European Network of Transmission System Operators for Electricity

entsoe

CONSULTATION SUMMARY REPORT ON THE STAKEHOLDERS' SURVEY ON OFFSHORE NETWORK DEVELOPMENT PLANS 2024

Final

EXECUTIVE SUMMARY

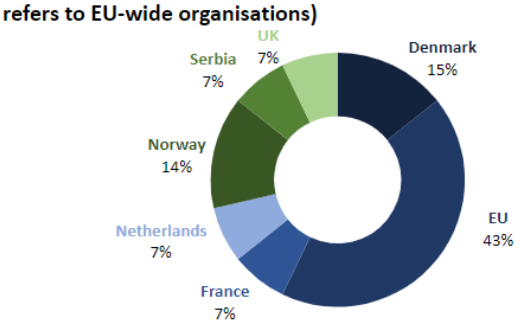
ENTSO-E published the **first edition of the Offshore Network Development Plans (ONDP)** on 23 January 2024, in compliance with the mandate laid out by the TEN-E regulation (EU Reg 2022/869). The ONDP 2024, which is part of the TYNDP 2024 package, delivers a high-level outlook for 2030, 2040 and 2050 of the transmission infrastructural needs aimed at integrating the offshore RES generation capacities included in EU Member States' non-binding agreements delivered on 19 January 2023.

Between 9 February and 22 March 2024 ENTSO-E ran a **survey aimed at gathering the feedback of the stakeholder's community** on the plans themselves and on the potential improvements to be implemented in future editions.

In total, **15 stakeholders** from diverse sectors engaged in the public consultation. Figure 1 shows respondents from various categories (the categories considered are those used in the TEN-E Regulation, with the addition of regulators and TSOs). While 43% of respondents are EU-wide organisations, more than half represent specific countries, mostly located around the North Sea (Figure 2).

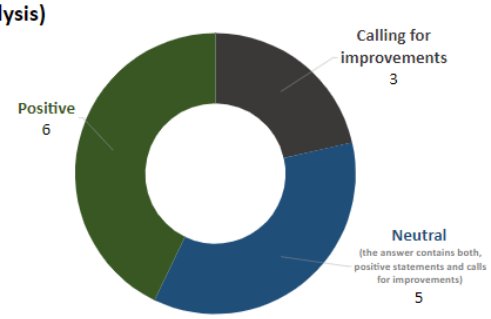
Figure 1. Number of responses by sector

Figure 2. Percentage of responses per country (EU refers to EU-wide organisations)



We have classified responses into three different categories based on a **sentiment analysis.** Positive answers (6 responses) indicate that most of the stakeholder's feedback is positive. Neutral comments (5 responses) highlight positive aspects of the ONDP but also contain criticism and feedback on areas in which the ONDP could be improved. Lastly, 3 answers mostly call for improvements. Figure 3 shows the outcome of the sentiment analysis based on the responses to our consultations.

Figure 3. Number of responses by type of response (sentiment analysis)



Based on the feedback received, the future editions of the ONDP will be further integrated in the TYNDP process, strengthening the link between the assessment of offshore needs with the onshore ones. In order to comply with the timeline defined by the TEN-E regulation, the ONDP 2024 has been developed through a dedicated modelling and development process, based on the TYNDP 2022 Scenarios: **the future editions will be fully integrated in the overall process behind the delivery of the TYNDP** (even though being kept as a separate product as requested by the legal text). This will mean that the assessment of the offshore transmission infrastructure will be fully aligned with the most recent Scenarios results with the overall methodological approach behind the development of the TYNDP system needs.

The **update of the non-binding agreements will provide the chance to further assess the potential investment framework** in the northern basins (which in the ONDP 2024 already reflected a good level of maturity of the offshore sector) and explore additional opportunities for development in the western and southern basins.

The **technological and cost sensitivities considered in the 2024 edition will be re-assessed** in order to improve and potentially expand the analysis performed. The target will be confirmed or update the standard sizes considered for **converters**, the data behind the consideration of **DC breakers** (which will be fundamental for the efficient deployment of hybrid transmission assets), and the impact of the **foundation solutions** for deep water installations. The **costs** considered in the analysis **will be updated** to the most recent values included in future editions of the Scenarios and additional analysis of the national data will be evaluated, to update the potential range of variation.

The aspects related to the deployment of **hydrogen infrastructure** will be expanded, starting from the consideration of any specific plans development by the single Member States and integrating the results obtained through the other TYNDP products.

Stakeholder engagement will be improved, using the existing interactions tools behind the development of the TYNDP and expanding the bilateral coordination with EC and ACER.

STAKEHOLDERS' ANSWERS TO THE PUBLIC CONSULTATION & ENTSO-E'S COMMENTS

In black: Questions in the consultation and Stakeholder answers

In blue: Comments by ENTSO-E

Organisation: GEIRI Europe GmbH

Question: Are you satisfied with the stakeholder's engagement process, and would you like to make proposals for next cycles? - Specify

Answer: I understand that we are developing the European Offshore Network. Since we are engaging with an international supply chain and value chain, I would strong suggest involving as many stakeholders as possible from all over the world to at least collect valuable voices and opinions.

Especially in terms of DC Circuit Breaker, China has already deployed 500kV DCCB and is currently developing 800kV level DCCB. The experience is valuable and can be shared at least to promote a timely development for European level.

Comment: We are aware that HVDC systems worldwide are under a strong development process, and the next cycle will see a larger interaction with the EU manufacturers also in the framework or the overall ENTSO-E engagements with on offshore development.

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) – Specify

Answer: The reports of Northern and Baltic Sea Basin are very detailed and full of information, whereas those of other Sea Basins are kind of simplified.

Comment: The countries in the North Sea and Baltic Sea regions enjoy an historically more mature investment framework for offshore RES infrastructure, thanks for a more favorable conditions for installations (shallow waters, with mostly sandy seabed), with more advanced maritime spatial planning for energy assets. This made easier gathering information on the needs to translate the MS targets into infrastructural needs.. For this reason, the reports covering these basins are more detailed compared to others. However, the potential offered by offshore RES is now clear also in the European countries interested by the western and southern basins, and the governments are quickly moving toward concrete plans to deploy the energy infrastructure to exploit this potential. The ONDP 2024 already included relevant information on the infrastructural needs to deploy the MS non binding agreements in the Atlantic, the Mediterranean and part of the Black Sea, showing the amount of assets and posing the accent on the needs for floating technologies allowing the installation of offshore RES in areas far from shore, where the full-load hours are higher. With the offshore RES gaining weight also in these regions, the next edition of the ONDP should see more information becoming available to better detail the infrastructural needs in the Atlantic, the Mediterranean and the Black sea

Organisation: Renewables Norway

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? - Specify

Answer: The ONDP could advantageously be more detailed and include specific recommendations, so that it becomes a more decision-relevant tool. When considering the need for offshore grid development, ENTSO-E also have to consider necessary onshore grid development. Additional grid reinforcement and expansion will be needed at national level to integrate the offshore infrastructure and distribute the energy to end users. When considering the grid needed onshore, ENTSO-E should also consider space availability and other relevant constraints. In this edition of the ONDP, costs follow the size of the project linearly. ENTSO-E should consider taking economies of scale into account in larger projects.It is important that once a wind farm is close to final investment decision, its grid integration configuration should not be changed. It is therefore important that ENTSO-E is in close contact with the national authorities and TSOs to have clarity in which connections are "fixed" and which connections that are still open for both radial or hybrid connection.

Comment: In this first version of ONDP the expansion of the offshore grid was done separately of the onshore grid in order to ensure an efficient development process and to be able to comply with the legal deadline imposed by the TEN-E.. ENTSO-E is fully aware though a holistic approach to planning is key to ensure sustainable development of the energy infrastructure, and already defined the full integration of the ONDP 2026 into the TYNDP 2026 process, when both off- and onshore grid will be part of the optimization. Regarding onshore grid reinforcement, the model used by the ONDP2024 process already considered a certain amount of expansion, coming from the Scenarios 2022 results. In addition, TSOs have considered spatial plans from the respective governments both when defining location of the generation and when assessing the results of the expansion study for the transmission infrastructure. ENTSO-E is aware that the linear expansion methodology alone cannot deliver all answers concerning an investment decision, but it has demonstrated solid enough to initiate the identification of strategic corridors, that will then be further refined through mixed integer assessment in the IoSN, where more detail cost data are considered.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer: It is important to have a good stakeholder process and we are positive that the TSOs, relevant industry associations and several important stakeholder groups are involved. It is also positive that ENTSO-E organized a publicly accessible workshop on "The future of offshore" in June 2023. It is important to ensure that anyone who wants to, can provide input. We believe it is especially important to ensure that offshore wind producers get to share their perspectives as developers. As the technology evolves fast, it is important that ENTSO-E and ENTSO-G involve technology suppliers and asset developers in the discussion about system integration options and technology options. This is especially relevant for DC breakers and offshore hydrogen production.

Comment: Due to the time constraints imposed by the legal deadline, ENTSo-E had to aim at targeted interactions mostly with institutions and WindEurope. However, as the ONDP 2026 will be a more mature products, we will expand the range of interaction to consider all relevant inputs that can help deliver the best possible product. So the target is to include even more wind producers and developers in the next ONDP edition as we recognise that technological development is a key factor to the development of the ONDPs .

Organisation: EDF

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specify

Answer: EDF welcomes this first ONDP exercise, based on MS' non-binding National Energy and Climate targets, aiming at enlightening the network needs and costs associated to European and national offshore RES development objectives. EDF thanks for already many useful data provided. EDF also understands that a deadline had to be kept. Though, from a methodological perspective, EDF:

- believes more explanations should have been provided about the choice of the only one scenario (TYNDP Distributed Energy) used for the exercise, as well as for the 8% linear increase of demand in the model (for which reasons? To avoid too much offshore energy curtailment? or for model convergence problems? or some other reasons?).
- considers some simplifications are highly debatable such as identical cost hypothesis used for the whole of Europe and are detrimental to the results.
- believes that a lot of questions and uncertainties around the development of hydrogen remain.
- regrets that the methodological report does not provide enough details (about climate scenarios, details about the modelling of offshore hybrid, of curtailment, of other flexibility sources (other than hydrogen), etc.).
- considers some important aspects are still missing: there is no assessment of the impact of offshore development on the onshore network and vice-versa in this first edition; environmental impacts seem to be considered in the localization choice of potential offshore sites, however, it does not seem clear whether environmental concerns could induce other impacts on the offshore development costs as well as on the associated grid costs.

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Comment: ENTSO-E is aware that multi scenario modelling is key to improve the robustness of the assessment, but the demanding timeline for the development of the first edition of the ONDP requested a pragmatical approach to the modelling set-up. The choice to use the DE scenario from the TYNDP 2022, was due to the fact that it was the most adequate choice (at the time of the initiation of the development process, Scenarios 2024 results were not available) in terms of generation and transmission capacities. In addition, the DE scenario was also deemed the most suitable for project assessment as in the last cycle was selected by the European Commission as reference for the PCI process. For the set-up of the ONDP 2024 model, the offshore generation capacities used for the model were aligned coming from the MS non binding agreements . The increase in the load, even though set linearly at 8% was chosen close to the average increase then considered in Scenarios 2024 (around 10%), to consider a demand-driven development of the generation and avoid unreasonable amount of curtailment.

The development of the first edition of the ONDP had to face a considerable amount of uncertainties, related to (but not only)

- Uneven development of the offshore RES investment framework throughout the European regions,
- Uneven availability of data in the different countries that have declared offshore targets.
- Uncertain spatial planning assumptions in the 2040 and 2050 time horizons

To cope with these uncertainties, simplifications and assumptions were needed to acquire a single Pan-European perspective on the development of the system. For this reasons, even though costs are applied uniformly in the European system three different cost sets have been applied to understand the impact that they might have on the development of the system. Another example is related to the hydrogen infrastructure: as many countries still miss concrete plans for the development of offshore H2, this resulted in missing data hindering the further expansion of the H2 system on top of what already performed in the Scenarios 2022 cycle. For this reason, it was decided to consider the capacities individuated by the Scenarios 2022 (34 GW of electrolysers in the North Sea) but not to expand the infrastructure on top of this, as the risk of obtaining distorted results was deemed too high.

The impact of offshore RES targets and corridors on the onshore system is being assessed in the process for the development of the Identification of System Needs 2024. Results shall be available at the end of the year for public consultation.

Question: Are you satisfied with the stakeholders' engagement process, and would you like to make proposals for next cycles? – Specify

Answer: EDF favors a comprehensive stakeholders' engagement process. Transparency and information/exchanges on the methodology and the data used are indeed key to build trust and provide reliable results. For this first exercise, it seems that mainly policy makers and WindEurope (that has a strong interest in the development of offhore RES) were involved. A broader process should be favored.

Comment: Due to the time constraints imposed by the legal deadline, ENTSO-E had to aim at targeted interactions mostly with institutions and WindEurope. However, the ONDP methodology was presented during a workshop open to all stakeholders on 6 June 2023. For the ONDP 2026 we will expand the range of interaction to deliver the best possible product. We already started on 1 March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognize that technological development is a key factor to the development of the ONDPs.

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) - Specify

Answer: The reports and visualization tool provide information in a user-friendly way. We would however expect more detailed information in the various reports, notably the methodology report.

Comment: thanks for the feedback, we will improve the level of detail of the methodology report to make it clearer. However, a methodology is by default a technical document. A high-level explanation on the methodology for non-experts can be made available in the next version of ONDP version.

Organisation: Danish Energy Agency

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specify

Answer: As the first edition, the ONDP provides good input to stakeholders and supports coordination across Europe and across many areas. Overall, the process and content could be more streamlined between the regional reports (in the Danish case, the Northern and Baltic Sea reports) to allow easier and better evaluation and comparison, as well as consider additional aspects to improve the quality and applicability of the ONDPs.

Most importantly:
1) the supply from offshore RE needs to be aligned with the onshore infrastructure and demand,
2) electricity infrastructure needs to be aligned with the hydrogen sector,
3) there should be more focus on hybrid projects than on radial connections, and
4) the ONDP needs to be properly aligned with the TYNDP and other analyses/reports.

More specifically, the modelling process should be made clearer in the methodology, as well as include data and assumptions. This would also enable comparison with national modelling approaches. Additional scenarios would also contribute to the comparison and contribution to national approaches. For example, alternative scenarios with a limited number of hybrid-projects and/or DC-breakers. Also, a clarification and/or differentiation between near-shore and far-

from-shore nodes should be made in the modelling. Furthermore, the offshore-targets could be applied as an upper limit for the model to decide on for flexibility. With a more flexible modelling approach, also wake effects should be considered. Instead of additional scenarios, sensitivity analyses could also be done.
Overall, Europe will have a less-balanced energy system with some countries becoming net exporters and others importers or transmitters, which is something to consider in future modelling process. A mapping exercise for grid assessment and planning could give a better picture of future systems.
We welcome the sections on costs and supply chain challenges and hope for an update of relevant offshore assets with the next ONDP cycles. Any additional information would be welcome regarding bottlenecks, feasibility of offshore wind farms, socio-economic and project-economic evaluations, and considerations on offshore bidding zones (OBZ).
In regards to hydrogen, clear information is missing on what has been included and what the assumptions are. An additional scenario with focus on hydrogen would be welcome, incl. an analysis if and where offshore electrolysis would supplement or replace electricity infrastructure to bring energy to shore. This is most relevant for far-from-shore wind farms.
More national details on the potential corridors would also be welcome, perhaps on a national level, e.g. a section on corridors to and from Denmark. Is it possible to evaluate optimal placements offshore and onshore-connection points across country borders?

Comment: Thank you for the valuable feedback and particular for the suggestions on the modelling part. We acknowledge the importance and the added value of those, and we will try to include in the future edition as many of those suggestions as possible. From the following edition, ONDP will be integrated into the TYNDP process and both off- and onshore grid will be part of the optimization.

In the framework of the improvement of the ONDP toward the production of the next edition, ENTSO-E is already exchanging with multiple actors (both from the industry and from the academia) to explore alternative modelling methodologies and additions to the first edition process in order to improve the final product. The consideration of flexibility solutions and wake effects are definitely a top priority topic.

Concerning hydrogen, as several countries in Europe are still missing concrete plans for the development of offshore H2, the missing data hindered the further expansion of the H2 system on top of what already performed in the Scenarios 2022 cycle. For this reason, it was decided to consider the capacities individuated by the Scenarios 2022 (34 GW of electrolysers in the North Sea) but not to expand the infrastructure on top of this, as the risk of obtaining distorted results was deemed too high. However, already this assessment allowed to explore the positive impact of H2 production on the amount of energy integrated in the onshore system, demonstrating that H2 will play a role in the efficient use of the offshore RES potential.

In the next cycle of the TYNDP, ENTSO-E will aim at further integrating the assessment of H2 infrastructure in relation to the development of offshore assets, through an integrated approach to on and offshore modelling and additional information coming from more mature national plans all over Europe.

The a quantitative assessment of connection points was not possible in the ONDP 2024 due to the granularity of the model used for the study which covered the market nodes of the different countries without going further into the details of the onshore system. However, ENTSO-E is deploying more granular models for 2040 and 2050 already in the Identification of System Needs 2024 (where the impact of offshore corridors on the onshore system will be assessed) and will be able to explore the very relevant topic of connection points in the next edition of the ONDP.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer: The stakeholder engagement (report) could be clearer and with more details on who influenced the ONDPs when and where. Overall, more stakeholders should be included in the process to contribute to technical aspects. Next to RGI contributing with a chapter on environmental aspects, other topics and stakeholders could be included, e.g. on energy security / security of supply. In that regard, latest research, and considerations from NSWPH, DTU and other stakeholders

could contribute to the ONDP, e.g. a chapter on wake effects or hub- and mesh-grid-designs (as presented at the workshop on 01/03).

On another note, stakeholders from the consumption side are not sufficiently represented and the ONDP should reflect more on the demand side. In that regard, the ONDPs could consider a bottom-up approach that adjusts the offshore expansion planning in relation to the demand side. This could have an impact on security and long-term planning of offshore build-out.
Finally, more details on participants from each country would be welcome, e.g. which stakeholders contributed from Denmark, when and how.

Comment: Due to the time constraints imposed by the legal deadline, ENTSO-E had to aim at targeted interactions mostly with institutions and WindEurope. However, the ONDP methodology was presented during a workshop open to all stakeholders on 6 June 2023. For the ONDP 2026 we will expand the range of interaction to deliver the best possible product. We already started on 1 March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognise that technological development is a key factor to the development of the ONDPs .

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) - Specify

Answer: Overall, the ONDP package is very sound and we see great value especially in the Northern Seas report as it offers valuable information (both in relation to other sea basins and in general). It would be nice if the other reports had a similar structure (for us BEMIP is of relevance and the possibility for comparison would be welcome).

Methodology and stakeholder reports could be elaborated.
The visualisation tool is valuable and user-friendly, which could be elaborated more in the report and on the homepage. A guidance document of its options or a guidance tap next to “Costs & Length” would make it easier to navigate. A suggestion for improvement of the tool could be the option to see percentages of hybrid corridors out of all transmission capacities (instead of absolute numbers).

Comment: Thank you for your comments.

The countries in the North Sea and Baltic Sea regions enjoy an historically more mature investment framework for offshore RES infrastructure, thanks for a more favorable conditions for installations (shallow waters, with mostly sandy seabeds), with more advanced maritime spatial planning for energy assets. This made easier gathering information on the needs to translate the MS targets into infrastructural needs. For this reason, the reports covering these basins are more detailed compared to others, the North Sea report in particular. Even though the Baltic Sea report already offers an impressive amount of information, we expect even more data to be used in the future editions, allowing the expansion of the analysis. In addition, the potential offered by offshore RES is now clear also in the European countries interested by the western and southern basins, and the governments are quickly moving toward concrete plans to deploy the energy infrastructure to exploit this potential. The ONDP 2024 already included relevant information on the infrastructural needs to deploy the MS non binding agreements in the Atlantic, the Mediterranean and part of the Black Sea, showing the amount of assets and posing the accent on the needs for floating technologies allowing the installation of offshore RES in areas far from shore, where the full-load hours are higher. With the offshore RES gaining weight also in these regions, the next edition of the ONDP should see more information becoming available to better detail the infrastructural needs in the Atlantic, the Mediterranean and the Black sea

Question: Open comments - Please use this field for any other comments on ONDP 2024 – Specify

Answer: ONDPs present many opportunities to coordinate and collaborate across Europe and sea basins. It is a good tool to communicate regional and across Europe, as many face the same development and challenges. We look forward to the integration and alignment, where possible, of ONDP, TYNDP, SB-CBCS, regional investment plans and system needs studies.

Comment: Thank you for your comments. ONDP and TYNDP will already from the next cycle be integrated and will be a single product. We do hope that ONDP will serve as a basis to outline the investment frameworks in Europe's waters and maritime regions, supporting regional and European cooperation in this critical sector.

Organisation: ACER

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specify

Answer: For the first ONDP, the methodologies and modelling seem to fit the purpose. Any further improvement is welcome in the next cycle, specifically engaging with ACER and EC in early development of the methodology and modelling principles, so that during the process our feedback could be taken into account earlier and methodologies adapted in case of a need.

Comment: Thanks for your comment. We plan to expand the cooperation with the Agency on the ONDP development through the stages of the process with both the EC and ACER..

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer: Stakeholder engagement process seemed to be well suited and allowed all stakeholders to be well informed. As mentioned in the above response, we see a need to involve main stakeholders early in the process in order that potential changes could be implemented already in the version for consultation.

Comment: Thank you for your feedback.

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) - Specify

Answer: We welcome an opportunity for consultation on the ONDP 2024. As there is no information weather any update of the ONDP 2024 is planned soon, we still see a need for minor but relevant improvements in the following aspects:

1. What we sees missing in the current ONDP 2024 is providing an input data on the costs being used for the assets and optimisations, like including an annex with unit investment costs used per each asset. The costs should be transparent for both the "low" and "high" costs assumptions input as used in the ONDP. Therefore, we call on ENTSO-E for further transparency of data used for calculations, adding the costs used in an Annex of the updated ONDP 2024. Further explanation to be included in the report/methodology whether country specific cost of assets have been used or was it a general figure for all EU.
2. In ONDP 2024 methodology document there should be further explanation of TOTEX approach (how it is used, is it yearly figures or any other approach is taken). In addition, what is the percentage of OPEX and CAPEX assumed per each infrastructure category.

3. We call on ENTSO-E to further elaborate in the ONDP 2024 what are the differences in running optimisation approaches between both processes, ONDP and TYNDP processes.

Comment: Thank you for your comments. Gathering as realistic as possible cost data was a challenge. We managed to find different costs from different TSOs and run different sensitivities (for example: low, high). based on those costs. On each sensitivity, same cost has been considered for all the EU. The costs considered in the expansion study are included at page 8 of the ONDP methodology document, including the references.

Organisation: Statkraft

Question: Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for the next cycles? – Specify

Answer: Statkraft supports ENTSO-E's work on the Offshore Network Development (ONDP) plans and seconds the use of socio-economic analysis to detail and prioritise recommendations in the ONDP. However, we believe that the method and process now described are at too high a level. It is important that the ambition to develop ONDP as a tool is followed up and that the results and recommendations over time become more detailed and specific. This will make ONDP more relevant for decision-making and allow it to be more easily used for planning hybrid cable and other offshore projects. Furthermore, it is important that the ONDP reflects that the final decisions will be company-specific with permissions granted by national authorities.

Statkraft encourages the attention to increased exchange capacity and supports TSOs' enhanced efforts on this. For the large amount of infrastructure that is needed in the development of renewable energy production at sea, good planning procedures are crucial. This will facilitate efficient and inclusive cooperation between several countries, TSOs and NRAs in the EU and neighbouring countries.

In the methodology that ONDP has published, the costs follow the size/length of the project linearly. We wonder whether this way of calculating total costs will render reliable results, and whether economies of scale should be considered in larger projects.

Comment: Thank you for your comment. ONDP is a high level study focusing on sea basin corridors and not on single projects. ENTSO-E is aware that the linear expansion methodology alone cannot deliver all answers concerning an investment decision, but this approach has demonstrated solid enough to be a first step in the identification of strategic corridors, that will be then further refined through mixed integer assessment in the IoSN, where more detail cost data are considered.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer: It is important to have a well-designed stakeholder process and Statkraft positively views the fact that the TSOs, relevant industry associations and several important stakeholder groups are involved. It is also positive that ENTSO-E organised a publicly accessible workshop on "The future of offshore" in June 2023. It is important to ensure that anyone who wishes to provide input, has access to do so. We believe it is particularly important to ensure that offshore wind developers' perspectives are taken into account when developing the regulatory framework, as there is a high level of interdependency between offshore production and grid development.

Comment: Thank you for your feedback. Due to the time constraints imposed by the legal deadline, ENTSO-E had to aim national targeted interactions mostly with institutions and WindEurope. However, the ONDP methodology was

presented during a workshop open to all stakeholders on 6 June 2023. For the ONDP 2026 we will expand the range of interaction to deliver the best possible product. We already started on 1 March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognize that technological development is a key factor to the development of the ONDPs .

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) – Specify

Answer: For the visualisation tool, it would be nice to have more of an explanation of its purpose and how to use it.

Comment: Thank you for your feedback. We can consider adding a user tutorial in the next edition.

Question: Open comments - Please use this field for any other comments on ONDP 2024 - Specify

Answer: In general, Statkraft is positive towards voluntary and negotiation-based solutions that are developed on a case-by-case basis. This facilitates targeted cost-sharing solutions that do not involve more countries or are more complex than necessary. Obligatory cost-sharing solutions based on socio-economic analysis alone are not supported.

When the Commission publishes its guidance on a methodology for cost-benefit analysis and cost-sharing analysis for the deployment of ONDPs in June , we hope for more clarity on what the recommendation/rules on cross-border cost sharing (CBSC) will be for non-EU Member States (non-MS). We will point to that Norway is not covered by the TEN-E regulation, which states that sea basin cross-border cost sharing (SB-CBCS) is mandatory for Member States (MS). Additionally, cost-sharing for non-hosting Member States is only voluntary, so it is uncertain how big a role this plays for non-hosting MS and non-MS. We would like more clarity here.

Moreover, in the final guidance on cost-sharing, we hope that the Commission will provide a list of requirements and optional areas that the MoU between Member States and the MoU between TSOs should include, as more clarity is needed here (assuming that the MoUs describes on page 59 of the cost-sharing report will also be part of the Commission's final guidance).

Comment: Thank you for your feedback.

Organisation: SuperNode

Question: Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specify

Answer Holistic Approach Needed

Given this is the first iteration of the ONDP, the time and effort in creating the methodology and modelling process must be commended. However, this first iteration of the ONDP has limited use as a planning tool for governments, developers and TSOs, because vital aspects such as onshore grids, demand and non-offshore renewable electricity is not integrated

in the model. ENTSO-E should therefore be careful in portraying the ONDPs as an accurate plan until the ONDP is fully integrated into the TYNDP framework.

The ONDPs seek to create an optimal offshore transmission system and yet they omit the onshore system which accounts for more than 80% of Europe's 2050 electricity generation and does not consider what happens to the offshore power once it lands on the beaches of Europe, integrates with the onshore grid and is ultimately delivered to customers. According to ENTSO-E the 2050 figures for offshore wind, onshore wind and solar are 496GW, 859GW and 1,936GW, respectively.

This iteration of the ONDPs reflect the infrastructure needed to deliver the power from the offshore renewable energy capacities announced by EU Member States, UK and Norway in January 2023 to the shorelines of Europe without due consideration of:
• what onshore reinforcements would be needed to handle that energy as well as onshore electricity production;
• how such a system can provide secure, sustainable and affordable energy;
• identification of technology gaps, beyond DC breakers, where innovation is needed to deliver on EU energy independence and climate goals.

Dividing the regions into 5 seas basins somewhat undermines an optimal modelling approach. To fully optimise Europe's energy system, a more holistic approach must be adopted in the future.
We recognise that the ONDPs will gradually be integrated with the 2024 TYNDP and aims at a fully holistic approach by TYNDP 2026. However, its important to note that the ONDPs are currently framed as a plan for developers and OEMs and should be utilised with caution.

Hybrid Offshore Assets
The ONDPs propose that by 2050 just 14% of offshore generating capacity will be connected to hybrid infrastructure, and just 15% in the North Sea. The security of supply and economic benefits of a meshed offshore grid has now been widely accepted. The EU Action Plan for Grids states that 'Offshore networks will be composed of radial and hybrid transmission projects evolving towards a future meshed grid' and the IEA's report on Electricity Grids and Secure Energy Transitions stated that "Meshed offshore grids are expected to play a critical role in European energy systems in the next 10 to 20 years." The Declaration of Energy Ministers at the Ostend North Seas Energy Summit stated a commitment to develop plans to develop a 'meshed offshore grid'.

Only 14% of the renewable energy capacity will be connected via dual purpose or hybrid infrastructure, according to the ONDP. This surprisingly low degree of meshing is undoubtedly the result of the methodology of identifying so-called "candidate links "for hybrid connections.

The criteria to identify these are based on i) proximity to generation and ii) whether two TSOs have already expressed an interest. Based on these two criteria the ONDP report even concludes that "The future European offshore transmission system will not be fully "meshed". ENTSO-E should refrain from making statements with such confidence on the future degree of meshing until more solid modeling to determine dual purpose and meshed connections has been applied to the scenarios.

This approach is near sighted and not designed to identify hybrid projects out to 2050 which would optimise the offshore network. This is evident from the ONDP including more existing and planned hybrid projects by 2050 than there are new projects identified by the model. The approach and criteria for determining an optimal degree of meshing must evolve in future iterations.

Comment: Thank you for your comment. The set-up of the ONDP reports, delivering a report for each sea basin reflect the mandate imposed by the Article 14.2 of the TEN-E. However, even though the results are divided into 5 reports, they have been obtained through the modelling of the European system as a whole, and not separately basin by basin. Please refer to the ONDP methodology for the details about the set-up and the implementation of the modelling approach.

As of today, considering the current set-up of assumptions and data on costs and potential locations of the offshore infrastructure, the prerequisite to imagine the full meshing of the infrastructure connecting all 496 GW of offshore up to 2050 are not evident. However, we strongly believe that through the progress of the current innovation efforts and clarification of the development framework ion all European regions, an increased number of hybrid corridors can be identified in the future editions, considering all basins and not just the northern European waters. The level of meshing of the offshore system will depend on several aspects, ranging from the supply chain challenges to the clarification of the system operation issues.

The results of the ONDP 2024 represent an effort to frame the space for development of offshore infrastructure given the information available at this time. This however, does not mean that the numbers included in this first edition are written in stone for the decades to come. At the beginning of each cycle of development of the TYNDP and ONDP, ENTSO-E reassess the assumptions at the base of the methodological approaches, aiming at enlarging the scope of the assessment toward an ever more complete study. For the ONDP this means examining the most updates features of the technological solutions serving the development of offshore RES infrastructure, their costs and the spatial planning data related to their installation.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer: SuperNode appreciates the opportunity to engage with ENTSO-E. The formal process seems good, but it could be improved. A very useful workshop was held on 6 June 2023, where many important concerns, observations and suggestions where communicated by stakeholders and discussed with ENTSO-E. However, these discussions, suggestions and concerns are not reflected in any meaningful way in the final ONDP. It would have been useful if ENTSO-E had added a session between the workshop and the final report to follow up and take action on the many issues raised.

It could be considered to expose the ONDPs to the scrutiny of a formal external expert group, similar to the Scenarios Expert Group overseeing the TYNDP scenarios.

Comment: Thank you for your feedback.

Question: Open comments - Please use this field for any other comments on ONDP 2024 - Specify

Answer: There a limited focus on technology and innovation in the ONDPs. Innovation in critical areas such as transmission is not considered. The only real consideration of innovation is in DC Circuit Breakers where two scenarios were evaluated with and without DC Circuit Breakers. DC Circuit Breakers are already at TRL9 in China and approximately TRL7 in Europe. Evaluating whether or not DC circuit breakers will be utilised is useful, but distorts the result when used in isolation. There are possible alternative grid designs limiting the need for DC breakers and high-capacity technologies such as superconducting subsea cables available within the 2050 timeframe.

There are various other game changing innovations that were not considered which could have a profound impact on Europe's energy system. There is a technology gap in grids and while this is not the direct scope of the ONDPs it would have been useful to address the challenges and innovations, for example by updating and including assessments of technologies from ENTSO-E's own Technopedia.

The ONDP assumes 2 GW cable sizes. In other words, it is assumed that transmission cable technology will not develop over the coming years from current state of the art. New innovative cable technologies with higher capacities are needed if we are to reach our 2050 climate and renewable energy targets.

A recent SuperNode study modelled an optimal European decarbonised network in 2050, that crucially was technology agnostic. The model identified the largest circuit size that can maintain stability for each transmission corridor. Each circuit costs money - it needs consent, right-of-way, landfall, installation and materials - so larger circuits translates to cost savings. The model found that the optimal average circuit size would be 6 GW, ranging from an average of 4.5 GW in Scandinavia to an average of 6.5 GW in Western Europe and 7 GW offshore. This study was presented at currENT's recent conference 'A Grid to Decarbonise Europe' which can be found here: https://www.currenteurope.eu/elementor-1356/

Current power transmission cable technologies can only carry 1 GW per cable. There is a need for innovative, high-capacity cable technologies, like high-capacity superconducting cables which can transfer up to 10GW in a single cable, both onshore and offshore. More importantly, high capacity cable technologies are being developed in Europe, US, Korea and China, ready for commercial application this decade. Failure to address the technology gap and upcoming innovative technologies will result in modelling results with an excessive number of landing points, cable projects, and infrastructure, using far too many critical raw materials and space. The next iteration of the ONDPs should place more emphasis on the game changing innovations and technologies that can address the grid technology gap.

Finally, the ONDP would benefit from updated cost assumptions. The AC cable cost seem low compared to ACER's cost catalogue and so does the assumed HVDC converter cost. Cable and converter cost are generally expected to continue to increase, partly as a result of increasing copper prices and supply bottlenecks. This should be better reflected in future iterations.

SuperNode would like to thank ENTSO-E for the ONDPs which are a hugely positive step towards designing a decarbonised European energy system.

Comment: Thank you for your feedback. When developing this first edition of the ONDP ENTSO-E concentrated on the one of the most critical system design aspects that will characterize the high densities of installation of offshore Res infrastructure: the potential high number of big size converters that might happen to be installed in relatively small areas of the sea. This pose a challenge in terms of costs as increasing the number of converters is one of the main drivers for the increase in the cost of the system, as the converters of the platform hosting it is one of the most expensive items in an offshore project. It imposes a challenges also from an operational point of view as there are many unsolved questions about the interaction phenomena that might interest a system with a high number of converters operating all in the same potion of the transmission system (being on or offshore). For this reason the first optimization assessed concentrated on the impact of DC breakers, as the advent of a commercially attractive solution for this sort of equipment will allow to lower the need for converters in the realization of hybrid corridors. We are aware that other technological challenges lay ahead, and the development of DC breakers alone might not be enough. However, from a modelling perspective the sensitivity performed on the availability of DC breakers demonstrated the absolute necessity of this component.

Concerning the technical assumption behind the HVDC converters, as of today we don't see any mature data on converters whose capacity will go over the 2 GW. In addition to this, to consider higher capacities, would have implications also in terms of operational challenges, as the size of the clusters would come closer to the reference incident of 3 GW. As of today, there are no operational means to face incidents higher than the reference value. For this reason, we stand by the choice of the 2 GW standard size. However, at the beginning of each cycle we will reassess the relevant technological assumptions to make sure that the ONDP will remain well rooted in the data driven evidence provided by developers and manufacturers.

Organisation: CurreENT

Question: Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specify

Answer Holistic Approach Needed

Given this is the first iteration of the ONDP, the time and effort in creating the methodology and modelling process must be commended. However, this first iteration of the ONDP has limited use as a planning tool for governments, developers and TSOs, because vital aspects such as onshore grids, demand and non-offshore renewable electricity is not integrated in the model. ENTSO-E should therefore be careful in portraying the ONDPs as an accurate plan until the ONDP is fully integrated into the TYNDP framework.

The ONDPs seek to create an optimal offshore transmission system and yet they omit the onshore system which accounts for more than 80% of Europe's 2050 electricity generation and does not consider what happens to the offshore power once it lands on the beaches of Europe, integrates with the onshore grid and is ultimately delivered to customers. According to ENTSO-E the 2050 figures for offshore wind, onshore wind and solar are 496GW, 859GW and 1,936GW, respectively.

This iteration of the ONDPs reflect the infrastructure needed to deliver the power from the offshore renewable energy capacities announced by EU Member States, UK and Norway in January 2023 to the shorelines of Europe without due consideration of:
• what onshore reinforcements would be needed to handle that energy as well as onshore electricity production;
• how such a system can provide secure, sustainable and affordable energy;
• identification of technology gaps, beyond DC breakers, where innovation is needed to deliver on EU energy independence and climate goals.

Dividing the regions into 5 seas basins somewhat undermines an optimal modelling approach. To fully optimise Europe's energy system, a more holistic approach must be adopted in the future.
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Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer: CurrENT very much welcomes the various stakeholder workshops and consultations organized by ENTSO-E, and the ability to ask questions to those involved in putting together the next ONDP. However, CurrENT is under the impression that much of the feedback submitted by CurrENT is insufficiently considered, and not incorporated into final documents, without proper argumentation. We would welcome further discussion around our concerns, while also understanding that some things will only be included in the 2026 edition.

Comment: Thank you for your feedback. Due to the time constraints imposed by the legal deadline, ENTSO-E had to aim at targeted interactions mostly with institutions and WindEurope. However, the ONDP methodology was presented during a workshop open to all stakeholders on 6 June 2023. For the ONDP 2026 we will expand the range of interaction to deliver the best possible product. We already started on 1 March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognise that technological development is a key factor to the development of the ONDPs .

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) – Specify

Answer: Under the energy surplus section

“Where CO2 emissions can be reduced most by intensify investment” the scale goes left to right, high to low, which feels counter intuitive. Sliding scale on graph beside it works left to right, low to high.

Comment: Thank you for your feedback.

Question: Open comments - Please use this field for any other comments on ONDP 2024 - Specify

The ONDP would benefit from updated cost assumptions. The AC cable cost seem low compared to ACER's cost catalogue and so does the assumed HVDC converter cost. Cable and converter cost are generally expected to continue to increase, partly as a result of increasing copper prices and supply bottlenecks. This should be better reflected in future iterations.

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Organisation: Orsted

Question: Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specifc

Answer: Ørsted strongly welcomes the publication of ONDPs as a necessary and overdue exercise to create more visibility for infrastructure needs. It is recognised that the first ONDP was under time pressure and that the scoping needed to be within the achievable. There are, however, several points we would like to propose.

First, it has not been explained very well, how the ONDP and the TYNDP is going to be integrated. This integration needs to be explained in both the TYNDP and ONDP process.

These two planning instruments cannot be done but taking due consideration of each other. For the ONDP the onshore grid reinforcements needs to be considered appropriately. This includes a view of the internal grid reinforcements needed versus what of the offshore wind is due for exports.

It is understandable that this first version of the ONDP only considered hybrid options that are currently under mature discussion or in the PCI list but in the next versions a more forward-looking approach will be needed considering all factors that can affect decisions at national level.

We find that the low share of hybrids is due to the bias that is in the modelling set-up – since the starting point is the radially connected wind farms. The modelling needs to instead allow for "green-field hybrid project", where the radial connections are not a given, but where hubs and islands can be planned from scratch as integral part of an optimised future energy system , which is more realistic and reflects how TSOs are able to make plans for the grid connection for the majority of all offshore wind capacity still to be built. This will help to enable timely build-out and a cost-efficient transmission system.

It was good to see how the environmental impacts have been handled with a separate chapter. With more cross-border cooperation this could easily be extended to cover more topics for instance the large piece of planning going on with the Maritime Spatial Plans and energy security.

Comment: Thank you for your comment.

We agree that the methodology for the modulization of hybrid infrastructure should improve in order to increase the accuracy of the results. If this first edition tried to capture a "screenshot" of the system in 2040 and 2050, looking at the evolution from radial to hybrid configuration, the focus of the next edition should be assessment of the configuration considering the optimal combination of radial, hybrid and interconnectors. The choice of the starting point for offshore generation as at least radially connected to the onshore system was due to 2 main factors

- Obligation for the ONDP to be in line with the MS non-binding agreements and thus connecting all capacities to the model.
- Need to cope with the uncertainty (especially in 2050) concerning the development framework for hybrids.

Based on these 2 reasons we had to develop a base that on side was allowing the ONDP to be compliant with its legal mandate but at the same time not hindering completely the exploration of the hybrid corridors. We can agree that improvements are needed in order to avoid being overly conservative on the development of hybrid infrastructure. For this reason, the methodological approach will be reassessed starting from the next edition to solve the shortcomings of the first version of the ONDP.

Part of this reassessment will also be based on the results of the link between the ONDP 2024 and the Identification of System Needs (IoSN) 2024, which has the mandate to explore the gaps on the onshore system. The integration of the ONDP 2024 results into the IoSN 2024 will give us the opportunity to test the integration of the 2 methodologies, as the ONDP has been developed through linear expansion of the candidates, while the IoSN uses a project-based evaluation of candidates, whose optimal mix is elaborated with a mixed-integer programming approach, in a multiyear simulation. The results will give the optimization of the complete transmission system needs, filling the gap between the offshore needs and the onshore ones.

The future editions of the ONDP will combine the flexibility of the ONDP 2024 modelling methodology with the robustness of the IoSN methodology, to arrive at an integrated and high-quality modelling approach, individuating a fully optimized combination of needs.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

We understand that for the first edition of ONDP there was a lot of time pressure but in the future more stakeholder engagement in the early phases would be helpful, also in the interest to receive best/most helpful feedback/inputs.

Comment: Thank you for your feedback. Due to the time constraints imposed by the legal deadline, ENTSO-E had to aim at targeted interactions mostly with institutions and WindEurope. However, the ONDP methodology was presented during a workshop open to all stakeholders on 6 June 2023. For the ONDP 2026 we will expand the range of interaction to deliver the best possible product. We already started on 1 March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognise that the exchange with the developers' community is a key factor to the evolution of the ONDPs

Question: Open comments - Please use this field for any other comments on ONDP 2024 - Specify

The ONDP is meant to pave the way towards an integrated onshore-offshore system planning and a new component of the TYNDP, focused on needs for offshore transmission infrastructure. It translates the EU Member states' non-binding agreements on offshore goals into offshore transmission corridors for each sea basin.

In the context of offshore wind development, questions that arise at the planning stage cover the sites which need to be connected to the onshore grid, the type of connection involved (radial or hybrid), the markets offshore assets will be connected to, the routing of the infrastructure, and the timing of projects.

Today's approach to planning both offshore development and offshore grid development encounters significant obstacles that hinder the identification of optimal grid configurations and the scaling up of the entire value chain. These obstacles stem from an over-reliance on bottom-up consolidation of national plans, lack of market clarity, and the absence of a holistic approach to planning that aligns with European ambitions for reaching net zero emissions.

Firstly, the reliance on bottom-up consolidation of national plans, as mandated by the Trans European Network – Electricity (TEN-E) regulation, presents challenges. While national targets are consolidated to form ONDPs, there exists a mismatch between offshore renewable energy potential and actual demand in different countries. This limitation restricts potential collaborations and may lead to over-exploitation of limited resources in some countries while underutilizing the potential in others. Offshore wind has the huge benefit that it - due to the location at sea - can serve consumers in different countries and price zones. Additionally, the default radial connections planned for offshore wind deployment overlook hybrid configurations, further complicating efficient grid development.

Moreover, the lack of market clarity inhibits investor confidence, hindering the scaling up of the entire value chain necessary to meet ambitious offshore wind targets. Political pledges and the ONDP alone are insufficient to drive the required transformation of the supply chain. The planning of the future offshore grid remains uncertain, impeding necessary investments in research and development and hindering supply chain growth.

To address these obstacles, new approaches to planning must be adopted. Firstly, there needs to be a shift towards projects that maximize benefits for Europe as a whole. This entails expanding the mandate of ENTSO-E to assess optimal energy system configurations that consider offshore renewable energy potentials separately from national targets. This

could be a particular scenario of the ONDP showing the contrast and potential up against the present approach. By optimizing infrastructure development in a coordinated manner and considering all realistic options, such as efficient hybrid systems, a more integrated approach can be achieved. This would lead to the adequate integration of offshore renewable energy sites and zones, efficient hybrid systems, and the connection of offshore wind capacity to the countries in need.

Likewise the ONDP process and processes round the Maritime Spatial Plans of each country should coordinate as early as possible and scenarios for offshore networks should feed directly into MSP authorities with a more binding character.

A coordinated approach would facilitate the integration of the best offshore RES sites and zones into the system, identify efficient hybrid systems, and connect offshore wind capacity to countries with underutilized resources. Furthermore, long-term scenarios should align with European ambitions to reach net zero emissions by 2050. This requires consideration of the societal cost of carbon emissions throughout the planning process, reflecting the true benefits of reaching net zero and ensuring that infrastructure needs are accurately identified and supported.

In conclusion, addressing the obstacles in offshore development planning requires a shift towards greater coordination, consideration of Europe-wide benefits, and alignment with ambitious climate and environmental goals. By adopting these new approaches, the identification of optimal grid configurations and the scaling up of the entire offshore wind value chain can be facilitated, ultimately contributing to the transition towards a sustainable energy future.

In addition, there is a strong case for improving the existing approach to funding and cost allocation for interconnector projects. The 2024 ONDPs highlight nearly 80 GW of hybrid interconnector projects in the North Sea region, likely a conservative estimate. Traditionally, interconnectors between countries are negotiated bilaterally, based on projects generating sufficient Socio-Economic Welfare (SEW) for both parties. However, projects failing to meet SEW requirements, despite potential benefits across Europe, often stall. While EU funding like the CEF can help, the inability to compel non-promoting countries to contribute is a significant hurdle, impeding progress on projects of Common European interest. Moreover, hybrids present additional complexities in risk allocation and differing perspectives among countries with surplus or deficit renewable energy potential. Given Europe's offshore ambitions, the current approach's shortcomings may hinder realizing new interconnector projects, necessitating a revised strategy.

Coastal nations within a specific sea basin should enhance cooperation, moving beyond project-by-project negotiations. Collaborating on common goals at a structural level is essential. Shifting focus to the entire sea basin and considering projects collectively rather than individually reduces the complexity of the often project-by -project negotiations. This approach spreads benefits more evenly, allowing countries to agree on projects that may not directly benefit them in exchange for future gains. Additionally, streamlining administrative processes accelerates project processing, approval, and development, facilitating smoother implementation of joint endeavors.

The integration of the good first edition of the ONDP into the TYNDP processes should take the above into account when identifying needs and translating this into planning and selection of the infrastructure projects that answer those needs.

In addition, the planning processes on TYNDP and ONDP also needs to be seen in context with what projects will later on be proposed, which in turn is dependent on funding and allocation of costs. Enhancing the current approach to funding and allocating costs for interconnector projects is crucial, especially considering the potential for hybrid interconnectors in the North Sea region outlined in the 2024 Offshore Network Development Plans (ONDPs). Historically, the establishment of new interconnectors has relied on bilateral negotiations between two countries, typically focusing on projects that generate sufficient Socio Economic Welfare (SEW) for both parties. However, this approach often disregards projects that do not meet SEW requirements, despite their potential benefits at a broader European level. Despite attempts to address this issue through mechanisms like the Connecting Europe Facility (CEF), shortcomings persist, hindering the advancement of projects of joint European interest.

Furthermore, the complexities associated with hybrid interconnectors, which involve both electricity transmission and generation, present additional challenges. Countries' perspectives on these projects vary based on their renewable energy potential, with exporting countries benefiting from increased producer surplus, while importing countries seek lower electricity costs for consumers. This asymmetry in perspectives complicates negotiations on issues such as funding infrastructure projects through transmission tariffs.

Given Europe's offshore ambitions, the shortcomings of current approaches may impede the realization of many new interconnectors, necessitating a new approach. Close cooperation among countries within specific sea basins is essential. Rather than engaging in ad hoc negotiations on a project-by-project basis, countries around the same sea basin should collaborate structurally. By considering a group of projects together, rather than individually, negotiations can be streamlined, reducing complexity and administrative burden. The complementarity of benefits across multiple projects within the sea basin can facilitate negotiations, allowing countries to agree to develop projects that may not directly benefit them in return for support on other projects. This approach promotes efficiency and accelerates project processing, approval, and development.

In conclusion, enhancing the approach to funding and cost allocation for interconnector projects requires a shift towards multilateral cooperation among countries within specific sea basins. By moving away from bilateral negotiations and adopting a more comprehensive approach, countries can overcome existing challenges and accelerate the development of vital infrastructure necessary for achieving Europe's offshore energy ambitions.

Comment: Thank you for your feedback. As mandated by the TEN-E regulation, ENTSO-E bases the development on the non-binding agreements signed by the MS. We remain fully available to support the cooperation process behind the definition of the offshore RES targets and to evolve the planning studies in order to provide the decision makers and the stakeholder with the data of the highest quality possible. In the development of the next edition of the ONDP we will strive for further enhancing the collaboration with the EC, the MS, the Agency and the stakeholder community so that the content of the reports can reflect the high expectations posed upon this important new product of the TYNDP package, through an ever more integrated and holistic approach, considering all relevant sectors and spatial data.

Organisation: Gasunie

Question: Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? – Specify

Answer: In our view, the ONDP's methodology and modelling process is could be enhanced. We propose the following improvements for the next cycles:

1. Include system integration and sector coupling principles
a. We recommend including offshore Hydrogen pipelines and offshore power-to-gas (PtG) as additional components of the offshore energy network infrastructure. The model setup should allow integration between PtG assets and electricity hub assets. Then, various scenarios could be investigated such as maximising Variable Renewable Energy (VRE) production, reducing costs, etc. The resulting expansion network model runs would then lead to identifying offshore energy corridors for both electricity and hydrogen under broad range of future scenarios.
b. We recommend integrating H2 storage potential in salt caverns in the North Sea.
c. We recommend to make appropriate assumptions for H2 transport pipelines in terms of costs, transport capacity, potential for natural gas pipeline reuse.
d. Take in account onshore electricity and hydrogen network components such as onshore electrolysers, onshore E/H2 grid capacities, onshore energy storage capacities.
2. Include technological and economic upscaling principles

a. Based on current technologies, offshore electrolyser capacities can range from ~ 100 to ~ 500 MW on a platform. Higher capacities can be achieved by installing multiple platforms or installing electrolyser arrays on an island. Choice of structure is on several criteria such as sea-basin, costs, timing, modularity, etc. Economic benefits (CAPEX/OPEX) of upscaling might exist when single compression station can offtake hydrogen production from large scale (~ few GWs) offshore electrolysers.
b. Include variety of offshore H2 infrastructure configurations such electrolysers located onshore with cables to offshore wind farms, offshore electrolyser platform and electrolyser integrated into wind turbines.
c. Include possibility for realising offshore energy hubs with platforms, islands or a combination of platforms and islands. Offshore energy hubs facilitate closer integration between electricity and hydrogen production + transport assets offering a point of flexibility in the energy system.
3. Include dependence of offshore infrastructure on onshore grids
a. Impact of additional costs of integrating offshore electricity as well as hydrogen infrastructure on onshore infrastructure should be taken into account. Without this, a skewed picture of advantages might emerge with hidden costs for onshore grid development.
b. Take into account timing aspect of realising offshore as well as onshore grids.
c. Take into account constraints on spatial needs offshore as well as at potential landing locations.

Comment: Thank you for your comments.as several countries in Europe are still miss concrete plans for the development of offshore H2, the missing data hindered the further expansion of the H2 system on top of what already performed in the Scenarios 2022 cycle. For this reason, it was decided to consider the capacities individuated by the Scenarios 2022 (34 GW of electrolysers in the North Sea) but not to expand the infrastructure on top of this, as the risk of obtaining distorted results was deemed too high. However, already this assessment allowed to explore the positive impact of H2 production on the amount of energy integrated in the onshore system, demonstrating that H2 will play a role in the efficient use of the offshore RES potential. In the next edition ONDP will be integrated with TYNDP and thus the offshore electrical grid infrastructure will be optimized together with the onshore. It is our goal to integrate even more flexibility like the ones you mentioned in our model as well as more constraints on spatial planning needs.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer Including a broader scope of stakeholders and associations representing sectors other than electricity would be desirable. They can indeed contribute efficiently with their system integration's perspective and enhance the quality of the upcoming ONDPs from that point of view. Moreover, hydrogen stakeholders should be consulted for the Energy system wide cost-benefit analysis (Art 11(2)) and on Infrastructure Gaps identification (Art. 13 (2)) in the TEN-E Regulation, which are also the elements that encompass offshore infrastructure.

ENTSO-E and ENTSO-G must collaborate closely with TSOs and national authorities to create a feedback mechanism/loop that connects the decisions made withing the framework of the ONDP/TYNDP with the subsequent infrastructure requirements at the national level, which will be managed by national authorities.
Moreover, several stakeholder's workshops, dedicated meetings and feedback loops are to be implemented with stakeholders before publishing the final version of the ONDP.
Include a dedicated workstream of stakeholder's Representatives Group – similar as the one established for TYNDP.

Comment: Due to the time contraints imposed by the legal deadline, ENTSO-E had to aim at targeted interactions mostly with institutions and WindEurope. However, the ONDP methodology was presented during a workshop open to all stakeholders on 6 June 2023. For the ONDP 2026 we will expand the range of interaction to deliver the best possible product. We already started on 1 March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognise that technological development is a key factor to the development of the ONDPs .

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) – Specify

Answer: We observe that the reports could be further enhanced to provide the meaningful insights it aims to. For instance, detailed analysis exploring the cost of VRE curtailing would add tremendous value. The corridor reports would require further content engagement with relevant stakeholders from across the various value chains and energy carriers. The visualisation tool offers interactive interface to view results, but due to extremely narrow modelling scope its practical relevance remains limited.

Comment: Thank you for your feedback. We will take it into consideration for the next edition.

Question: Open comments - Please use this field for any other comments on ONDP 2024 - Specify

ONDP expansion modelling framework lacks the inclusion of offshore PtG conversion and transport assets. Despite this limitation, the ONDP Pan-European summary report states that it estimates 34 GW worth of offshore PtG projects. The term 'estimate' in a summary report does not accurately reflect the ONDP methodology, as 34 GW is a sum of existing offshore projects. These existing offshore projects are not incorporated into the initial grid of the ONDP model. We recommend to widen the scope for future ONDP cycles to include not only planned offshore H2 projects into the modelling framework, but also allow expansion model to identify additional needs for offshore hydrogen grid that is sector coupled and integrated with electricity grid.

Comment: Thank you for your comments - as several countries in Europe are still miss concrete plans for the development of offshore H2, the missing data hindered the further expansion of the H2 system on top of what already performed in the Scenarios 2022 cycle. For this reason, it was decided to consider the capacities individuated by the Scenarios 2022 (34 GW of electrolysers in the North Sea) but not to expand the infrastructure on top of this, as the risk of obtaining distorted results was deemed too high. However, already this assessment allowed to explore the positive impact of H2 production on the amount of energy integrated in the onshore system, demonstrating that H2 will play a role in the efficient use of the offshore RES potential.

Organisation: National Grid Ventures

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? - Specify

Answer: NGV welcomes the first pan-European ENTSO-E Offshore Network Development Plans (ONDPs) which were released on 24 January as well as the opportunity to provide our views to the plans.

The ONDPs are a first of its kind tool providing a high-level perspective on the future needs for infrastructure development in the European sea-basins for up to 2050 and are crucial for enabling faster deployment of offshore renewable energy across Europe. Having a comprehensive view of the sea basins around Europe and of what the political ambitions of national governments translate into with respect to need for grids to enable the speedy integration of offshore wind in the short, medium and long-term is a very important instrument to also help provide visibility for the supply chain industry and for the necessary investments for the green transition.
It is equally imperative however that the ONDPs appropriately reflect the latest national commitments to offshore RES targets at sea basin level, including also connecting third countries such as the UK, etc.
With respect to work on the next cycle of ONDPs, NGV suggestions the following additions/considerations to the methodologies and the modelling for the ONDPs which could be useful for enhancing the value of the ONDPs as a tool to provide further useful insights at seabasin level for the offshore needs:
• ENTSO-E's analysis uses the TYNDP Distributed Energy 2022 scenario, where the EU's offshore wind capacity is at its maximum. There is also a counterfactual where all offshore wind farms connect radially. The factual (hybrids) is being determined by linear optimisation (capacity expansion) which takes into account transmission costs and CO2 reduction

to compute the optimal hybrid Interconnection capacity. The total amount of offshore wind remains the same in both simulations. It would be useful to look at other TYNDP scenarios that reflect more realistic wind deployment to provide some insights for comparison.
• The analysis suggests that there will be a significant amount of RES curtailment. While ENTSO-E's optimisation is mainly based on cost and CO2 reduction, it may be worth factoring in RES curtailment to identify more hybrid options and to determine the level of hybrids' expansion alongside CO2 and transmission costs.
• It would be worth clarifying the assumptions that ENTSO-E makes for structuring offshore bidding zones in the model. It is also worth clarifying if cable/converter losses are accounted for.
• It could be useful if in the next ONDP update, ENTSO-E would also consider connecting demand (data centres) to offshore wind clusters/islands.
• It is unclear if floating wind is considered and if load factors for offshore wind farms differ per cluster; it would be helpful if the methodology document provides reference load factors/profiles.
• ENTSO-E acknowledges that the first ONDPs are a starting point and that future versions will also consider the benefits for generators and consumers. It is important to ensure proper engagement with relevant authorities and stakeholders and ensure a sea-basin approach, including respectively with third countries connecting as sea basin level with respect to discussions on cost-benefit and cost sharing methodologies.
• ENTSO-E provides a cost breakdown per component and applies some sensitivities. However, it is unclear which set of CAPEX/OPEX assumptions determines the final results, and if there is any weighting factor applied.
• It would be worth considering a cost sensitivity analysis where technology matures, supply chain issues ease, and thereby, costs decrease, especially for the later years.
• The cost of UK radials is not included in the analysis. It would be beneficial to include UK counterfactual costs as well.
• For some hybrid configurations where the distance between the two interconnected countries is short, it may be possible for two or more offshore wind farms (depending on their capacity) to share a common offshore HVDC platform. It would be useful if this option were considered as well.
• The successful deployment of the offshore wind capacity considered in the study hinges upon the assumption that projects will be receiving the necessary environmental permits in order to proceed according to plans. However, in some cases, the potential significant number of landfalls may be subject to public opposition and disruption to coastal communities which may create further risks to project development and timely deployment. It would be useful if wider societal and environmental impacts of various options for infrastructure would be addressed too in the future ONDPs.

Comment: Thank you for your comments. ENTSO-E is aware that multi scenario modelling is key to improve the robustness of the assessment, but the demanding timeline for the development of the first edition of the ONDP requested a pragmatical approach to the modelling set-up. The choice to use the DE scenario from the TYNDP 2022, was due to the fact that it was the most adequate choice (at the time of the initiation of the development process, Scenarios 2024 results were not available) in terms of generation and transmission capacities. In addition, the DE scenario was also deemed the most suitable for project assessment as in the last cycle was selected by the European Commission as reference for the PCI process. For the set-up of the ONDP 2024 model, the offshore generation capacities used for the model were aligned coming from the MS non-binding agreements. The increase in the load, even though set linearly at 8% was chosen close to the average increase then considered in Scenarios 2024 (around 10%), to consider a demand-driven development of the generation and avoid unreasonable amount of curtailment. Of course further improvements in the modelling is something we have in mind for future editions. Cable and converter losses have also been considered. The ONDPs do not focus on single projects and thus floating wind farms have not been specifically studied.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Answer In order to reach net zero targets effectively, we need reliable, long-term and coordinated planning providing a pan-European coordinated system across borders and in sea basins. In that context, better cooperation with connecting non-EU neighbours such as the UK, Norway etc. in long-term system planning processes is essential to deploy optimally the North Seas' potential together. This will help frontload investments; provide visibility and transparency to the supply

chain and increase manufacturing capacities; as well as enable long-term framework agreements and a coordinated cross-border approach.

Interconnections, offshore hybrid assets, and the evolution towards a meshed grid can only be planned regionally and not simply nationally. This is all the more important given that on the UK side, the first Transitional CSNP has just been launched by the ESO, and it is a new planning exercise that provides a UK view on the additional necessary investments in infrastructure beyond the 2030 horizon in order to reach the green transition, which has been done in parallel to the ENTSO-E ONDP for the North Seas. However, as there is no formal mechanism for engagement on this area between UK TSOs and ENTSO-E, these two plans have been developed separately.

For the next planning and development cycle of the ONDPs, there should be a process for engagement between ENTSO-E and UK TSOs that provides an opportunity for starting discussion at an early stage of the start of the work on ONDPs and ensures regular exchanges with the UK TSOs. Having the possibility for UK TSOs and ENTSO-E to discuss together relevant data gathering processes, methodologies, assumptions, scenarios, etc. taken for the development of the next ONDPs/TYNDPs, is essential in order to ensure that the EU and the UK visions of the development of the North Seas can be better looked at together beyond simply the national level, and at a more regional level. Such an approach would enable the development of a joint view of the countries per a sea basin and not just on a national level, e.g. it is absolutely essential to ensure that the North Seas' countries discuss together a full view per sea basin including the UK and Norway – this would enable countries to work on shared understanding of how they see together the longer term evolution of the needs for grids through a full sea basin approach and ultimately enable countries to exploit better together the potential/opportunities of the North Sea.

Closer coordination of onshore and offshore across borders at pan-European level, and involving the connecting third countries, such as the UK, Norway as well as ensuring a more holistic thinking will also help support more informed discussions on cost benefit and cost sharing aspects as well, and facilitate alignment across a wider system perspective on the infrastructure needed to achieve the 2050 net zero targets in a more optimal manner and to the benefit of all European and UK consumers.

Comment: Thank you for your comment. We acknowledge that the development of offshore infrastructure should be planned regionally and not nationally and thus we are open for a good communication between all relevant stakeholders in the future cycle.

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) – Specify

Answer: The comprehensive dashboard created by ENTSO-E to communicate the ONDP results and facilitate stakeholder analysis of the modelling output, is a very useful tool. However, it would also be valuable to create a similar dashboard for the assumptions used in the modelling process (modelling inputs).

Comment: Thank you for your comment. We will consider providing more details regarding the modelling process in the future edition.

Organisation: Hydrogen Europe

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? - Specify

Answer: The ONDP did an exercise to include multi-modal infrastructure and estimated 34 GW of potential offshore electrolysis (e.g. in Dutch/Danish/Irish waters). However, the TEN-E Regulation goes even further and contemplates an offshore hydrogen backbone to maximize VRES production potential, which, in our view, is to be realized in the model with the following considerations:

1. H2 pipelines should be a configuration option in the ONDP given their cost-effectiveness compared to HVDC energy transportation.
The ONDP has included two configuration options for connections: hybrid and radial, Hydrogen Europe proposes a third one consisting of H2 pipelines.
Having a Two system approach (pipelines + electric cables) is more cost-effective than an "all or nothing" approach that solely relies on electrical connections (which is the characteristic of the hybrid and radial approaches).
HVDC is three times more expensive than hydrogen pipelines1, and pipelines can transport three times more energy than one HVDC cable2 à H2 infrastructure can be up to 9 times more cost-efficient (x3 capacity x3 less cost)
The TEN-E regulation establishes that H2 infrastructure and storage are to be considered in the TYNDP – of which the ONDP is part of – and should have a comprehensive and consistent assessment of their costs and benefits for the energy system (recital 16)
Accounting for the cost-effectiveness of offshore H2 pipelines so that the social acceptance of the clean transition is not jeopardized.
For instance, the expected cost for Germany's offshore grid alone is 160 billion EUR, raising concerns about consumer affordability and public perception of the clean energy transition.

2. Consider the repurposing potential of Natural Gas Infrastructure:
The TEN-E Regulation states that the development of trans-European energy infrastructure should take into account, where technically possible and most efficient, the possibility of repurposing existing infrastructure and equipment.
TEN-E establishes that hydrogen infrastructure should consist of a significant extent of assets converted from natural gas assets, complemented by new assets dedicated to hydrogen.
This is to be urgently included in the ONDP as ENTSO-E is responsible of planning the offshore H2 backbone.
Include the repurposing of natural gas pipelines in the North Sea Basin as repurposing entails 20 – 30%3 of the costs of building new H2 pipelines.

3. Greater infrastructure granularity:
Factor in in the ONDP and TYNDP system integration costs and constraints before making any decisions. It is insufficient and potentially misleading to base decisions about offshore infrastructure capacities and integration options for offshore wind solely on the technological costs of transporting energy from point A to point B offshore. Other considerations, such as the availability of space, the feasibility of landing points, or whether future infrastructure investments will be necessary to distribute the energy further - be it as electricity or hydrogen - must also be taken into account. These considerations, along with the capital (CAPEX) and operational (OPEX) expenditures of the energy carrier technology, must all be integrated into the decision-making process.
Consider Electrolyser's capacities: the model should consider the possibility to install an array of electrolysers capacities as it may be technologically challenging to build one 1.4 GW electrolyser offshore, but it is possible to build 3 of 0.4 GW electrolyser's capacity in platforms – as it is already planned in some projects offshore H2 projects (i.e. Esbjerg 1GW Offshore Hydrogen project4).
Include a variety of possible offshore H2 infrastructure configurations, comprising: onshore electrolysers with cables to offshore wind farms, offshore electrolyser stations with hydrogen pipelines, and wind turbines with integrated electrolysers connected to an offshore pipelines network.
Integrate H2 storage potential in salt caverns in the North Sea so H2 can be supplied to continental Europe in periods of low VRES supply.
Consider increasing with distance prices of HVDC: HVDC cable costs increase exponentially with distance (instead of a linear way) impacting projects like floating wind. For offshore wind turbines, consider the costs for floating wind.
Introduce in the model grid physics and performance, plus ancillary needs as they heavily influence grid operations and impacts the costs of the system.

The ONDP assesses how DC breaker availability affects the capacity connected via hybrid and radial connections (a bigger or a lesser percentage of connections would be made via hybrid connections depending on DC breaker availability). And the same analysis should be done on how DC breaker availability would affect which percentage of connections is done via hybrid, radial or hydrogen connections.

4. Account for the impact of offshore infrastructure on onshore grids
The ONDPs, as well as the TYNDP as a whole, should take into account the current status of national (onshore and offshore) network development and expansion plans. To incorporate offshore infrastructure and deliver energy to end-users - whether through offshore hybrids, radial connections, or as offshore renewable hydrogen - further grid strengthening, expansion, optimization, or additional infrastructure will be necessary at the national level. Still, we witness significant delay in the design and delivery of those national plans, which might impact the ONDP robustness in the following manner:
It is important to account for the extra costs associated with integration of the ONDP plans on the onshore grids at national level.
The ONDP should account for grid deployment delays and their effects on the onshore grid.
Bundesnetzagentur has confirmed that the German Network Plan is 6 years delayed5.
Integrating the national dimension would entail accounting for expected congestion.
Factor in expected capacity available in landing points vs. offshore wind potential capacity installation in the maritime space and consider other avenues of energy transport infrastructure to maximize the VRES production in the maritime space.
Include how H2 pipelines could aid with repowering aspects: In 2033 12 GW of offshore wind turbines will be over 20 years old. And, if those turbines are repowered and ELY capacity is addedd - along with H2 pipelines - there won't be a need to increase cable's capacity resulting from this repowering. Hence, speeding up and reducing the pressure on TSOs to expand their network's capacity.

5, Integrate H2 demand and production coming from National Plans:
The ONDP should be more coherent with national developments. The modelling should include specific national H2 plans and their respective Maritime Spatial Plannings (such as Germany's Power Plant Strategy, Ireland's H2 Strategy, etc. and National H2 efforts in general).
Germany plans 1GW of wind-powered green H2 production at sea, with a pipeline to shore with a dedicated area in their Maritime Spatial Planning called SEN-1. By 2035, this infrastructure is anticipated to channel up to 1M tonnes of hydrogen yearly to Germany, with potential links to a forthcoming hydrogen pipeline connecting Norway and Germany,
The Netherlands has also chosen the site of the world's largest Offshore Wind-to-Hydrogen project, representing 500 MW of electrolyser capacity7. Their operational target is for 2031, with an existing offshore wind farm and repurposing of a nearby natural gas pipeline for transport of green H2 to the shore.

Comment: As ENTSO-E we fully support an energy system that integrates the complementarities offered by the different sectors. In addition, the mandated of the TEN-E require the infrastructural needs related to offshore hydrogen to be considered when developing the ONDP. The future editions, starting from the next one, will move forward in outlining the investment framework for offshore H2.the assessment though must be based on mature and robust data, to assess the realization of the national plans of the MS interested in exploring this solution.

As of today there are aspects that needs improvements in the assessment of H2 infrastructure, like standard size for windfarm scale electrolysers and costs figures that are based on the realization of pilot projects of relevant size.

Currently, even imagining the highest level of efficiency for the electrolysers (70-80%), to conceive H2 as an alternative transmission solution to satisfy electricity demand would be not efficient, as between 40% and 60% of the energy would be lost in the double transformation.

H2 transmission is needed to satisfy H2 demand. For this reason, the data on H2 demand should be reliably defined, avoiding unrealistic scenarios such as domestic H2 usage (today not corroborated by any mature application).

To not base the assessment of H2 infrastructure needs on robust data and figures would impact the quality of the analysis , distorting the outcoming results and the information delivered by the ONDP.

Question: Are you satisfied with the stakeholders engagement process, and would you like to make proposals for next cycles? – Specify

Including a broader scope of stakeholders and associations representing sectors other than electricity would be desirable. They can indeed contribute efficiently with their system integration's perspective, and enhance the quality of the upcoming ONDPs from that point of view. Moreover, hydrogen stakeholders should be consulted for the Energy system wide cost-benefit analysis (Art 11(2)) and on Infrastructure Gaps identification (Art. 13 (2)) in the TEN-E Regulation, which are also the elements that encompass offshore infrastructure.

ENTSO-E and ENTSO-G must collaborate closely with TSOs and national authorities to create a feedback mechanism/loop that connects the decisions made withing the framework of the ONDP/TYNDP with the subsequent infrastructure requirements at the national level, which will be managed by national authorities.

Moreover, several stakeholder's workshops, dedicated meetings and feedback loops are to be implemented with stakeholders before publishing the final version of the ONDP.

Include a dedicated workstream of stakeholder's Representatives Group – similar as the one established for TYNDP.

Comment: Thank you for your feedback. Due to the time constraints imposed by the legal deadline, ENTSO-E had targeted interactions, mostly with institutions and WindEurope. However, as the ONDP 2026 will be a more mature product, we will expand the range of interaction to consider all relevant inputs that can help deliver the best possible product. We already started on the 1st of March 2024, when a dedicated public physical workshop has been held in ENTSO-E premises to allow an open discussion on the improvements of the ONDP, with 80 people participating physically and over 250 online. The target for the next edition of the ONDP is to exchange with a larger audience of stakeholders, as we recognise that technological development is a key factor to the development of the ONDPs

Question: Please share here your comments on the ONDP package (reports and interactive data visualisation tool) – Specify

Answer: Hydrogen Europe observes that the reports lack depth and fail to provide meaningful insights. What is noticeably absent is a detailed analysis that could elevate the utility of these documents. Echoing our previous comments, an analysis that, for example, explores the cost implications of reducing curtailment to 0% (or to a similarly low figure) would add significant value for instance. Currently, there is minimal incentive to engage with the corridor reports due to their lack of compelling content. Enhancing them with more in-depth analyses and specific scenarios could greatly improve their relevance and usefulness.

Comment: Thank you for your feedback. We will consider your improvements proposals for the next edition.

Question: Open comments - Please use this field for any other comments on ONDP 2024 – Specify

Answer: It is understandable that this initial iteration of the ONDPs focused solely on hybrid options that are either in advanced stages of discussion or listed in the PCI, but future versions will require a more holistic strategy that maximizes VRES offshore production potential whilst minimising the spatial footprint to ecosystems. This approach should consider all factors that could influence decisions likely to be taken at the national level.

The ONDP expansion modelling framework currently lacks the inclusion of offshore power-to-gas conversion and transport assets within its parameters. This omission indicates that the model does not consider the potential expansion of the offshore grid through hydrogen technologies. Despite this limitation, it is important to point out that the ONDP Pan-European summary report assertively predicts the existence of 34 GW worth of offshore power-to-gas projects. The term "estimate" may not accurately reflect the methodology employed, as ONDP's figure primarily derives from the aggregation of existing offshore hydrogen projects. It is critical to note that these identified hydrogen projects are not even incorporated into the initial grid data used for the modelling exercises. Hence, the need to have a wider scope of approach that encompasses not only planned offshore H2 projects but also the potential projects and different Hydrogen configurations for Hydrogen production and transport offshore.

In general, hydrogen transport by pipeline is very affordable per unit of energy transmitted and linepack of pipelines acts can also act as internal energy storage. With Hydrogen pipelines the energy production per surface can be maximised as the evacuation capacity is not restricted to landing points. Hence, leading to the production of a greater amount of energy while utilizing fewer full load hours in a given area (e.g., through specific power, distances between masts, etc.).

As a general remark, Hydrogen Europe finds the sections dedicated to the national corridors in the ONDP consultation document to lack substantial utility. The content presented doesn't significantly extend beyond what is already detailed in the main report. For these sections to offer genuine added value, HE suggests incorporating additional elements such as more comprehensive sensitivity analyses, exploring alternative scenarios, or providing more detailed cost data. By enriching these sections with deeper insights and more specific information, their usefulness and relevance could be significantly improved.

Implement the EU Sector Integration Strategy in the ONDP planning, for an enhanced efficiency and lower system costs and footprints:

As stated earlier on, the TEN-E regulation also specifies that the TYNDPs have to consider how H2 infrastructure contributes to sector integration and decarbonization. (recital 16).

Include Sector Integration’s perspective in the ONDP to optimize VRES consumption on end-consumers' side as well as to maximize the VRES production on the supply side so that the clean transition can be done faster, smoother and more affordably.

Consider developments of cross-border carbon dioxide networks and identify demand centres for clean molecules (such as chemical industries) so that CO2 captured from CCS and CO2-emitting industries can be utilized to synthesize synthetic fuel gases with H2 produced offshore and H2 can further contribute to their decarbonization (this is a Priority Thematic Area of the TEN-E regulation).

Fully implement the TEN-E regulation:

Art. 14 of TEN-E regulation on offshore grid planning states that the high-level strategic integrated offshore network development plans shall provide a high-level outlook on offshore generation capacities potential and resulting offshore grid needs, including the potential needs for interconnectors, hybrid projects, radial connections, reinforcements, and hydrogen infrastructure. Hence hydrogen pipeline infrastructure is explicitly included in the TEN-E regulation as an infrastructure (offshore pipelines – not HVDC connected to ELYs) and as such should be fully included in the next ONDP.

In Art. 14 (2), when ENNOH is finally implemented, this body should participate on the modelling and design of the ONDP, the same way ENSTO-G also collaborates with ENTSO-E for the TYNDP.

Indeed, in the TEN-E regulation, Hydrogen is mentioned in the North Sea, BEMIP, SW, and SE offshore grid corridors planning describing that their offshore electricity grid development, should include: “integrated offshore electricity, as well as, where appropriate, hydrogen grid development and the related interconnectors to transport electricity or, where appropriate, hydrogen from renewable offshore energy sources to centers of consumption and storage or to increase cross-border renewable energy exchange”.

Incorporate the Baltic Energy Market Interconnection Plan in hydrogen (BEMIP Hydrogen) in the ONDP planning as it is included as a priority hydrogen corridor in the TEN-E regulation (it's the only offshore corridor on the Hydrogen Priority Corridors):

BEMIP hydrogen corridor focuses on developing hydrogen infrastructure and repurposing existing gas networks to create a comprehensive hydrogen backbone. It connects Baltic Sea region countries, either directly or through third-country interconnections, catering to specific regional hydrogen infrastructure needs.
The Plan also aims to decrease energy isolation for islands and island systems by promoting innovative solutions involving at least two Member States, significantly impacting the sustainability of island and Union-wide energy systems.

Comment: Thank you for your comments.

Organisation: WindEurope

Question: In your view, are the methodology and modeling process of the ONDP satisfactory and would you like to propose improvements for next cycles? - Specify

Answer: WindEurope welcomes the first version of the Offshore Network Development Plans 2024. Joint offshore infrastructure planning at sea basin level is crucial for the fast deployment of the offshore wind energy that Europe needs. The ONDP 2024 is a good first version but we would like to highlight several areas for improvement for the next versions.

Please find our feedback on the first version of the ONDPs and recommendations for the future cycles regarding four areas of interest.

i. Using the potential of cross-border synergies

The ONDPs' objective is to pave the way towards an integrated onshore-offshore system planning and a new component of the TYNDP focused on needs for offshore transmission infrastructure. It translates the EU Member states' non-binding agreements on offshore goals into offshore transmission corridors for each sea basin.

The bottom-up approach applied in this first version seems to be over relying on national targets and plans without fostering synergies and coordination among countries at sea basin level. Even though this is a fair approach for the first ONDP version, in the next cycles it can lead to mismatches between countries' renewable energy potentials and their actual demands. It also cannot enable the potential of collaboration among nations limiting the ones with limited offshore energy resources to restrict development or to overexploiting them while others cannot share their surplus. As a result, this bottom-up approach will probably fail to identify optimal projects and grid configurations across Europe.

Moreover, a lack of holistic planning inhibits the confident expansion of all value chain components necessary for meeting Europe's offshore wind targets. Accelerating installation rates to ~20 GW annually over two decades demands a fundamental transformation of manufacturing, project development, and investment, estimated to be over €100 billion by 2040. Without clear market signals and reliable planning, investor confidence will waver and slow down the essential supply chain growth that is needed.

To create clear market signals the methodology will need to prioritise maximising benefits for Europe as a whole. ENTSO-E and ENTSO-G, under the TEN-E regulation, are tasked with envisioning an optimal energy system aligning with the communicated offshore renewable energy targets of individual Member States. This mandate includes educating decision-makers about the benefits of a coordinated sea basin approach and why this is essential.

A coordinated approach would indicate the best offshore RES locations considering national targets and plans as an input but also aspiring to optimise these national plans and create a feedback loop towards national authorities. It would also prioritize efficient hybrid systems and connect underutilized offshore wind capacity to high-demand regions ensuring a minimal cost path towards climate neutrality.

There is a strong case for improving the existing approach and creating a level-playing field for interconnector projects. The 2024 ONDPs highlight nearly 80 GW of hybrid interconnector projects in the North Sea region, likely a conservative estimate. Traditionally, interconnectors between countries are negotiated bilaterally, based on projects generating sufficient Socio-Economic Welfare (SEW) for both parties. However, projects failing to meet SEW requirements, despite potential benefits across Europe, often stall.

While EU funding like the CEF can help, the inability to compel non-promoting countries to contribute is a significant hurdle and can impede progress on projects of Common European interest. Hybrid interconnectors combining transmission and generation functions present additional complexities in risk allocation and differing perspectives among countries with surplus or deficit renewable energy potential. To remove such barriers and create awareness about the shared benefits Europe will need a revised strategy.

Coastal nations within a specific sea basin should enhance cooperation, moving beyond project-by-project negotiations. Collaborating on common goals at a structural level is essential. Shifting focus to the entire sea basin and considering projects collectively rather than individually reduces the complexity of the often project-by -project negotiations. This approach spreads benefits more evenly, allowing countries to agree on projects that may not directly benefit them in exchange for future gains. Additionally, streamlining administrative processes accelerates project processing, approval, and development, facilitating smoother implementation of joint endeavors.

The integration of the ONDP into the TYNDP processes should take the above into account when identifying needs and translating this into planning and selection of the infrastructure projects that answer those needs.

ii. Assumptions and inputs for system integration

Our first recommendation is that the ONDPs (and the TYNDP overall) should be considering the state of play of national network expansion and reinforcements. Additional grid reinforcement, expansion or optimisation or other infrastructure will be needed at national level to integrate the offshore infrastructure and distribute the energy to end users whether this will be with offshore hybrids or radial connections or as offshore renewable hydrogen.

Integration and distribution considerations will need to be made already in the offshore infrastructure capacity calculations (“corridors”) and not only at the stage of selecting final projects. For this ENTSO-E and ENTSO-G will need to work closely together with TSOs and national authorities, not only of member states but also the UK and Norway. It is crucial to establish a feedback loop between the ONDP/TYNDP decisions and the additional infrastructure needs that these will bring at national level and will need to be handled by authorities at national level.

Overall ONDPs and TYNDP should not make project recommendations without broader system integration considerations. Deciding about offshore infrastructure capacities and integration options for offshore wind only based on the technology cost of the energy carrier being transported from offshore point A to offshore point B is not adequate and can be misleading.
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For instance, space availability and the possibility for landing points will also need to be considered. Or whether additional infrastructure investments will be needed to further distribute the transmitted energy - as electricity or hydrogen in the future - and whether these additional infrastructure investments will be feasible at national level economically and politically wise. Getting such input data is only possible by means of a direct exchange between the ENTSOs and national regulatory authorities and not only TSOs who might not have direct access to all necessary information. All relevant constraints and costs need to be considered additionally to the CAPEX and OPEX of the transmitting technology.

A concrete example is the choice between the radial and the hybrid connections. It is understandable that this first version of the ONDPs only considered hybrid options that are currently under mature discussion at national and bilateral level or already in the PCI list. However, the low share of hybrid capacities is also due to the modelling set-up that considers radial connections as the starting point.

In the next versions a more forward-looking approach will be needed considering all factors that can affect decisions at national level. This modelling set-up will need to allow for "green-field hybrid project" where the radial connections are not a given and where hubs and islands can be planned from scratch. This is more realistic and reflects how TSOs can make plans for the grid connection of most offshore wind capacity still to be built.

The ONDP should strive to align the planning of offshore grids with the timings of the offshore generation planning. Once a wind farm or cluster of wind farms are close to a final investment decision, its grid integration configuration cannot change or be re-planned based on the ONDP/TYNDP outcome. The pricing of the wind farm and of its generated energy and the agreement it has reached on a potential Contract for Difference or Power Purchase Agreement or other finance option will most probably become irrelevant if its grid integration mode will change.

Even if in certain cases radially connected wind farms could be technically adjusted to connect to an offshore hybrid, economically wise this will not happen in most cases because the investment will not be the same. For this reason, ENTSO-E and ENTSO-G will need to work very closely with national authorities and TSOs and have clarity on the planned auctions not only for member states but also for the UK and Norway. The same level of consideration should be given to the specific auction design and which offshore wind capacities can be realistically considered as radial or hybrid-connected options. This information will need to be handled as an input to the ONDP simulation.

Another example is renewable hydrogen from offshore wind. This could be considered as a third integration option for offshore wind energy further to radially or hybrid fully electrically connected wind farms. However, adding this option would require - as all other integration options - careful consideration of all cost factors and constraints including technology readiness and space constraints or additional costs for infrastructure development or reinforcement that will be needed onshore.

To our knowledge the current maximum electrolyser capacities are too small (50MW potentially up to 100MW for offshore and 100MW up to 200MW for onshore) compared to the average capacity of offshore wind farms currently under construction or under permitting (for instance 0,85 -1,2GW in the North Sea). If this option will be modelled in the next ONDP version, it will be necessary to consider realistic configurations based on feedback from relevant stakeholders such as asset developers and electrolyser manufacturers.

The transportation of hydrogen via pipelines is an issue that remains unresolved. The ENTSOs utilize a modelling tool called PLEXOS which employs a simplified model for pipeline transport akin to that of electricity. This model assumes that hydrogen can instantaneously reach its destination at the time of production. However, in real life, hydrogen or any gas transportation through pipelines takes time differing substantially from the instantaneous model. This simplification impacts the accuracy of the results and might give misleading results regarding the investments needed for pipeline infrastructure and storage solutions. This issue is not exclusive to offshore scenarios but also pertains to onshore pipeline systems.

iii. Modelling

The model used by ENTSO-E assigns one model zone per country. This configuration typically accommodates a maximum of 2-3 offshore nodes per country that inherently constraints the potential for a more meshed network. Moreover, each country is limited to a single onshore landing node. For instance, even if Germany has two offshore nodes, they would both link to a single onshore node.

This setup favours radial connections but also represents a significant challenge in the context of long-term capacity expansion planning. The model needs a higher resolution. Given the size of the problem and substantial number of involved decision variables, these models require extensive computational resources. The complexity necessitates a

compromise in model granularity, either through reducing the number of zones or by adjusting temporal resolution for instance by omitting certain hours, days, or weeks.

Another critical limitation of linear capacity expansion models is the absence of load flow calculation particularly when utilizing AC technologies. Validating investments through load flow simulation would be advantageous. In a system increasingly reliant on inverter-based resources, conducting dynamic/fault analyses using aggregated models would also be insightful.

iv. Assumptions and inputs for technology

The development and optimisation of grid integration technologies for offshore wind and of HVDC technology is evolving very quickly and can change significantly between the upcoming ONDP cycles. Here is some feedback regarding technology assumptions in this first version:

- AC cable costs: the assumed costs are too low compared to the ones awarded in projects in Europe in 2023 or the ones considered by ACER in its relevant cost catalogue from 2023. This can impact significantly the simulation favoriting AC connections based on misleading assumptions.

- HVDC converter costs: the assumed costs are lower than the average in recently awarded projects in Europe. Newest trends also show that these costs will increase but this is very challenging to estimate with precision.

- The considered maximum rating of 2GW (bipole) for HVDC is probably too conservative for the future developments beyond 2030. It is anticipated that higher voltages, such as 640 kV and possibly beyond, will be introduced, along with advancements like floating wind and subsea substations. These should be considered in scenarios that account for significant technological progress.

- Offshore AC platform costs: the assumed average costs are too high

- Example of a hybrid configuration without DC breakers:
o (Figure 12): it is not clear how the costs have been calculated. The topology suggested in Figure 12 can lead to high costs for additional converters which might not be needed

- the simulation does not adequately consider technologies that can be in several cases used alternatively to DC breakers. In desktop studies and simulations it is evident that the DC-DC converters mitigate the DC fault propagation in the DC grid and limit the use of DC breakers
- the simulation does not consider technologies that could optimise the electrical design and costs of the connection: further to DC-DC converters neither superconducting subsea cables nor hybrid full-bridge HVDC converters or superconducting fault current limiters have been considered.

Technology CAPEX is a particularly sensitive area. In long-term scenarios it is very challenging to predict costs while considering macro-economic aspects that can have substantial impact. A pragmatic approach could be to conduct thorough sensitivity analysis to examine the effects of changing technology costs, either across the board or selectively, on preferred solutions.

Our recommendation for action is that ENTSO-E and ENTSO-G involve technology suppliers and asset developers much deeper in the discussion about system integration options and technology options and costs. This involvement will not be sufficient if it limits only to the public consultations but requires much more regular exchanges so that the model assumptions remain up to date for each cycle.

Comment: Thank you for the good and comprehensive feedback. ENTSO-E acknowledges the added value of cross border coordination. However, in the ONDP we had to stay first aligned with the national targets. Taken that into consideration we decided to go along with the bottom up approach. In future editions we plan to further utilize spatial planning tools where more information about the space availability and more precise landing points.

However, as ONDP does not focus on single projects, the exact location of onshore substation only has a minor influence on the final results. The ONDP2024 considered in both timeframes an increase transfer capacity for the onshore grid, coming out of the results of the DE Scenarios, whose reference grid is built starting from the know projects at national level. The Scenarios transfer capacities, even though not refined as the ones coming out of the IoSN, are the result of an initial expansion aimed at dispatching the generation capacities considered in the Scenarios themselves. Is not the target of the ONDP and the TYNDP in general to make projects recommendations. The high level objective of the studies is to outline the needs in terms of transmission capacity (also considering flexibility assets) that are necessary to pursue a certain policy target. For this reason ENTSO-E develops the TYNDP thinking about what promoters would need to in terms of info to arrive at an investment decision. The ONDP2024 has been the first product of the TYNDP that considered actively the spatial planning information (whenever available) to better refine the energy models used. We strongly believe that enhanced consideration of the spatial data and more detailed information on landing points will be a crucial improvement of the next editions of the ONDP. We agree that the methodology for the modulization of hybrid infrastructure should improve in order to increase the accuracy of the results. If this first edition tried to capture a "screenshot" of the system in 2040 and 2050, looking at the evolution from radial to hybrid configuration, the focus of the next edition should be assessment of the configuration considering the optimal combination of radial, hybrid and interconnectors.

ENTSO-E already developed a pilot methodology, as an R&D activity in the framework of he TYNDP 2022, to explore the potential higher benefits of hybrid solutions compared to single purpose solutions such as direct interconnectors and a separate offshore RES connection. This was done in order to complement the project-based expansion performed in the IoSN. The future editions of the ONDP will combine the flexibility of the ONDP 2024 modelling methodology with the robustness of the IoSN methodology, in order to arrive at an integrated and high quality modelling approach, individuating a fully optimized combination of needs. We fully agree that the ONDP should not endanger any investment decision already taken by developers. In order to ensure that, ENTSO-e applies a bottom up approach when building their models for the expansion studies, ensuring that all the project initiatives that are mature are duly included in our starting and reference grids. In addition to the above, when modelling the connection capacities in our models, ENTSO-e breaks down the generation numbers into granular quantities reflecting the windfarms that are deployed or that are going to be deployed as a results of an auction. Already in the ONDP2024 ENTSO-e observed the impact that H2 can have in the integration of the offshore RES potential of the European sea basins. The North Sea report include the details of how much more energy can be integrated by the 34 GW of electrolysers individuated via the Scenarios 2022. However, we are aware that the analysis of sector integration should move toward the identification of the infrastructural needs concerning offshore H2. The ONDP 2026 will progress to also implement this aspect of the mandate. This of course will be done through the consideration of, not only concrete plans by the MS, but also robust and mature data on the technical solutions to realize these plans.

The model used to develop the ONDP 2024 was the result of a compromise between granularity and speed/flexibility of the simulations. Usually, ENTSO-E investigate system through the use of zonal models and multi year simulations in order to capture not only the necessary geographical level of detail but also the evolution of the system from the starting point up to the target year. It is indeed to extend this modelling approach to the next edition of the ONDP, allowing the evaluation of the landing areas and improving the accuracy of the expansion model when assessing the benefits of the hybrid infrastructure.

We are aware that since the definition of the ONDP costs, the overall infrastructure market suffered a spike in prices that should be reflected in the future studies. ENTSO-E is committed also to improve the collaboration with ACER in order to align on the costs considered and with the ACER cost catalogue. We considered 3 different cost set exactly trying to capture the uncertainty affecting the infrastructure market.

As of today we don't see any mature data on converters whose capacity will go over the 2 GW. In addition to this, to consider higher capacities, would have implications also in terms of operational challenges, as the size of the clusters would come closer to the reference incident of 3 GW. As of today there are no operational means to face incidents higher than the reference value. For this reason we stand by the choice of the 2 GW standard size. However, at the

beginning of each cycle we will reassess the relevant technological assumptions to make sure that the ONDP will remain well rooted in the data driven evidence provided by developers and manufacturers.

The sensitivity-based approach of the ONDP 2024 is for us a good way forward to cope with the uncertainty of the future framework. The intent is to try to keep this approach while improving the models, limiting as much as possible the increase in simulation times, in order to keep the development flexible.

A flexible will also favour a more extended consultation process, not only at the end of the development process, but also during it.

Question: Open comments - Please use this field for any other comments on ONDP 2024 – Specify

Answer: Our high-level recommendations are:

- ONDPs need to move away from the bottom-up approach that over relies on national plans and targets. They will need to promote projects that maximise renewable energy and system integration at sea basin level. And not just put together national plans in a joint one without substantial optimisation;

- ENTSO-E will need to develop the ONDPs in direct exchange not only with TSOs but also with NRAs, asset developers and technology suppliers. This is the most efficient way to get up to date and realistic information about all relevant costs and system integration constraints e.g. scheduled auctions at national level and their design, landing points space constraints, state of play of national grid development, feasibility of grid investments that will be needed for the offshore integration and will be handled at national level;

- ENTSOs will also need to create a feedback loop from the ONDP and TYNDP towards national network development plans. The latter will need to integrate extra needs to support the cross-border infrastructure plans;

- The ONDP modelling tool should not consider radial connections as the starting point neither favor these which is the case as it stands. It should equally consider radial and hybrid connections as potential starting points and realistically assess their benefits and constraints.

- Renewable hydrogen production from offshore wind can be considered in the future as a third system integration option. But the transport of hydrogen via pipelines is still technologically unresolved and not realistically modelled in the ENTSOs models and the maximum size of commercial electrolysers – onshore or offshore - is much lower than average offshore wind farms under construction and permitting.

- Deciding infrastructure capacity only based on the technology CAPEX and OPEX to transmit energy from point A to point B can be misleading. System integration costs and additional infrastructure needs at the integration points need to considered from the start e.g. grid reinforcements, additional hydrogen distribution network;
Please find more detailed feedback in our answer No4.

Comment: Thank you for your feedback.