ENTSO-E Position on Offshore Development

Assessment of Roles and Responsibilities for Future Offshore Systems

November 2022

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ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The 39 member TSOs, representing 35 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the interconnected power system in all time frames at pan-European level** and the **optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources.

ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with **climate objectives** and **social welfare** in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility.**

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with **transparency** and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its legally mandated tasks, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

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Executive Summary

Offshore wind energy will bring a key contribution to reaching the objectives of the EU Green Deal. The EC's offshore RES strategy anticipates the integration of 300 GW offshore wind generation capacity into the energy system by 2050. The magnitude of this transition will raise new challenges for the European electricity system: accomplishing the necessary connections and grid development at least cost; keeping the system secure; accommodating a complete redefinition of power flow patterns; considering key constraints linked to spatial planning, environmental protection and public acceptance; achieving an integrated perspective over time, space and sectors; and ensuring flexible resources to keep the power system balanced.

In a series of papers, ENTSO-E assessed possible solutions to contribute to the realisation of the EC's Offshore strategy. Whereas earlier papers have already presented a vision on system development, market design, interoperability, system operations and support options for renewable generation, the present paper examines the governance of an offshore grid and provides insights into the possible roles and responsibilities for future offshore systems.

The future challenges expected to be brought by the large-scale integration of offshore renewables, notably through the development of dual-purpose offshore hybrid projects, highlight the need for such an analysis. Integrated and holistic planning, anticipatory investments, interoperable asset design, financing the increasing asset base offshore, and facilitating an efficient operation of the offshore grid are some of the main issues identified by TSOs that call for an assessment of existing roles and responsibilities in the offshore domain. The paper specifically aims to address the question of whether an extension of these roles is sustainable and can deliver the necessary transmission infrastructure to integrate large amounts of offshore wind generation capacity in a timely manner.

To tackle this question, ENTSO-E has defined and explored 5 different grid delivery models. The following graph shows the assessed model options.

Models	Network planning	Asset design & building	Ownership	Maintenance	Operation
Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO
Offshore TSO	Offshore TSO Onshore TSO	Offshore TSO	Offshore TSO	Offshore TSO	Offshore TSO
Competitive Light	Onshore TSO	Third party	Onshore TSO	Onshore TSO	Onshore TSO
Competitive	Onshore TSO	Third party	Third party	Third party	Onshore TSO
Competitive ISO	ISO Onshore TSO	Third party	Third party	Third party	ISO

These five models are described at greater length in Chapter 2, with a particular emphasis on how roles and responsibilities would be split or shared in each one of the five grid activities, from network planning to system operations.

	Criterion	Onshore TSO	Offshore TSO	Competitive Light	Competitive	Competitive ISO
Efficient Development and Operations	Anticipatory Investments	Teal	Teal	Teal	Red	Orange
	Pace of development	Yellow	Yellow	Teal	Orange	Orange
	Integration of innovative solutions	Teal	Teal	Orange	Orange	Red
	Coordination Onshore – Offshore	Teal	Yellow	Yellow	Orange	Red
Financing offshore Infrastructure	Availability of Equity	Yellow	Orange	Yellow	Teal	Teal
	Equity remuneration	Teal	Yellow	Teal	Orange	Orange
	Cost recovery	Grey	Grey	Grey	Grey	Grey
	Risks and liabilities	Yellow	Yellow	Yellow	Red	Red
Regulatory and legal framework	Certification	Teal	Red	Teal	Orange	Red
	Regulatory oversight	Teal	Red	Yellow	Orange	Red
	Compliance with existing regulatory frameworks	Teal	Red	Teal	Yellow	Red
	Rules for cost sharing	Yellow	Orange	Yellow	Yellow	Yellow
	Permitting process across countries	Teal	Orange	Yellow	Yellow	Orange

- Teal: Model option is fit for purpose.
- Yellow: Some challenges would likely arise, outcome should be further assessed.
- Orange: Risks and challenges would likely delay and/or hinder the development of an offshore grid in line with the EU targets.
- Red: Challenges would pose significant barriers to the delivery of the offshore grid and may conflict with existing EU principles and governance structures.
- Grey: Outcomes remain unclear and need to be further assessed.

From the analysis, it is clear that the Onshore TSO model offers the greatest certainty, especially regarding efficient development and operation and the fit to the regulatory and legal framework.

Given the ambitious targets for the deployment of offshore renewables by 2030 and 2050, the following aspects support the Onshore TSO model as the most appropriate governance model:

- The ability to retain a holistic view on system planning on- and offshore, thus capturing gains from coordinated planning for hybrid and single-purpose offshore projects, more efficient use of the new infrastructure, coherent CBA analysis for all the considered infrastructure and simpler pathway towards a final investment decision. .
- The ability to make anticipatory investments.
- The integration of innovative solutions that can safeguard system reliability, multi-vendor interoperability requirements and reduce the overall impact on the environment.
- The existence of a fit-for-purpose regulatory approach with minor need for revisiting the legislation.

These are critical criteria for achieving the EU's aim for a decarbonised electricity system. However, improvements needed to the Onshore TSO Model were also identified. The pace of development of offshore projects needs to be accelerated and can be supported by a simplification of permitting processes and by working on means to increase public acceptance. These improvements would, in fact, support any of the abovementioned grid delivery models. In addition to this, one could consider, on a case-by-case basis, coexistence with the competitive-light model to align with the pace of development of Offshore RES. Regarding the availability of equity, co-investor models with minority shares in certain projects or adequate incentives for identified offshore projects could be a solution.

Finally, the paper shares preliminary ENTSO-E views on further questions in the context of offshore governance models, which deserve further attention in discussions and future publications. The questions revolve around cost-allocation between countries with both direct and indirect roles in developing offshore hybrid projects and the limitations to a harmonised offshore regulatory framework

1. Introduction

This document is part of the ENTSO-E position paper series related to offshore developments. The series contributes to the ongoing debate in the context of the European Green Deal, triggered among others by the European Commission's offshore Renewable Energy System (RES) strategy, which anticipates the integration of 300 GW offshore RES in the European energy system by 2050.

ENTSO-E expects a stepwise and modular development of technologies and designs, especially with an increasing number of dual-purpose solutions ("offshore hybrid projects") being part of the offshore installations. This is a development from single-purpose solutions to a more integrated network. For this development, clarity on the roles and responsibilities of future offshore systems is crucial.

To assess the several combinations for the repartition of roles applicable to offshore hybrid projects, defining the exact scope of assets comprised by offshore hybrid projects is a necessary first step.

ENTSO-E considers that an offshore hybrid project refers specifically to the transmission assets, serving the dual purpose of connecting offshore RES generation and interconnecting two or more bidding zones. Such offshore hybrid projects facilitate the transmission of offshore RES to two or more market zones, with the direction of the flows depending on the market prices (from low prices to high prices). Through this set-up, rules and regulations which are in force onshore today can also already largely be applied offshore [1].

The Offshore RES itself, connecting to an offshore hybrid project, is treated separately as a generation asset just like any other generation asset in the electricity system, following EU unbundling rules.

Next to the offshore RES, the cables connecting the offshore RES to the offshore hub are worth mentioning as the regulatory frameworks in various countries might differ, with the responsibility for these lines either being borne by the offshore RES developer, the TSO or, in the case of Great Britain, by an Offshore Transmission Owner (OFTO).

The development of offshore hybrid projects as defined above can include the following assets, as represented schematically in Figure 1:

- DC Connection Point/Offshore hub (3): node of the offshore system connecting one or more generation units to the transmission backbone. Its physical structure can be designed in several ways (caisson/sand island, jacket, floating etc.) based on the characteristics of the marine location. It hosts transmission equipment such as converters and transformers (4).
- Electricity transmission assets (5) (6): equipment composing the transmission backbone of the offshore system, spanning across borders and connecting the hubs, countries or zones between each other and with the onshore transmission systems.
- Onshore connections and equipment including converter stations, substations and sometimes even including onshore grid reinforcements (depending on the applicable regime) (7) (8)

Offshore Hybrid Projects with their dual-purpose functionality and their cross-border (and/or cross-bidding zone) character require additional effort compared to today's classical projects.

This paper considers their development across five grid activities:

- **i) Network Planning,**
- **ii) Asset design and Building,**
- **iii) Ownership,**
- **iv) Maintenance and**
- **v) Operation.**

1 See also earlier ENTSO-E Position papers: ENTSO-E's views on offshore development

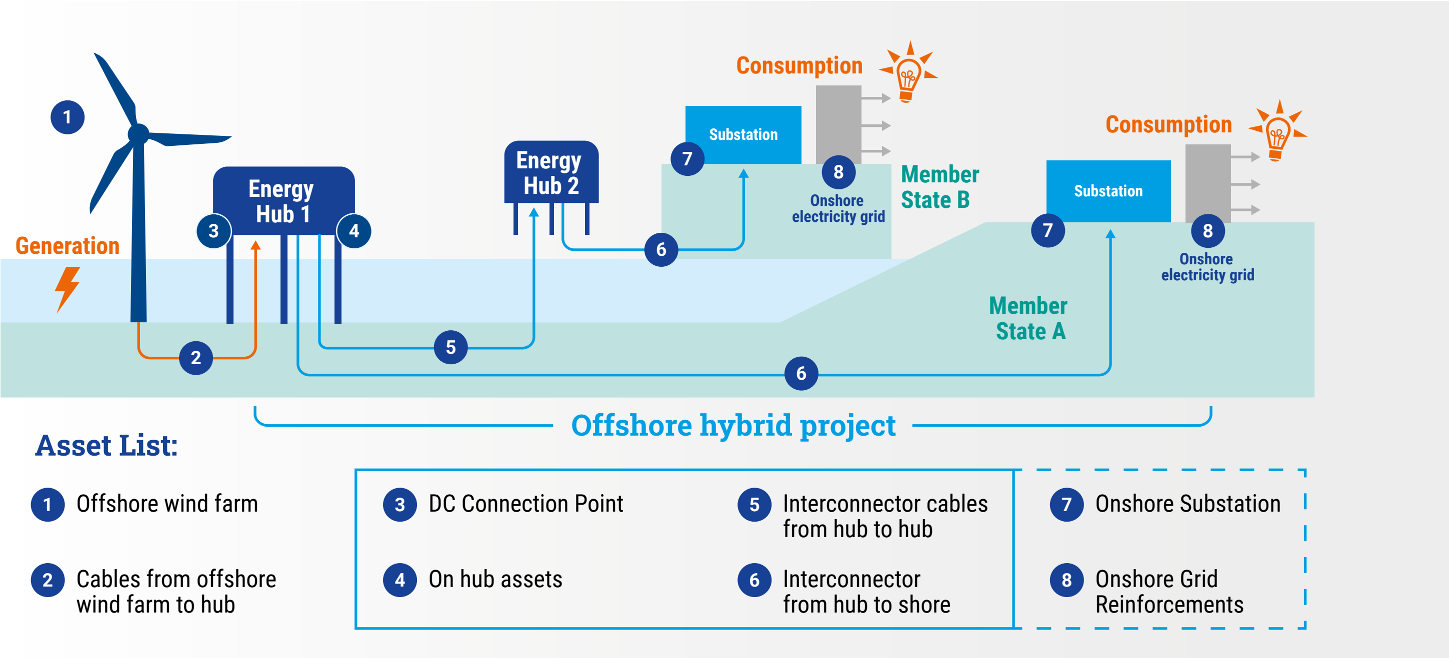

Figure 1: Offshore Hybrid Project – Distinction between transmission and generation assets

General future challenges

In network planning, offshore hybrid projects require an integrated approach, both related to the onshore-offshore interface but also related to a strong international coordination. Dimensions of RES integration and transport are too huge for one country to solve this alone. As in future RES-based interconnected national systems, weather will be the driving force; long distance international transport to non-correlated weather areas will be the rule. This requires consideration from the planning phase already.

In addition, the modular character of such projects requires consideration when analysing the abovementioned five grid activities. This means that not everything will necessarily be built from the start, but either future elements – or at least a potential expansion of the project – will already be considered from the start. This implies that parts are eventually first realised at a later stage. These projects are "hybrid by design" and can, more-or-less easily, be expanded at a later stage. It is expected that the number of cases of existing single purpose projects (radial connections or point-to-point interconnectors) being "hybridised" will be small as they have been designed and built without consideration of possible further extensions or integration with other projects and this might also turn out to be difficult with respect to existing guarantees for assets.

Regarding asset design and building, it is necessary to ensure multi-vendor interoperability and a reasonable level of standardisation. However, at least during the first stages of this long-term development, enough room for individual and flexible solutions needs to remain to not hamper a fast realisation of early projects by letting them wait for standards to evolve. Project development and development of standards need to run in parallel. Otherwise, the necessary acceleration emphasised in the EC's offshore RES Strategy[2] will not be achieved.

As investments into the future offshore system require massive capital, to attract investors, a future-proof and reliable regulatory framework is a precondition for TSOs to attract the necessary equity and avoid an unsustainable cash-flow situation, which would otherwise ultimately lead to a significant rise in the transmission tariffs borne by onshore customers[3].

It is crucial to ensure that capital is invested in a manner that most benefits European society. Increased benefit is expected to be delivered by the new concept of dual-purpose solutions as they combine benefits from RES connection with the socioeconomic welfare benefits delivered by markets' integration while keeping the impact on maritime environment at a minimum. Like classic interconnections, they facilitate the sharing of balancing reserves across borders, which improves the adequacy situation of a region.

2 EC "A EU strategy to harness the potential of offshore RES for a climate neutral future"
3 ENTSO-E (2014). Fostering Electricity transmission investments to achieve Europe´s energy goals: Towards a future-looking regulation

With a large shift of generation capacity offshore, which simultaneously means a shift to inverter based resources, managing onshore frequency on the one hand, and balancing the overall energy system on the other hand, requires a holistic perspective across time, space and sectors.

The development towards dual purpose solutions is expected to increase over time as, currently, some technological developments still need to be fixed and tested[4], especially with respect to multi-vendor interoperability. However, with the assistance of the EC's "Horizon Europe" Programme, first demonstration projects are on their way and will ensure that important steps are taken to facilitate accelerated offshore development. The necessity of acceleration is clearly highlighted in the European offshore RES strategy[5] to reach the Green Deal targets.

First projects appearing

The development as described above has already begun and is taking up speed. A first of its kind offshore hybrid project has already entered operation in December 2020, connecting Denmark and Germany (the Krieger's Flak Combined Grid Solution (KF CGS)). It is foreseen that several further projects will be developed in the coming years. Examples are listed in the recent draft Ten-Year-Network Development Plan (TYNDP) list of project candidates[6]. Many of them are expected to enter operation in the second half of the 2020s (see Table 1).

Project TYNDP ID	Project name	Project promoters	Status*	Commissioning year foreseen by the project promoter(s)	Existing or new project
121	Nautilus: multi-purpose interconnector Belgium – UK	Elia, National Grid	2	2029	was in TYNDP 2020
260	Project 260 – Multi-purpose HVDC interconnection between Great Britain and The Netherlands	National Grid, TenneT-NL	1	2030	was in TYNDP 2020
335	Project 335 – North Sea Wind Power Hub	Energinet.dk, TenneT-NL, TenneT-DE	1	2035	was in TYNDP 2020
1088	Offshore Wind Park in Latvia and Estonia – ELWIND	AS Augstsprieguma tikls (AST) and AS ELERING	1	2030	new in TYNDP 2022
1092	Triton Link: Offshore Hybrid HVDC Interconnector Belgium – Denmark	Energinet and Elia Transmission Belgium	1	2030	new in TYNDP 2022
1106	Bornholm Energy Island (BEI)	Energinet, 50Hertz	1	2030	new in TYNDP 2022

Table 1: List of offshore hybrid projects included in the draft TYNDP22 project portfolio (January 2022)

Paper Structure

Chapter 2 proposes a short description of the different grid activities, based on which options for the allocation of roles and responsibilities are presented. These model options are described, in some cases with certain assumptions made to allow for a more in-depth subsequent discussion. Chapter 3 introduces 13 criteria, clustered around three categories, based on which the model options are evaluated. For each category, a traffic light table summarises the main findings. Finally, Chapter 4 concludes the analysis by recommending the improvements necessary to ensure regulatory frameworks support the delivery of future offshore systems. Open questions for further discussions are also highlighted.

4 See ENTSO-E Position on Offshore Development "Interoperability"
5 EC "A EU strategy to harness the potential of offshore RES for a climate neutral future"
6 Link to the Draft TYNDP22 project list (January 2022)

2. Mapping of the Options for the Allocation of Roles

2.1 Background and assumptions

Future infrastructure delivery models for offshore hybrid projects will need to be adapted to the higher level of complexity associated with the development towards a more integrated offshore grid infrastructure. As already stated in the introduction, intense cross-border coordination is necessary for the gradual evolution towards a future offshore infrastructure, which will include an increasing number of dual-purpose elements i. e. connecting bidding zones and integrate offshore RES.

To cope with the expected upcoming challenges, several options related to potential roles and responsibilities of potential players are discussed below. Whereas some options rely on existing actors in the transmission space, others consider the introduction of new entities to help develop and/or operate offshore assets in a well-coordinated manner.

For a systematic assessment of the presented options, the relevant grid activities introduced in the introduction are considered below:

Network Planning

Long-term planning of offshore infrastructure development is an integral part of network planning for the European electricity grid as a whole. It is usually done at least in close cooperation with competent national authorities, building on their maritime spatial plans. These authorities, be it the same or several, are also responsible for issuing the permits for the offshore grid infrastructure and eventually also for the related necessary onshore network reinforcements. In upcoming regulations, the Member States are asked for close cross-border cooperation to optimise the usage of European sea basins. This considers many aspects beyond the exploitation of offshore RES potential. Their collaboration shall facilitate the sustainable development of integrated offshore network infrastructure.

TSOs in EU-countries are obliged to cooperate in terms of strengthening the cross-border interconnection between Member States . Related to submarine infrastructure, the needs are identified through a cooperative effort by the involved system operators based on the envisaged offshore RES and also considering the onshore generation and consumption. Every two years, ENTSO-E publishes a TYNDP which provides an overview of the possible network developments for a 10 to 20 years' time horizon based on joint future scenarios.

Asset Design and building

The design of the specific project includes, among others, the technology-choice, technical specifications and the definition of the cable route. Multi-vendor interoperability needs to be ensured while leaving sufficient room for innovation amongst the relevant parties. Building includes the construction, assembling and testing of the necessary technical components. The party responsible for building may award the construction of individual assets to specialised suppliers and technology-providers.

Ownership

Ownership of the physical assets includes the commitment of financial resources as well as responsibility for all rights and obligations connected to the property. This is especially relevant as the owner of the infrastructure is liable for the proper functionality and availability towards the trading and generating parties, which includes the claim for compensation in the event of unavailability.

Maintenance

The responsibility for maintaining the transmission infrastructure typically belongs to the owner of the infrastructure. The owner is responsible for the availability of the asset even if the maintenance activities may be awarded to specialised service suppliers. Different contractual arrangements can be agreed upon bilaterally. These contractual arrangements are outside the scope of this paper.

Operation

Operation means the physical operation of the transmission assets considering the technical availability (e. g. due to maintenance). Operation includes transport of energy from generation to demand centres, maximising the available network capacity and the coordination of planned and the management of unplanned outages with the maintenance responsible party and with Regional Coordination Centres (RCCs). RCCs will support the coordination of system operation tasks between all TSOs (be they onshore or offshore), regardless of ownership model, based on the tasks defined in Art. 37 of Regulation (EU) 219/943. System security benefits significantly from regional coordination, for example through Regional Security Centres (RSCs), future RCCs and Synchronous Area Monitors (SAMs).[7]

7 See also ENTSO-E Position on Offshore Development – System Operation and Governance

2.2 Description of the options

In the following, several potential variants of which parties could be responsible for the relevant phases and aspects related to a project, as described in the previous section, have been setup and investigated.

Models	Network planning	Asset design & building	Ownership	Maintenance	Operation
Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO
Offshore TSO	Offshore TSO Onshore TSO	Offshore TSO	Offshore TSO	Offshore TSO	Offshore TSO
Competitive Light	Onshore TSO	Third party	Onshore TSO	Onshore TSO	Onshore TSO
Competitive	Onshore TSO	Third party	Third party	Third party	Onshore TSO
Competitive ISO	ISO Onshore TSO	Third party	Third party	Third party	ISO

Figure 2: Mapping of identified model options

2.2.1 Onshore TSO Model

Model	Network planning	Asset design & building	Ownership	Maintenance	Operation
Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO	Onshore TSO

Figure 3: Onshore TSO Model

The Onshore TSO model extends the current approach used onshore to the offshore environment. This means that TSOs have the responsibility for planning and further developing their networks according to the needs within their dedicated control area and exclusive economic zones (EEZ) offshore of the countries they operate in.

Network Planning

In this setup, the TSOs plan the entire interconnected electricity transmission system in Europe according to the current and future needs of the electricity system. In addition to national development plans, TSOs in the EU are obliged to cooperate inter alia in terms of strengthening the cross-border interconnection between Member States[8]. This alignment of on- and offshore planning is today covered by national TSOs and reflects expected cross-border flows within the European

8 See EC No 714/2009; updated regulation EC No. 347/2013, EC No. 943/2019

interconnected electricity system. Offshore hybrid projects are, inter alia, considered within the framework of the TYNDP.

Today, a holistic system view is generally used, providing a basis for a forecast of future developments of supply and demand. Included in this is the most recent database of new grid connections and decommissioning plans of generation parties, the latest information of demand parties and in-depth knowledge of the onshore transmissions system is.

Asset Design and Building

Where a cost–benefit analysis confirms the net-benefit of a development project, the TSOs study the technical options to meet the need and design the detailed technical characteristics and functionalities of the assets in the context of the overall system. Environmental specificities are also studied, e. g. the environmental impact mitigation measures and concrete conductor routes. TSOs apply their expertise in the field of relevant activities such as assessing selection criteria relevant to the overall system, permitting and onshore grid integration. TSOs are already leading the development of rules and requirements for multi-terminal multi-vendor HVDC systems and facilitating the standardisation of systems[9].

TSOs will contract adequate service providers to deliver the relevant technical assets and construction services to realise the transmission assets. By launching public international tenders, TSOs apply a competitive and efficient procurement process. Third party participation would be allowed under similar exemption rules as for normal point-to-point interconnectors.

Ownership

TSOs own the hybrid transmission assets i. e. from the offshore hub to the connection to their respective onshore grid. When two or more TSOs cooperate, ownership is separated on a project-by-project basis as applied today for single purpose interconnectors.

The costs for the hybrid transmission assets are borne by the TSOs. As the pressure to finance the future grid build-out needs is increasing, TSOs could make use of joint ventures or special purpose vehicles to separate projects and sell a minority of shares to raise the necessary equity for the specific investments.

Maintenance

TSOs are responsible for maintaining the integrity of the grid, for which the reliable technical status of their assets must be maintained. The operational maintenance of the assets is usually provided by the construction company, the services provider of the TSO or their partners, or the TSO itself. The responsibility towards the generating entity and to the regulator for the availability of the asset remains with the owner and thus the TSO in this case.

Operation

The system operation of the transmission system is done by the TSO of the concerned control area. In national and European legislation, certified TSOs have to fulfil strict requirements and standards to ensure security of supply and safe operation.

The system operation of the offshore grid and the system operation of the rest of the transmission system cannot be considered in isolation. Balancing the system is a crucial task, with security standards that must be fulfilled. With the situation that the offshore grid (nearly) only connects generators, there are no balancing capacities available within the offshore grid and tight cooperation with the onshore operation is thus essential. Furthermore, it must be considered that the consequences of an offshore incident are significantly larger onshore as they would affect consumers.

The role of the RSCs/RCCs that support TSOs with relevant security analyses automatically extends to the offshore space under the current framework, so that the regional coordination of system operation of offshore and onshore networks is ensured.

9 See ENTSO-E's third offshore position paper on interoperability

2.2.2 Offshore TSO Model

Model	Network planning	Asset design & building	Ownership	Maintenance	Operation
Offshore TSO	Offshore TSO Onshore TSO	Offshore TSO	Offshore TSO	Offshore TSO	Offshore TSO

Figure 4: Offshore TSO Model

An Offshore TSO Model could foresee the creation of a single entity at sea basin level that would take responsibility for all steps in the delivery model for offshore hybrid projects. Such regional entities would thus ensure that transmission ownership and operations is the responsibility of the same party, while network planning would require strong on- and offshore coordination with national onshore TSOs.

In this option, such a party would most likely be a new separate entity appointed to cover the whole sea-basin irrespective of EEZ borders. As installing separate offshore TSOs per EEZ in a sea basin is close to the onshore TSO model and just adds a separate entity under the control of the responsible onshore TSO, this option is not considered here. Similarly to the set-up of RSCs, such offshore regional TSOs could be jointly owned by the region's national onshore TSOs or their subsidiaries, aiming to ensure strong alignment with national plans and any necessary onshore reinforcements, while also securing a more "centralised" approach with regard to cross-border investments and the associated costs and benefits. This potential setup would not interfere with unbundling rules; therefore, this is the working hypothesis used for further analysis in this document.

Network Planning

The network planning would be close to that of the "onshore TSO model" as it is assumed in this document that the onshore TSOs jointly own the sea-basin based offshore TSO. This means that system needs, both on- and offshore, could be considered "under the same roof". In contrast to the onshore TSO model, offshore planning would be executed in one process and across national borders represented by the EEZs. In the classic "onshore TSO model", this is expected to be done in joint work under the ENTSO-E umbrella and single elements in bi- or multilateral TSO collaboration.

Asset Design and Building

This stage is very close to the "onshore TSO model", the difference being that some offshore developments and provision of standardised solutions might easier facilitated *across EEZs* compared to the onshore model. However, within the EEZs it can be expected that national rules and legal obligations would still apply, no matter who is responsible for offshore. Thus, in practice the potential for smoother cross-EEZ working might be limited. Some of these pieces of national legislation / standards usually ensure a smooth connection between on- and offshore systems. It must be ensured that this compatibility remains.

Ownership

As this entity does not exist today, the potential ownership of assets would also need to be organised in a manner most beneficial for European society, forward looking and pragmatic.

The exact design would need to be specified. Today, cross-border transmission investment costs are typically recovered through a combination of network tariffs and congestion income[10]. Network tariffs' are largely borne by onshore consumers and a minor or null part sometimes by generators, subject to national rules. With no or very few consumers within the area operated by an offshore TSO in the foreseeable future, options for recovering the full cost of developing and operating the system would be limited. Accordingly, offshore TSOs, co-owned by the adjacent onshore TSOs, would likely pass the financing of the offshore grid assets on to onshore consumers. It would need to be agreed how this distribution of costs could be organised across the several countries in each sea basin. Given the massive investment volumes, the sharing of equity provision would also be a crucial point as no country would be able to solve this alone. Further considerations on cost-sharing are elaborated on in Chapter 3 and 4.

Maintenance

Similarly to the other models, the general rule would apply that the entity who owns the assets is responsible for maintenance. Offshore TSOs would, over time, need to develop strong maintenance competences regarding offshore assets.

10 Art. 19 of the Electricity Regulation EU 2019/ 943 ensures that congestion income is not a windfall profit for TSOs but rather is used to fund cross zonal-related activities to the benefit of the network tariff payer. More information can be found in ENTSO-E's paper on Assessing Selected Financial Support Options for Renewable Generation (2021

Operation

As mentioned for the previous model, the system operation of the offshore grid and the system operation of the rest of the transmission system (i. e. onshore) cannot be considered in isolation to one another. Balancing the overall electricity system, i. e. matching generation and demand, is crucial to ensure that security standards are fulfilled. As balancing capacities are not available within the offshore grid, the balancing of offshore systems independently from onshore systems cannot be achieved. The offshore TSO can perform several operations tasks in the offshore domain (outage planning, forecasting, real-time system operations), but balancing the offshore system would need to be ensured by contracting reserves from connected onshore balancing markets and would generally rely on onshore TSOs system services[11]. In addition, the role of RSCs/RCCs would continue to support the regional coordination of system operation, both offshore and onshore.

2.2.3 Competitive Model "light" as a variation of the Onshore TSO model

Model	Network planning	Asset design & building	Ownership	Maintenance	Operation
Competitive Light	Onshore TSO	Third party	Onshore TSO	Onshore TSO	Onshore TSO

Figure 5: Competitive Light Model

A variation of the standard "Onshore TSO model" could be to let a third-party design and build a relevant part of the offshore grid infrastructure, which upon completion is taken over by the relevant onshore TSOs linked to the related EEZ.

Network Planning

In general, the onshore TSO is responsible for the planning of the overall system. Applying the usual holistic view across time, space and sectors, the TSO might identify future needs of further offshore developments. These might require anticipatory investments, i. e. the need to build assets today in view of future needs. In the event a third party does the planning alone, these aspects would not be considered due to a different planning focus. Close cooperation between the third party and the responsible onshore TSO is crucial to ensure long-term efficient and robust solutions, among others bridging the gap between lead times for RES and lead time for infrastructure development.

Third party selection

Before the offshore hybrid project can be designed or built, a selection process needs to be established to pick the entity responsible for the next stage. This model could be implemented through a joint tender by public authorities for offshore renewable generation and related transmission exporting the related energy.

Asset Design and Building

The awarded offshore RES developer could eventually, subject to national rules, bear the responsibility (and the risk) for the design and construction of the cable between the offshore RES and the DC connection point (see Figure 1). This would need to be done in close cooperation with the adjacent TSOs who will subsequently have to operate the system. This cooperation would be necessary to avoid the RES developer having to solely optimise the project at the expense of wider system benefits. In practice, the design plans could be submitted by the developer to the TSO and the National Regulatory Authority (NRA) for validation, also ensuring that potential future expansion needs are properly covered. Sufficient multi-vendor interoperability per sea basin (while avoiding the fact that standardisation stifles innovation) would be necessary to avoid having to overcome issues from different specifications on a case-by-case basis.

Ownership

Under the Competitive Light model, and depending on the national regime, at least the interconnection related assets would need to be sold to adjacent TSOs after being constructed as they will own and operate this part. Assuming the offshore RES developer is the actor responsible for designing and building the assets, non-interconnection related assets could remain with the offshore RES.

Maintenance

The principle applies that the one owning the asset is responsible for maintenance. The scheduling of maintenance activities still has to be done in a coordinated manner through the RCCs. This can be optimised with larger area system operation.

11 This is described in ENTSO-E's fourth offshore position paper on System Operations and Governance

Operation

The successful operation of the system would depend on the degree of cooperation between the TSOs and the project developer during the asset design and building phase as a sound design and building is a precondition for safe operations.

As in the models described above, the responsibility for system operation lies in the hands of the onshore TSOs with the support of RCCs.

2.2.4 Competitive Model – Merchant or cap-and-floor regime

Model	Network planning	Asset design & building	Ownership	Maintenance	Operation
Competitive	Onshore TSO	Third party	Third party	Third party	Onshore TSO

Figure 6: Competitive Model

A "competitive" grid delivery model would heavily rely on introducing competition in the asset delivery phase. The model could, e. g. follow the idea of the merchant regime or follow a cap-and-floor regime as exists already today, e. g. in the UK.

Network Planning

Network planning would be executed and coordinated between the adjacent national onshore TSOs.

The work done by the onshore TSO would underpin key assumptions for possible project promoters and determine options for further development and decision making. These assumptions could include an optimisation not only to export the offshore RES at hand but in addition consider expected trade flows or other further expected developments, which are based on the TSOs' holistic view. The planning phase would be followed by a call for tender.

Third party Selection:

Following the submission of project proposals by third party project promoters, a dedicated project assessment phase would need to be set-up whereby the concerned national regulators, together with the TSO, would assess the costs and benefits of the proposed offshore hybrid projects and their impact on onshore consumers. This would subsequently need to be followed by a more in-depth assessment carried out by regulators to assess the costs associated with the development, construction, maintenance and decommissioning of assets, which could inform the cap and floor levels (if applicable). Any exemption decision then needs to be notified to the EC, which may request amendments or withdrawal. Any third-party would then be certified as a TSO, in compliance with existing unbundling rules.

Asset Design and Building

Once the project has been awarded to a third party and the final investment decision is confirmed, the third party is appointed and bears responsibility for the design and construction of the offshore hybrid projects. Special attention must be given to aligning with any necessary onshore reinforcement such as to ensure timely connection to the onshore network as well as coordinating with the offshore generation projects.

Ownership

Following the construction of the offshore hybrid projects, the project promoter would retain ownership of the asset and bear responsibility for maintaining it. Given that an exemption under Article 63 of the Regulation (EU) 2019/943 is granted, remuneration may take place in one of two ways:

- **Fully merchant:** This fully exposes the project promoter to the volatility and price-risk of congestion rents. As mentioned in ENTSO-E's paper on Assessing Selected Financial Support Options for Renewable Generation, the application of Advanced Hybrid Coupling would have an impact on the price formation in Offshore Bidding Zones connected to the Nordic, Core and Hansa regions. It appears that a fully merchant remuneration model would not be attractive for project promoters.
- **Cap-and-floor:** Under this model, if congestion income is between the cap and floor set by the national regulator(s), no adjustment is made. Revenue above the cap is returned to consumers and the shortfall of revenue below the floor requires payment from consumers (via transmission charges). Project promoters would still face an incentive to identify efficient investment opportunities while also being ensured of the overall viability of their investment. In contrast to a fully regulated model, part of the risk is borne by the owner, whereas the other part is subsidised by onshore tariff payers.[12]

Suitability of fixed regulated revenue-based regimes for future offshore hybrid projects

For the development of offshore radial connections, the UK has relied for some years on the so-called "OFTO-model", where the asset ownership is transferred to a private company that is certified as the transmission owner. In exchange for incurring the task to maintain the asset and part of the liability towards other market parties in case of asset unavailability, the OFTO receives a stable Tender Revenue Stream, i. e. a fixed remuneration over several years (typically 15 or 20).

This paper does not consider this type of remuneration model to be applicable to offshore hybrid projects owned by third party investors. As offshore hybrid projects combine both functions of interconnecting bidding zones and connecting offshore RES to shore; a fixed remuneration framework as is done for certain radial connections in the UK would likely not provide the necessary flexibility to adapt to different project designs or capture different revenue streams (congestion income, connection charges, ancillary services, participation in capacity markets).

Furthermore, a fixed remuneration for a hybrid project would allocate a disproportionate share of the construction and market risks to onshore grid payers, with little inherent incentive for commercial developers to identify and implement the most efficient solutions from a system perspective, unless explicitly indicated in the tendering process.

Maintenance

Whereas the actual maintenance tasks may be contracted out, the responsibility for the availability of the asset can either lay with the TSO or the owner (third party) depending on the cause of the non-availability.

Operation

The operation of the offshore hybrid project and, more generally, the offshore system (e. g. balancing, maximising the grid capacity) would still be ensured by the connected onshore TSOs, in cooperation with RCCs, as defined in the Clean Energy Package[13].

2.2.5 Competitive Model – with an independent system operator (ISO)

Model	Network planning	Asset design & building	Ownership	Maintenance	Operation
Competitive ISO	ISO / Onshore TSO	Third party	Third party	Third party	ISO

Figure 7: Competitive Model

A Competitive Model with an Offshore ISO would foresee the creation of a single entity at sea basin level that would take responsibility only for part of the network planning and system operation within its control area. Such regional entities would thus imply the separation of transmission ownership and system operations tasks, which would be the responsibility of different parties. Network planning would require strong on- and offshore coordination with national onshore TSOs.

The competitive model with an independent system operator would involve, as with the competitive model, a significant number of players and focuses on competitive elements for most roles and responsibilities. While national onshore TSOs (or their subsidiaries) could compete in the tenders for the construction, ownership and maintenance of offshore transmission assets, this model is designed to incentivise private ownership by third parties[14].

12 On 13 December 2021, Ofgem announced that it would "run a pilot cap and floor scheme for the first-time inviting bids for "Multiple-purpose Interconnectors" (MPIs) which can link up clusters of offshore RES directly to an interconnector."

13 Articles 6, 36 Regulation (EU) 2019/943

14 While other variations on a possible Offshore ISO model can be thought of, it is assumed here that ownership of assets would in most if not all cases go to private investors, for the purpose of the paper covering the full range of options

The principal aim of such a model is to confer the coordinated planning and operation of the future offshore grid infrastructure with a more centralised approach and attempt to establish greater independence from transmission investments[15]. The possible introduction of an independent system operator for offshore has been mentioned in the EU Offshore Renewable Strategy Staff Working Document[16] as a possible approach to coordinating the development and operation of future offshore assets.

Network Planning

Under this competitive model, a new legal entity separate from the onshore TSOs, a so called Independent System Operator (ISO), would be designated to plan the offshore network in each sea basin in a dedicated process separated from onshore infrastructure planning.

This grid planning would be based on the to-be-established offshore network development plans per sea basin[17]. This separation would highlight the need for and importance of integrated planning of the onshore and offshore grid. This planning would specifically focus on the grid development needs to connect offshore RES generation to the onshore systems and on facilitating power flows due to cross zonal trade of the EU power market. The first focus is currently part of national planning activities and the latter is currently part of ENTSO-E's TYNDP activities.

A regional offshore ISO would centralise network planning activities in the offshore domain but would strongly depend on increased coordination with national onshore TSOs. This includes, for instance, the integration of information from national network development plans, coordination for the selection of onshore connection points and necessary onshore reinforcements.

Third Party Selection

Similarly to the Competitive model, the planning phase would be followed by a call for tender. Following the submission of project proposals by third party project promoters, a dedicated project assessment phase would need to be set-up, whereby the concerned national regulators, together with the ISO, would assess the costs and benefits of the proposed offshore hybrid projects and their impact on onshore consumers. This would subsequently need to be followed by a more in-depth assessment carried out by regulators to assess the costs associated with the development, construction, maintenance and decommissioning of assets, which could inform the cap and floor levels (if applicable). Any exemption decision must then be notified to the EC, which may request amendments or withdrawal.

Asset Design and Building

Similar in nature to the description under the Competitive model. In addition to the need for coordination with onshore TSOs to align with the onshore system planning (onshore connection, onshore reinforcements), the third party would also need to coordinate with the offshore planner (offshore ISO).

Ownership

Similar in nature to the description under the Competitive model. The Offshore ISO would not effectively own any of the transmission grid assets.

Maintenance

Similar in nature to the description under the Competitive model. The responsibility for the availability of the asset can either lay with the operator (ISO) or the owner (third party), depending on the cause of the non-availability.

Operation

The most relevant difference from other models is that operation is performed by a separate ISO that neither designs nor owns the assets and whose principal aim would be to optimise flows over the concerned assets, as opposed to guaranteeing their availability in the short and long term. This would require careful regulatory intervention to avoid a diverging incentive structure in the trade-off between project costs and costs of system operation. For this task of system operation, the offshore ISO would heavily rely on onshore TSOs' system services to operate and balance the power system. In this structure, RCCs would support the ISO. However, live operations lie solemnly with the designated System Operator

15 Brard (2017). A North Sea offshore grid governance model. The allocation of ownership and operating responsibilities for a Meshed Offshore Grid.
16 See EU Offshore Renewable Strategy SWD, page 6
17 As outlined in TEN-E Revision (Regulation (EU) 2022/869) Article 14

3. Assessing the Proposed Model Options from a Holistic Perspective

Chapter 3 aims to evaluate the above-described models based on a set of criteria, thus allowing for a rating of how each option fares against one another.

These criteria are split into three categories, namely:

› efficient development and operation,

› project financing,

› and legal and regulatory compliance.

In the following sub-chapters (one for each category), the criteria are elaborated upon and subsequently used to assess the models. Regarding this qualitative assessment, which is presented with colour codes in tables, it should be noted that not all criteria are necessarily weighted the same. For the points considered more critical for the sound development of the future offshore system, some further trade-offs and recommendations are subsequently addressed in Chapter 4.

3.1 Efficient development and operation

3.1.1 Delivery of anticipatory investments (Project-by-project vs holistic picture)

This criterion evaluates – from a holistic system perspective – how cost-efficiently the infrastructure can be developed to achieve a long-term robust system. A stepwise development is expected to take place first, by looking at single project, or "hybrids by design" and subsequently at hybrid projects being interlinked with each other which, in a modular way, thus allows for a gradual evolution towards a more meshed network. Such development, combining various technologies and grid designs, must be both sufficiently coordinated yet flexible to consider technology maturity and relevant time horizons. In this regard, anticipatory investments will be essential, be it to allow for additional offshore connections to a hybrid project or to make the necessary onshore reinforcements to efficiently integrate future offshore RES capacity and avoiding retrofitting costs.

There are several barriers to the realisation of anticipatory investments, from the pressure to keep short-term costs low (and thus avoid additional spending which does not satisfy an immediate need), the treatment of these costs in the TSOs regulatory frameworks, and the possible difficulties arising from competing projects having to cooperate in cases where competition is introduced. Ultimately, the need for anticipatory investments calls for a greater holistic network planning and asset design which is able to identify the least cost solutions and avoid the undue negative effects of inefficient infrastructure development.

3.1.2 Pace of development

The pace of development refers to the ability of the various actors involved in the planning, design and construction stages to deliver the infrastructure assets in a timely manner in line with national objectives. Looking beyond the main actor responsible for these stages (be it the national onshore TSO or a different certified entity), other players also play a role, such as the national regulators, local communities, Non-Governmental Organisations (NGOs), and EPC contractors and suppliers.

Specifically examining the development of future offshore systems, this criterion needs to be considered with regards to both the **deployment of individual offshore hybrid projects** (e. g. projects currently listed in the TYNDP 2022, expected in the second half of the 2020s) and the **connection, extension or integration of these projects** with one another or with existing radial connections, thus gradually evolving towards a meshed offshore grid (which could take place from the 2030s onwards).

Several factors impact the timely deployment of single hybrid projects (e. g. identified need for infrastructure, permitting, sufficient capital, technical design of the project, availability of skilled workforce and necessary components, cost sharing arrangements, etc.). Among these, several may be even more challenging for the next "sequences" of offshore grid development (i. e. connecting hybrids to one another or extending them further). These notably include the availability of capital, complexities with regards to the technical design of the project, or the cost sharing arrangement in place. Furthermore, an additional factor may also be the potential impact of other pre-existing projects due to diverging priorities or conflicting incentives with the already established actors.

In summary, the ability to deliver the transmission infrastructure on time is a key criterion for assessing the different grid delivery models. In particular, attention should be paid to the fitness of these models to deliver the entire future offshore grid, not just single projects.

3.1.3 Integration of innovative solutions

The continuous development and integration of innovative transmission technologies are decisive for long-term cost efficiency. Innovative grid solutions are understood in this document from the system perspective. This refers to innovation with a focus on saving overall long-term socioeconomic cost and the reduction of environmental impact. Grid solutions have already evolved over time to keep energy bills low and environmental footprints small. Several innovative cost-reduction measures have been identified and implemented by TSOs such as the development of first offshore hybrid projects, e. g. the Krieger's Flak Combined Grid Solution, which is in operation, and further upcoming projects as described in the introduction.

Future developments, such as multi-terminal systems, are expected to provide further benefits related to cost, environment and operations[18], although they might require anticipatory investments. These are facilitated with the EC's recent offshore RES strategy[19] from November 2020. Further innovations will be required, in particular for cable technology, to accommodate large volumes of offshore RES.

Additional innovations related to multi-use hubs could be developed. These hubs could combine multiple functions such as environmental monitoring, connections of test sites, maritime culture, etc. within the same infrastructure. This can offer significant benefits in terms of economics, optimised spatial planning and the reduced impact on the environment.

Innovations can not only optimise the grid assets but also the operation of the grid to utilise the existing grid as much as possible. Therefore, system operation measures as well as IT solutions are considered here.

18 See also ENTSO-E Position on offshore Development: Interoperability

19 Offshore Renewable Energy Strategy, 19 November 2020

3.1.4 Coordination of onshore/offshore planning and operations

Intensive coordination efforts between different players are necessary in today's power system to allow for synergies and pan-European processes. At the same time, the coordination of interfaces can lead to efficiency losses and transactions costs.

Challenges in coordination can occur and increase the more players are involved and the less mature cooperation processes are. These might be planning processes or choices of technology that are not yet standardised as well as the operation of the grid or its parts and the linkage to the onshore grid. The more interfaces need to be imbedded, the higher the value of standardisation becomes and the lower degree of freedom each party needs to be granted to limit efficiency losses. In hybrid projects, the Offshore RES developer(s) and the (two or more) onshore TSOs are the minimum parties involved.

Coordination issues can be vertical (across all players, e. g. between a TSO and third party and/ or a TSO and an ISO) and horizontal (within a role, e. g. between TSOs or third parties). Both should be considered here.

Specific attention should be given to the coordination between the operation of the offshore and onshore grid. This is a crucial interface, and the onshore integration of the power generated offshore is a particular coordination challenge to be implemented[20] also in the light of maintaining onshore system security.

Criterion	Onshore TSO	Offshore TSO	Competitive Light	Competitive	Competitive ISO
Anticipatory Investments	High, but less so for more complex projects involving several countries.	Similar to onshore TSO	Same as onshore. Depends on framework in place with TSO.	Low – project specific view may clash with identified needs.	Medium to low – developer incentives are not naturally aligned with SEW
Pace of development	Medium – separation of projects between OWF developers and TSOs means timelines may not exactly match.	Similar to onshore TSO	High time efficiency if construction is ensured by the OWF developer.	Medium – time efficiency gains may be offset by the tendering process itself; more parties involved, more interfaces.	Medium – time efficiency gains may be offset by the tendering process itself; more parties involved, more interfaces
Integration of innovative solutions	High – there will be a focus on the overall system and long-term cost saving and reduction of environmental impact. This is driven by the fact that the onshore TSO is responsible for the whole life-cycle efficiency.	Quite similar to onshore TSO; prerequisite that on- and offshore systems need to match is inherent.	Medium – third-party designer/constructor might be more willing to choose innovative technical solution in case this is cheaper to realise and win the tender; only asset related innovations might be in the focus. Integration of different solutions would be a challenge, putting a greater burden on the definition of award criteria in the tender phase.	Medium – the third parties might be more willing to opt for innovative solutions in order to reduce investment and maintenance costs; this would not automatically facilitate innovative operational possibilities. Also, possibilities for optimised spatial planning would be lower compared to e. g. "competitive light".	Low – similar to Competitive. Also, possibilities for optimised spatial planning would be lower compared to e. g. "competitive". Replication of innovative solutions from onshore domain becomes more burdensome.
Coordination Onshore–Offshore	High – same entities onshore and offshore. Existing processes and mechanisms are already established and operational.	Medium – network planning would be a joint task of Onshore and Offshore TSO; one additional main interface; (degree of complexity would depend on ownership structure)	Medium – although close to "onshore TSO", more efforts needed to align incentives between actors on the technical specificities. Limited degrees of freedom in designing would be needed to reduce coordination issues.	Low – vertical and horizontal coordination issues, as planning and design, ownership and operation are separated. Addition of third party means additional interface with onshore TSOs.	Similar to competitive model, with an additional interface towards the ISO.

Model option is fit for purpose. Some challenges would likely arise, outcome should be further assessed.
Risks and challenges would likely delay and/or hinder the development of an offshore grid in line with the EU targets.
Challenges would pose significant barriers to the delivery of the offshore grid and may conflict with existing EU principles and governance structures.

20 For more details, see ENTSO-E's fourth offshore position paper on system operations and governance - https://www.entsoe.eu/2021/07/14/new-entso-e-paper-on-offshore-development-focuses-on-system-operation-governance/

3.2 Financing of offshore infrastructure

3.2.1 Equity remuneration and equity acquisition

Ownership models lead to different levels of risk, corresponding to a required equity remuneration[21]. Those levels of risk and remuneration affect the ability of investors to raise capital on the market. Although the level of remuneration does not represent per se a reason to choose one ownership model or the other, it is a factor that should be kept in mind.

The various ownership models differ with respect to their level of risk and, consequently, the level of the necessary return on equity (RoE) to compensate the risk. The capability to raise sufficient equity to finance the large investments at stake depends on the regulation that applies to the project and, in particular, the expected RoE. Indeed, even if this capacity is influenced by the situation on financial markets, it mainly depends on the general behaviour of investors. These will link each one of the proposed models with the RoE it is expected to yield as the remuneration of equity is mainly dependant on the risk associated with the distinct undertakings of the considered company.

Any transmission business conducted under the Onshore TSO model, the Competitive Light model and the Offshore TSO model generally operates in a relatively stable and reliable environment for investments due to the strong regulated nature of these models as a fair remuneration of capital should be allowed by the tariff regulation. The trust in such regulated undertakings depends of course on the extent to which the allowed cost of equity reflects the real investment risks. The projected investments in offshore transmission infrastructure will require considerable amounts of capital and, in many cases, they will constitute a major share of established TSOs' regulated asset base. Investors will thoroughly assess if the allowed cost of equity corresponds to the real risk associated to the offshore business. In the event of an insufficient return to cover the risks, the acquisition of equity is endangered as investors' appetite will remain low.

In direct comparison to traditional onshore TSOs, the business of the Offshore TSOs appears to have a higher risk. As mentioned in the previous sections, it is assumed that new regulation would need to be established for such transnational actors and there is no experience of such regulation yet. Depending on the precise ownership structure, an offshore TSO might have a limited asset base to offer a fair level of investment security (in contrast to onshore TSOs for which the risk of new assets is mitigated by older ones that are not yet fully depreciated). Furthermore, regulators may consider a higher RoE for the offshore TSO considering the higher overall risk profile of its investments.

The Competitive model faces even higher risks due to the fact that the income is determined by competition and is, therefore, more uncertain. Shareholders of the project may legitimately expect a higher return of equity. A light level of regulation may mitigate some of that risk.

The riskiest option would be a fully merchant model whereby the only income would be the congestion revenue (plus other possible smaller revenues such as participation in the balancing of the onshore zone, for example). The fluctuation of congestion revenues under the influence of many different factors and their evolution over time represent the highest risk for the investor.

Such a risk can be kept within boundaries by the application of a special regulation called the "cap & floor model": the missing revenue (below the floor) to ensure a minimum profitability for the investor is compensated by network tariffs whereas any revenue above a threshold (the cap) is returned to network tariffs. The regulated cap and floor can be fixed by the competent regulators or determined by competition. Competition may help to limit the RoE claimed by investors under the condition that the number of competitors is sufficient.

In principle, the flexibility to involve external, commercial parties for specific projects should also help regulated companies acquire the necessary capital to undertake the investments, should their financial structure reach a limit when the need to invest in an offshore asset comes.

21 Equity remuneration is the profit a business must retrieve in order to reward shareholders for making the capital available

3.2.2 Cost recovery

The question of how costs incurred to plan, develop, build and maintain the network will be recovered by the involved entities is an important one and is, to a large extent, independent from the model chosen to develop a hybrid interconnector at sea. In contrast to the above paragraphs on equity acquisition and remuneration, which address how the offshore infrastructure investments are financed, cost recovery focuses on which party ultimately bears the cost associated with the newly built infrastructure.

Regulated monopolies recover their costs (including the cost of debt and a fair remuneration of shareholders) through regulated tariffs, mostly paid by electricity consumers.

In contrast, in **purely merchant models**, investors recover their costs via the congestion income (and other smaller revenues from ancillary services and other types of services). The "Cap & Floor" type of hybrid model is a mix of both and provides a balance between the contribution of transmission tariffs and what is paid via the price of electricity (through the congestion revenue).

The main challenge TSOs and regulators face is that with the energy transition and the upcoming massive electrification, investments and related costs are expected to rise steadily, at least for the coming decade. Electricity transmission tariffs have already been on the rise for some time with the large investment waves due to the enhanced interconnection of European countries and related internal network expansions, the integration of massive, decentralised renewable energy sources, and permitting and planning constraints. The question that therefore arises is whether the capacity of electricity consumers to bear the whole cost of the transformation of transmission networks will soon reach its upper limit.

This paper does not intend to recommend a particular cost allocation method as the choice will depend very much on the national situation, in particular on the magnitude of the overall electricity invoice (of which the share of transmission cost still is small) and whether or not it is made heavier by peripheral costs (taxes, surcharges). This paper merely aims to stimulate discussion on the possible alternatives for the allocation of costs related to regulated hybrid interconnectors as particular assets.

First, a difference needs to be made between two types of assets: assets that connect the offshore RES to the hub and assets that link the hub to the shore (or that link hubs to one another)[22]. These two have different functions; therefore, their cost allocation rule may differ.

- Typically, assets to connect offshore RES to the transmission network are considered as generation assets, in which case these costs may be allocated to those users exclusively. In some national regulatory frameworks, these may be considered as transmission assets, in which case the allocation of costs depends on the grid connection regime.
- As for assets that link the hub to the shore (or the hub to another one), this is a (section of an) interconnector that is used by all market players, regardless of whether they are consumers or producers. In a fully merchant option, both consumers and producers contribute to the income of the interconnector via the congestion rent. Thus, it could be defendable to allocate costs to all grid users in a regulated option too.

However, to avoid distorting market competition, the amount of transmission costs that may be invoiced to electricity generators is capped pursuant to EU regulation 838/2010. Part B of the annex specifies that transmission charges that apply to generators (excluding connection charges and charges related to ancillary services or losses) are capped at an average of 0.50 EUR/MWh[23].

This means that, under the current EU legislation, distributing the cost of interconnectors (excluding the connection part) between consumers and generators is not an option.

The remaining alternative is to cover all costs or part of them in the framework of a Cap & Floor mechanism through public funds. Funding could be provided by governments only or by the EU, or by a mix of both options. The question of which countries should participate in the funding is discussed in the following section. The mix of options could provide a solution when that money could be paid based on declared costs plus a regulated profit (depending on the regulatory regime applied), after due control by electricity regulators.

22 Although this paper focuses on the latter, individual national approaches differ, whereby OWF-to-hub assets may be considered as part of the transmission grid.

23 Certain countries are partly exempted as foreseen in Reg 838/2010 – DK, FI, SE, RO, GB, NI

3.2.3 Risks and liabilities

The allocation of risks among the different actors and how strong they are to handle these risks is a key factor when assessing the robustness of grid delivery models. This is already a key issue for radial connections today, whereby various judicial or contractual arrangements exist across countries to allocate responsibility between the TSO, the service contractors and the generator. The risk of transmission asset unavailability or late delivery lies either entirely with the developer or is supported by the community of grid users through the payment of compensation to make up for the loss of income. When compensations are socialised, they are paid by the TSO but recovered through network tariffs. Depending on the legal provisions in the concerned jurisdiction, the TSO may be held liable for all or part of the compensation under specific circumstances, in the event of gross negligence for instance. If the construction and/or maintenance is outsourced to a contractor, the affected party (TSO or generator) can transfer all or part of the burden to the contractor through contractual provisions if they are involved.

Examining offshore hybrid projects and the expected evolution towards a more meshed offshore network, the financial impact of such a risk is even further exacerbated when considering the significant amount of generation capacity expected to be connected. The number of assets (cables, HV and LV equipment) in large scale offshore transmission infrastructure multiplies the risk of failure. Even more importantly, the duration of asset unavailability for large-scale offshore transmission assets would far exceed that of any onshore lines (outage durations may range from several weeks to several months). Policymakers and regulators therefore need to carefully weigh the implications of the willingness to invest (be it in transmission infrastructure or in generation).

When considering the specific risks and the liability they imply for the responsible parties, the following use cases arise:

- **Force majeure:** usually no or limited compensation from the TSO to the generator.
- **Unplanned Outages:** compensation is owed to the generator for the entire duration of the asset unavailability (though contractual or legal specificities may mitigate the risks for the TSO).
- **Planned maintenance:** in principle, timing can be adjusted based on weather conditions and offshore RES production programmes – some number of days may even be allowed in the contract or by law.
- **Downward Redispatch:** EU Regulation 2019/943 Article 13 states that TSOs shall compensate generators for redispatch measures taken[24]. Offshore transmission assets are dimensioned for the entire capacity of connected generators. However, unlike the onshore grid, they are not designed to accept a "N-1" situation. Thus, in the event of outage of part of the infrastructure, a share of the production may have to be curtailed. In theory this should not occur due to the dimensioning of the transmission assets (compared to radial connections, there would be "excess" transmission capacity). However, there may be a case for downward redispatch actions being necessary due to the missing capacity onshore. In the event of a separation of onshore and offshore roles for system operations, different principles for the allocation of responsibility for these costs would apply depending on the concerned Capacity Calculation Region (CCR).

From this description, two points are instantly salient: first, the separation of tasks between the onshore and offshore domains may pose a significant issue for determining the fair allocation of risks between actors. Secondly, any asset-light entity or business whose asset base depends essentially on offshore transmission assets may be heavily impacted by the costs incurred in the event of asset unavailability. Policymakers and regulators therefore need to carefully weigh the implications of such a distribution of responsibilities on the willingness to invest (be it in transmission infrastructure or in generation).

24 Except in the case of producers that have accepted a connection agreement under which there is no guarantee of firm delivery of energy

Criterion	Onshore TSO	Offshore TSO	Competitive Light	Competitive	Competitive ISO
Availability of Equity	TSOs may face challenges in raising sufficient equity at the required pace.	New entity would need to rely on equity provision by Onshore TSOs while having an overall higher risk profile	Same as Onshore TSO model; might have a relative advantage if no lump-sum payment from the TSO is required.	Risks of offshore investments are better reflected by the cost of equity. Would also alleviate pressure on onshore TSOs	Similar to Competitive
Equity remuneration*	Lower than for competitive model as tariff regulation covers unexpected cost variations and provides a degree of certainty and stability. Model is less risky.	Remuneration arrangements would have to be established. RoE may be higher than for the onshore TSO considering the overall risk profile	Same as Onshore TSO model	Higher than where regulated monopolies are owners, as in principle competitive players would bear more risk. Mitigated under Cap-and-Floor.	Same as Competitive.
Cost recovery	Deep costs are socialised and recovered from electricity consumers through network tariffs.	Costs are shared between shareholders (TSOs) based on the articles of association. Deep costs are covered by onshore consumers based on onshore tariff regulation.	Same as Onshore TSO model.	In a merchant model, costs are covered by the congestion income and other revenues and, if insufficient, by shareholder means. In a Cap-and-Floor model, consumers contribute in the event of insufficient revenue (below the floor) and recover a share of the income above the cap.	Same as Competitive.
Risks and liabilities	Impact on Onshore TSOs would likely be high and may have strong repercussions on the overall company profile with the increasing number of offshore investments; however, costs can be rolled over while certain risks could be shared across TSOs.	Similar to Onshore TSO Model. Risk sharing across national TSOs may be more straightforward.	Risk level is similar as previous models, though impact on Onshore TSOs may be mitigated through burden sharing with third party (e. g. for late delivery).	Third parties would be strongly deterred from investing. Onshore congestions lead to downwards RD offshore.	Third parties would be strongly deterred from investing. Onshore congestions lead to downwards RD offshore. For the ISO, how do such costs become part of its regulated costs?

- Model option is fit for purpose.
- Some challenges would likely arise, outcome should be further assessed.
- Risks and challenges would likely delay and/or hinder the development of an offshore grid in line with the EU targets.
- Challenges would pose significant barriers to the delivery of the offshore grid and may conflict with existing EU principles and governance structures.
- Outcomes remain unclear and need to be further assessed.

*Equity remuneration strongly depends on the risk level which is determined by the regulation model applied. A hypothesis is made for each model.

Onshore TSO: Revenue cap regulation with non-controllable costs, volume variations neutral, onshore and offshore costs considered equally;

Competitive-light: same as onshore;

Offshore TSO: Revenue cap regulation with non-controllable costs, volume variations neutral. Costs are shared between shareholders (TSOs) and deep costs are covered by onshore consumers based on onshore tariff regulation;

Competitive: revenue provided by congestion income and other sources of income (explicit auctions, ancillary services etc.). No contribution from tariffs except if cap-and-floor model;

Competitive with ISO: same as Competitive.

3.3 Regulatory and legal framework

3.3.1 Certification

The purpose of certification is to ensure compliance with the unbundling rules. Directive 2019/944 provides articles on the certification process[25]. The complexity and amount of work associated with the process depends on the specifies of ownership models to be certified. The directive foresees that any new TSO be certified as Ownership Unbundled (OU), whereas pre-existing ITO or ISO certified entities can continue unchanged. Next to the EU framework, the national implementation of the certification procedure is also decisive for the effort required to certify a new entity.

The issue of unbundling of Third Parties investing in offshore hybrid projects, especially if they also have an interest in generation, may pose limitations to the introduction of competition for offshore transmission infrastructure. Even under the Competitive Light model, sufficient safeguards will need to be implemented to ensure that the design and construction of transmission assets by the third party (which may be the offshore RES Developer) are done in a cost-efficient manner from a holistic viewpoint.

Certification of a cross-border offshore TSO or Offshore ISO will require new legislation and cooperation among regulators to certify these entities.

3.3.2 Regulatory oversight

Regardless of the grid delivery model chosen, there will be an increased need for cooperation between involved NRAs and the establishment of new fora linking both the onshore and offshore domains.

The introduction of more players will, however, increase the need for coordination even further. Furthermore, the design and implementation of new regional entities (offshore TSO or offshore ISO) may require a more formalised framework among NRAs, or even the definition of a single regulatory entity per sea basin, validating grid plans, tendering offshore RES, possibly tendering transmission ownership, defining cost recovery schemes and regulatory incentives for the TSOs in the sea basin, among other things. This may require fundamental changes to both EU and national legislation.

25 For details, see Articles 40(2), 43(8), Article 44, Article 52 and Article 53.

3.3.3 Compliance with existing legal & regulatory frameworks

Currently, there is no single operator covering an entire sea basin. Onshore TSOs operate offshore network infrastructure, comprising interconnections and offshore RES connections to shore. Some private companies finance and own merchant interconnectors, with an exemption granted under Article 63 of the Regulation (EU) 2019/943. In Great Britain, OFTOs own and operate offshore RES connections. All these actors are certified as TSOs.

Looking towards an increased share of future dual-purpose projects in the offshore infrastructure, the implementation of new grid delivery models in a timely manner is essential to meet the targets set out for the deployment of offshore renewable capacity by 2030 and 2050. As such, several models may prove significantly cumbersome to effectively design and implement, especially considering the need to create an entirely new regulatory framework to accompany new entities spanning across several jurisdictions.

3.3.4 Rules for cost sharing

Among the existing options for cost sharing, the following can be mentioned:

The traditional (onshore) interconnector model usually involves connecting TSOs only and shares the cost on a **50/50 basis**. In the event of a significant difference in the distance covered by the interconnector on both sides of the border, a more proportional arrangement can be made. However, this model ignores the fact that expected benefits might be different for the involved parties

For Projects of Common Interest (PCIs), ENTSO-E, ACER and the EC set-up a **Cross-border cost allocation methodology** establishing the sharing of investment costs of a PCI between the countries significantly impacted by the project. NRAs jointly analyse the investment projects, assess the benefits for all impacted countries and determine which countries will contribute to financing them and in which proportion. The Cross-Border Cross Allocation (CBCA) methodology is applied for investment costs but could also be extended to upstream (planning, design) and downstream (maintenance, operation) costs.

Finally, the involved parties can also deviate from any established cost-sharing model to reach a negotiated arrangement.

The difficulty of finding an efficient and fair cost-sharing approach that is well-suited to the expected investments in offshore transmission infrastructure is, for the most part, independent of the grid delivery model option chosen. Additional views on cost-sharing approaches are notably provided under Section 4.3. In this section, the focus is instead on identifying the parties involved.

In cases where offshore hybrid projects are owned and operated by the relevant onshore TSOs, costs and congestion income have to be shared between TSOs as for any interconnector but with a higher degree of complexity due to the multiple actors involved and possible future evolutions. Under an Offshore TSO, and based on the assumption that such an entity would be co-owned by the neighbouring onshore TSOs, costs may be shared on the basis of equity shares between the aforementioned TSOs. This would, however, be very challenging to agree on in practice, even more so given the sequential order of projects. Cost allocation under any of the two models with competition for the financing and ownership of offshore hybrids may be more straightforward for individual hybrid projects at first, but would eventually face limitations when additional projects affect the congestion income received by the incumbent.

3.3.5 Permitting processes across countries

Finally, the co-existence of different national permitting and administrative processes may prove more burdensome for new entrants than for incumbent TSOs. Consent for the offshore transmission assets (including environmental assessment and any required leases or licences) must also be coordinated with any necessary onshore reinforcements. Different lead times and planning horizons can lead to substantial delays and increased costs in the realisation of offshore hybrid projects, for which the responsible entity bears the risk.

PCIs benefit from a faster and streamlined permitting process and environmental assessment procedures, though certain regulatory barriers still remain (see section 4.3).

Criterion	Onshore TSO	Offshore TSO	Competitive Light	Competitive	Competitive ISO
Certification	Onshore TSOs will own, maintain and operate the assets. There is no need to certify new entrants.	The offshore TSO needs to be certified. New regulation may be necessary, as well as an enabling cooperation framework among NRAs.	Similar to Onshore TSO Model. No need to certify new parties.	Similar to merchant interconnection, with a need to certify new players. Third party has to be certified as a TSO (or TO) (unless given exemption).	Need for a new regulatory setup, and a change in the legislation. Doubtful that an offshore ISO could be certified through an exemption. Third party has to be certified as a TSO (or TO) (unless given exemption).
Regulatory Oversight	National TSO(s) regulated by national regulator.	Would rely on a new regional regulatory framework which may require changes to the legislation; alternatively, this may require the definition of a single regional "offshore" regulator, which may be very burdensome and complex.	Similar to onshore TSO-model. NRA (or government) would need to tender the design and construction of the asset separately and oversee the transfer of the asset back to the TSO.	Unclear regulatory setup. Which parties should be involved in which cases? Cost recovery schemes and incentives would require careful handling.	Similar to Offshore TSO model, with the additional difficulty of regulating various certified third parties.
Compliance with existing regulatory frameworks	Current situation for most interconnections and offshore generation connection.	New situation for Europe offshore. National regulation might need to be reviewed on sea basin level to ensure a coherent environment for a supra-national offshore TSO, that covers various EEZs	Current situation for most interconnections and offshore generation connection	Current situation for single asset operators (contingent on exemptions by the EC)	New situation for Europe offshore. National regulations may need to be reviewed on the sea basin level to ensure a coherent environment for a supra-national ISO that covers various EEZs
Rules for cost sharing	Cost sharing agreement between involved TSOs and NRAs (CBCA), and interoperability agreement.	Requires a specific agreement between onshore TSOs / offshore TSO and NRAs. Cost sharing could be based on equity shares among TSOs co-owning the offshore entity. It would be very difficult to find the relevant criteria to initially determine and change over time with every new investment.	Same as onshore TSO, with part of the costs borne by Third party (e. g. costs overruns for design and building phase).	Requires a specific agreement between onshore TSOs / Third party and NRAs. Sequential projects may be difficult to address. Onshore TSOs responsible for operation costs.	Requires a specific agreement between Onshore TSOs / Third party / ISO and NRAs. Sequential projects may be difficult to address. Onshore TSOs & ISO responsible for operation costs.
Permitting process across countries	National permitting process and regulation managed by national TSO(s).	Offshore TSO must cope with different national regulations and national permitting process.	Third party must cope with different permitting processes, which may be a stronger burden than under Onshore TSO.	Third party must cope with different national regulations and national permitting process.	Third party / ISO must cope with different national regulations and national permitting process.

Model option is fit for purpose.
Some challenges would likely arise, outcome should be further assessed.
Risks and challenges would likely delay and/or hinder the development of an offshore grid in line with the EU targets.
Challenges would pose significant barriers to the delivery of the offshore grid and may conflict with existing EU principles and governance structures.

4. Recommendations and Way Forward

4.1 Summary of the assessment

In the two previous chapters, grid delivery concepts for dual purpose offshore solutions (hybrids and multi-terminal offshore hubs) were described and subsequently discussed from the perspectives of efficient grid development and operations, project financing, and regulatory and legal barriers.

Onshore TSO model offers the greatest certainty

Although this assessment has revealed the possible benefits of all 5 models described, it nonetheless unequivocally shows that **the Onshore TSO model offers the greatest certainty**, in particular regarding the 1st and 3rd perspectives. Given the targets set for the deployment of offshore renewables by 2030 and 2050, the ability to retain a holistic view on system planning on- and offshore and to make anticipatory investments, the integration of innovative solutions that can safeguard system reliability, multi-vendor interoperability equirements and reducing the overall impact on the environment, as well as the existence of a fit-for-purpose regulatory approach with a minor need for revisiting the legislation are the critical criteria for achieving the EU's aim for a decarbonised electricity system.

Considering the above, the combination of the stages "ownership", "maintenance" and "operation" and their allocation to the same entity seems efficient as it does not create diverging incentives during and between any of the stages and ensures that neither under- nor overinvestment occurs. Without this combination, several risks would arise, finally increasing costs for consumers; e. g. structural higher costs for construction or maintenance and operation (low standards with lower technical reliability).

Introduction of competition

The introduction of competition for the ownership of offshore infrastructure (c.f Competition model and Competition with ISO Models) implies the need to coordinate across more actors (both horizontally – across projects and between the onshore and offshore domains – as well as vertically between the system operator and the transmission owner) and to align incentives between them. This requires new interfaces, with sometimes complex implementation frameworks (e. g. for the exchange of high quality and highly detailed data) and may both affect individual offshore hybrid projects and, subsequently, their extension or integration with other infrastructure projects. It may even be the case that a strengthened regulated approach may be necessary to ensure this alignment of incentives, which may offset the hypothetical benefits of competition. Finally, the design and implementation of the competition process itself may be too time-consuming to justify any possible time-gains during the construction phase, even when observing the offshore grid development on a case-by-case basis.

Defining a new regulatory framework

The requirement of defining a **new regulatory framework** to accompany the creation of transnational entities responsible for some of the stages of the grid delivery model (Offshore TSO and Offshore ISO Models) brings additional challenges. New regulation, be it in the form of a Network Code or other, would therefore need to be discussed, drafted and implemented to define the competences and obligations of these offshore TSOs. Usually, this requires several years.

This lengthy process would, furthermore, be confronted with fundamental questions which could pose a challenge to the governance of the European electricity system. Indeed, any framework establishing a regional TSO in the offshore domain would need to address the persistent differences between each national regulatory framework (e. g. permitting and administrative procedures, contractual obligations towards the connecting party, etc.) and would also need to ask who regulates it, be it an appointed existing NRA, a new entity entirely, or via a defined obligation for a cooperation framework. Either way, a change of national legislation would be necessary and may take several years to be agreed on.

The challenges above might, however, be addressed gradually, by learning through experience, starting with limited initiatives and a small number of players.

4.2 Improvements required to the Onshore TSO Model

Although the prevalence of the Onshore TSO model appears clearly in the assessment carried out in Chapter 3, the unprecedented scale and complexity of activities linked to the delivery of the future offshore grid and the safe operation of the interconnected system raises some important questions with regards to the model's sustainability in achieving the set objectives.

4.2.1 Pace of development

Whereas the Onshore TSO model ensures a sound overarching framework, delays in building the required infrastructure may occur regardless of the grid delivery model in place. These may be due to permitting and administrative procedures, public opposition, technical complexities, and alignment among the actors involved.

Several options are available:

- **A simplification of the permitting process** is key not only for RES but also for grid infrastructure projects. For PCI projects, since 2013 the TEN-E regulation (347/2013) has improved the situation and accelerated infrastructure permitting. In general, ENTSO-E highlights the importance of ensuring coordination between the authorisation procedures of RES plants and the necessary transmission infrastructure projects to connect and integrate them in the system. Time-lags between different processes for generation and transmission should be avoided. The revised TEN-E regulation (Regulation (EU) 2022/869) addresses better coordination via the introduction of sea-basin offshore network development plans. These are a joint exercise between Member States collaborating on sea-basin goals; TSOs, who, based on joint Member State goals develop information on infrastructure; and the EC giving guidance on some methodologies. These plans will provide an improved outlook on potential, needs, costs and benefits.

- To **gain public acceptance**, efforts must be made to engage with local citizens and address their concerns and needs, and to jointly develop approaches to protect, inter alia, nature and human health. An example is the "better projects" initiative, which aims to develop locally tailored, transparent and participatory planning. Some principles and best practices are mentioned in ENTSO-E's 2021 paper on financing future transmission grid investments[26].

- For certain projects, depending on their individual characteristics, a **competitive light model** may be implemented on a case-by-case basis such that it may coexist with the onshore TSO model elsewhere in the same sea basin, in accordance with EU unbundling rules.

- **Coordinated and joint planning** will be key to ensure that the realisation of single projects connecting offshore RES to shore in the first phase of offshore development does not impede on the realisation of the medium/long-term developments necessary for achieving the EU's offshore RES ambitions. Modularity and anticipatory investments will be necessary to ensure that these further developments can be achieved in a time- and cost-efficient manner.

26 See https://www.entsoe.eu/news/2021/04/14/investing-in-the-energy-transition-entso-e-calls-for-a-fit-for-purpose-remuneration-framework-for-transmission-grid-investments/

4.2.2 Availability of equity

The availability of equity will raise a significant challenge for TSOs, who face huge investment programmes to connect 300 GW of offshore wind by 2050. The remuneration of capital will remain a key pillar for the TSO business model to access equity while limiting the increase in grid tariffs for grid users and keeping the transmission business viable for the future. However, the remuneration of capital for national onshore TSOs does not generally distinguish between onshore investments and riskier offshore ones. This can raise difficulties for TSOs in acquiring sufficient equity to meet the required targets.

Some options available to alleviate this situation:

- **A first option** would be for NRAs and TSOs to agree on setting adequate incentives or additional remuneration for identified offshore projects. This could take the form of so-called "WACC adders" to incentivise specific investments, as is already currently applied in some countries. While an effective tool, implementing WACC adders faces the difficulty of raising costs for onshore grid users.
- **A second option** is to bring in external equity to offshore investments, which can be done via Special Purpose Vehicles (SPVs), a financial mechanism relying on project financing whereby the national onshore TSOs form a substructure facilitating equity partnerships with private investors. The TSO(s) would maintain the majority voting rights, control over strategic decisions and receive the congestion income in full, while external investors receive a share of the regulated income. By law, an SPV would need to be certified as a TSO, even though it delegates all operations and market roles to the Onshore TSOs via a service contract.
- **Finally,** a theoretical variation on the SPV model is a model where the offshore wind generator(s) connected to the hybrid project is the minority equity provider. Similar to the above, the delivery of the hybrid projects would be entrusted to a structure (be it an SPV or an incorporated joint venture) co-owned by the TSO and the prospective offshore wind generator owner in order to best manage the risks during the development and construction phases of the hybrid and offshore wind projects. Here, however, ownership unbundling requirements may prove challenging to meet in order to obtain the necessary certification[27]. This option would necessitate complex discussions with the relevant regulatory authorities on a case-by-case basis and is, therefore, not scalable.

27 See article 46.1.a of Directive 2019/944

4.3 Additional questions for consideration

This section addresses additional questions for consideration related to the roles and responsibilities that are kept out of the scope of the present paper. The questions revolve around cost-allocation between countries. Countries can have direct roles, e. g. coastal countries hosting offshore RES and/or offshore infrastructure; or they can be indirectly impacted by e. g. consuming the energy which has been produced by offshore RES. Thus, the related costs and benefits can also be classified as direct or indirect benefits. Other questions beyond this document include the potential need for a harmonised offshore regulatory framework. The questions included below are not exhaustive.

4.3.1 Allocation of costs and benefits between countries

This section addresses the distribution of costs and benefits between the countries directly (and indirectly) involved in the connection and integration of offshore RES. Costs and benefits refer to all phases of the lifetime of an offshore hybrid project: the planning, design, construction, maintenance or operation.

For cross-border assets, more than one country is involved. Moreover, to capture the huge RES production potential at sea, it becomes clear that no single country or group of countries will be able to solve this task alone. Thus, the EC's ambition as laid out in their offshore RES strategy[28] is to provide a framework for all European waters and countries. This framework facilitates, e. g. the creation of multiple hubs in a sea basin, connected to several countries and possibly connected with one another. Some first hubs are already on their way (see Table 1). If later connected to one another, one offshore hybrid interconnector would deliver benefits to several countries. Furthermore, the countries receiving the benefits are not necessarily exclusively countries with a direct connection to the hubs nor only coastal countries. This means that land-locked countries will also reap benefits, depending on e. g. their distance to the sea basins, their production and demand profile. Applying the idea which underlies the TEN-E regulation, costs and benefits would need to be shared between beneficiaries and cost-bearers at a country level. In practice, however, defining how this could be addressed is far from trivial.

Socioeconomic welfare benefits are composed of benefits due to market integration by connecting markets, RES integration, improved adequacy situation and CO_2 savings – to name but a few. As flows vary over time, benefits will also vary over time, which implies that a related theoretically perfect cost sharing mechanism would need to consider this. In practice, a more pragmatic approach must be identified as even the most advanced simulation will never be able to reflect the costs and benefits of future flows considering all unknowns.

It may be advisable, in the case of large offshore hybrid transmission assets connecting gigawatts of renewable energy, to deviate from any established cost-sharing model to reach a negotiated arrangement between all parties involved in e. g. a joint venture, should they be regulated or commercial companies. In fact, the sequential and transnational nature of future offshore infrastructure developments may justify the search for more advanced cost-sharing approaches to ensure the "coalition" of participating countries remains as large as possible and that the distribution of costs is equally broad as the sharing of benefits. Within the revised TEN-E regulation, this is partly reflected in the setup of the new offshore corridors. However, not all land-locked countries are included in these corridors.

Related to offshore RES, it is worth mentioning that a mechanism has been set-up by the EC (**the Union renewable energy financing mechanism**) to enable Member States who are willing to improve their contribution to climate targets to make funds available to RES-generation projects in countries that have large potential but require help to finance support mechanisms. Contributing Member States receive "statistical benefits" (i. e. a contribution to their climate objectives) in return for their funding.

28 see EC's offshore RES strategy

4.3.2 Need (and possibility) of a harmonised offshore regulatory framework?

Currently, national offshore regulatory frameworks differ from one another, both in the deployment of generation capacity (support mechanisms, tendering and auctioning schemes, taxation) and transmission infrastructure (e. g., permitting rules and administrative procedures, grid charges, technical and environmental standards). In both cases, closer cooperation across countries and actors (regulatory agencies, TSOs, producers, suppliers) will be required to ensure a no-regret scenario, though a harmonisation of national practices is, in most cases, not necessary.

The joint planning of offshore hybrid projects will heavily depend on forward-looking strategic planning, supported by the coordinated planning of offshore wind plans per sea basin, as introduced by the revision of the TEN-E Regulation and the TYNDP. In addition to the responsibilities for joint planning contained in the new TEN-E regulation, offshore development (both for transmission and generation) will furthermore rely on strong regional cooperation between governments, TSOs and other relevant actors. Initiatives such as the North Seas Energy Cooperation (NSEC) or Baltic Energy Market Interconnection Plan (BEMIP) provide good examples of such regional cooperation at sea-basin level.

Fit for purpose specifications of system components in the design phase will be necessary to ensure sufficient multi-vendor **interoperability** and the extension of offshore hybrid projects into multi-terminal systems, for which a mutual effort between TSOs, regulators and manufacturers is key. In this regard, the replication of new methods and learning effects must be ensured across stakeholders from all concerned countries. Some degree of standardisation of models, interfaces and processes will therefore be required. However, sufficient flexibility should also be safeguarded to ensure smooth integration to local onshore systems and the uptake of innovative solutions. With a view to future offshore grid expansion and multi-vendor interoperability, national regulators will also need to bear in mind the need to possibly accept costs that are not strictly necessary in the short term ("anticipatory investments") but that will enable the later development of complementary assets at a more efficient cost.

Finally, **transmission tariffs and first connection charges**, through which transmission infrastructure costs are recovered, differ from one country to the next[29]. In the case of offshore hybrid projects, the reliance on national tariffs to recover the costs of cross-border investments (with benefits accruing to different countries) may raise questions regarding the fair or burden-sharing between national consumers across multiple countries and offshore generators. ENTSO-E believes that a harmonisation of grid charges (be they grid tariffs or first connection charges) is not necessary as a single regime may not be well suited to different countries with different regulatory regimes and policies in place and may thus give rise to inefficient and suboptimal investments in both generation and grid capacity. Instead, sound principles for tariff setting, based on the provisions of the Clean Energy Package, should be upheld to provide and maintain a level-playing field [30].

29 See https://www.entsoe.eu/publications/market-reports/#european-transmission-tariffs

30 See https://eepublicdownloads.azureedge.net/clean-documents/Publications/ Position%20papers%20and%20reports/entso-e_pp_Offshore_Development_05_Financial_Support_211102.pdf

Abbreviations

Acronym	Meaning
ACER	Agency for the Cooperation of Energy Regulators
BEMIP	Baltic Energy Market Interconnection Plan
CCR	Capacity Calculation Regions
EEZ	Exclusive Economic Zones
ENTSO-E	European Network of Transmission System Operators for Electricity
ISO	Independent System Operator
NSEC	North Seas Energy Cooperation
OFTO	Offshore Transmission Owner
OU	Ownership Unbundled
PCI	Project of Common Interest
RCC	Regional Coordination Centres
RES	Renewable Energy Sources
RoE	Return on Equity
RSC	Regional Security Centres
SAM	Synchronous Area Monitor
SPV	Special Purpose Vehicles
TEN-E	Trans-European Networks for Energy
TSO	Transmission System Operator

Way forward

ENTSO-E is prepared to contribute to offshore development and to be involved in upcoming debates about how this can best be organised. This position paper, which contains the ENTSO-E position on offshore development – assessment of roles and responmsibilities for future offshore systems – will be followed in the upcoming months by further publications.

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