EXPERT PAPER II

Offshore TSO Collaboration

Unlocking the potential of the North Seas

Executive summary

Following the North Sea summits in Esbjerg, Denmark (2022), and Ostend, Belgium (2023), nine countries committed themselves to progressively developing around 300 GW of offshore renewable energy capacity in the North Seas by 2050. Realising this objective will be key for the EU, the UK and Norway to reach net zero by 2050 based on national cumulative targets and will be crucial for supporting Europe's energy security and competitiveness.

To achieve these goals, the nine countries involved want to focus on the development of offshore hybrid projects, such as hybrid interconnectors or energy hubs, and hydrogen infrastructure. Since the last summit in Ostend, we - as the expanded Offshore Transmission System Operator Collaboration (OTC) Group - have been working intensively to identify an initial bundle of offshore hybrid projects and solutions that fit the three framework conditions discussed here: supply chains, offshore market design and cost sharing.

This document builds on our 'Esbjerg Cooperation' expert paper and harnesses the expertise of the expanded group of North Seas transmission system operators (TSOs). It sets out both the key projects that will underpin the development of a North Seas grid in the long term and an initial grid map of hybrid projects. Also it presents a series of policy recommendations, each of which falls into one of the three areas, that builds on both North Sea summits and which the OTC views as essential for the development of the North Seas grid. In addition, considering further initiatives such as under the Vilnius Declaration focusing on the Baltic Sea region, we hope that lessons learned from the North Seas can contribute to strengthening offshore development also in other sea basins, which equally profit from enhanced cross-border collaboration

Supply chain enhancement

Fulfilling Europe's intention to massively expand its wind power capacity and the associated grid infrastructure will be challenging due to supply chain bottlenecks and the expected rise in the price of essential grid components. This, unsurprisingly, means that the implementation of offshore hybrid projects will also be challenging. To overcome these challenges, Europe needs a long-term perspective with European and national targets that show which project pipelines can be developed. In particular, TSOs need:

- procurement processes to be reviewed to enable more flexibility, especially in urgent situations;
- public guarantees and funding to increase the production capacity;
- the development of a digital platform that provides enhanced transparency regarding future TSO asset and production demands;
- the establishment of a European Offshore Academy: Fostering skills, innovation, and technology in Europe;
- technology partnerships.

Market framework conditions

In order to develop offshore hybrid projects, setting the right market framework conditions is essential. The OTC supports the move towards offshore bidding zones (OBZs) for offshore infrastructure, such as hybrid interconnectors and offshore hubs. However, several challenges regarding the development of OBZs remain, including in particular:

- how to secure investment in wind farms which are connected to offshore hybrid projects through support schemes in a non-distortive way;
- the need to consider OBZs in the context of UK-EU projects[1] and the return to implicit price coupling between the UK and the EU markets.

Cost sharing and funding

As we deploy increasing amounts of infrastructure in the North Seas, the scale of investments will become enormous. This will require countries to adopt a holistic approach to offshore development, within the framework of national energy and climate targets. There is a clear need to go beyond the existing framework in order to find ways to share projects' costs and benefits of offshore hubs and projects in an appropriate manner, so that countries who might host such infrastructure in their waters, but don't directly benefit from its capacity are not disincentivised from investing in them. In particular, as OTC we propose to[2]:

- strengthen joint TSO-led planning at sea basin level which focuses on establishing an optimal offshore grid comprising the most valuable projects for society;
- agree on simple cost and benefit sharing rules from the start to avoid project deadlocks;
- unlock projects, i.a. through setting up dedicated funds at sea basin level;
- incentivise investments from participating non-hosting countries through improved benefit and cost sharing and backing of co-financing contributions with tangible benefits such as shares in the asset base, usage rights of the assets or similar;
- simultaneously consider offshore grid infrastructure and offshore generation, in full recognition of unbundling rules.

[1] Given the United Kingdom's exit from the European Union leading to a change in GB market trading arrangements with the European Union

[2] Although this paper's focus is on offshore wind development around the North Seas, it should be noted that the principles on cost sharing & funding might also be applied to another geographical or technical scope.

I. From ambition to implementation

> Statnett is pleased to collaborate with our colleagues around the North Sea basin to jointly overcome regulatory and market challenges for realising key offshore hybrid projects. These are important steps to reach our common ambition for a net zero society in 2050.

Hilde Tonne
CEO Statnett

From ambition to implementation

As TSOs who operate in the North Seas, we have a special responsibility to drive forward the development of 300 GW of offshore wind capacity. Via our grids, we connect offshore wind farms to the coasts of the countries we operate in and will soon connect them to two or more countries at once. Indeed, we are planning out and developing an offshore grid which includes hybrid interconnectors, energy hubs and hydrogen infrastructure. We believe that transforming our North Seas into a green power plant on time and within budget will be most efficient if it is approached in a coordinated manner. For over a year, in response to the political declarations made at the North Sea summits in Esbjerg and Ostend, the TSOs from all nine countries involved in the latter have been working closely together to make progress on implementing the ambitious goals which were laid out.

Expert papers

Via our first expert paper published in 2023, we proposed an initial offshore grid that would stretch between Belgium, Denmark, Germany and the Netherlands and addressed the fundamental adjustments that would need to be made to the framework conditions. This current paper is our second expert paper. It outlines an expansion of our initial grid proposal by including Norway, the United Kingdom, Ireland, Luxembourg and France, and explores three central topics: supply chain, offshore market design and cost sharing. The objectives of our work are to facilitate the realisation of the ambitious goals to drive the decarbonisation of our societies; increase our energy independence; and support the competitiveness of our industry, whilst strengthening the net-zero technology manufacturing ecosystem in Europe.

Reaching **300 GW** of offshore wind capacity means that about **1,400 TWh** will be produced annually. The same amount of energy produced from a 50/50 mix of gas power plants and coal power plants would lead to about **1 billion tonnes of CO_2** being emitted. As a comparison, total European CO2 emissions amounted to **3-4 billion tonnes by 2023.**

The path to climate neutrality in 2050

Cross-border political support for offshore expansion and close co-operation via various fora, such as the North Seas Energy Cooperation, ENTSO-E and the Offshore TSO Collaboration, have made it possible to identify both the challenges that stand in the way of implementing a hybrid offshore grid in the North Seas and how to overcome the initial hurdles. Nevertheless, there is still a long way to go. We want to make an important contribution to getting closer to establishing a sustainable offshore grid in the North Seas. If we succeed in ensuring that the North Seas countries act quickly to establish hybrid interconnectors more broadly across them, we will be able to enjoy more energy independence – and show the world that a sustainable and competitive future is possible.

II. What is the OTC

The OTC is an informal group of offshore TSOs from nine Member States and third countries which border the North Seas. Our purpose is to accelerate the development and implementation of an offshore grid and to support the realisation of ambitious political goals in the best possible way. We are therefore working on the implementation of an offshore grid in the North Seas that includes hybrid interconnectors, energy hubs and hydrogen infrastructure and is based on the political declarations of the North Sea summits in Esbjerg and Ostend.

Our work focuses on complementing the coordination and investigation processes regarding possible project topologies in the North Seas. We base our concrete project ideas on the transmission needs identified in ENTSO-E's Offshore Network Development Plans (ONDPs) in order to incorporate them into the Ten-Year Network Development Plan (TYNDP) and our respective national planning processes. We also explore what adjustments should be made to the framework conditions, particularly with a view to implementing the first hybrid projects.

If we work together on designing pragmatic solutions as part of a coordinated approach to European offshore grid expansion, we will be able to tap into the potential of the North Seas and maximise the societal benefits.

1 Filling the missing link - towards a multi lateral project definition

The OTC fulfills the role of the missing link between conceptual long term studies and the creation of a short to medium term coherent multi-lateral project portfolio. Indeed, the current practice, which is very much focused on singular projects, is best complemented by a multi-lateral approach, allowing all impacted TSOs to contribute already at the early stages of infrastructure development.

2 Complementing international and national planning

The OTC builds upon the foundations layed by the work performed at ENTSO-E level (TYNDP and ONDP), and ensures a continuation of the work on the concrete projects between subsequent editions of these long term plans, including at national level;

3 Focus on implementation

The OTC will not deliver new concepts or plans for the long time horizon. Instead, we bring focus to the table. Indeed, our mission is to support governments around the North Sea Basins with concrete policy recommendations and implementations proposals for the issues at hand.

III. Grid map

An extended offshore grid map

This paper includes an extended version of our initial offshore grid map. This new grid map is aligned with ENTSO-E's ONDPs and has been developed by the TSOs of the nine countries which formed the Ostend coalition. The map covers a similar time frame to its predecessor, (covering projects which will run into the mid-2030s) compared to the first expert paper from 2023, but includes proposals for further hybrid interconnectors and energy hubs in the North Seas.

We are convinced that this updated map, along with status updates regarding each project, will serve as a vital tool for strategic planning, investment decisions and policy formulation amidst an evolving energy landscape.

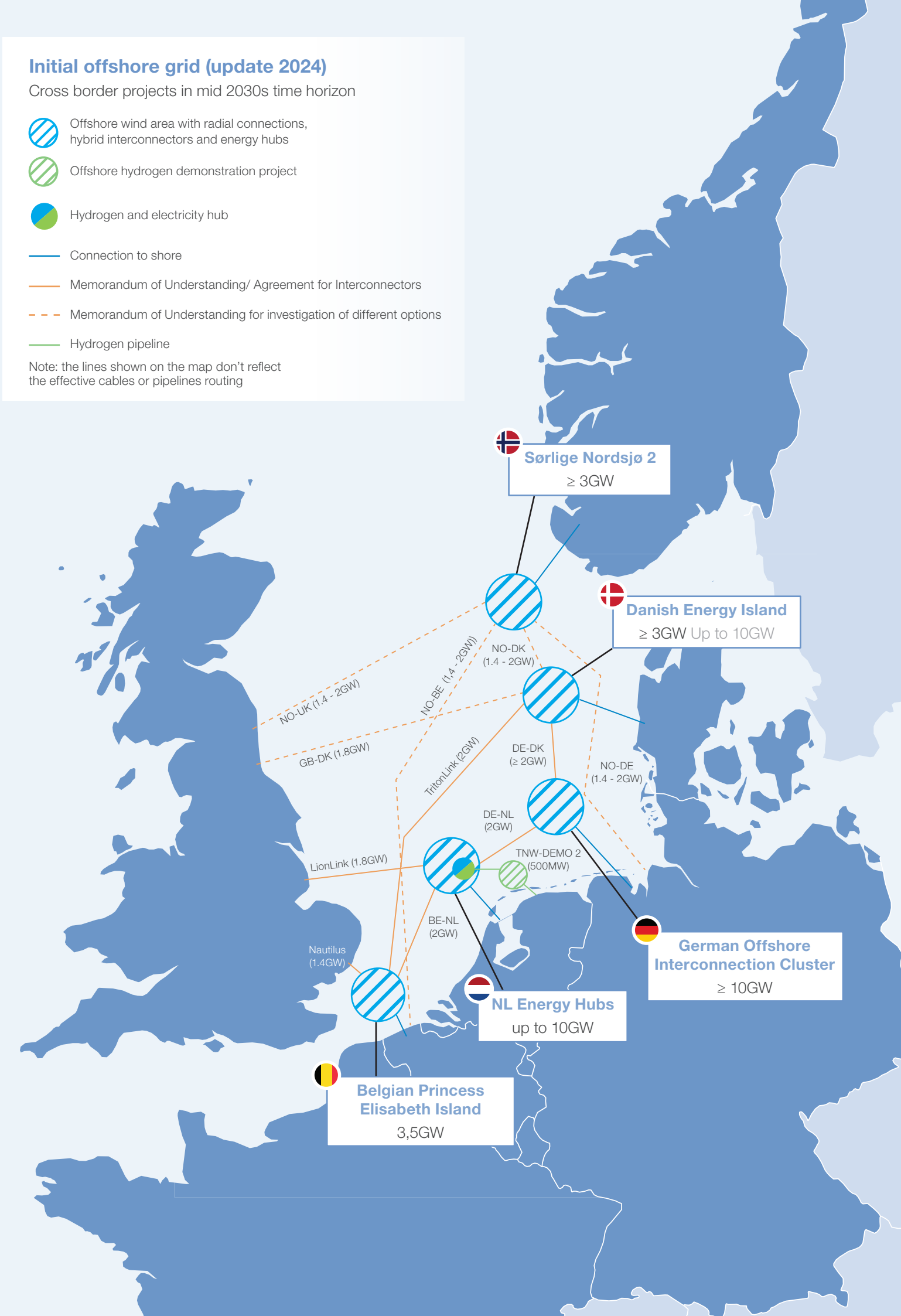
Projects status updates (as of March 2024)

Energy Hubs	
Belgian Princess Elisabeth Island 	• Construction contracts for the island have been awarded to a consortium; construction of the island began in 2024 and is expected to be finalised by mid-2026. • Ongoing collaboration with nature conservation experts to develop a 'Nature Inclusive Design' approach to the island's construction. The main aspects of this approach have been finalised. • Tendering for AC and HVDC equipment has been launched.
German Offshore Interconnection Cluster 	• The German Offshore Interconnection Cluster comprises projects for interconnecting offshore platforms both nationally and internationally. The first phase of the cluster includes two international and two national offshore interconnection projects. • The international interconnector projects cover two hybrid interconnectors which will link Germany to the Netherlands and Denmark after 2035. • The two national interconnection projects were included in the national grid development plan which was published by the Federal Network Agency (BNetzA); the offshore platforms are due to be commissioned between 2032 and 2037. • As part of a second phase, the cluster could be expanded to include further projects such as a hybrid interconnector that would link Germany to Norway.
Danish Energy Island 	• Various alternatives to enhance the financial viability of the project are being investigated. This includes redesigning of the Energy Island from an artificial island to a platform-based structure. • Political decision is pending.
NL Energy Hub 	• Offshore wind search area 6/7 is foreseen as area for energy hubs in the period after 2031. • Energy hubs may be developed or applied in different topologies as e.g. radial, hybrid or meshed.

Hybrid interconnectors	
Nautilus 	• A joint (UK+BE) cost-benefit analysis was performed in 2023 with further technical development ongoing, mainly relating to the interconnector's Belgian landing point being on the Princess Elisabeth Island. • The national regulatory authority's position in the UK is pending. • The interconnector is due to be operational in 2030.
TritonLink 	• The project's scope has been refined following different technical studies relating to aspects such as the cable routing and HVDC system design. • The location of the interconnector's onshore connection points has been selected for both ends (Belgium: Baekeland substation, Denmark: Revsing substation). • Significant challenges faced in terms of cost sharing and funding, despite important benefits for EU society.
BE-NL 	• Memorandum of understanding (MoU) signed on 24 April 2023 between Elia (BE) and TenneT (NL) that covered a study of electrical interconnector options that would link Belgium to the Netherlands. • Joint task force has been launched and grid studies are due to be undertaken throughout 2024 to, amongst other things, investigate the potential socio-economic benefits of multi-purpose or hybrid interconnectors.
Hybrid interconnector Norway-DK/DE/BE/UK 	• Statnett (NO) has signed MoUs with five other TSO's Amprion (DE), Elia (BE), Energinet (DK), National Grid (UK) and TenneT (DE). • Task forces have been set up to investigate grid topologies and technical and market issues related to possible hybrid connections. • First assessments are expected to be published at the end of 2024.
DK-NL (2GW) 	• MoU signed between DK and NL. • The focus is on the period after 2040 and has such not been deleted from the grid map in this paper.
DE-DK (>2GW) 	• Energinet (DK) and Amprion (DE) signed an MoU in April 2023 to investigate the potential for a dual-purpose offshore hybrid interconnector that would link the Danish Energy Island to a German offshore grid connection. • Since then, a joint task force has driven the project's development in close coordination with Germany's Federal Ministry for Economic Affairs and Climate Action and the Danish Ministry of Climate, Energy and Utilities.
DE-NL (2GW) 	• TenneT has started to investigate the possibility of an offshore hybrid interconnector that would link the Dutch and German exclusive economic zones (EEZ) together. • A TenneT project team has started undertaking grid studies and is in continuous contact with the ministries of both countries.
LionLink NL-UK 	• The development phase started in 2023. • The stakeholder consultation and licensing processes are due to occur between 2023 and 2026. The final investment decision (FID) is due to be taken in 2026. • The interconnector should be operational in 2030/31. • The national regulatory authority's position in the UK is pending.
Hydrogen	
TNW-Demo 2 	• Gasunie is developing an offshore hydrogen pipeline network (HyONE) for the transport of hydrogen produced by electrolysers which will be located on vast future wind sites in the Dutch EEZ. • A 500 MW electrolysers (referred to as Demo 2) is located next to the TNW wind farm and represents a first stepping stone on the way to the establishment of 12 GW of electrolysis capacity by 2040. • The FID is due to be taken in 2026, with TNW due to start operating in 2031.

As well as the projects included in the project status table and the updated map ‘initial offshore grid’, a number of other offshore electricity transmission projects are being assessed. These include hybrid interconnector projects in the Celtic Sea area that would be delivered between 2035 and 2040 or even beyond. Such projects would provide transmission capacity between Ireland and the UK and Continental Europe and would enable offshore wind farms in the Celtic Sea area to be connected to the coast. If such projects are shown to be viable, they will be included in later versions of this offshore grid map.

It is important to note that in addition to these hybrid projects, many radial offshore grid connection systems and point-to-point interconnectors between countries are also being envisaged. These projects are not included in the updated grid map but will contribute to the optimal harvesting of the offshore renewable energy potential held by the North Seas.


Initial offshore grid (update 2024)
Cross border projects in mid 2030s time horizon
Offshore wind area with radial connections, hybrid interconnectors and energy hubs
Offshore hydrogen demonstration project
Hydrogen and electricity hub
Connection to shore
Memorandum of Understanding/ Agreement for Interconnectors
Memorandum of Understanding for investigation of different options
Hydrogen pipeline
Note: the lines shown on the map don't reflect the effective cables or pipelines routing
Sørlige Nordsjø 2
≥ 3GW
Danish Energy Island
≥ 3GW Up to 10GW
NO-DK (1.4 - 2GW)
NO-BE (1.4 - 2GW)
NO-UK (1.4 - 2GW)
GB-DK (1.8GW)
TritonLink (2GW)
DE-DK (≥ 2GW)
NO-DE (1.4 - 2GW)
DE-NL (2GW)
TNW-DEMO 2 (500MW)
LionLink (1.8GW)
BE-NL (2GW)
Nautilus (1.4GW)
German Offshore Interconnection Cluster
≥ 10GW
NL Energy Hubs
up to 10GW
Belgian Princess Elisabeth Island
3,5GW

IV. Unlocking the right framework conditions

> "We need to go further to enhance the supply chain of critical grid component: the OTC's proposals for procurement processes are an important step forward toward a bigger offshore European sovereignty."

Xavier Piechaczyk
President of the Managing Board, RTE

Major technical, regulatory and market challenges are being raised across all countries as the planning and implementation of the offshore grid is undertaken. It is important to recognize that this is an issue for all of Europe both EU Member States and third countries and particularly true for hybrid projects. The challenges related to these cover (but are not limited to) issues regarding fragile supply chains, the offshore market design and the fair allocation of project costs and benefits. The next few sections outline specific problems we have identified based on our experience and the possible solutions we would like to propose and bring to the attention of national and European policymakers.

Supply chains

Strengthening supply chains, optimising procurement and other measures to ensure that ambitious offshore expansion goals can be realised.

The rapid expansion of offshore wind power is rendered vulnerable by massive bottlenecks in grid component supply chains. However, this expansion is an essential prerequisite for the implementation of hybrid projects. Volatile and rising energy prices, prices for raw materials and increasing transport cost, as well as the shortage of available grid asset production slots, skilled labour, access to suitable ports and construction vessels are significant obstacles to this expansion. Ensuring resilience is paramount for avoiding an over-reliance on a few suppliers and sustaining stability within supply chains.

Today, critical areas include resources related to cable manufacturing, available slots in factories and the vessels needed for the installation of cables. In terms of offshore platforms, engineering resources and slots in construction yards are scarce, whilst high-voltage equipment production capacities and means for transport and installation are limited. The reservation of sufficient port capacities and space is also difficult. A key lever to address the issue of tight supply chains is to standardise the key elements of offshore projects (such as converter platforms) and ensure interoperability through the harmonisation of technical prerequisites. TSOs are already working on this area along with manufacturers to establish a reliable development and procurement path. In addition, we propose the following measures to further booster supply chains.

1. Need for revision: the OTC's proposals for procurement processes

It is imperative to adjust the duration of processes and procedures in line with the fast-paced dynamics of the grid technology market, in accordance with competition law and regulation relating to public procurement.

- In urgent situations that require emergency repairs or project modifications, TSOs should be empowered to resell equipment to other TSOs without needing to launch a new procurement procedure. These transactions will not disturb competitive procedures but be limited to situations of acute need. In case where joint projects are being worked on, TSOs should be allowed to make use of framework agreements which other TSOs have already entered into.
- Negotiations should be facilitated by applying a preferred bidder process in tender procedures that eliminates the need for pro forma negotiations with all bidders. This adjustment would reduce the burden of lengthy negotiations that typically result in limited added value. The implementation of a preferred bidding procedure would be an option to pursue in cases where it delivers advantages and would not be a restriction in cases where no clear preference is apparent.
- Growing demands will require the addition of new capacities. Therefore, it is important to avoid creating competitive moats and barriers to entry. Regulatory adaptations should always consider the need for flexibility and openness to welcoming emerging participants into the market.

2. Supply chain stability requires public guarantees and funding

TSOs can enhance the availability of increased production capacity by establishing contracts with suppliers and construction companies early on, which will provide vendors with better certainty. However, this requires guarantees to be put in place for manufacturers, which are a burden on the balance sheets of TSOs and can block the release of financial resources which they require for other projects. Therefore, public guarantees and financing can play a relevant role in securing the expansion of production capacity. Good examples of this, such as infrastructure development or renewable energy projects funded by Germany's KfW Development Bank, have shown that public loans have been able to secure investments in additional production capacity. It is assumed that all support schemes are designed with conditions and incentives in place that promote lower costs and faster progress. Also, vendors can benefit from guarantees which safeguard their obligations towards TSOs. Vendors need to give guarantees for technical components to TSOs which can be very costly as risks are significant, especially in interconnected systems and for innovative technology. A backup for these risks would be beneficial as it might lower the capital expenditure of TSOs.

We welcome the prospect of funding for wind companies and TSOs[3] and for other actors along the supply chain. This will improve the incentives and conditions for investment in new manufacturing capacity. In addition, a well-designed de-risking framework could facilitate investment without the need for direct state aid, allowing for a faster ramp-up in a competitive environment.

[3] Outlined in Actions 8 and 9 of the Wind Power Package (WPP) and Action 9 of the EU Grid Action Plan (2023)

As for the TSOs, having a part of their debt be guaranteed by a European body to obtain lower-cost loans will be helpful. Such a guarantee:

- could be linked to the completion of a limited number of well-defined investments (i.e. those which contribute positively to European socio-economic welfare) to mobilise funds for investments with real added value;
- would give the instrument a higher rating;
- could be accompanied by an obligation for regulated electricity grid companies to 'pass through' the real cost of the debt, enabling consumers to benefit directly from lower interest charges.

This guarantee would be a first step towards a public-private partnership for the financing of electrical infrastructure.

3. Increasing transparency is critical for the operation of supply chains

As outlined in Action 2 of the WPP, improving the transparency of demands through a digital EU platform is relevant. Providing accurate and robust information relating to areas such as cable length and converter numbers is essential for clarity and a thorough evaluation.

International cooperation regarding planning and data provision - including collaboration with third countries such as the UK - is crucial. Enhanced transparency regarding TSO equipment requirements nurtures supplier confidence and enables manufacturers to take investment decisions and expand production capacities and, ideally, enables optimised supply chains through a convoy approach (e.g. for platform manufacturing). Finally, enhanced transparency also helps TSOs in their project planning and execution activities, mitigating disparities in capacity usage.

Transparency is a prerequisite for standardisation as all parties need to commit to defined future and common necessities. The ENTSO-E and UK TSOs could provide additional information about future TSO demands aimed at the European Commission. The ONDPs can play a valuable contribution in this regard. Moreover, more data can be derived from national network development plans and their projections regarding future grid infrastructure.

For TSOs, a first and concrete step in this direction would be to tie future equipment needs to offshore projects and their respective timelines and compile the data to the extent permitted. One approach could be to allocate estimated figures relating to cable lengths, converter numbers, etc. to the recently published Joint Tender Planning of the North Seas Energy Cooperation Member States. By doing so, Joint Tender Planning[4] would be complemented by an indication of the grid infrastructure equipment needed to realise Europe's offshore ambitions. If this helps to ensure investor certainty and the timely manufacturing of infrastructure, this will then mitigate congestion in terms of production capacities and reduce infrastructure planning uncertainties. Such initiatives will be carried out in compliance with competition law.

[4]See 231117 NSEC tender planning - November 2023_0.pdf (europa.eu)

4. European Offshore Academy: Fostering skills, innovation, and technology in Europe

Recognising the importance of free trade, increased global competition, and extensive global supply chains, prioritising the retention and development of skills, innovation and technology within Europe is key. One possible approach for facing this challenge would be through the establishment of a European Offshore Academy in partnership with different universities, institutions, industrial development agencies and manufacturers. This academy could provide targeted offshore training with a specific emphasis on offshore structures to mitigate skill development and innovation roadblocks. Partnering with Europe's foremost academic institutions to create centres of excellence would be key. This approach would support a high level of skills, innovation, and technology, thereby cultivating a co-operative environment for long-term expansion and accomplishment, thus ensuring domestic production capabilities. Different options for the development of such a European Offshore Academy exist, ranging from the use of existing courses from universities through to the creation of specific degrees at different qualification levels (e.g. diplomas, undergraduate degrees and master's degrees). TSOs and industry should collaborate with academic institutions to establish this academy.

5. Technology partnerships enable further development in a safe environment

Recognising the importance of cultivating a secure atmosphere which enables manufacturers to share ideas and lessons learned, whilst strictly observing intellectual property and competition regulation, is paramount. By providing a safe space for collaboration and a framework that allows intellectual property to be shared in a secure environment, TSOs support the development of a robust supply chain ecosystem – just like the InterOPERA project, which is funded by the EU's research and innovation funding programme, Horizon 2020. By providing strategic support and facilitating collaboration, this approach could establish an effective and ethically sound supply chain network that encourages innovation, fair competition, and responsible partnerships across the global market. This could be achieved by establishing coordinated research facilities, where technology partnerships between different vendors would be formed by testing and simulating new technological set-ups. Additionally, the possibility of positive synergies with other similar ongoing research projects exists. A mixture of larger centrally steered projects along with smaller laboratories working on specific problems would probably be the best fit. Therefore, funding should be granted to a more diverse range of research facilities.

> I am very pleased that National Grid has been able to contribute to this work – it is vital that we continue to co-operate across borders to develop the right market and regulatory regimes to enable the North Seas Green Power Plant. It's essential we find a solution to efficient energy trading between the UK and the EU, as well as ensuring that carbon border tariff policies do not create unnecessary trade barriers, in order to facilitate the development of new complex infrastructure and reduce costs for European and UK consumers.

Katie Jackson
President of National Grid Ventures

Offshore market design

Offshore bidding zones (OBZs) and maintaining the offshore wind farm investment case for hybrid interconnectors and hubs in the North Seas.

Without wind farms to produce green energy, no offshore grid can be built in the North Seas. Wind farm developers are facing new challenges with the development of hybrid interconnectors and energy hubs due to the current market design. In our first paper, we discussed the question of appropriate regulatory frameworks for the offshore market design. The implementation of OBZs lies at the heart of possible solutions. In comparison with the home market model used for radial offshore connections, the implementation of OBZs for hybrid projects carries substantial advantages because they reflect physical flows much better, facilitate congestion management, lead to more efficient price formation and improve competition for onshore and offshore capacity. Furthermore, the OBZ concept is also particularly suited for system integration, as it enables the seamless integration of offshore loads, such as offshore electrolysis. However, despite the clear advantages of OBZs, the OBZ concept needs further refinement in order to be successfully implemented[5].

As the OTC, we have a special set-up for discussing the expansion of hybrid projects in the North Seas, as we can take into account and represent the interests of TSOs from the UK and Norway in addition to TSO views from across the EU. This is why we have focused on the following two challenges in particular: the viability of OBZs from the perspective of wind farm operators; and the implementation of OBZs in the EU-UK context.

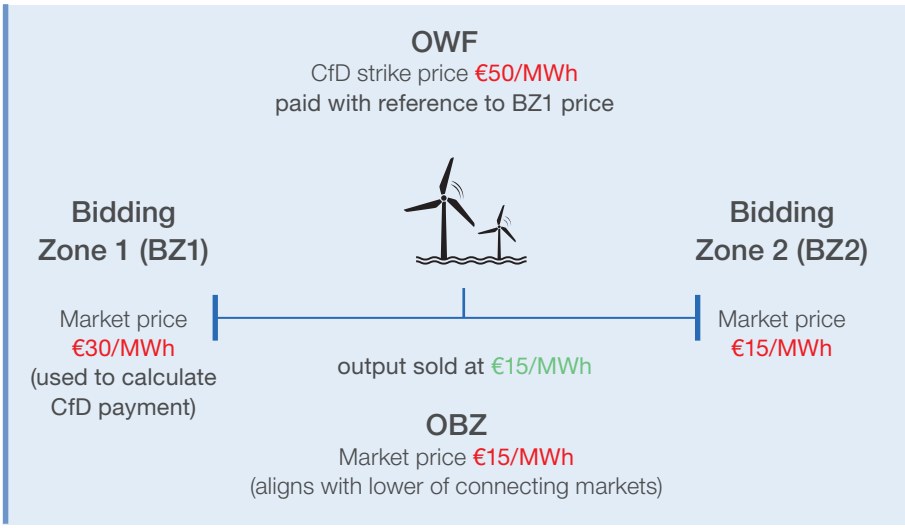
Viability of OBZs from the perspective of wind farm operators

A significant challenge related to the realisation of OBZs for hybrid interconnectors and energy hubs is the securing of investment in their wind farms. Hybrid projects can have an impact on the offshore wind farm operator's business case calculations, so it is essential that the market arrangements are absolutely clear before the tenders take place. In addition, one of the most common ways of providing security for offshore wind farm developers is support schemes, such as contracts for difference (CfDs). These guarantee fixed price ranges for the energy generated by the wind farm operator. We expect that models like two-way CfDs will continue to play a central role in the implementation of the expansion of offshore wind in the future, particularly in relation to the EU's reform of the market design. In the following sections, we would like to briefly discuss what we consider to be two important aspects of a suitable CfD design.

[5]Therefore, without repeating all the developed principles, specific emphasis is here being put on the extensive work performed in relation to the rollout of OBZs. As a concrete example, we refer to the principles developed as part of the framework for the Princes Elisabeth Island project, which demonstrate that solutions exist for the practical issues such as the design of balancing markets in an OBZ context.

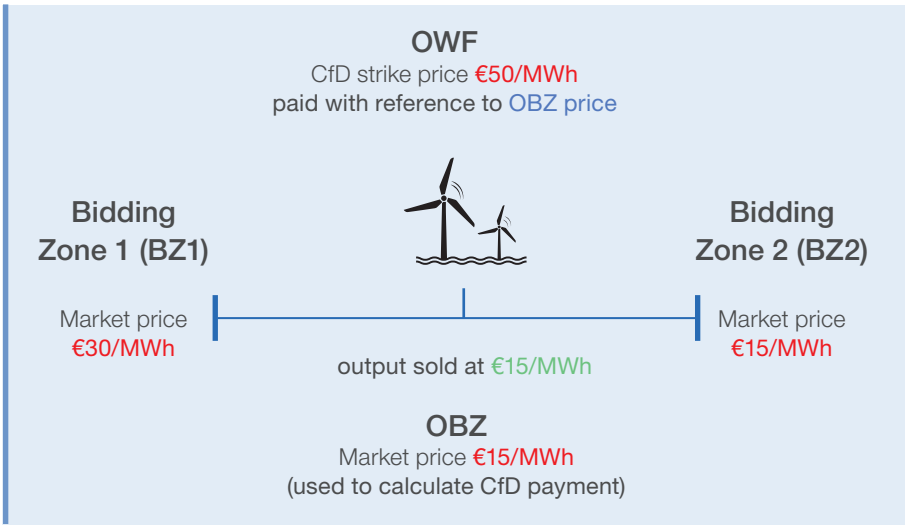
- **Reference price in an OBZ**

In order for an OBZ to work effectively, the price of the OBZ should be taken as the reference price. The price of the OBZ should be shaped by implicit price coupling. Otherwise, it is possible for the offshore wind farm operator in an OBZ to not be topped up to its full strike price if any other bidding zone is used as the reference price. This lack of certainty could have a significant negative impact on the investment decision for hybrid offshore wind farms.



Example 1: CfD paid with reference to BZ1 price

- CfD top-up is calculate as €50 (strike price) – €30 (BZ1 price) = €20/MWh
- But – OWF will not have received BZ1 market price and will have instead been paid the OBZ price
- Remuneration = €15 (OBZ price) + €20 (calculated top-up) =€35/MWh
- This falls well short of expected revenues of €50/MWh



Example 2: CfD paid with reference to OBZ price

- CfD top-up is therefore €50 (strike price) – €15 (OBZ price) =€35/MWh
- Remuneration = €15 (OBZ price) + €35 (calculated top-up) = €50/MWh
- OWF is paid strike price in full

- **The move to a non-distortive CfD design**

CfD schemes are generally based on financial compensation for electrical energy which is produced by a renewable asset. While this intuitively makes sense, such an approach could severely hamper the efficient operation of the market. Although several criteria play a role in this, one of the most obvious is that the renewable asset is not incentivised to inject electricity into the system if negative market prices arise. This distortion of real electricity prices endangers economically efficient dispatching and ultimately leads to higher system costs overall.

For this reason, we recommend the application of non-distortive CfD designs that decouple CfD payments from dispatching decisions. As outlined in a recent paper[6], ENTSO-E supports the same principles, explores possible designs, and identifies non-production-based designs as being better than production-based ones based on several criteria.

One such design, the capability-based CfD design, is particularly appropriate for offshore wind since it can take into account asset-specific (and thus very local) elements like wind speed or the OBZ price to effectively cover the risk for offshore wind farm developers. A capability-based design uses a real-time metric for the maximum feed-in potential of a wind farm. This value corresponds to the infeed of renewable energy into the grid regardless of whether or not it is actually fed into the system; indeed, the operator may take the decision to limit production due to market conditions, e.g. excess supply or insufficient transmission capacity. In the latter case, the actual production of the wind farm is lower than its fixed capacity. The remuneration for the wind farm operator is calculated on the basis of this 'capability' to produce energy, and not on the actual energy produced. It is therefore independent of the dispatching decision, and the operator is incentivised to use the asset in line with market prices, and thus in line with the interests of the system.

While it may seem counter-intuitive to pay for energy that is not produced, it is important to note that encouraging production at times when there is an excess of supply or negative energy prices is not beneficial as it would lead to a decrease in production from other RES that are not subsidised (as much), and/or increased demand to the extent that the energy is not properly paid for and therefore has no value.

Thus, there is significant added value to be gained from CfD designs that decouple CfD payments from dispatching decisions (as opposed to conventional, production-based CfDs).

Implementation of hybrid projects in the EU-UK context

One of the key features of the OTC is that the UK perspective is also included in discussions. Looking at the offshore market design in particular, some special aspects need to be considered with regard to hybrid projects established between the UK and European countries.

In order to achieve maximum efficiency gains from hybrid projects, the allocation of offshore wind volumes and interconnector capacity must ideally take place simultaneously in one step. This is referred to as implicit price coupling. EU-UK market arrangements are still being considered following the departure of the UK from the EU, which marked the end of the implicit price coupling of markets. Current EU-UK agreements envisage the implementation of the Multi-Region Loose Volume Coupling (MRLVC) market coupling method, which a cost-benefit analysis has proven to be a very challenging solution to implement.

[6]ENTSO-E Position Paper – Sustainable Contracts for Difference (CfDs) Design

In simple terms, MRLVC involves the coupling of two markets by determining the size and direction of the traded volume based on the order book data for the UK and for the bidding zones directly connected to the UK as well as flow forecasts from these neighbouring bidding zones. It is currently unclear whether this MRLVC mechanism is at all compatible with the establishment of hybrid projects. Any model that combines MRLVC and hybrid projects is less efficient than a system with (full) implicit price coupling, in particular due to the high risk of allocating suboptimal volumes due to incorrect forecasting. In order to achieve the EU's ambitious offshore targets and realise hybrid projects that link the EU and the UK together as early as in the next decade, a workable solution for the market set-up is absolutely required. Viewed from purely an electricity system efficiency perspective, the development of offshore wind in the North Seas would be best served by a return to implicit price coupling between the UK and EU.

In a related issue the EU Carbon Border Adjustment Mechanism's (CBAM) application to electricity trading between the EU and UK presents a significant challenge for North Sea investment with the current regulation leading to both potentially serious administrative and tariff barriers for clean electricity trading between GB and the EU. As the recent study by AFRY[7] demonstrates, the impact of the EU CBAM on electricity exports from the UK will be counter-productive for both the EU and the UK given their shared carbon reduction ambitions.

The implementation of the currently designed CBAM mechanism is expected to lead to a reduction in UK electricity exports towards the EU, an increase of UK renewables' curtailment, leading to an increase of wholesale electricity prices for EU consumers, a significant reduction of socio-economic welfare benefits for both UK and EU consumers, an increase in emissions in both the EU and the UK, and ultimately the creation of significant investment disincentives for the development of interconnectors and offshore hybrid assets in the North Sea. In order to avoid such counterproductive impacts, we would like to encourage the EU and the UK government to start discussions on linking the EU and the UK Emissions Trading Systems as soon as practicable, so that clean electricity trading is not negatively affected by the CBAM as of 2026. In parallel, in the short term, the UK and the EU should continue engaging on practical improvements to the EU CBAM design, including developing better methodologies on the carbon content of UK electricity imports and a recognition of the UK ETS price that is already paid domestically.

[7] AFRY study shows how the EU CBAM could jeopardise North Sea offshore grid infrastructure | AFRY

> Landlocked countries need incentives in the shape of concrete and recognised benefits if they are to participate in offshore projects.

Laurence Zenner
CEO Creos
Luxembourg S.A

Cost sharing and funding

The ambitions linked to the harnessing of offshore wind in the North Seas are huge. At the same time, the conditions needed for harnessing its full potential, which requires unprecedented investments in new infrastructure, are not yet clear. While countries which have an excess supply of renewables lack sufficient incentives to make the most of their potential, the perceived benefits for countries which lack renewables are not sufficient to compensate for the cost either. As we deploy increasing amounts of infrastructure across the North Seas, the scale of investments will become enormous, involving many cross-border connections. This concerns primarily offshore, but there could also be onshore projects with the primary purpose of transmitting decarbonized electricity to countries without similar resources. This will require countries to adopt pan-European and holistic thinking. There is a clear need to share these costs and benefits appropriately so as not to disincentivise countries which might host such infrastructure but would not directly benefit from its capacity.

Today's cost sharing framework is not fit for purpose

The current European regulatory framework already tries to provide solutions to the challenges explored above. This includes mechanisms for the sharing of grid infrastructure costs, such as the cross-border cost allocation (CBCA) mechanism under the TEN-E Regulation, as well as tools such as the EU renewable energy financing mechanism on the generation side. However, these are insufficient for addressing the identified challenges.

Firstly, the mechanisms above fail to appropriately account for the benefits that can be associated with a given project. As a result, to date, no country has ever contributed to the funding of an electricity transmission project outside of its own borders, even though the benefits of such assets are broadly distributed and felt beyond country borders.

Secondly, rather than seeking out the most efficient configuration for offshore infrastructure, current governance and related processes are focused on assessing individual projects rather than finding synergies across multiple projects on a regional (sea basin) level.

Thirdly, the processes that need to be followed for each project under the current regulatory cost sharing regime involve significant administrative burdens and require a great deal of time to be invested in them (which has become a scarce resource in itself). Moreover, there is only a small chance of them succeeding.

Viable cost and benefit sharing through enhanced transparency and planning on regional sea basin level

As OTC, we recognize the need for new approaches on the sharing of costs and benefits between countries to unleash the full offshore potential in the North Seas. As said, current mechanisms are not fit for purpose for projects in the pipeline even today, so new ways need to be pursued already in the short term.

To avoid deadlock, any solution that shares out costs and benefits:

- maximise transparency relating to the projects' costs and benefits;
- ensure that the future offshore configuration is planned out as efficiently and swiftly as possible.

All recommendations provided hereinafter can be implemented in the short-term, while they do not block future, potentially more far-reaching solutions. This is relevant considering that the discussions around cost sharing for transmission infrastructure are still ongoing and sometimes controversially debated. This includes, for example, contribution of (and for) non-hosting countries as well as the consideration of relevant onshore reinforcements and opex. As OTC, we recognize that the scope of a future cost sharing approach could contain solutions for these aspects in addition to capex for assets located offshore only. However, considering their complexity and the need for unlocking projects in the short term, including those developed in this collaboration, we strongly encourage policy makers to consider the following list of recommendations and build upon them in any future framework:

1) Strengthen joint TSO-led planning at sea basin level which focuses on an optimal offshore grid comprising the most valuable projects for society

A – if not "the" – key element for the efficient implementation of an offshore grid in the North Seas is the identification of projects which carry the most value for European society. The starting point for such a process is the offshore ambitions set out by governments; for the North Seas more specifically, these were most recently outlined in the Ostend Declaration.

Based on these targets, as TSOs, we are ready to conduct joint studies at sea basin level to define the most valuable projects in terms of the generation of European welfare. To maintain buy-in from relevant actors, such an approach needs to be incremental in the sense that regular touch points with relevant stakeholders (such as governments, offshore investors, and national regulators) are needed to ensure alignment and avoid time being wasted on lengthy negotiations once an optimised topology has been identified.

As a next step, we will continue to work on new projects within the OTC and aim to publish our next results during the spring of 2025 for policymakers. Just like for the Esbjerg follow-up process, the feasibility of the projects which are identified as being most valuable can then be checked in the subsequent ONDPs, TYNDPs and national grid developments plans. This includes checking for interdependencies between sea basins, the link to European onshore planning, as well as cross-sector optimisation with hydrogen.

2) Agree on simple cost and benefit sharing rules from the start to avoid project deadlocks

Under the current regulatory cost sharing regime (first and foremost the CBCA process under TEN-E), expected contributors only receive calls for cost sharing once the project parameters have been largely agreed on, and are given no chance to engage in the project design process. However, early engagement is needed to obtain the necessary buy-in from all relevant parties. At the same time, as noted earlier, almost all interconnected offshore projects will interact with each other, so interdependencies need to be made clear at an early stage to take advantage of network effects. This requires rethinking the way offshore projects are originated, initiated and developed today. A clear starting point which involves the joint planning of the offshore topology (see message no. 1) and subsequently involves relevant partners at regional level and addresses crucial elements such as funding, cost sharing and governance aspects from the beginning should contribute to the progress, acceptance and implementation of an initial offshore grid.

3) Unlock projects, i.a. by setting up new financial instruments such as a dedicated fund at sea basin level

The amount of infrastructure that is needed to turn the North Seas into Europe's green power plant will lead to unprecedented capital needs. Significantly increasing current funds (such as the Connecting Europe Facility) appears as a self-evident first step. However, the current regime has already reached its limit in terms of unlocking projects of common European interest. Therefore, in addition to dedicated funds facilitated by EU institutions, we ask the North Seas countries to consider setting up a dedicated fund at sea basin level for the implementation of the initial offshore grid in the North Seas. Such funding should be open to contributions from the EU and its institutions, Member States and third countries (both hosting and non-hosting), and private investors subject to compliance with regulatory regimes. In addition to financial contributions, loans and guarantees (for example, such as those granted by the European Investment Bank and national development banks) can help to raise the capital required.

4) Incentivise investments from participating non-hosting countries through improved benefit sharing and backing of co-financing contributions

Non-hosting and landlocked countries need incentives in the shape of concrete and recognised benefits if they are to participate in projects outside their own spheres. At country level, access to renewable energy and the statistical transfer of renewables shares, as well as enhanced security of supply and system security constitute obvious benefits.

At the same time, for TSOs, the current CBCA regime remains a significant challenge, since funding is usually requested from countries for projects which lie outside of their own asset base. This is a threat to company bankability and ratings and limits their financial resources for other grid projects. One way forward could be to back the co-financing contributions from non-hosting countries with benefits which could include (for example) shares in the asset base of projects, usage rights of the assets, or similar.
This would increase the possibility of engagement and acceptance by TSOs and Member States alike, and also allow a stable yield for TSO shareholders.

5) Offshore grid infrastructure and offshore generation must be simultaneously considered, in full recognition of unbundling rules

No generation without grids, and no grids without generation. It is a simple equation that needs to be considered thoroughly when aiming for the future offshore grid topology. Naturally, it all starts at the planning stage, when offshore targets turn into energy system needs. In line with that reasoning, when optimising the offshore grid, North Seas countries should also seek to jointly optimise the designation of offshore wind areas in order to find the most efficient configuration. This is an iterative process as part of which TSOs provide recommendations from a system perspective and future connection needs to be sufficiently robust for (anticipatory) grid investments.

In addition, we acknowledge that funding and de-risking constitutes a bottleneck both for grids and for the generation side. Thus, there is a need to simultaneously address the financing challenges for generation projects. This should be carried out without question, in full recognition of unbundling rules. In essence, a solution for grids or generation only effectively means no solutions can be reached at all, so any political agreement needs to sufficiently address both.

V. Next steps: Road to the North Sea Summit 2025

> Cooperation between the North Seas TSOs will be critical in realising a clean energy future for Europe. We're proud to be part of the Ostend TSO collaboration, working together to deliver on our shared ambition.

Liam Ryan
Chief Digital & Information officer
EirGrid

Looking ahead to 2025, we as the OTC have already set ourselves concrete goals. While this paper continues to focus on the projects announced for the middle of the next decade and the electrical grid, in our next paper, we will concentrate on the year 2040 and focus specifically on the integration of electrical and hydrogen infrastructure. We will also highlight intelligent topology development. In addition to exploring bilateral projects, we will take a closer look at multilateral projects for the first time. Furthermore, in light of increasing transparency regarding improvements to the functioning of supply chains, we will add indicative numbers relating to cable lengths, the number of converters, etc. to the next iteration of our grid map. Last but not least, we will also examine the topic of nature and the environment in more detail.

Now, though, we are focusing on the upcoming opportunities to discuss developments in the North Seas. Real barriers and obstacles lie in the way of the rapid development of hybrid projects, and we would like to use our experience and knowledge jointly to overcome these. Our ambition for the North Seas, as Europe's green power plant, is for them to make a significant contribution to achieving Europe's climate targets and to secure a sustainable and secure energy supply in the next decade.

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