report according to the Regulator's (Autorità per l'energia elettrica il gas ed il sistema idrico-AEEGSI order 48/2004. In addition, there is also the National Energy Strategy[21] published in March 2013. This is prepared by the Ministry of Development and the Ministry of Environment, updated every 3-5 years. The time horizon of the study is 8 years but with some considerations up to 2050.

Other relevant documents include the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP). Both documents are legally binding and

[20] http://download.terna.it/terna/0000/0109/45.pdf
[21] http://www.sviluppoeconomico.gov.it/images/stories/normativa/20130314_Strategia_Energetica_Nazionale.pdf

publically available. In parallel to the Electricity Transmission Development Plan, there is also the Ten-Year development plan for Gas[22] which is prepared by the Gas TSOs/ITOs (in particular the plan of Snam Rete Gas), updated on an annual basis with a study horizon of 10 years.

The electricity scenario planning process is based on two scenarios that are built on various assumptions and data sources and prepared with the contribution of stakeholders. The assumptions are not officially approved. Relevant data are included as annex of the Plan, as well as other studies (e.g. from the International Energy Agency). The scenarios are not explicitly and separately subject to opinion or approval. In the framework of the plan, they are subject to consultation and subsequent opinion of the NRA and then approval of the Ministry.

The TSO uses network modelling tools (load flow software), as well as market modelling tools (PROMED). For the development of the national generation adequacy study there is not a discrete scenario building activity, but the calculation of needed generation capacity is based on probabilistic modeling.

For the development of the National Energy Strategy there are multiple scenarios that are developed with the contribution of stakeholders and the utilization of domestic data sources. The assumptions are not officially approved. For the development of the NREAP two bottom-up scenarios are developed. The NREAP is officially approved. For the development of the NEEAP 3 scenarios are developed (including 2 for comparison purposes).

5.2.2 Cost Benefit Analysis

The Italian TSO applies a CBA methodology for the projects of the National Electricity Transmission Development Plan, which is described in the Plan itself. The methodology is currently under update/consultation by the Regulator[23]. In the Plan of 2015, the CBA was performed by the TSO for the projects with investment cost above 25 million Euros (47 out of 184 projects). The standardized methodology for CBA is presented in the Annex III of the Plan.

The requirements for the CBA methodology are expected to be defined by the Regulator, even though the versions of the CBA methodology currently in use since - at least - 2006 built on some provisions in the TSO license (given by the Ministry) and in the transmission grid code (verified by the Regulator) and did not receive an official approval by the Regulator (or by the Ministry).

The scenarios developed include assumptions on generation mix, demand, cross border capacities, fuel and CO2 prices, while no sensitivity analysis is conducted. The market and network studies (including e.g. probabilistic studies for calculation of expected energy not supplied) lead to the monetization of eight benefit categories (electricity exchanges with neighbouring countries, reduction of internal network congestion, reduction of local constraints on RES generation, variation of losses, reduction of expected energy not supplied,

[22] http://www.snamretegas.it/export/sites/snamretegas/repository/file/Anno_termico_2014x15/piano-decennale/pubblicazione/Piano_decennale_2015-2024.pdf

[23] http://www.autorita.energia.it/allegati/docs/15/464-15.pdf

avoided investments, reduction of costs of ancillary services and variation of CO_2 emissions), while a benefit/cost ratio is calculated for each project.

5.3 Austria

5.3.1 Power system planning

The Transmission Network Development Plan is a legal requirement (in accordance with § 37 ElWOG 2010). It is based on the long-term strategic planning in the Austria Power Grid (APG) Master Plan 2030 as well as on the Network Development Plan 2014. By publishing the NDP, APG informs all market participants about the main transmission grid infrastructures that need to be upgraded or expanded within the next ten years (2016 – 2025). The National Electricity Transmission System Development Plan is conducted on an annual basis and with a study horizon of 10 years (n+10 years).

The Master Plan for 2030 is prepared by Austrian Power Grid AG[24] as the basis for medium- and long-term grid planning. The foreseeable developments in the energy market until 2030 were analysed in detail and the necessary expansion steps in the APG transmission grid were defined.

The Master Plan envisages three scenarios and its preparation is prepared through consultation and workshops with public participation (NGOs, Universities and experts). Data sources are APG's internal data, as well as data from TU Wien and Graz. The model used for the simulations is called ATLANTIS and has been developed by TU Graz.

The development of the National Electricity Transmission System Development Plan is based on the APG–Masterplan scenarios.

The national report on Security of Supply is carried out by E-Control Austria (the NRA) on an annual basis and with a 10-year horizon. Three main scenarios are built based on national data. The MEDA model is used.

5.3.2 Cost Benefit Analysis

In Austria no CBA is performed for electricity transmission projects included in the National Transmission Development Plan in addition to the one that is anyway performed for projects included in the TYNDP.

[24] https://www.apg.at/en/grid/grid%20expansion/masterplan

5.4 Belgium

5.4.1 Power system planning

The National Electricity Transmission System Development Plan is prepared by the Belgian TSO (Elia) every four years with a study horizon of 10 years. It is a legally required and publicly available[25].

The study includes 1 scenario for 2020 and 4 scenarios for 2030 exactly like the TYNDP. The scenario for 2020 is based on a bottom-up methodology using adequacy criteria, while the 2030 scenarios on top down and bottom up scenarios based similarly on adequacy criteria. The study has been developed with the contribution of stakeholders and the main data sources include ELIA's internal data and ENTSO-E/TYNDP data. The assumptions made for the development of scenarios are officially approved. The models that are used for simulations are ANTARES, PROMOD and PSA.

The national generation adequacy study is legally required and a publicly available document[26]. It is prepared by ELIA annually with a study horizon of 3 winters ahead. The study includes only one baseline bottom-up scenario with sensitivities. The building of scenarios has been based on ELIA's own data, data from IHS and CERA, as well as data from studies of neighboring TSO's and ENTSO-E SO&AF. The simulations have been done with ANTARES.

Apart from these two documents there is also the National Renewable Energy Action Plan (NREAP)[27]. It has been prepared by Federal Public Service and Regions in 2010 with a study horizon until 2020. Respectively, the National Energy Efficiency Action Plan was prepared by the same authority in 2014 with a study horizon until 2020. For both Action Plans only one bottom up scenario has been developed based on own data and studies. For the NEEAP the PRIMES model has been used.

The base for planning process are the scenarios built for the TYNDP (ENTSO-E). However, in order to be in line with the scenarios developed by the Federal Public Service, described in the report 'prospective study electricity by 2030', a check of important parameters is done (renewables, demand, installed capacity thermal units, etc.). The scenarios resulting for the national electricity transmission system development plan are a combination of both sources. These scenarios are evaluated by the Federal Public Service and through public consultation on the national electricity transmission system development (with a chapter on scenarios), which is subject to approval by the Minister for Energy.

The scenarios are in line with the NREAP targets for 2020. However, since the NREAP dates already from 2010, a shift between different technologies is taken into account based on

---

[25] http://www.elia.be/~/media/files/Elia/Grid-data/grid-development/Plan-de-Developpement-federal-du-reseau-de-transport_2015-2025.pdf

[26] http://economie.fgov.be/nl/ondernemingen/energie/Energiebevoorradingszekerheid/strategische_reserve_elektriciteit/

[27] http://economie.fgov.be/nl/binaries/NREAP-BE-v25-NL_tcm325-112992.pdf

already installed capacity and regional studies. The national electricity transmission system development plan covers the horizon 2015-2025.

5.4.2 Cost Benefit Analysis

A CBA is performed for the projects embedded in the TYNDP process. These projects represent the development of interconnectors as well as the development of transmission and generation accommodation capacity throughout the whole internal Belgian backbone. In terms of voltage levels this represents the entire 380kV grid, complemented with the interconnected 220kV grid in the South East area. The ENTSO-E methodology is implemented.

The current scenario framework is developed around 2 time horizons, 2020 and 2030, taking into account all the relevant hypotheses and assumptions on: electricity consumption, integration of renewables, the planned nuclear phase out, integration of new central production units and the merit order. A sensitivity analysis is conducted as well, for example with respect to the availability of the nuclear capacity in Belgium.

This scenario framework forms the basis for:

- Market studies: carried out with ANTARES (in the past PROMOD) to identify the economic interest of developing additional interconnection capacity.
- Adequacy studies: carried out with ANTARES to identify the risk of not covering the demand by production or import. These adequacy studies are performed using a probabilistic method, evaluating the probability of different events taking place via Monte Carlo analysis.
- Load flow studies: carried out with PSA (and in the future with Power Factory) to evaluate grid security.

In the context of the CBA market simulations are performed. For surrounding countries, the data used are from data ENTSO-E (TYNDP-SO&AF) or bilateral contacts, while for Belgium own data, and data from consultants (HIS, CERA, Pöyry) are used.

The output of the market simulations is an input for the network studies. The network model used for the network studies contains both a national dimension as well as an international dimension. The national dimension is based upon own data (information on grid structure, generation and load). The international dimension is based upon data exchange with the neighboring TSOs in the context of ENTSO-E studies.

The scenarios developed by the Federal Public Service are a main source of information (update about every 4 years). However, they cannot be used as such in order to fulfill the storylines developed for the TYNDP. The scenarios resulting for the national electricity transmission system development plan are a combination of both sources (storyline TYNDP and scenarios Federal Public Service).

5.5 Latvia

5.5.1 Power system planning

The National Electricity Transmission System Development Plan28 is a legally required document prepared by the TSO Augstsprieguma Tikls (AST) with annual frequency and a 10-year horizon. The study considers two scenarios, one baseline (conservative) and one optimistic. Stakeholders are involved in the scenario planning process. Scenarios are neither evaluated nor officially approved. The main source of data is internal TSO sources. According to the respondent of the questionnaire no computer models or other tools are used. The National Electricity Transmission System Development Plan scenarios are not compatible with other energy planning scenarios.

The National generation adequacy study[29] is a legally required document prepared by the TSO with an annual frequency and a 10-year horizon. Similar to the Transmission Development Plan, two scenarios are developed one baseline (conservative) scenario and one optimistic. Stakeholders are not involved in the generation adequacy study, only power system participants. The assumptions are officially approved, while no computer tools or other specialized software are used. Planning scenarios are neither evaluated nor officially approved.

The National Energy Program is based on only one scenario, it is developed with stakeholder involvement, while data are provided by power system participants. The NREAP and NEAAP are currently under development by the Ministry of Economics.

5.5.2 Cost Benefit Analysis

In Latvia no CBA is performed for electricity transmission projects included in the National Transmission Development Plan. Only for strategic transmission projects (PCI), a CBA is conducted based on the Pan-European TYNDP results, after harmonized for internal network based on energy field expert opinion.

5.6 United Kingdom

5.6.1 Power System Planning

The transmission needs of United Kingdom are served by several TSOs, most of whom own and maintain the assets, and two who operate the networks. National Grid Electricity Transmission PLC owns the network in England and Wales, Norther Ireland Electricity

[28] http://www.ast.lv/eng/par_ast/public_reports/development_plan_of_transmission_power_system/
[29] http://www.ast.lv/eng/par_ast/public_reports/tso_annual_statement/

Networks owns the network in Northern Ireland, and Scottish Hydro Electric Transmission PLC and Scottish Power Transmission PLc, owns the Scottish networks. Offshore wind-farm connections and interconnectors are also owned by separate companies who have been competitively developed or selected. National Grid is also the system operator responsible for real time operation covering the whole system on the island of Britain, and for indicating where the network will develop. System Operator for Northern Ireland Ltd (SONI) is the system operator for the island of Ireland.

The National Transmission Development Plan is covered in the document "*Electricity Ten Year Statement*" and covers a planning horizon of 20 years. It is developed by National Grid in consultation with the other transmission owners. A detailed plan for the first ten years is provided. It is published annually under a legal mandate. Stakeholders are deeply involved in the process to perform the "*Electricity Ten Year Statement*" through an extended and well established public debate. The main sources of data used are the TSOs (own data) and data derived by the stakeholders during the public consultation; government targets and fuel prices' projections are also taken into consideration.

The National Generation Adequacy Study is also a legally required document performed by the National Grid Electricity Transmission. It is executed and published every year covering the next 5 years. A *Winter Outlook Report* and a *Summer Outlook Report* are also published every year by the NGET. The capacity adequacy study and the "*Electricity Ten Year Statement*" are performed based on the same data scenarios and data. A probabilistic methodology is applied by the National Grid to assess future capacity adequacy using an in-house software. The stakeholders are not involved in the process as there is no legal obligation for public consultations.

Four future scenarios are considered to perform the studies mentioned above called Future Energy Scenarios (FES)[30] covering a long-term horizon up to 2050. These FES are produced by the NGET and refer to Britain as a whole, but not Northern Ireland. The scenarios are intended to provide a broad range of future states of the UK energy system: gone green, slow progression, no progress and low carbon life. These parameters represent a matrix with affordability and sustainability as key drivers. There are multiple parts in producing the scenarios: e.g. policy drivers are considered to prepare the top down scenarios, assumptions of specific generation and demand are based on customer submissions and econometric elements are included.

These scenarios are published to support the stakeholders with longer term planning decisions (up to 2050). The indicators of each of the scenarios are presented across the entire time horizon. These scenarios are in general compatible with ENTSO-E approach: 2 top down and 2 bottom-up scenarios are constructed and considered. Also some sensitivity analysis is performed to assess the impact of future contracted generators. The scenarios are widely shared extensively debated through public consultations but the assumptions are not formally approved outside the NGET.

[30] http://fes.nationalgrid.com/

5.6.2 Cost Benefit Analysis

The FES scenarios are used in the CBA, together with local sensitivities and information on the costs and transmission capacity improvements of transmission investments. Each scenario is applied to assess costs and benefits and a "least regret" approach is used to determine whether to progress or defer transmission investments.

The Electricity Ten Year Statement first identifies whether current border capacities (the national network is split into a number of zones for the purpose of the analysis) are able to fulfil security and economic criteria across the full lengths of the 4 FES scenarios. It then takes potential transmission solutions where it is economical to invest at certain time-points, which include a variety of offshore, conventional, operational and commercial solutions, as input to perform a regional cost-benefit analysis. A standardized CBA methodology publicly available is applied to evaluate future transmission projects. This methodology is proposed by the TSOs and approved by the Regulator. More specifically, a CBA is performed for the following project categories:

A. Onshore investments (Strategic Wider Works that are projects to provide additional transmission boundary capability): financial threshold of £100m investment cost (for the National Grid; thresholds for Scottish TSOs are lower). For onshore investments the National Grid considers a range of possible scenarios for generation and demand in order to assess the costs and benefits of large-scale network reinforcements. If the optimal reinforcement varies with the scenario, a regression analysis to assess the outcome of each option in each scenario in order to identify the one that has the least worst regret across all the scenarios.

B. Interconnectors (cap and floor regime). These are HVDC subsea interconnectors proposed by competing developers, given regulatory support and price control. To date project sizes have been in the range of 0.5GW – 1.4GW. For Interconnectors the CBA is undertaken by the regulator, subject to multiple public consultations.

In general, larger projects are individually assessed (e.g. Strategic Wider Works projects > £500m in cost for England and Wales). Practically, all "Wider Works" are reviewed.

Market and network studies are performed to support decisions; both are deterministic rather than probabilistic. Market studies use the ELSI tool and are based on the FES scenarios. Network studies are used to assess the transmission transfer capabilities that are used in in the market simulations that are part of the CBA's.

The scenarios and data used internally in NGET are aligned with information provided to ENTSO-E for TYNTDP scenarios. There are 2 points to note here:

- Firstly, there are timing differences given that the Future Energy Scenarios and Electricity Ten Year Statement work is carried out each year whereas the TYNDP is produced every 2 years. In practice, this means that by the time the TYNDP is published, an updated set of Future Energy Scenarios will have been published.

- Secondly, there may not be a one to one mapping of FES scenarios to TYNDP scenarios/ visions given the national context of the FES as opposed to the European context. In practice FES scenarios are matched to TYNDP scenarios/ visions where reasonable.
- The two ‘extreme’ FES scenarios ‘gone green’ and ‘slow progress’ are the basis for National Grid’s submission to the ‘bottom-up’ ENTSO-e scenarios.

5.7 France

5.7.1 Power System Planning

The document referring to the regular planning activities in France is primarily the National Ten-Year Development Plan (SDDR). It is a legally required document which is released every year and includes all the transmission projects for the next decade (sometimes exceeding to longer time horizon for projects with commissioning dates beyond the 10 years’ horizon). The Plan is carried out by the French TSO (RTE) after consultations with the stakeholders and it is publically available every year. The Plan is evaluated by the Regulator, who runs a public consultation and assesses whether the plan adequately fulfills the needs of the market. The SDDR is based on the assumptions and results by the generation adequacy study (see below); extensive network analysis is performed for 4 different scenarios.

The National Generation Adequacy Study is also a legally required document performed by the TSO. It comprises a Generation Adequacy Report on the electricity supply-demand balance in France. The study is performed and published every year: the study released in odd years covers the mid-term horizon (5 years), while the one released in even years covers both the mid-term and long-term horizons (15 years), thus being the basis for all the long term planning activities in electricity and relevant action plans. The study is subject to extensive consultation with stakeholders.

The Generation Adequacy report is the basis for all planning activities in France. Four (4) distinct scenarios are developed being used in all above mentioned activities. These scenarios describe different, but possible futures for the long term. This long term exercise is conducted once every two years and concludes on the possible energy mix at this horizon. The scenario building methodology is based on an extensive data collection with external and internal partners. To build those 4 scenarios, each one is built upon the following 8 axes: Demography, Economic growth, CO_2 and commodities prices, energy efficiency, electrical transport, nuclear share, renewable growth and interconnectors’ level. Each of these axes can have 3 values: High, Medium and Low. The combination choice is driven by national laws (as “Loi pour la transition énergétique et la croissance verte”), RTE’s expertise and stakeholders’ feedbacks. The study is performed at the European scale to better assess the interconnection contribution so assumptions for 12 others countries are taken based on public and private information. Probabilistic simulations are carried out to assess generation adequacy for each scenario. Stakeholders are deeply involved in several stages of the process. The whole study (assumptions and results) are an input for the national ten-year network development plan (SDDR).

The elaboration of a National Energy Program is also a legal requirement. Furthermore, it is prepared by the Direction Generale de l' Energie et dy Climat (Ministry of Ecology, Sustainable Development and Energy) every 5 years and covers a 10-year horizon ahead. A National Renewable Energy Action Plan and a National Energy Efficiency Action Plan are also developed by the Ministry of Ecology, Sustainable Development and Energy. These documents are also a legal requirement and are publically available.

5.7.2 Cost Benefit Analysis

RTE performs CBA for all new transmission projects but only results from ENTSO-E TYNDP for interconnectors are reported in the SDDR. The principles of the modelling methodology are displayed in annex of the SDDR. There is only some information in the SSDR describing the basic procedures. The CBA methodology itself is not subject to approval on a standalone basis, but is analysed by the Regulator as part of the SDDR as a whole. The uncertainties are mainly treated through the different scenarios, with certain projects being pointed as relevant only in certain scenarios or assumptions.

The cost and benefit components are calculated through extensive Market simulations and Network studies based on TSO data. A variety of tools is utilized to perform those studies. The French data in ENTSOE bottom up scenarios (V1 and v3) are fully consistent with the corresponding scenarios from French Generation Adequacy Report.

5.8 Germany

5.8.1 Power System Planning

The German electricity system has the specificity of having four TSOs. The network development is a responsibility of the Federal Network Agency (BNetzA). Similar to France, the long term planning documents for the electricity sector in Germany include:

The National Transmission System Development Plan (NTDP) is a legally required document. It is carried out in collaboration with the German TSOs and it is published by the Federal Network Agency every two years. It covers both the mid-term (10-15 years) and the long term horizon (15-20 years). The Plan is officially approved by the Regulator after consultations with the stakeholders. No information has been provided on the methodology for the construction of scenarios (bottom-up or top-down) and the compatibility with ENTSO-E scenarios (data provided to ENTSO-E by TSOs).

The National Generation Adequacy Study is also a legally required document performed by the TSOs under the supervision of the Federal Government. It is executed and published every year covering the short term horizon (1 to 4 years). The stakeholders are not involved as there is no legal obligation for public consultations.

The Federal government is also responsible for the publication of National Energy Programs, the National Renewable Energy Action Plan (under legal mandate) and National Energy Efficiency Action Plan. Such reports cover various time horizons (up to 2050) for various sectors) and are released not in a regular time basis. These documents are publically available; stakeholders are not participating in the process.

Concerning the scenarios used, four scenarios (3 mid-term and 1 long-term) are used for the NTDP. These scenarios are evaluated by the public in a 5-week consultation process. The scenarios are officially approved by the Federal Network Agency. These scenarios are compatible to the ones considered for the National energy programs.

5.8.2 Cost Benefit Analysis

There is no a standardized CBA methodology, as there is no legal provision to be approved by the Regulator. Market simulations and network analyses are reported though. TSOs are the main source of data.

5.9 Poland

5.9.1 Power System Planning

The main planning activities in Poland include the development of the National Transmission System Development Plan[31], which is a legally required document. The Plan is carried out by the Polish TSO (PSE) every 3 years and is developed with a planning horizon of 10 years ahead. The Plan is agreed with the Regulator, released after consultations with the stakeholders and it is publically available.

A National Generation Adequacy Study - being also a legally required document - is performed by the TSO. This study is performed every 3 years in the framework of the Plan but sometimes more frequently. It covers a period of 15 years ahead. Also, an additional document is prepared regarding the balancing of the system for a 15-year horizon. Although it is not subject to public consultation, the answers by the generation stakeholders on specific questionnaires referring to future power plants are taken into consideration. This study is not public.

The Ministry of Economy is also responsible (under legal mandate) for the execution of the National Renewable Energy Action Plan, the National Energy Efficiency Action Plan and a National Energy Program. The two Action Plans are updated every four years and refer to the

[31] http://www.pse.pl/uploads/kontener/Plan_Rozwoju_2010_2025.pdf
http://www.pse.pl/uploads/kontener/Plan_Rozwoju_2010_2025_aktualizacja_2014-2018.pdf

long-term horizon (longer than 20 years), while the national Energy Program refers to the energy policy goals of 2050. All the aforementioned documents are prepared after consultations with the stakeholders and are publically available.

The same scenarios are considered for both the Transmission Development Plan and the generation adequacy assessment. Two scenarios are elaborated under the objective of system balancing using indigenous sources. These scenarios are constructed considering and composing one demand scenario (the most likely) and two generation scenarios. The scenarios for electricity demand are performed for a 25-year horizon. The scenarios for generation and balancing are performed for a 15-year horizon. These scenarios are evaluated by the TSO, but they are not officially approved. TSO tools and models are used in both the aforementioned studies. The scenarios used are compatible with the Polish Energy Policy as far as development of RES, maintenance and expansion of existing coal and lignite-fired power plants and the construction of nuclear power plant after year 2025 are concerned. Thus, as a general remark, the Plan takes into account the direction of development of generation sources as set in the Polish Energy Policy.

5.9.2 Cost Benefit Analysis

There is no a CBA methodology used in general. Nonetheless, some form of CBA analysis is performed for some NTDP projects even though no further information is provided.

5.10 Slovakia

The National Electricity Transmission System Development Plan in Slovakia is required by the national legislation; it is prepared and published by the TSO (SEPS) in an annual basis for a planning horizon of 10 years ahead.

A generation adequacy study is carried out every year in the framework of the NTDP using the same data and hypotheses. The study applies the deterministic methodology developed by ENTSO-E to carry out the System Outlook and Adequacy Forecast (SO&AF).

The stakeholders are involved in the process and the main sources of data used are the TSO (SEPS) and the stakeholders. The assumptions that are used for the scenario building are not officially approved.

The Ministry of Economy prepares also a National energy program (referring to a 20-year period ahead), the National Renewable Energy Action Plan (every 5 years for a planning horizon of 10 years) and the National Energy Efficiency Action Plan (every 3 years). Those documents are legally required and publicly available.

For the development of the NTDP (and consequently the generation adequacy assessment), 3 scenarios are developed and considered by the TSO. These scenarios are constructed using a bottom-up approach; low, medium and high load scenarios vs. multiple generation patterns (considering generation development of major units and RES) are considered. Mid-term and long-term perspectives of demand and generation given by stakeholders, the Ministry of Economy and TSO experts are considered. The scenarios are not evaluated or approved by any authority and they are not publicly available. Network studies are executed to develop the NTDP.

The scenarios developed and used by the TSO respect the main policy lines of the strategic documents (National energy program, National Renewable Energy Action Plan and National Energy Efficiency Action Plan) prepared by the Ministry of Economy of Slovakia, but are not the same as the scenarios used by the Ministry of economy are not communicated to the TSO.

The data delivered to ENTSO-E to develop TYNDP scenarios are the same as used for development of National Development Plan. No CBA analysis is performed for the transmission projects. No relevant methodology is reported.

5.11 Overall findings from MS review

5.11.1 General remarks on Transmission Development Plans

With respect to the Transmission Network Development Plans, the following general following remarks can be made:

- The Transmission Network Development Plans are prepared by the relevant TSOs in most of the MS reviewed under a legal requirement, with the exception of Spain (responsibility of the Ministry of Industry) and Germany (responsibility of the "Federal Network Energy").
- The Network Development Plans are public documents released on an annual basis with the exception of Belgium (every 4 years), Poland (every 3 years), Spain (every 4 years) and Germany (every 2 years). The dates of release vary significantly among the various MS.
- The planning horizon of Transmission Network Development Plans is in most of the cases 10 years (Spain reported a planning horizon up to 2020, United Kingdom reported a planning horizon of 20 years while Germany's NTDP covers both the mid-term (10-15 years) and the long term horizon (15-20 years)).
- With respect to the provisions of the national legal frameworks, the Transmission Network Development Plans are usually officially approved by the Regulator or the relevant Ministry e.g. Spain (Regulator), Italy (Ministry). In some cases, e.g. in France, the SDDR is evaluated by the Regulator, while in Poland, the National Transmission System Development Plan is agreed with the Regulator.
- The scenarios are subject to evaluation by relevant national authorities (Regulator and/or Ministry) in UK, Belgium, Spain, Italy, Austria and Germany. Also the scenarios in the aforementioned countries are evaluated by the stakeholders during public consultation processes.
- Usually TSOs organize the public consultations on the Network Development Plans results. In Italy, the TYNDP is subject to consultation and then an opinion by the NRA

while in Germany the NTDP is officially approved by the Regulator after consultations with the stakeholders. The level of involvement of stakeholders, the number/rounds of consultations and the subject of the consultations vary by MS. For instance, in France a permanent stakeholders' body has been established while in some MS stakeholders provide data and prognoses to the TSOs that are considered in the scenarios development and consequently in the Network Development Plans.

- The main data sources are mostly the national TSOs themselves with possible contributions by the Ministries, DSOs, stakeholders etc. at various combinations.

5.11.2 Scenario building process

In most of the Member States reviewed there is no formally established scenario development process similar to the one followed by ENTSO-E at the European level, except in France and Germany. In general, the future scenarios are developed in the framework of the Transmission Development Plan process driven mainly by the national TSOs. In large countries (such as France and Germany) the scenario development process is better organized and supported by the active involvement of stakeholders. In some countries the main hypotheses and assumptions for the scenarios building are officially approved (usually by the Regulator and/or the relevant Ministry, as in Latvia, Belgium, Spain and Germany) while in others they are just consulted with the public or indirectly approved by the Regulator as a part of the Transmission Development Plan.

It is also worth noting that in the big countries (Germany, France, and United Kingdom) there is a long term view (up to 2050) considered in relevant scenarios and acting as the basis for the national policies towards 2050. These scenarios have a major role in informing the stakeholders on all (electricity) planning activities on a national level. Such scenarios seem to be highly compatible with the relevant European views for the long – term horizon.

With respect to the number of scenarios considered in each MS, in general more than one scenario is considered by the TSOs and up to 4 with additional "sensitivity" analysis cases. Most of the TSOs follow a bottom-up approach to develop the relevant scenarios. In some cases, (e.g. France) there is also a top-down approach implemented to determine a balanced result in terms of compatibility with the national targets and generation adequacy requirements. In most of the cases, the scenarios of the Transmission Plans seem not to be (fully) compatible with the NREAPs (developed using a top-down approach with reference to 2020). Actually, the compatibility of the scenarios used for Transmission Development Plans, generation adequacy and NREAPs is quite unclear.

Although in most of questionnaires a very high consistency level between the scenarios used at national level and the ones considered by ENTSO-E is claimed, it is not always confirmed by the relevant answers to specific questions. The level of compatibility among the national and ENTSO-E scenarios cannot be easily verified. In some cases, the compatibility level is high (such as France, Germany and the United Kingdom) especially for the bottom – up scenarios as concluded by the relevant processes but for most of the MS the national scenarios are rather different than the ones used by ENTSO-E. The top – down scenarios developed by ENTSO-E are obviously different than those used at the national level as they have been developed through a different methodology.

5.11.3 Generation adequacy

Generation adequacy studies are inextricably related to the Transmission Development Plans and the relevant scenarios considered for its development. In most of the countries investigated, generation adequacy studies are performed under a legal requirement (except for Slovakia and Spain). TSOs are mandated to perform such studies (in Germany), sometimes in the framework of the Transmission Development Plan. The results of these studies are public or partially public (except Slovakia, Poland and Spain). The study horizon of the generation adequacy studies published significantly varies among MS from one year ahead (United Kingdom) up to 2030 (France).

Since both Transmission Development Plans and generation adequacy studies are performed - in their majority - by the TSOs, the background scenarios are in general highly compatible and, in any case, not far to each other, but still much different than the ENTSO-E top-down scenarios. The compatibility to the hypotheses used in other national planning activities (such as NREAPs, National energy programs, etc.) is very unclear though.

As a conclusion, it seems that the scenarios used at the national level are in general different than those used by ENTSO-E, especially the top-down scenarios. The big countries (Germany, France and the United Kingdom) show a higher degree of compatibility with ENTSO-E since they apply similar approaches in developing future views and have published detailed plans and roadmaps towards 2050.

In general, there are no scenario building methodologies and processes established at the national level. Also, the procedures followed are not harmonized. It seems that the national policy dimension is much stronger than the European aspects although there is a trend to increase the impact of the European energy targets.

5.11.4 CBA issues

Traditionally, some European TSOs used to perform CBA studies for the major transmission projects. This is becoming a requirement recently triggered mainly by the EC and the relevant processes to harmonize and optimize transmission infrastructure development in the continent. Actually, the “official” requirement for CBA of transmission projects is a rather new issue for TSOs, especially under the deregulated electricity market environment. At this early stage of CBA application, the main findings of the investigation are summarized below.

The majority of the TSOs perform a CBA assessment for certain transmission projects included in the National Transmission Development Plan (e.g. in Italy the CBA was performed for projects with investment cost above 25 million Euros in the Plan of 2015, in Spain CBA is conducted specifically for electricity transmission projects related to structural reinforcement of the transmission grid, in Latvia CBA is performed for strategic PCIs while in Poland some form of CBA analysis is conducted for certain NTDP projects). No CBA analysis is performed in Slovakia, Germany (for which some market simulations and network analyses are reoirteed to be performed though) and Austria.

Standardized CBA methodologies have been developed and applied in the United Kingdom, Italy and France. These methodologies are publicly available only in the United Kingdom and Italy. Several TSOs reported that they follow the ENTSO-E CBA methodology principles but this cannot be verified since the relevant documents are not public. The methodologies used are subject to approval by the relevant NRAs (UK, B, IT, FR).. Most of the TSOs perform market and network studies to assess the costs and benefits of each project. The tools used for the market studies (the most crucial ones for the CBA) vary a lot among TSOs with respect to the type of methodology (deterministic vs probabilistic) and the modelling of generation. A large variety of software tools is used, some of them being in house tools but also some commercially available tools.

5.12 Recommendations for further harmonisation

The analysis shows that certain steps towards harmonization have been taken. Nonetheless, there is still a need to accelerate the procedures and actions in many aspects so as to increase transparency and facilitate the required level of collaboration and common planning activities of European TSOs. These activities are required in order to determine the transmission needs and optimize the transmission infrastructure development in Europe and therefore facilitate the integration of the internal electricity market. In Consultant's view the main issues on which further harmonization is required include:

- The number and type of scenarios used for the Transmission Development Plans should gradually converge with those elaborated by ENTSO-E.
- The establishment and application of a formal "scenario building" process should be progressively aligned with ENTSO-E relevant provisions, including among others the institutional participation of stakeholders.
- The methodologies of scenario building and relevant policy assumptions to develop future visions should be gradually harmonized to the largest extent possible.
- Data sources and the possible contribution of stakeholders should be better described and organized.
- The compatibility of the scenarios considered by the TSOs to develop the NTDPs (bottom-up scenarios) with the ones used by ENTSO-E in the TYNDP should be verified by ENTSO-E.
- Top – down scenarios used at the national level (wherever applicable) should be aligned with the respective ENTSO-E scenarios.
- The market studies methodologies should be harmonized at least at the overall methodological approach level (treatment of intermittent RES, availability of thermal generation, modelling of hydros and pump-hydros, etc.) and most preferably at the level of software tools used.

- The entire process of Transmission Development Plans release should be harmonized, including the frequency of execution (an annual basis is recommended), but roughly the dates of the official release, so as to avoid discrepancies.
- In Consultant's view, the establishment of an "official" and commonly applied CBA methodology at the European level being followed by all TSOs in a compulsory mode is feasible. Practically, this should be probably the ENTSO-E CBA methodology (and its updates) being approved centrally (by NRAs in the framework of ACER). This seems a realistic task that could be easily achieved at this early stage of national CBA processes development.

6 CONCLUDING OVERVIEW

This Section outlines the main findings and conclusions discussed throughput this Report. In line with the ToR requirements, the analysis performed by the Consultant has focused on the following areas:

- The processes used by ENTSO-E to build future scenarios for the electricity sector.
- The CBA methodology developed by ENTSO-E and its application.
- A high level review of the relevant processes both on scenario building and CBA utilised in 10 selected Member States.

The analysis carried out throughout the Study aimed to:

- Assess the compatibility of the methodology with the provisions of the relevant legislative framework.
- Identify weak and unclear points in the processes and make reasonable recommendations.
- Assess the clarity of the methodologies for the external stakeholders.
- Assess the level of transparency and publicity of data and relevant results, as well as the stakeholders' involvement.
- Identify the future challenges and elaborate relevant recommendations.
- Assess the compatibility and level of harmonization of relevant processes at national level among Member States.
- Assess the level of adjustment of the methodologies to the comments made by the Agency and other stakeholders to the scenario building and the CBA methodologies.

In general, the progress achieved so far in view of the preparation of TYNDP 2016 is quite significant in all aspects and considerable improvements have been made in comparison to the 2014 TYNDP. Nevertheless, there are still steps in the processes that should be further clarified or improved.

The majority of the comments made by ACER on the basis of the 2014 TYNDP have been addressed by ENTSO-E in the 2016 Scenario Development Report. Some of them which are still pending were identified in this Report. It should be also noted that the major weak points of the methodologies used and future challenges expected to be faced (such as the provision and treatment of ancillary services, the assessment of storage projects etc.) are well recognized by the TSOs and ENTSO-E is understood to have launched relevant processes for tackling these issues commented by ACER and other stakeholders.

Scenario building and CBA assessments are performed to a large extend in a decentralized manner by member TSOs or at regional level by the corresponding Regional Groups of ENTSO-E. In fact, ENTSO-E relies heavily on the work of its member TSOs. Thus, the scenarios / visions for the preparation of TYNDPs are developed on the basis of a pan-European global view at the ENTSO-E level, i.e. taking into account the power system of all ENTSO-E members (which includes non EU members as well), while the CBA of each project is performed by the ENTSO-

E Regional Groups, principally on the basis of the corresponding regional part of the power system. Therefore, depending on the case, some processes may be carried out on different subsets of data. Generally, the impact of the TSOs' view is crucial even for the centralized processes and mainly for the construction of top-down scenarios. The level of harmonization of local (TSO level) or regional views (RG level) is an important issue that is recommended to be further assessed by ENTSO-E.

The following sections present a concluding overview of the findings and recommendations derived from the analysis of the scenario planning process and the CBA methodology at European level, as well as the analysis of these two issues for specific MS.

6.1 Scenario Building

The scenario building methodology implemented by ENTSO-E has contributed in the improvement of the European power system planning in comparison to the previous years. The methodology described in the TYNDP 2016 Scenario Development Report is a large step towards the positive direction but there is still large room for improvement in various respects.

A major issue related to the scenario planning and the CBA as an integrated process is that the time frame of the studies focuses explicitly on the 2030 failing to provide policymakers and stakeholders an intermediate picture of the evolution until that point. Targets set for renewables, energy efficiency, de-carbonization and interconnections, frame the direction of the studies and resulting recommendations for grid development up to 2030. Nonetheless, the absence of an intermediate roadmap towards the generation mix foreseen for 2030 (e.g. annually, every two or five years) does not provide a clear picture of the evolution of the EU power system.

In Consultant's view, even though the development of the 2020 scenario is towards a positive direction, still the disclosure of all intermediate steps and a more accurate trajectory towards 2030 remains a prerequisite to allow for a complete CBA but also to allow stakeholders and NRAs to obtain a better comprehension of each view and relevant justification. Furthermore, there is need for a different treatment of the long term horizon (> 10 years) than the medium term. In this context, the role of stakeholders could be much more useful in developing long term views as TSOs have no data on very long term developments.

There is a strong policy dimension with regard to determining the detailed scenarios and parameters and the targets and interaction with other energy sectors. On the other hand, there is quite a number of other studies developing future scenarios, some of them officially endorsed by EC, performed by entities such as EC-DG Energy, IEA and other institutions and organisations. The Consultant recommends that the EC and Member States are more actively involved in the process of scenarios / visions development and potentially even undertake the overall exercise in broader collaboration with stakeholders. This approach would allow for more consistency with policy directions in one hand but it would also take into account the most up-to-date evolution of technologies. Such a procedure would also increase significantly the transparency and acceptability of the scenarios among stakeholders and facilitate the effective distribution and communication of both the approaches and methodologies utilized and the results.

The Agency and NRAs should keep having a key consulting role by providing opinions and assessments on the scenarios in the framework of this process. This approach would release as well ENTSO-E resources to be used in other activities related to the CBA assessment and allow him to focus in assessing the technical aspects of the scenarios implementation from the transmission infrastructure point of view.

According to ENTSO-E the four visions 'provide the envelope within which the future is likely to occur'. There is a strong debate whether this 'envelope' contains all or the major part of the possible feature system evolution states in the long term. On the other hand, the extremes represented by the 4 scenarios / visions may not present the most adequate basis for the assessment of projects. This is evident by the deviation of CBA results among visions. In general, as far as the CBA results are concerned, these high deviations do not provide a clear ground for decisions (related to CBA, CBCA etc.). The probability of the CBA assessment results actually becoming reality, i.e. the robustness of the results across scenarios is of much more value for the readers and should be somehow tackled.

Therefore, the development of a "best estimate" scenario until 2030 attaching the probability of occurrence along with a sensitivity assessment (addressing the potential variation of the key assumptions adopted for the 'main' scenario) would provide a clearer view of what is anticipated or at least a complementary set of results referring to the most likely future evolutions. It is noted that in this direction, ENTSO-E has developed an intermediate 2020 scenario reflecting the "expected progress" according to TSOs best estimate, but not until 2030.

The 2016 Scenario Development Report could be characterized as a high level description of specific tasks rather than a concrete and detailed methodology. As such, it occasionally fails to explain and elucidate to the reader various aspects of the process. It is, thus, unclear, to the reader if and how certain considerations are taken into account. Specific aspects of the methodology that could be improved or presented more clearly to the reader include: (a) a detailed explanation of how visions are (technically) translated into scenarios (b) an explanation on the rationale for choosing the specific parameters and a quantifiable description (c) clarifications are required on how these parameters are used and clustered to develop the scenarios (d) a clear distinction between assumptions/parameters and results (e) a clearer presentation of the implementation details on the building of top-down scenarios from bottom-up scenarios. The elaboration of a well substantiated, documented and commonly approved methodology would vastly alleviate the quality, reliability and transparency of the scenario building process.

With regard to the stakeholders' involvement to scenario building process, it is noted that the number consultation meetings already carried out seems adequate, However, despite the existing formal procedure for interaction and consultation with stakeholders, it is not clear to what extend stakeholders can contribute and affect the formulation of scenarios and how the respective contributions are taken into account. A streamlining of the consultation process, in terms of an advance consideration by ENTSO-E of the role and involvement of each stakeholder in the consultation process would result in higher efficiency and transparency.

Last but not least, apart from the presentation of the methodology a more detailed reporting on scenario findings and especially the publication of: (a) country balances, (b) capacities and (c) cross-country imports/exports would improve the planning process and increase transparency.

6.2 Cost Benefit Analysis

The CBA methodology developed by ENTSO-E addresses quite successfully the challenging specific requirements posed by the relevant EU regulatory framework, both from the methodological, as well as from the organisational / procedural points of view. The numerous consultations carried out and comments expressed by various stakeholders have helped considerably towards the improvement of the methodology. In this context, the remarks expressed in the previous sections attempt to address and fine tune issues which in the opinion of the Consultant will contribute to the clarity and further improvement of the methodology.

Transmission investments are frequently clustered together and the CBA is performed on the resulting cluster. Clusters aim to support avoiding the underestimation of the potential net benefit resulting from the completion of more than one projects which are located in the same area or along the same transmission corridor and contribute to achieve a common measurable goal. One of the two rules currently used by ENTSO-E for clustering the individual projects takes into account the influence of the project on the GTC and the other the time distance of the commissioning dates which is up to 5 years. However, the definition of the first rule in the CBA methodology requires a more comprehensible definition. The second rule also when applied literary seems problematic and rather arbitrary. It could however be used in a more flexible way, by allowing reasoned justifications for clustering projects which break this rule by a small margin, while it could at the same time, become stricter (i.e. allowing a shorter difference of commissioning times) so as to create pressure for better time alignment of clustered projects.

In the same direction, it is important that GTC, which is a very significant factor in the whole TYNDP process is defined and explained more comprehensively to its in order to ensure that it takes into consideration realistic power flows, any applicable transmission margins (i.e. margins allocated for regulation or other system security issues), etc. Gradual adoption of flow based methodologies for calculation of GTCs would allow taking into account potential crucial internal congestions within each TSO area, which could be expected due to the high uncertainties caused by high RES penetration and the markets' volatility.

Currently the CBA indicators are calculated only for the end year of the time period analysed (i.e. 2030) as it is evidenced by the results for each project which were presented in the TYNDP 2014, while in the forthcoming 2016 TYNDP, they are expected to be calculated for 2020 as well. This approach practically eliminates the impact/benefit which is accumulated by a project from the commissioning date till the end of the studied period and therefore the respective cumulative benefits. In other words, if a project is commissioned in the beginning of the studied period the calculated benefit will be the same to that of a similar project commissioned at the end of the studied period.

As the resources and the effort required for assessing each year of the studied period are very significant, the task for extending the scope and depth of the CBA analysis to address each year of the studied period is a very challenging issue. However, this should be counterweighted against the higher credibility of the CBA results. Potential improvements in the process of application of the CBA methodology could also assist in saving effort and resources which could be allocated to the aforementioned task, e.g. the adoption of a common tool for the performance of the market studies uniformly for all projects assessed and at the EU level instead with different tools and at regional level which is the case today, calculating the Security of Supply indicator only for the whole TYNDP and selected individual projects which are expected to have a high relevant impact, as discussed in the respective sections of the Report. In any case, as an intermediate step, the CBA should align with the 5-yearly time periods foreseen by the regulation.

CBA methodology employs 2 impact indicators, 7 benefit indicators plus the cost of a project in order to conclude the analysis. Out of the benefit indicators, B2 which measures the benefit from the project on social welfare is the one with the highest significance as it internalizes the "B3: RES integration" and "B5: Variation in CO2 emissions" indicators and it usually represents the major portion of the benefits achieved by a project. On the other hand, indicator B7 ("Flexibility"), in the opinion of the Consultant is a "mixed" bag, attempting to capture complicated aspects of the power system operation, seemingly on the basis of the experience alone of TSOs and with too high level guidelines by the CBA methodology. In the opinion of the Consultant, B7 should be restricted in indicating the adaptability of a project on the various system conditions (as expressed by the different scenarios), and this could be accomplished in a more concrete manner, i.e. by assessing the relative variation of a project's benefits across the scenarios.

The environmental benefit is internalised in indicator B2 ("Social Welfare"), by considering the avoided CO2 costs due to the decrease of thermal generation, whereby the avoided CO2 cost is based on the future value per ton of CO2 emissions. However, it is not certain that this value of CO2 emissions captures the real external cost of electricity in relation to GHG. Furthermore, the impact on human health from thermal generation, and therefore the benefit from the reduction of such generation, is not considered at all. A more thorough assessment and potential reconsideration of the environmental benefit of transmission projects is recommended.

Regarding the impact of a project on the flexibility of a system in terms of ancillary services, which is of high importance again due to the high penetration of RES, and due to the high difficulty and complexity of such an assessment, it is recommended that this assessment becomes a future task for ENTSO-E. A methodology for the calculation of ancillary services should be provided within the framework of the "target model" on an ENTSO-E-wide base. On the basis of this methodology, an additional benefit indicator (B8) reflecting the benefits related to ancillary services could be potentially added in the current CBA methodology.

Market studies provide the main results to support the calculation of the benefit indicators for each project. It is understood though that sometimes the number of market studies carried out is greater than the minimum required as in many RG more than one market study tools are applied by different TSOs. Although the concepts followed by ENTSO-E RGs in market studies methodologies are very similar, it seems that there are differences among the methodologies used by the various RGs around Europe. Several different relevant tools are reported being used. This could lead to inconsistencies of the results among ENTSO-E regions. The lack of uniformity of either the methodology or the tools utilized for market studies among RGs is understood to impose a heavier work load and additional effort for resolving any kind of inconsistencies. It is recommended that, after consultation with the stakeholders, a common methodology is applied Europe wide, by all regional groups and preferably, a commercial widely used market studies S/W tool should be adopted.

Finally, due to the importance of the CBA for future investments in electricity transmission and storage, not only for projects planned and promoted by the ENTSO-E members (European TSOs) but also for projects promoted by 3rd parties as well as for PCI selection, the transparency of the application of the CBA methodology is of high importance as well. Therefore, the necessary data for performing the CBA, should become publicly available, to the extent that practical and/or other considerations allow. A relevant road map for the release of this data is therefore highly recommended.

6.3 Review of Selected Member States

In line with the ToR requirements, 10 MS have been reviewed using information collected by questionnaires on issues related to the scenario building and CBA at national level. Although all MSs fully respect the 3rd Energy Package provisions related to the development of a National Transmission Development Plan in terms of legal obligation, stakeholders' involvement and publicity, there are still several issues that should be harmonized in the underlying processes such as the scenario building and CBA. More specifically:

Scenarios Development

In most of the MS analysed there is not an established "scenario development" process at the national level similar to the one followed by ENTSO-E at the European level. In general, the future scenarios are developed in the framework of the National Transmission Development Plan process driven mainly by the national TSOs. Most of the TSOs follow a bottom-up approach to develop the relevant scenarios. In some cases, there is also a top-down approach applied to achieve a balance compatible with the national targets and generation adequacy requirements.

The level of compatibility among the national and ENTSO-E scenarios cannot be easily verified. In some cases, the compatibility level is high (e.g. France, Germany, United Kingdom) especially for the bottom – up scenarios as concluded by the relevant processes but for most of the MS the national scenarios are rather different than the ones used by ENTSO-E. The top--down scenarios developed by ENTSO-E are obviously different than those at the national level as they have been developed through a different methodology. Furthermore, in the aforementioned big countries the scenarios development process is better organized with the deep involvement of stakeholders.

It is also notable that in the big countries (Germany, France and United Kingdom) the long-term perspective (up to 2050) is reflected in relevant scenarios, being the basis for the national policies towards 2050. We recommend that the construction of such scenarios should be extended at EU level. Similarly, the time horizon covered by NREAPs might be extended accordingly. Special care should be given to the compatibility of such scenario to the ENTSO-E views.

CBA issues

With respect to the CBA, the requirement for CBA of transmission projects is a rather new obligation for many TSOs, especially under the deregulated electricity market environment, even though some European TSOs traditionally used to perform CBA studies for major transmission projects. The majority of the TSOs reported that they perform CBA only for major transmission projects, with very few TSOs performing CBA for all the projects included in the National Transmission Development Plan.

Standardized CBA methodologies have been developed and applied only in specific countries (United Kingdom, Italy and France). Several TSOs reported that in general they follow the ENTSO-E CBA guidelines but this cannot be verified since the relevant documents are not public. The methodologies used are usually subject to approval by the relevant NRAs. The CBA results (when available and if any) are either fully or partially published for selected projects in the relevant National Transmission Development Plans.

6.4 Overview of proposed recommendations on scenario development and CBA methodology

Proposed recommendations for the improvements in scenario development and CBA methodology have been discussed in detail in the respective sections of this Report. The following Tables 6.1 and 6.2 present a critical overview of the main recommendations with regard to scenario development and CBA methodology respectively, including their objectives and a qualitative assessment of the anticipated level of difficulty for their implementation, the resources needed, the priority for addressing them. The table includes as well the anticipated risks and the bodies that should have a main role in implementing these recommendations.

Table 6.1: Overview of proposed recommendations on scenario development

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies involved
Formulation of Visions/Scenarios							
Selection of basic parameters of scenarios/visions (i.e. climate targets and strengthening of European governance) difficult to justify.	Broader collaboration with other more expert bodies (EC, IEA, etc.) especially for the long term period.	To improve transparency and credibility of visions and effectiveness of the scenario development process	Med	Low	Hi	Coordination of the collaboration	ACER, ENTSO-E, EC
• Ongoing significant activity on development of scenarios for the future outlook of the EU energy system by several organisations, including development of scenarios endorsed by the EC • Strong policy dimension with regard to determining the detailed scenarios and parameters and the targets and interaction with other energy sectors (e.g. gas, etc.).	EC and Member States should take a more active role on the definition of scenarios / visions, and potentially undertake this activity. NRAs and ACER should have a major consultative role in this process.		Med-Hi	Med	Med	Potential conflicts - coordination issues.	EC, MS, ACER, NRAs

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies involved
Extensive debate on the "envelope" of future power system states created by the 4 scenarios / visions	Development of a Best Estimate Scenario, accompanied by variation range for key parameters	Clearer view of future expectations for the system development	Med	Low	Low-Med	Reaching a commonly acceptable set of key assumptions and respective values	ENTSO-E, ACER, EC
Methodology for scenarios / visions development							
Poor description of certain aspects of the methodology.	More clarifications on the methodology are needed by ENTSO-E.	To improve clarity, transparency, consistency of results	Low	Low	Hi	- Time consuming process - Involvement of many TSOs	ENTSO-E, TSOs
Unclear process of construction of the bottom up scenarios at the TSO level.	Harmonization among TSOs		Med	Low	Med		
Unclear level of harmonisation with the national energy policy / goals and unclear assumptions for the development of the bottom-up scenarios in the 2020-30 period.	Development of guidelines for bottom up scenario building by the TSOs		Med	Med	Med		
- Not accounting for interactions and substitution effects among energy sub-sectors and elasticity of demand. - Unclear coordination with ENTSO-G	- Interaction among energy sub-sectors should be considered more explicitly - Coordinate ENTSO-E/ ENTSO-G TYNDPs (harmonise scenarios, dates of release etc.).	Improve quality and credibility / acceptability of results	Med-Hi	Med	Med	- Agreement on initial hypotheses - Views of Gas TSOs and relevant stakeholders to be aligned to electricity sector views	ACER, ENTSO-E, TSOs

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies involved
Scenario definition and inputs							
Poor description of input data and initial hypotheses	Full disclosure of the scenario building methodology and assumptions.	Improve clarity	Low	Low	Hi	Difficulty to agree generation mix among stakeholders	ACER, ENTSO-E, TSOs
Some key parameters for each scenario are presented in qualitative terms. Unclear how these are quantified.	Clarifications on the use of parameters to scenario formulation and quantification hypotheses.		Hi	Low	Med		
Missing info on future internal networks.	A full description of inputs referring to future development of internal networks (publicly available data).	Increase transparency	Low	Med	Med	Confidentiality issues may arise	ENTSO-E
Time frame of scenarios							
System outlook is defined for only 2 time points (i.e. 2020, 2030) per scenario.	Definition of system outlook for more time points of the TYNDP time period to allow for better scenario definition and performing a CBA over the complete TYNDP period.	Improve quality of the results, increase transparency.	Hi	Hi	Hi	Large workload for ENTSO-E	ENTSO-E

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies involved
Top-down scenarios							
Unclear points on data and individual methodologies: - Temporal and spatial allocation of the new conventional and RES generation within each country - Resizing and reallocation of hydros	- Clarifications on data and more detailed description of the methodologies. - Common/harmonized methodology applied for all TSOs.	Increase clarity and consistency	Low	Low	Med	Involvement of many TSOs	ENTSO-E
Technical and economic sustainability of Scenarios							
The technical and economic sustainability of Scenarios is not assessed against crucial parameters	ACER and/or ENTSO-E set public techno-economic criteria for "Vision acceptance"; take into account all parameters concerning generation adequacy, viability of thermal and RES power plants, compatibility with ENTSO-G TYNDP, etc.	Increase value and credibility of scenarios	Med-High	Med	Med-High	Time consuming process/need for extensive Public Consultations	ACER, ENTSO-E
Smart Grids							
Not clear consideration of Smart Grids	Systematic approach / specific methodologies and metrics to be applied	Increase Credibility of scenarios	M-H	H	M-H	Lack of ENTSO-E counterpart to assess impact of smart grid options in the distribution networks	ENTSO-E, Distribution Operators

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies involved
Engagement of Stakeholders							
Involvement of stakeholders can be enlarged and improved.	ENTSO-E issues an explanatory document at the beginning of the TYNDP building process dealing with stakeholders involvement and relevant roles on methodologies proposed and data publication (with respect to confidentiality issues).	Increase transparency and scenario acceptance	L	L	M	Increased work load for ENTSO-E	ENTSO-E, Stakeholders

Table 6.2: Overview of proposed recommendations on CBA methodology

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies
Clustering of transmission projects							
• The clustering rules seem unclear and arbitrary. • Competitive project" term is unclear	• Clarifications needed as well as a brief presentation of the concept leading to the clustering rules. • 5-year time threshold rule for clustering to be reconsidered allowing for more flexibility / pushing for higher time alignment of projects commissioning	• Increase clarity and transparency • Increase credibility of results	L	L	H		ENTSO-E
Time horizon and CBA assessment							
• The time horizons applied differ from Regulation 347/2013 provisions. • Time horizons considered do not allow a CBA of a project over the entire TYNDP period	ENTSO-E provides input data sets and relevant network and market analysis results for at least four time horizons within the TYNDP	Compatibility with the Regulation, more accuracy with respect to results	L	H	H	Considerable increase of work load for ENTSO-E	ENTSO-E

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies
- CBA indicators seem to be assessed only for the end year of the TYNDP period - Effect on the CBA indicators of the commissioning year of a project is not taken into account	CBA indicators should be assessed considering the whole TYNDP period	To consider project impacts over the complete TYNDP period	Low	Hi	Hi		
Availability and transparency of CBA background data for verification							
The necessary data to reproduce and verify CBA results are not sufficiently provided to the public.	ENTSO-E should define a roadmap for making publically available all the necessary data for the CBA.	Increase transparency	Med	Low	Hi	Confidentiality issues which may arise	ENTSO-E
CBA indicators							
Indicator B7 attempts to capture several complicated issues of system development, however provided methodological guidance is insufficient	Indicator B7 is focused on the adaptability of a project to the various system development scenarios	More clarity for Indicator B7	Med	Low	Med	-	ENTSO-E

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies
Methodology for assessment of the environmental benefit of transmission projects seems to underestimate benefit	Assessment of the environmental benefit should be based on the external cost of thermal electricity generation	More accurate capture of environmental benefit	Med	L	Med	Agreement on value of external cost of thermal generation	ENTSO-E
The SoS indicator is not monetised	To be monetized especially in sounding cases (new areas connection or weak connections) using an agreed VOLL (approved regionally)	Improve credibility of results and transparency	L	L	H (for specific projects)	Differentiation of VOLL/hypotheses on VOLL	ENTSO-E
Additional impact of transmission projects (ancillary services)							
Ancillary services are not considered in the CBA through appropriate indicators.	Introduction of an additional impact indicator (B8) accounting for contribution to ancillary services (especially system "flexibility").	Improve credibility of results	H	H	L-M	Difficulties in the assessment of ancillary services. Some entities claim that it is not possible to assess the ancillaries' requirements	ENTSO-E

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies
Market and Network studies							
It seems that there are differences among the methodologies and the S/W tools used by the various RGs. This could lead to inconsistencies of the results among ENTSO-E regions.	ENTSO-E proposes a common methodology (and preferably common tool) to be applied by all RGs.	Enable much higher consistency level of the results and increased transparency and potentially decrease considerably the work load for consistency checks	M	M	H/M	Differentiation among TSOs and difficulties in harmonization.	ENTSO-E
Transmission capacity (GTC)							
Calculation of GTC is described very briefly, thus the whole process is unclear to the reader.	• More information is provided on GTC calculation • Relationship of GTC and NTC is explained • In any case, the utilization of harmonized “flow-based” methodologies is proposed at least for the calculation of the GTCs.	Increase the credibility of the results	L H	L H	H L-M	Possible delays / need for agreement among TSOs	ENTSO-E

Issue / comment	Recommendation	Objective	Level of difficulty	Resources needed	Priority	Risks	Bodies
Assessment of storage projects							
There is no information on the modelling of storage projects in the market framework and their operational objectives (i.e. profit maximization, overall system cost minimization, minimization of RES spillage etc.).	ENTSO-E proposes a general methodology on the modelling and simulation of storage projects in the market studies (to be adopted by the Agency after consultation with the stakeholders)	Increase transparency and the credibility of the results	M	M	H	Difficulties to converge towards a harmonized / common methodology	ENTSO-E