ENTSO-E Position on Offshore Development

25 May 2020

entsoe

About ENTSO-E

ENTSO-E, the European Network of Transmission System Operators for Electricity, represents 42 electricity transmission system operators (TSOs) from 35 countries across Europe. ENTSO-E, which was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, aims to further liberalise the gas and electricity markets in the EU.

Table of Contents

Executive Summary

Evaluating the current and anticipated fundamental transition of the overall European energy system, ENTSO-E has identified five pillars for a successful offshore development, which is key to achieving the European carbon neutrality targets.

1. Holistic planning and timeliness

Holistic planning and coordinated development of on- and offshore transmission systems are needed to ensure timely development, low costs for end consumers, and electricity systems that are both technically sound and environmentally friendly. Applying their usual integrated perspective over time, space and sectors, **ENTSO-E and TSOs are prepared to play a full role in offshore and onshore system development and spatial planning contributions** — e. g. by performing techno-economic and environmental assessments in order to ensure efficient and secure operation of integrated onshore and offshore networks and to minimise costs, delays and adverse effects on the maritime environment.

2. A modular and stepwise approach based on consistent planning methods

Regarding pathways for offshore grid infrastructure, a modular and stepwise development, combining various technologies and grid designs – sufficiently flexible to take into account technology maturity and relevant time horizon – is necessary in order to achieve an integrated European maritime transmission network including pooled assets such as hybrid projects. **ENTSO-E and TSOs already provide a regularly updated and consistent planning support tool** — the TYNDP — and are ready to further explore synergies and savings through concrete project studies — e. g. within the North Seas Energy Cooperation (NSEC) countries or the Baltic Energy Market Interconnection Plan (BEMIP).

3. Interoperability unlocking smarter integrated and secure system operations

With an increasing share of variable generation, a one system view both off- and onshore is essential to preserve required security margins in the system while enhancing smart solutions. **ENTSO-E and TSOs will continue carrying out fundamental system engineering studies and standardisation** to achieve vendor interoperability of offshore HVDC systems.

4. Keeping energy bills and environmental footprint low through innovation

Several **innovative cost- and environmental footprint-reduction measures** have already been identified (e. g. standardisations, hubs, hybrid projects, multi-use platforms) and implemented by TSOs. Further solutions and cooperations will be developed in order to meet common climate targets and reduce costs.

5. A future-proof regulatory framework

In order to facilitate the implementation of the abovementioned pillars, ENTSO-E makes the following calls on policymakers:

- Application of **consistent unbundling rules** for on- and offshore systems in order to ensure neutrality, non-discrimination, fair competition and security of supply.
- Regulatory frameworks of different member states should **incentivise forward-looking and anticipatory investments** and must be made compatible with each other.
- **Governments should ensure confidence** in market- and system-operation setups in order to provide a robust framework and financial security for investors. Allocation of responsibility for grid development and operation to TSOs is consistent with a holistic and 'one-system' approach, and provides visibility to investors.
- **Regarding hybrid projects,** flexible rules concerning the contribution by each member state to European climate targets should be developed. The concept of offshore bidding zones may be a promising solution as it could facilitate efficient integration into the electricity market of offshore generation connected to two or more bidding zones, also if connected as a hybrid project under current regulatory and legal framework.

This position paper, which contains the basic pillars to address key challenges, will be followed in the upcoming months by further publications.


elia

ENTSO-E Position on Offshore Development

The European energy system is currently undergoing an unprecedented transition supporting the fulfilment of the European Energy Targets, the EU Energy Union and European Green Deal. One of the key elements of the European targets is to decarbonise the power sector by 2040 while also electrifying other sectors to a great extent, thereby triggering a massive increase in electricity consumption[1], with estimates of a doubling by 2050. Generation and consumption patterns evolve, while decentralisation and digitalisation change the flows between different voltage levels.

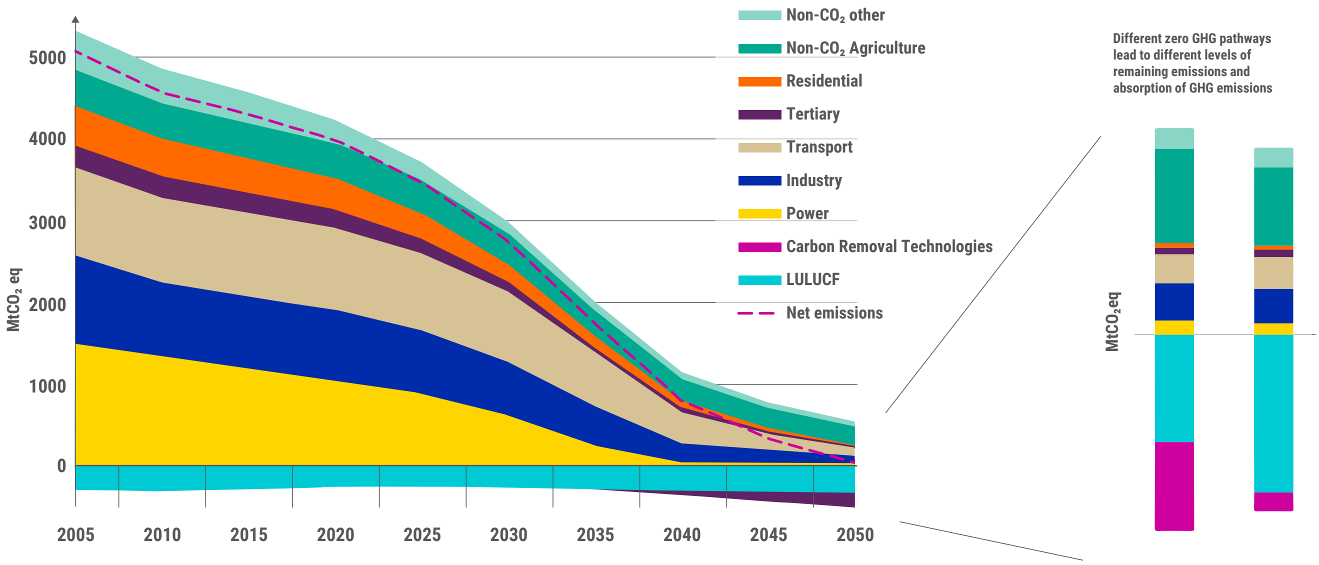


Figure 1 GHG emissions trajectory in a 1.5 degree C scenario

A complete remake of the European electricity production is underway. Nuclear and fossil fuel-based electricity production has already been partially replaced by other primary energy sources and/or different power plant types, which can also be installed in other locations. A massive increase of electricity production from variable RES already began some decades ago, but needs to further accelerate in order to achieve the carbon neutrality targets. Offshore wind generation will play a major role in decades to come, as it has high availability rates and higher public acceptance than onshore wind, together with a substantial utilisation potential across Europe.

All the above-mentioned changes and trends have a direct impact on the transmission infrastructure that must, in turn, evolve simultaneously. Offshore development is but one of multiple aspects necessary to consider when developing future energy systems.

In order to contribute to the debate on reaching the European Green Deal objectives on sustainable green transition and cutting emissions, this document provides an ENTSO-E perspective on the strategies and approaches for integrating offshore wind and other offshore RES generation into the European Energy System.

1 EC, EP, European Council et al.: A clean planet for all, November 2018, COM 2018 (773), 2018.

1. Opportunities and Challenges

Today, 22.1 GW of offshore wind capacity is installed in European waters[2]; 2030 estimates reach 100 GW, while 2050 estimates vary between 230 GW – 380 GW[3] (EC) and 450 GW (WindEurope[4]).The ENTSOs' bottom-up scenarios based on the NECPs foresee 78 GW – 131 GW in 2030 and 2040 respectively[5]. Offshore wind is abundant, has the potential for high-capacity factors in numerous areas, and enjoys falling cost-curves. Thus, it is an attractive contributor to the European Green Deal. However, time pressure is high, as not providing the offshore wind generation and necessary infrastructure will lead to missing the decarbonisation targets of the European Green Deal.

It is obvious that unprecedented grid and spatial[6] planning, engineering, construction and financing efforts are required offshore to facilitate the large scale roll-out of offshore wind and other offshore RES, considering that:

- **i) depending on technology and distance, the expected average connection cost of offshore wind to the onshore transmission system is significant7 and will increase in time, as**
- **ii) the distance to shore is expected to further increase, since available nearshore areas have already been developed;**
- **iii) lead time for offshore generation is shorter than for infrastructure, and**
- **iv) space for offshore wind generation and cable routing to shore is limited due to the necessity to preserve maritime biodiversity and uses.**

The same is valid onshore, as electricity must be further transported to the consumer in a consistent way with offshore grid developments. Onshore grids were developed step by step over nearly a century. Now, the offshore transmission infrastructure and related onshore connections and reinforcements need to be built in only a few decades. This requires holistic planning of concepts and infrastructure-building.

2 WindEurope: Offshore wind in Europe – key trends and statistics 2019, Feb 2020
3 EC: In-Depth Analysis in support of the Commission Communication COM (2018) 773 'A clean planet for all, November 2018, p77
4 WindEurope: Our energy, our future, November 2019
5 See 2020 scenarios and data: https://tyndp.entsoe.eu/scenarios
6 EU Directive on Maritime Spatial Planning (2014/89/EU). All coastal EU MSs have to prepare cross-sectorial maritime spatial plans by 2021
7 Navigant: Connecting Offshore Wind Farms – July 2019

The large-scale roll-out of offshore wind does not come without challenges. ENTSO-E identifies six key challenges:

- **Costs:** Massive investments must be made for offshore wind power generation as well as for off- and onshore transmission infrastructure. Both the distance-to-shore from the offshore generators and onshore corridors for the grid connection system will increase over time. For these necessary investments, financial security is needed and stranded investments must be avoided.

- **Spatial planning:** Up to 450 GW of offshore wind capacity will have to be allocated, and the space available for cable routing and landing points as well as onshore networks is expected to become scarcer. Coordinated maritime and onshore spatial planning is needed.

- **Integrated perspective over time, space (land & sea) and sectors:** the main load centres, industry and large cities are often far away from offshore generation. The solutions for integrated development and operation of the offshore and onshore transmission grids and solutions for market design must ensure overall affordability, sustainability, security, timeliness and reliability of power supplies.

- **System balancing:** a massive share of variable RES with a locally high degree of simultaneous generation patterns causes high ramps at onshore connection points calling continuously for more advanced flexibility products in balancing markets to satisfy operational flexibility — e.g. ancillary services. This operational flexibility can be provided by other sectors as well. Thus, while a high share of offshore wind unlocks the potential to decarbonise other sectors on the one hand, these sectors are, on the other hand, able to deliver important services to the electricity sector. A global system view is needed to organise this properly. An efficient market design must ensure maximum alignment of physical reality and markets.

- **System security:** very high shares of variable renewables can, depending on the system, have adverse effects on frequency stability, voltage stability, admissible line loading and voltage profiles. This is already seen in small isolated systems today, but can be expected in larger areas in the next decades as well, if the evolution of the system is not carefully planned. Systems and technical requirements need to be prepared in due time.

- **Environmental protection and public acceptance:** The relevance of actions that will minimise the environmental footprint of offshore grid infrastructure and facilitate public acceptance is increasing as opposition to offshore and onshore wind generation and transmission systems grows in many countries.

Below, perspectives for addressing the above challenges are presented, ensuring efficient development and integration of offshore and onshore energy systems and achieving the objectives of the European Green Deal.

2. ENTSO-E's view of basic pillars on offshore developments

In order to grasp the opportunities and tackle the challenges listed in the previous section, ENTSO-E identifies in this initial document six basic pillars on successful offshore development supporting offshore wind integration in electricity systems over time, space and sectors, promoting system security, cost efficiency and the ambitions of the European Green Deal.

2.1 Holistic planning and timeliness

Electricity generated by offshore wind and other offshore RES has to be connected to the onshore transmission grids that will transport the energy further to the load centres. Today's transmission grids thus need to be extended with offshore grid infrastructures to which the offshore generators can connect. Off- and onshore systems need a coordinated development. At an early stage, careful planning is needed to keep the overall costs of on- and offshore development as low as possible and to create technically sound, environmentally friendly, and efficient future electricity supply systems in the interest of society. A holistic perspective is essential.

TSOs have the responsibility to ensure that combined networks across land and sea are developed, built and operated in a secure, cost efficient and sustainable way. Their responsibility covers the application of a long-term global system view comprising the complete generation portfolio (rather than one generation type only) and considering technology developments, while also planning and coordinating across borders.

ENTSO-E already covers both the on- and offshore transmission infrastructure in the TYNDP, and offshore grid infrastructure planning will continue to be an integral part of future TYNDPs. Unprecedented grid and spatial planning[8], engineering, construction and financing efforts will be required in the years to come. ENTSO-E and TSOs are ready to step up their role in these areas — e.g. by higher engagement in offshore spatial planning contributing with techno-economic analyses of proposed variants. Wind generation potential, associated transmission needs, and spatial constraints should be assessed jointly by policy makers, authorities, NGOs, project developers, and TSOs to achieve a joint view on the offshore wind potential and how to integrate it. Where relevant, this should include regional joint assessments across borders. This joint view could serve as a basis to develop holistic spatial offshore development plans, including offshore wind potential and transmission infrastructure, aimed to minimise costs and negative effects on the maritime environment.

8 EU Directive on Maritime Spatial Planning (2014/89/EU)

2.2 Combination of technologies and designs

As stated in earlier ENTSO-E investigations on offshore grid infrastructure[9], ENTSO-E expects that the complexity of the offshore system requires – dependent on technology maturity and time horizon – a combination of various technical solutions in order to ensure overall system efficiency. The grid developments of the Northern Seas may serve as an example. In these waters, the use of various technologies (AC and DC) and of various designs developing in parallel is expected:

i. point-to-point interconnections between member states,

ii. radial connections between offshore wind power plants and the onshore systems,

iii. radial connections of several wind power plants to hubs that are radially connected to the onshore system

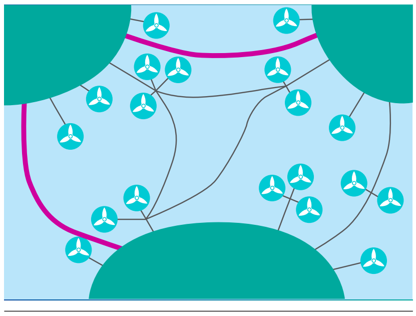
iv. hybrid projects (combination of offshore wind connections
and interconnections), and

v. multiterminal offshore hubs connecting multiple platforms
and member states (with or without offshore wind being connected)

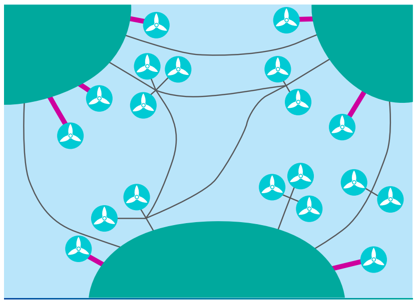
Designs iii) through v) can also comprise solutions including other forms of energy (i.e. energy hubs including sector coupling solutions).

The above designs can also be understood as development stages: real examples for stages i) through iv) do exist already, while examples for stage v) multi-terminal offshore hubs do not exist yet.

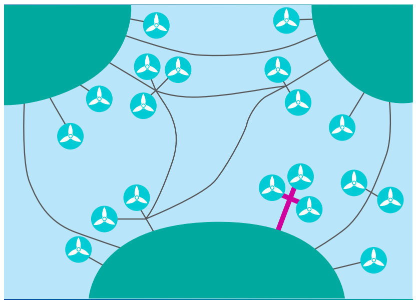
Even first smart-sector integration visionary projects are under consideration, including links to P2X plants, thereby linking different energy sectors. This can generally evolve on- and offshore. In the future, a multi-sectorial planning approach could be considered to facilitate optimal exploitation of offshore energy, essentially allowing it to flow into the sector where it provides the most value.



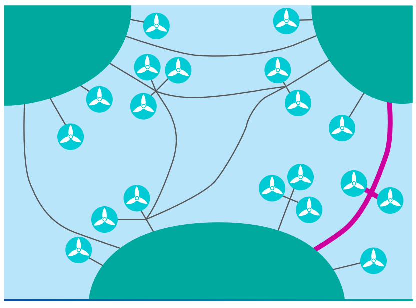
i) Point-to-point IC



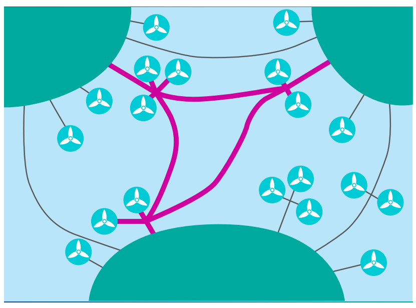
ii) Radial offshore park-to-shore



iii) Radial hub-to-shore



iv) Hybrid project



v) Multi-terminal offshore hubs

c.f. NSCOGI study 2012

9 Studies and initiatives are summarised in ENTSO-E's TYNDP 2018; Regional Group Northern Seas Regional Investment Plan 2017 (RGNS RegIP17) and Northern Seas Offshore Grid (NSOG) Report 2018

2.3 Realisation of synergies with a modular, stepwise approach and consistent planning methods

ENTSO-E expects a modular and stepwise offshore development, with choices being made for each project based on technical, environmental and economic parameters for the project at hand. However, beside this organic growth, decisions always include a long-term system view as well, and are therefore to some extent influenced by assumptions about the developments of the overall system. ENTSO-E provides a regularly updated planning support tool — the TYNDP— giving an overview of infrastructure developments and projects for a long-term time horizon. ENTSO-E takes care that these tools also support infrastructure planning in relation to offshore grid developments.

Compact hybrid offshore projects can be envisaged in cases where the scheduling and technology required for interconnection and wind connection align. Cooperation among all stakeholders of all countries involved is essential in these cases.

Early analysis of offshore development from both ENTSO-E (2011) and North Seas Countries' Offshore Grid Initiative (NSCOGI – 2012, served by ENTSO-E), identified theoretical synergies and savings from coordination appearing for offshore wind capacity levels beyond 60-80 GW for the Northern Seas. TSOs, member states and regulators are exploring such synergies and savings further through concrete project studies within the North Seas Countries' Energy Cooperation (NSCOGI's successor organisation).

Synergies from coordinated infrastructure development in general (not offshore only) are confirmed in each TYNDP. This joint TSOs' planning instrument promotes consistent planning methods across borders as well, which is important when planning large offshore infrastructure projects.

2.4 Interoperability unlocking smarter integrated system operations

The offshore development and simultaneous change in the onshore electricity generation portfolio already challenges system stability in some countries today as flows and operational patterns change. These phenomena are expected to spread across larger areas. System operation (onshore and offshore) must be integrated and optimized as one system, applying similar methodologies and approaches.

The "one-system" approach is a prerequisite for secure and long-term cost-efficient system operation. The approach helps to identify the needs and realise the potential for system flexibility, in order to manage variability of RES generation and of loads. Such an integrated perspective promotes the development of smarter, integrated system operations. Smarter and more integrated system operation is needed to achieve the European Green Deal while guaranteeing the required security margins in the system.

To unlock these benefits and to guarantee a stable system with a high reliability level and an acceptable risk level, fundamental system engineering studies are necessary, which must be led by TSOs as they are responsible for system stability. These studies will require data from offshore wind project developers and suppliers of electrical infrastructure to promote interoperability of sub-systems. Typically, these data are not shared between developers and asset-suppliers due to intellectual property rights concerns. TSOs, however, can serve as a neutral entity to facilitate such studies.

A general important prerequisite for offshore grid development is interoperability of offshore HVDC systems from different vendors — that is, technology vendors must ensure to deliver compatible modular systems. This is important to avoid lock-in effects. TSOs will further trigger this development by standardisation, which will incentivise vendors to strive for interoperability. It is expected that this will not appear automatically.

2.5 Cost reduction and innovation

Grid connection and reinforcement is a major component of the overall cost of offshore wind power, and this share is expected to grow as wind farms will be established farther off the coast and consumption centres over time. Optimising grid connection costs is, therefore, an essential condition to keep energy bills low. Several innovative cost-reduction measures have already been identified and implemented by the TSOs, and further innovations are needed.

Standardisation

Standardisation across a given portfolio of projects is an essential factor of cost reduction. The following are examples of evolved standardisation:

i. Transmission capacity, such as:
   a. 700 MW (AC),
   b. 900 MW – 2,000 MW (DC).

ii. OWF connection voltages, such as:
   a. inter-array voltages stabilised to 66 kV,
   b. the connection-to-shore in AC stabilised to 220 kV,
   c. the connection-to-shore in DC stabilised to 320 kV or 525 kV.

Innovative grid solutions

For the purpose of cost saving and reduction of environmental impact, grid solutions have also evolved over time. Examples are the development of:

i. radial offshore hub solutions — i.e. wind park clusters with radial connections to the onshore system,

ii. hybrid projects — e.g. the Krieger's Flak Combined Grid Solution.

Future developments, such as multi-terminal systems, are expected to provide further cost, environmental and operational benefits. New innovations and cooperations will be needed in order to accommodate large volumes of offshore RES, particularly for cable technology.

Multi-use platforms

The development and operation of maritime infrastructure exert environmental pressure on the oceans and influence maritime ecosystems. Offshore platforms that combine multiple functions (environmental monitoring, connections of test sites, maritime culture, etc.) within the same infrastructure can offer significant benefits in terms of economics, optimised spatial planning, and reduced impact on the environment.

2.6 Development of proper regulation

Regulatory measures are required both at an overall level and at the project level. In general, ENTSO-E expects the existing energy market regulation to work offshore as well as onshore. The overall system must be treated as one integrated system. For this to happen, the following issues should be addressed:

Unbundling:

Consistent unbundling rules for both the on- and offshore systems ensure neutrality, non-discrimination, fair competition and security of supply. ENTSO-E strongly recommends application of the same rules on- and offshore.

Equal opportunities, anticipatory investments:

All investors in offshore development should face the same conditions and should be treated equally, ideally across country borders to ensure efficient offshore development. The regulatory frameworks of different member states must be made compatible with each other and should incentivise forward-looking investments to deliver the most economic, efficient and reliable offshore transmission infrastructure from a sustainable and end-consumer perspective. Forward-looking investments might need anticipatory investments, which should therefore be facilitated by regulatory frameworks.

Roles and responsibilities

Roles and responsibilities of involved investors need to be clear. Offshore generation connection should follow the same principles that are valid onshore (non-discriminatory, cost-efficient, robust in the long term, system-compatible). Currently, responsibility varies between countries, but some studies[10], as well as TSOs' own investigations and recent developments[11], indicate that allocation to TSOs is the best way forward. Stranded investments, inefficient infrastructure development and discrimination must be avoided.

Cost efficiency and market integration:

In order to achieve the required investments, price signals, market integration (bidding zones) and support mechanisms must efficiently promote security of supply, cost efficiency and the targets of the European Green Deal. New offshore wind-power plants will be integrated in the existing EU electricity markets. The concept of offshore bidding zones may be a promising solution as it could facilitate efficient integration into the electricity market of offshore generation connected to two or more bidding zones, also if connected as a hybrid project under current regulatory and legal framework.

Financial risks:

Financing the investments of the offshore infrastructure will be challenging. High risks are key drivers of costs. Thus, adequate regulatory frameworks should help attract capital by providing a good balance between incentives and risks. The market setup should be known before investments are made, in order to provide a robust framework and financial security for investors who need to know if and how investments pay back. Insecurity endangers progress, which endangers reaching the climate targets.

Contribution to common climate targets:

In the case of hybrid projects, given the cross-border scope of the infrastructure in question, flexible rules should be developed concerning the contribution by each member state to European climate targets. Efforts to connect renewable generation should indeed be valued, based not only on generation location

10 Navigant Connecting Offshore Wind Farms – July 2019

11 https://renews.biz/57749/ofgem-to-probe-new-offshore-wind-connection-regime/

Way forward

ENTSO-E is prepared to contribute to offshore development and to be involved in upcoming debates about how this can best be organised. This position paper, which contains the basic pillars to address key challenges, will be followed in the upcoming months by further publications.

Picture credits:

page 6, 13 below: courtesy of Elia
page 9, 10, 13 middle: courtesy of TenneT
page 13 above: courtesy of 50Hertz

European Network of
Transmission System Operators
for Electricity