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A methodology for societal cost-benefit analysis for meshed offshore grids

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SUMMARY

A meshed European offshore transmission grid connecting offshore wind farms to shore could provide significant financial, technical, economic and environmental benefits to the European electricity market. Launched in January 2016, PROMOTioN [1] aims to explore and identify these potential benefits. To fully understand the economic and societal consequences of such a grid, it is necessary to perform a societal cost benefit analysis (SCBA). Existing SCBA methodologies, however, are not designed to assess complex offshore systems. A study was performed within the PROMOTioN project to develop a suitable methodology. The study delivered a set of guidelines for performing an SCBA analysis for offshore grids, as reported in Deliverable 7.11 [2]. This paper presents the results of this study. It describes requirements for an SCBA for offshore grids, challenges in comparing offshore grid solutions and the choices made in developing an appropriate methodology. The presented methodology aims to enable the comparison of alternative offshore grid configurations in a certain geographical area, given offshore wind capacity development in this area. The methodology sets out the criteria and guidelines for the assessment of costs and benefits of a complex offshore energy system.

An offshore grid is defined in the context of the SCBA methodology as a configuration of offshore infrastructure assets that enables: (i) the connection and evacuation of (future) offshore wind energy in a defined offshore area to surrounding onshore grids, and (ii) the enhancement of market integration through offshore cross-border interconnections.

The presented SCBA methodology provides guidelines on the choices and options when comparing offshore grid solutions, the common set of defined key performance indicators (KPIs) to value alternative grid configurations and the assessment framework used for the SCBA execution. Both an ideal and a practical methodology have been developed. The ideal methodology provides a more accurate reflection of the costs and benefits but will be more time consuming and onerous to collect the data and perform required model-based simulations. There is also a risk that many of the data points do not exist. The ideal methodology thus encompasses more complexity and levels of detail. To fit within the scope of the PROMOTioN project, a practical SCBA methodology has additionally been described to enable the assessment within the scope and time constraints.

KEYWORDS

Societal Cost Benefit Analysis - Meshed - HVDC - Offshore - Wind - Northern Seas

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1. INTRODUCTION

1.1 Background

Projected developments in the Northern Seas foresee 90 to 205 GW of offshore wind capacity to be installed by 2050 to contribute to emission reduction targets within Europe [1]. Installing this large capacity will require moving further offshore. This poses technical challenges that could be overcome by, for example, introducing meshed HVDC offshore grid configurations. A meshed offshore grid could provide significant benefits to the European energy market by increasing market integration and connecting far-shore wind parks helping to achieve the European socio-economic principles of affordable, sustainable and secure energy for consumers. To understand the economic and societal consequences of undertaking such a development, it is necessary to perform a societal cost benefit analysis (SCBA). To perform this assessment, a clear and objective methodology should be employed that sets out criteria and guidelines for the transparent comparison of alternative offshore grid configurations. Existing SCBA methodologies are mostly designed to assess single element incremental changes to a system and are unsuitable to assess complex systems that continuously develop in space and time. Therefore, there was a need to develop an SCBA methodology within the scope of the PROMOTioN project [1]. This paper presents the requirements for such an SCBA to assess the value to society of future offshore energy systems, based on work done in and quoted from Deliverable 7.11 [2]. Departing from generic guidelines for SCBA methodologies and a literature review of existing methodologies, a set of guidelines has been developed to perform an SCBA for complex offshore grids.

1.2 SCBA methodologies

Two types of CBAs can be distinguished; *project/financial* and *societal* CBAs. *Project/financial CBAs* assess the financial value of a project, typically by monetising all relevant indicators (including project costs and revenues) to calculate the net present value (NPV) of each considered project alternative. Guidelines are based around quantification and monetisation of the indicators. *Societal CBAs*, in contrast, intent to assess the value of considered project alternatives to society. This not only includes monetary aspects but also a broader set of societally relevant indicators. A similar structure (steps) can be identified for both methodologies. Both require clear guidelines to perform the assessment and comparison of various project alternatives in an objective manner. This common generic structure of CBA methodologies has been found through a review of multiple theoretical and practical methodologies [3-11]. The generic structure is defined in this work through "dimensions", see Figure 1 and subsequent paragraphs. Each dimension needs to be explicitly defined to allow for the assessment and comparison of the considered project alternatives.

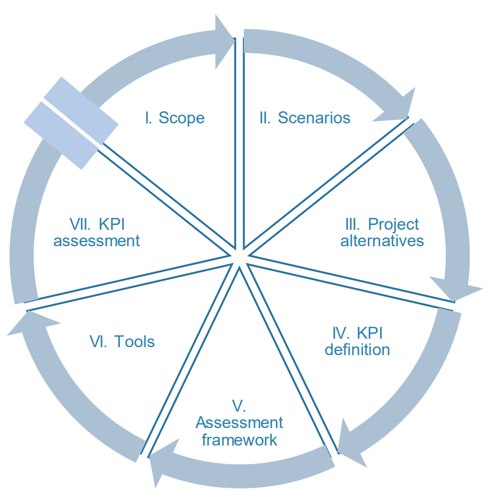

Figure 1: Dimensions of an SCBA methodology (adapted from [2]).

1.2.1 Dimension I: Scope of the project alternatives and CBA methodology

The purpose and scope of analysis of the projects under consideration are defined (financial vs. societal CBA and single incremental project vs. system CBA).

1.2.2 Dimension II: Scenarios for energy system development

Guidelines are defined regarding the number and scope of the scenarios under which to assess the cost and benefit KPIs of each project alternative. Scenarios represent possible futures of energy system development in the considered region, including a medium- or long-term vision on renewable energy production, load development, fossil fuel prices, CO_2 prices, generation mix and regulatory framework. The minimum number of scenarios used for the assessment, the parameters to be specified for each scenario and the guidelines on how to develop the scenarios should all be specified.

1.2.3 Dimension III: Project alternatives

All considered project alternatives should fulfil (a) similar purpose(s) to allow for transparent comparison. Project alternatives should fulfil a similar purpose and consider different strategic or technical alternative solutions to achieve this. Project promotors will be able to assess "the best" alternative from the considered projects through a CBA. Transparent and unbiased comparison between the considered project alternatives can only be ensured by using a clear set of guidelines: the CBA methodology. Throughout literature, various CBA methodologies have been described that are each tailored to specific projects and sectors, mostly single-sector and project-based (clearly bound in space and time). Guidelines are defined on the minimum number of alternative projects that should be included in the assessment and on how to develop alternatives. Guidelines are therefore required for the definition of the common

(i) purpose(s) or function(s) of the considered project alternatives;
(ii) the scope of variation (in terms of, for example, considered technologies, components and sectors) between considered project alternatives; and,
(iii) the scope of services and technologies that could/should be included in each project alternative.

Important are also guidelines on the reference of comparison between project alternatives, i.e. the reference project or "null-alternative". Also, guidelines are defined on the boundaries, physically and in time, common to each project alternative, as well as a definition of "the project".

1.2.4 Dimension IV: KPI definition / identification

Guidelines are provided to define and determine the KPIs used to assess the project alternatives compared to the reference project. These indicators can be qualitative, quantitative, or monetized. The selected KPIs and their respective determination methods will affect the assessment framework and project comparison. KPIs should be selected based on the understanding of the cost and benefit impacts of the considered project alternatives. These impacts will reflect the different assets that are part of each project alternative and their functionality, as well as the purpose common to each considered project alternative.

1.2.5 Dimension V: Assessment framework

Guidelines are included to define the assessment framework, which must explicitly specify the conditions and parameters to be used for the assessment. Guidelines include the definition of the evaluation time period and the method to evaluate costs and benefits over time. The assessment could include a financial analysis (NPV calculation), an economic analysis (monetisation) or a scoring through multi-criteria analysis [7]. Guidelines should also include a view on risk and sensitivity analysis.

1.2.6 Dimension VI: Use of tools

Finally, guidelines on the tools needed to assign a (qualitative, quantitative, or monetary) value to the defined KPIs are provided. These guidelines include the types of models required - for example, market or network models for projects in the energy sector - and key assumptions and implementation approaches. These are required to ensure that the considered project alternatives are evaluated under similar conditions.

1.2.7 Dimension VII: KPI assessment and scoring of projects

After the definition of all SCBA dimensions, the CBA can be executed following the described guidelines resulting in a value for each project alternative for each KPI. A comparison of the different project alternatives can subsequently be performed based on a combination of the results of the KPI assessment.

1.3 Scope of the developed methodology

The scope of the methodology developed under the PROMOTioN project is illustrated in Figure 2. Established methodologies in literature mainly focus on financial or societal analysis of a "single project".

A *project* is defined by ENTSO-E as a cluster of investments in a similar development stage [9-10]. A project can represent a single investment, a cluster of investments or an entire system. A *cluster* in the energy infrastructure sector represents the smallest group of investments that are required to transport power to meet a goal (e.g. enhancing socio-economic welfare or reducing CO_2 emissions) [9-10]. Existing methodologies have been investigated to develop a CBA methodology that fits with the complexity of offshore meshed grids [3-11]. This methodology will be an SCBA methodology as this is most appropriate to assess complex offshore systems in this context, considering that

- an offshore meshed system in the North Seas is only in the study phase and contingent on the outcomes of political decision-making. Before moving to the financial implications, first the impact to society as a whole needs to be analysed;
- PROMOTioN studies the development of societally optimally integrated offshore wind; and
- complex meshed offshore systems consist of cross-border energy infrastructure. This type of infrastructure in Europe requires an SCBA to be eligible to be identified as a project of common interest (PCIs often concern transmission interconnections between two countries).

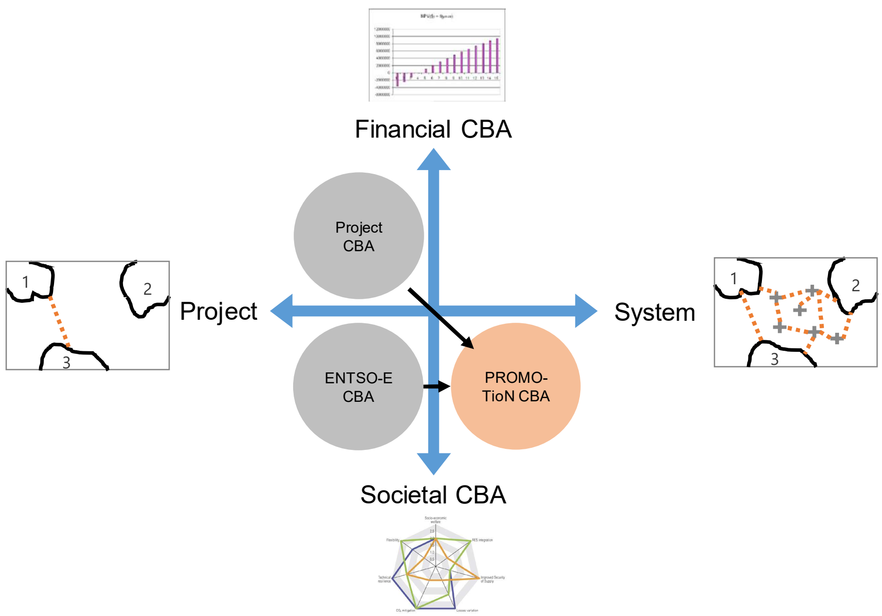

Figure 2: Scope of the CBA methodology developed in D7.11 of the PROMOTioN project (source [2]).

1.4 Paper structure

The remainder of this paper gives an overview of the requirements, choices and decisions in developing an SCBA methodology for complex systems, such as a meshed offshore HVDC grid, that continuously develop in space and time. This is followed by a discussion and conclusion.

2. METHODOLOGY

2.1 Approach

The SCBA methodology for offshore grids was developed as follows. First, a literature review was conducted into established and developed methodologies. From this review, an initial guideline was defined for each dimension departing from the "2nd ENTSO-E Guideline for CBA of grid development projects" [10]. The ENTSO-E guideline is currently applied to assess Ten-Year Network Development Plan (TYNDP) projects through a common methodology and multi-criteria framework, and the results of these assessments constitute the input for the selection of *projects of common interest* (PCIs) by the European Commission. While the evaluation of these projects is already complex, an offshore grid touches upon many more issues than a single transmission project. In this paper, the development is described of a methodology to evaluate different design options of a complex system. With the ENTSO-E Guideline as starting point, first the limitations for the evaluation of offshore grid systems were investigated based on the desired features (requirements and characteristics) of meshed offshore grids. Based on these characteristics and desired features, the initial guideline was evaluated and where required extended to develop a suitable SCBA methodology for meshed offshore grids.

2.2 Requirements for offshore grids

Based on the initial guideline for each dimension, a gap analysis was conducted between the initial guideline and the required features for offshore grids. The gaps are summarised in Table I. Per dimension an assessment needed to be made on how to fill the gaps. This includes decisions on the level of complexity and discussions on assumptions and choices. The challenges in comparing offshore grid solutions are part of this discussion. This exercise resulted in both an ideal and a practical methodology.

From *an ideal point of view*, the developed methodology should be applicable for a broad range of projects and should have a great level of detail for each dimension to accurately capture all possible effects and developments of offshore grids. The ideal methodology will provide a more accurate reflection of the costs and benefits but will be more time consuming and onerous to collect the data. There is also a risk that a large number of the data points for the ideal CBA do not exist. From a *practical point of view,* to ensure the practical feasibility of the execution, assumptions and simplifications will be required. The extent of these are discussed for selected dimensions in the following section.

Table I: Main gaps in existing SCBA methodologies to accommodate for offshore grids (source [2]).

Dimension	Main gaps
Scope	- Incorporate complete offshore network (complex system) in the form of project alternatives; - Consider, and where appropriate incorporate, explicit geographical distribution of offshore wind farms in the and project alternatives; - Consider the multiple purposes of wind energy evacuation and market integration.
Scenarios	- Guidelines for specific *"sea scenarios"* that describe the development of offshore wind capacity in the offshore area.
Project alternatives definition	- Clustering of long-term, complex projects (project vs system CBA); - Scope of boundaries, technologies, sectors to be used and evaluated in alternative projects; - Consider alternative infrastructure (mainly: gas networks) for evacuation; - Consider energy storage as part of the alternatives.
KPI definition/ identification	- What additional KPIs do we need? - Do we need a different description/valuation of (some of) the initially defined KPIs from the ENTSO-E Guideline? - How does the system develop over time (potentially spanning multiple decades)? - What degree of monetisation is desired?
Assessment framework	- Project assessment framework inappropriate (timeline + baseline); - Reference/base vs. null-alternative.
Tools	- Market modelling of the offshore area to capture costs and benefits; - Boundaries of the network model (onshore grid).

3. AN SCBA METHODOLOGY FOR MESHED OFFSHORE GRIDS – Challenges in comparing offshore grid solutions

For each dimension, except for the actual execution of the CBA (VII), choices and decisions have to be made, resulting in a practical and an ideal methodology. The extent of these discussions is summarised for a few examples in the following sections. The discussions focus on the project of a meshed offshore grid in the Northern Seas. However, these could be applied to offshore energy networks more generally.

3.1 Scope

The scope of the SCBA methodology, the degree of monetisation of the KPIs and the common purpose of the alternative projects, will affect the assessment framework. The methodology should, both from an ideal and practical perspective, measure the value to society of the alternative projects. The purpose of the considered projects is to evacuate the planned offshore wind energy in the offshore area *and* to increase market integration. Hence, both must be included in the assessment methodology.

3.2 Scenarios

Scenarios are required for various developments. This not only includes the definition of scenarios in the onshore markets, i.e. "land-scenarios", - for the development of, amongst others, generation mix and fuel prices - but also the definition of scenarios in the offshore area, i.e. "sea-scenarios", for wind capacity development in each considered future time step, locations of this wind capacity (clustered in areas or dispersed towards the shores, see Figure 3) and used wind turbine technologies. Scenarios should be chosen as to not bias a certain project alternative over another. For example, if all sea-scenarios have dispersed wind park locations, this might favour project alternatives with a lot of radial connections rather than meshed solutions. In the ideal methodology, a certain number of variations for each parameter (capacity, location, technology) of the "sea scenarios" should be included. However, from a practical perspective, this will lead to a non-workable number of alternative scenarios. The choice was therefore made to use three scenarios for offshore wind capacity development in the North Sea, representing a high, business-as-usual (BAU) and low wind development towards 2050. Given that a high number of wind parks will be developed regardless of scenario, not much variation is possible in wind farm locations considering shipping routes, Natura 2000 areas and territorial boundaries will significantly limit the degree of freedom in siting decisions. As such, for each of the considered development scenarios of wind capacity, only a single 'most appropriate' location and technology combination of wind parks is included in the practical methodology. Each considered project alternative will therefore connect the same wind capacity and wind parks, with merely a different offshore grid configuration.

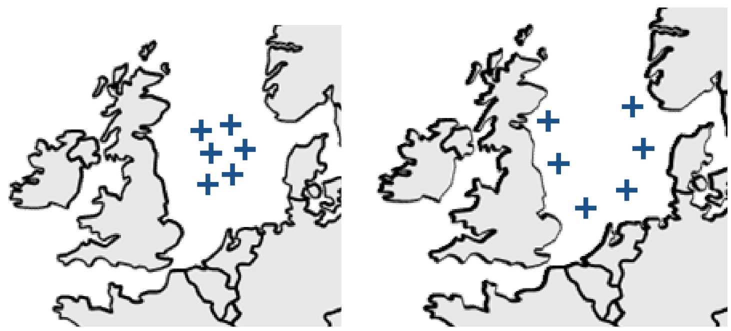

Figure 3: Schematic example of clustered (left) and dispersed (right) wind farm locations (source [2]).

3.3 Project alternatives

Project alternatives are options of different topologies and technologies for offshore infrastructure that fulfil the same purpose(s). To define project alternatives, a set of guidelines is required that details the scope of technologies, sectors and boundaries that can/should be considered in setting up a wide enough range of project alternatives to ultimately obtain the "best" overall solution for society. In addition, also a base-line must be defined that serves as a point of reference for project comparison. The different decisions/choices regarding project alternatives are detailed below.

A first choice concerns the scope of sectors to be considered in project alternatives. This requires deciding on whether only different topologies of electricity infrastructure will be considered, or that possible alternatives could also (partly) include other infrastructure such as the offshore gas infrastructure, storage or power-to-X options. In the ideal methodology, a broad range of project alternatives should be compared, including alternatives with hybrid electro-gas infrastructure or storage, as this would help to identify the offshore infrastructure most beneficial to society. However, from a practical perspective, only a limited number of alternatives can be compared. In the practical comparison, possible topology options of electricity networks are recommended as PROMOTioN focusses on offshore electricity infrastructure.

A second choice involves the onshore grid. Apart from onshore and offshore scenarios that describe the evolutions in the market, also a decision will need to be made regarding how to represent the evolution in onshore grid infrastructure to ensure the necessary infrastructure upgrades/reinforcements required to accommodate for growth in offshore wind energy. From the ideal perspective, the full development and reinforcement needs of the onshore grid - to take on offshore wind energy and transport it to load centres - should be considered to provide a clear and complete picture of the costs and benefits that will be raised by the project. This would involve a full planning exercise of the European transmission network. However, from a practical point of view this is not achievable with the currently available modelling tools. Given the large need for offshore infrastructure and the high level of wind energy that needs to be evacuated to onshore load centres in each project alternative, the reinforcement need of the onshore grid is expected to be significant regardless of project alternative.[1] Also, the onshore grid is assumed to be very similar for all project alternatives. Differences may be aligned by specific measures or investments. A practical assumption could therefore be that the costs for onshore grid reinforcement will likely be in a similar order of magnitude across all project alternatives. This is a reasonable assumption if the landing points of the offshore grid are assumed similar across the topologies. The difference in onshore grid reinforcement costs between project alternatives could thus be neglected for the practical assessment. However, the costs of onshore grid reinforcement to reach an appropriate onshore substation should be included.

A final choice involves the definition of the reference base for comparison of project alternatives. The approach used by ENTSO-E, which consists of the definition of a *reference grid* and subsequent project assessments using *PINT* and *TOOT*[2] methods [9,10], is not appropriate in the context of a system CBA, which deals with the long-term development of offshore transmission capacities over time rather than the marginal benefit of individual projects at a given moment of time. Therefore, each (system) project alternative will be compared to a business-as-usual (BAU) reference development of the offshore area, as schematically depicted in Figure 4. The BAU development of the offshore area will be the "null-alternative" of development, using only existing established technologies, such as radial connections of wind farms with AC. Given that the purpose of the offshore network is to both evacuate offshore wind energy and increase market integration, interconnectors could also be part of the null-alternative. The null-alternative project assessment should be adopted in both the ideal and practical CBA methodology.

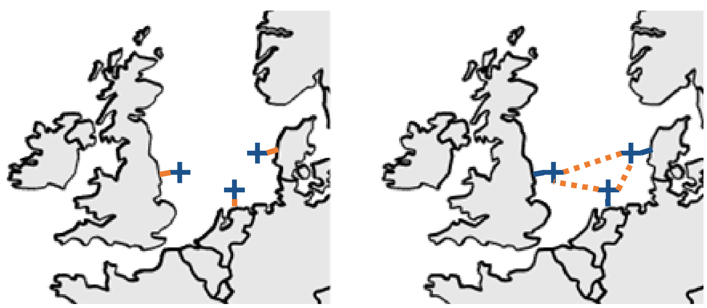

Figure 4: Schematic example of a "null-alternative" (left) and project alternative (right) (source [2]).

3.4 Tools

Several tools are required to determine the different KPIs for each project alternative. These tools include market and grid models of the area under research. The models use scenarios and other assumptions to model a certain geographical area. Depending on the implementation aspects and assumptions, the results of simulations, and hence the KPIs, might differ. Market models typically evaluate the exchanges, generation dispatch, unit commitment, and local price formation processes whilst minimising variable generation costs. Network models evaluate the behaviour of physical network flows. The main focus in this paper is the market model. Three main aspects have to be decided upon in building the market model for the CBA execution:

(i) the geographical scope of analysis (region);
(ii) the scope of the onshore market model; and
(iii) the scope of the offshore market model.

[1] This work looks at the value to society as a whole. When one would look at how costs would compare for individual countries, different project alternatives might favour more development (and thus costs) of the onshore grid in a particular market. However, this is beyond the scope of the SCBA methodology.

[2] The ENTSO-E Guidelines compares each project against one of two extreme baselines or reference grids. Projects can be included in the reference grid (and are subsequently assessed following the "take one out at a time", or TOOT principle), or excluded from the reference grid (and are assessed following the "put one in at a time", or PINT principle).

The geographical scope could be limited to the countries that border the offshore area and have a direct connection with the offshore grid. However, the effects of the offshore grid could have an impact on the countries that are remote in a second or third degree from the onshore connection points. Additionally, in the context of an SCBA, the value to society as a whole needs to be determined. For an offshore grid in the Northern Seas this implies the value to the pan-European area. In practice, the pan-European energy system also has connections with surrounding countries beyond its borders. As a minimum in both the ideal and practical SCBA methodology, the society as a whole as defined at the start of the CBA methodology should be considered, potentially with the consideration of any surrounding connections.

Power markets are currently organised in Europe on a zonal basis, mostly coinciding with country borders. For that reason, market models used to estimate the benefits brought by transmission projects of international importance in Europe (e.g. projects gathered in the TYNDP) are typically based on a zonal representation of the power system, consisting of different bidding zones, where each zone is seen as a "copper plate" without internal congestions but with exchange possibilities with neighbouring bidding zones. A major limitation of such a zonal market model is its inability to value the impact of a transmission project on congestions within a bidding zone, i.e. its impact on internal redispatch needs. From an ideal perspective, implementing a zonal market model complemented by a representation of the internal redispatch at a nodal level could be beneficial to assess the full impact of offshore transmission projects. However, given that bidding zones are already set to reflect the main congestions and that the amount of offshore wind energy to evacuate in the different project alternatives is the same, internal congestions are not expected to be a determining factor for the project alternatives. Consequently, from a practical perspective, a zonal onshore model will provide enough detail.

Currently, territorial waters belong to the onshore bidding zone where they are physically connected to. In a meshed system, another configuration might be required to maximise the benefits to society by, for example, letting wind farms from one country bid into the bidding zone of another, or defining (a) (multiple) dedicated offshore bidding zone(s). The foreseen offshore market and bidding zone configuration are of major importance as the governing market design impacts the development of the grid and operational strategies a well as certain KPIs and hence the results of the CBA. Note that any political considerations regarding market design are beyond the scope of this work. Ideally, each project alternative should be assessed under different (virtual) bidding zone configurations to assess the impact on KPIs. Bidding zones configurations could also be part of offshore scenarios. From a practical perspective, this will lead to a very large number of potential configurations, which are not all relevant or likely to materialise for certain project alternatives. Therefore, a practical assumption has been made to select the most appropriate (virtual) bidding zone configuration for each project alternative that enables to reap most benefits from the offshore grid to society and that reflects internal bottlenecks. These (virtual) bidding zones do not necessarily need to correspond with national territories nor should be interpreted as a recommendation for offshore market design.

3.5 Assessment framework and KPIs

Guidelines for the comparison between project alternatives need to be formulated based on the developed tools and defined KPIs. The approach to compare projects depends on the type of CBA (financial vs social) and the extent of monetisation of the KPIs. From an ideal perspective, each KPI should be expressed as much as possible in monetary terms on the condition that objective monetisation parameters can be obtained, and that monetisation is relevant. For each project alternative, the overall value to society can then be expressed in monetary terms (through a net present value (NPV) calculation), which allows for ready comparison between alternatives. However, in practice, objective monetisation is not always attainable or relevant for all KPIs. Therefore, some KPIs might be expressed in monetary terms, whereas others are reported in other quantitative units (e.g. MWh) or even qualitatively. The aim in the practical SCBA is to quantify and monetise the KPIs as much as possible. Comparison could be attained through multi-criteria analysis by assigning weighting factors to the KPIs and combine them into a single value or through, for example, a spider diagram. The "best" project will be sought through the importance that the involved stakeholders and project promotor will put on the different KPIs. To measure the value to society of projects, the KPIs will be based around cost (CAPEX, OPEX), benefits that align European objectives of affordability, sustainability and security of supply of the electricity system, and environmental impacts.

Additionally, choices need to be made regarding the evaluation period of the offshore grid, the time steps for development, the time steps of KPI evaluation, and related parameters required to perform the assessment of each project alternative, including; the economic lifetime of components, the interest rate and the residual value of the offshore grid. The recommended values from ACER as adopted in the ENTSO-E Guideline will be followed as much as possible [10,12]. These parameters should be used for both the ideal and practical SCBA execution. The parameters include an economic life of components of 25 years, no residual value and a societal interest rate of 4% [13].

3.5.1 Dealing with uncertainty

The offshore grid will be developed over the course of several decades. It is uncertain how the power system, in particular load and generation, will evolve over that period of time. This uncertainty could have a significant impact on the development of the offshore grid and is partly addressed through the scenario approach. For example, an offshore hub and meshed assets have high upfront investment costs that will only become fully operational and show benefits to society in a later stage, after other assets have been subsequently constructed and taken into operation. This could pose a risk to the financial viability of the project. Additionally, unforeseen developments in cost trajectories of onshore technologies might decrease the need for large-scale offshore infrastructure. It is therefore important to consider risks linked to uncertainties in the SCBA. There are a couple of methods to account for uncertainty, such as the minimum-maximum regret or a real-options approach [14]. In addition to uncertainty in scenarios, risks exist in the timing and development of an offshore grid. For example, the timely availability and training of a skilled work force, and the risk of not being able to manufacture the assets in the required multitude due to process or resource constraints. A full risk assessment is beyond the scope of a practical, high-level SCBA assessment. In the ideal SCBA methodology, however, risk assessment should be part of the assessment and comparison of project alternatives.

4. DISCUSSION AND CONCLUSION

Projected developments in the Northern Seas require installing large capacities of offshore wind, inevitably leading to a move further offshore. This poses technical challenges that could potentially be overcome by meshed HVDC offshore grid configurations. To understand the economic and societal consequences of undertaking such a development, it is necessary to perform a societal cost benefit analysis (SCBA). To perform such an analysis, a clear and objective methodology was developed that sets out criteria and guidelines for the comparison of alternative offshore grid configurations to allow for this comparison in a transparent manner. Existing SCBA methodologies are mostly incomplete to assess complex offshore systems that continuously develop in space and time. Therefore, there was a need to develop an SCBA methodology within the scope of the PROMOTioN project [1]. The various choices and decisions to be made for each SCBA dimensions to develop such a methodology were detailed in this paper.

From literature, the generic structure of SCBA methodologies was identified through multiple dimensions. With the identified requirements for offshore grids, an initial guideline was formulated departing from the 2nd ENTSO-E Guideline [10]. For each dimension, decisions and choices were made to fill in the gaps and finalise the methodology in an ideal and practical form. The ideal methodology provides a more accurate and complete reflection of the costs and benefits but will be more time consuming and onerous to collect the data. There is also a risk that a large number of the data points necessary for the ideal SCBA simply do not exist. To fit within the scope of the PROMOTioN project, a practical SCBA methodology is additionally described in Deliverable 7.11 [2].

The presented methodology aimed to enable the comparison of alternative offshore grid configurations that continuously develop in space and time in a certain geographical area, given developments of offshore wind in the considered area. Alternative electricity infrastructure projects considered for analysis have as common purposes: (i) the connection and evacuation of foreseen offshore wind energy in a defined offshore area to surrounding onshore grids, and (ii) the increase of market integration through offshore cross-border interconnections.

The “best” configuration of an offshore grid is defined as the “project alternative” that will derive the greatest value to society. The value to society will be evaluated through various key performance indicators (KPIs) and an assessment methodology. The developed SCBA methodology serves as a decision support tool. Note that the “best” decision from a societal perspective is not necessarily the same as the most cost-effective project alternative. Not all interests can be expressed in monetary terms and weighted in an objective way. The analysis does highlight the consequences of different offshore grid alternatives on broader society. The final decision in the decision-making process will probably be taken by a range of stakeholders, for whom, with the help of the information from the SCBA, the discussion can be structured, rigorous and transparent.

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©PROMOTioN – Progress on Meshed HVDC Offshore Transmission Networks
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