North Sea
Wind Power Hub

MODULAR HUB-AND-SPOKE CONCEPT TO FACILITATE LARGE SCALE OFFSHORE WIND

THE CHALLENGE

To meet the Paris Agreement climate goals on time, the accelerated deployment of large-scale offshore wind and its integration in the energy system needs international coordination, long term policy targets and a robust regulatory framework.

The Paris Agreement will transform the energy systems of the North Sea countries

The deployment of renewable energy sources needs to increase significantly to support the goal of net zero greenhouse gas emissions by 2050. At the same time energy end use needs to decarbonise. This will change both energy supply and demand patterns, requiring the energy system to become increasingly flexible to maintain security of supply everywhere and at all times.

Offshore wind capacity deployment rates in the North Sea need to more than double up to 2040

All energy scenarios consider offshore wind as a major renewable energy source in the future European energy system. Current national plans do not add up to the required 150 GW of offshore wind capacity in the North Sea by 2040. Installed capacity of offshore wind is currently 13 GW and the growth rate ~2 GW/year. A continuation of today's offshore wind deployment rate clearly is insufficient to realise the targets implied by the Paris Agreement. An average deployment rate up to 7 GW/year over the period 2023-2040 is required.

The integration of renewable energy requires cross-border and cross energy system coupling and a fit-for-purpose design

Nowadays, energy systems are planned, designed and operated in silos with a strong national focus. However, large-scale offshore wind production needs to be transported to deep inland locations, across country borders. The increased peak generation capacity of renewable energy sources will, at times, significantly exceed demand. The traditional solution of continuously reinforcing and extending the electricity grid is not sustainable from a cost and societal perspective. Successful integration of offshore wind and transmission to inland demand centres therefore requires cross energy coupling to other sectors (hydrogen, heat, etc.) to provide the required flexibility. Large scale roll-out of offshore wind farms in the North Sea requires an international approach to spatial planning to secure benefits of scale, reduce cost and increase deployment rates.

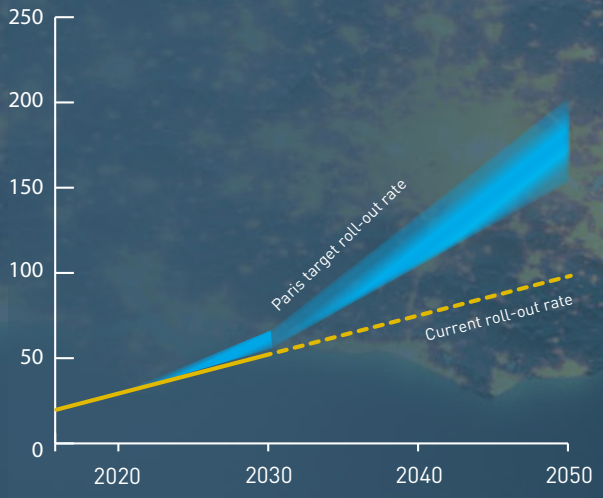
Current regulatory frameworks and market designs do not support an integrated energy system approach

The current regulatory framework and market design pose barriers to much needed solutions such as:

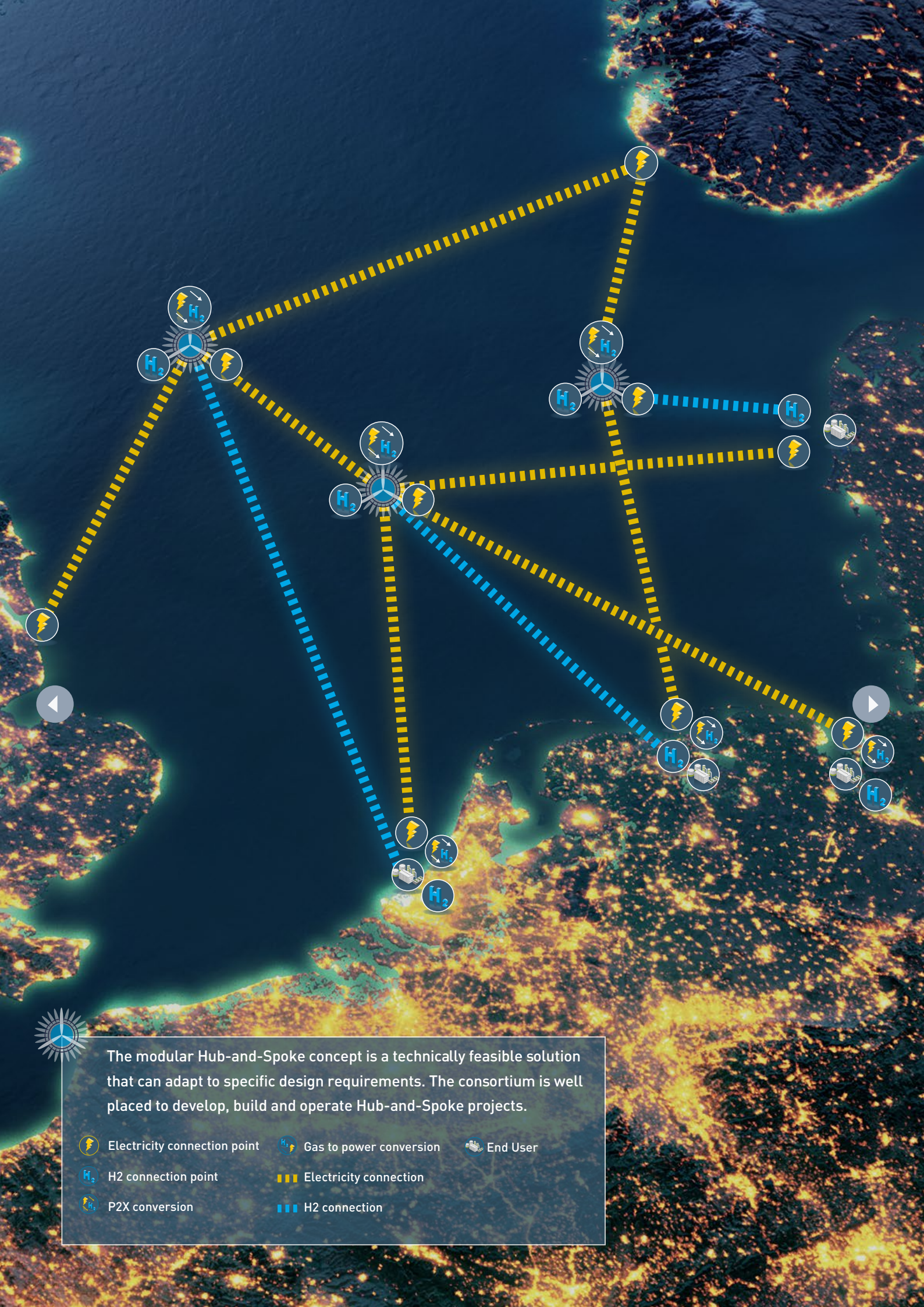
- combining offshore wind connection and cross border interconnection functionality,
- connecting offshore wind farms from one country to demand centres in another,
- cross energy sector coupling at scale,
- anticipatory investments in e.g. sector coupling infrastructure that ensure benefits, beyond project and sector boundaries, and throughout the energy transition.

These changes are urgent because of the long lead times of infrastructure projects

Lead times of large-scale energy infrastructure projects are typically 10 years or more. International coordination, long term policy targets and a robust regulatory framework and market design are urgently required to ensure a timely and cost-effective development of the required energy system to meet the Paris Agreement climate goals.



Current roll-out rate of offshore wind is insufficient to meet Paris target. *Projected installed offshore wind capacity range in the North Sea (GW)*


The modular Hub-and-Spoke concept is a technically feasible solution that can adapt to specific design requirements. The consortium is well placed to develop, build and operate Hub-and-Spoke projects.
Electricity connection point
Gas to power conversion
End User
H2 connection point
Electricity connection
P2X conversion
H2 connection

THE SOLUTION

The modular Hub-and-Spoke concept - developed by the North Sea Wind Power Hub consortium - is key to large-scale offshore wind energy deployment in the North Sea. Central to the vision is the construction of modular hubs in the North Sea with interconnectors to bordering North Sea countries and sector coupling through power-to-Hydrogen conversion.

An internationally coordinated roll-out of offshore wind energy, supported by one or more Hub-and-Spoke projects, is technically feasible, reduces system cost and provides long term security of supply.

The modular Hub-and-Spoke concept ensures a cost-effective and timely ramp-up of offshore wind energy

The step-by-step roll-out of the modular Hub-and-Spoke concept coordinates the international development of wind farm connections and interconnections to minimise the need for onshore grid reinforcements. This is a cost-effective way to transport offshore wind energy whilst securing energy supply, providing a robust market outlook and securing timely deployment. It is foreseen that the optimal Hub-and-Spoke project size is around 10-15 GW and a first project could be operational in the early 2030s.

The modular Hub-and-Spoke concept provides flexibility to adapt each project to location specific needs

A large-scale roll-out of offshore wind implies that multiple offshore wind clusters are required further offshore with varying physical conditions. Hub connections to shore can be optimised to maximise synergies with coastal and inland demand centres, by combining electricity and hydrogen conversion and transmission to shore. The modular Hub-and-Spoke concept allows for a step-by-step roll-out of projects. This enables the adaptation to specific local physical conditions and minimises environmental impact. The concept allows to balance benefits of scale against planning risks to facilitate the timely ramp up in offshore wind deployment.

Interconnections and sector coupling maximise offshore wind integration

The modular Hub-and-Spoke concept offers flexibility to integrate increasing shares of renewable energy through two main routes. Firstly, it increases interconnections between countries to distribute renewable energy and connect markets across the larger North Sea region. Secondly, it provides power-to-Hydrogen – or to other energy carriers (P2X) – facilities to enable sector coupling and maintain security of supply by addressing the mismatch between electricity peak generation and demand. Facilitation of local conversion capacity and (re-)using existing gas infrastructure offers seasonal flexibility (storage), and long-distance energy transmission (pipelines). This minimises the need for additional onshore electricity grid extensions and grid reinforcements after 2030, and provides valuable renewable gasses and fluids to end users like industry. Electricity conversion and transmission via pipelines may further relieve congestion in the electricity grid, reducing offshore wind curtailment.

The NSWPH consortium partners are well placed to develop, construct and operate Hub-and-Spoke projects

The NSWPH consortium partners include leading TSOs of North Sea countries, which take a long term and integrated perspective on the energy transition and are tasked to maintain security of supply. They are committed to developing the energy infrastructure for the future, acting out of a strongly felt social responsibility to enabling the energy transition and reaching the climate goals in time.

HOW TO GET THERE

Action is required by policy makers to define post 2030 renewable energy targets and adapt regulatory frameworks and market designs, to ensure that all stakeholders are properly incentivised throughout the energy transition.

Post 2030 renewable energy targets should be specified and internationally coordinated planning of the North Sea is needed

Renewable energy targets, including specific offshore wind targets, need to be in line with the ramp-up as implied by the Paris Agreement. These targets are required to provide industry with a secure market outlook that allows them to build up supply chains accordingly. In addition, as the North Sea is intensely used and of great environmental value, co-utilisation of space in the North Sea is required to accommodate the required offshore wind deployment. Fragmentation of wind areas should be avoided to ensure benefits of scale. A dialogue between North Sea stakeholders is required to agree on an approach that ensures meeting the overall climate targets, while minimising impact on other stakeholders.

Regulatory frameworks should be adapted to support integrated energy infrastructure development

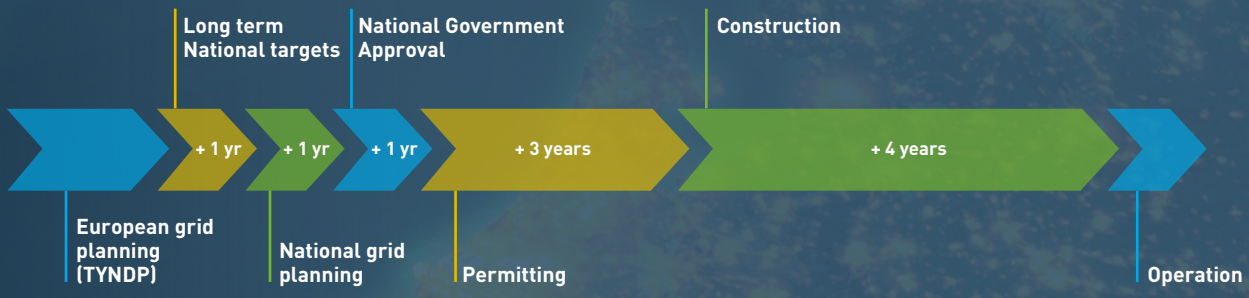
Regulatory frameworks based on the current cost benefit analysis framework need to be adapted to properly reflect the lead time (10+ years) of large-scale energy infrastructure projects. Also, they should enable anticipatory investments in assets such as P2X facilities that create long-term benefits in the wider energy system. Finally, the cost benefit analysis framework needs to enable hybrid assets (combined wind farm connections and interconnectors), and/or sector coupled projects. It should account for optimisation of overall energy system cost and proper valuation of its benefits.

A structured stakeholder dialogue is needed for consensus on required market designs

Integrated infrastructure projects require decision making on market design. This ensures offshore wind farm developers can access markets; infrastructure developers can facilitate and integrate their assets; and energy conversion infrastructure, such as P2X, is properly incentivised. This includes decisions on access to markets and bidding zones, access to transmission capacity, and market rules for ownership and operation of assets. A focussed stakeholder dialogue is required to define the required adaptions to the regulatory framework, that properly incentivises all stakeholders throughout the energy transition.

The NSWPH consortium is ready to develop Hub-and-Spoke projects together with all stakeholders

The NSWPH consortium stands ready to develop a first Hub-and-Spoke project to be operational in the early 2030s to ensure the timely ramp up of offshore wind energy. This requires action now, in terms of setting post-2030 offshore wind targets and development areas in the Netherlands, Germany and Denmark by 2020. It subsequently allows for appropriate grid planning procedures to secure sufficient time for development and realisation. The NSWPH consortium can initiate and facilitate discussions between policy makers and North Sea stakeholders, on co-utilisation of offshore areas, and reconsiderations of regulatory frameworks and market design. In these discussions, the NSWPH consortium can add a techno-economic perspective on grid developments and system impact.



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to become the most sustainable port in the world

ENERGINET

Danish transmission system operator working for a green, reliable and sustainable energy supply of tomorrow

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European energy infrastructure company serving the public interest and facilitating the energy transition by providing integrated infrastructure services

TenneT

TenneT is a Dutch-German electricity TSO and is one of Europe's major investors in national and cross-border grid connections on land and at sea in order to enable the energy transition.

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