North Sea
Wind Power Hub

THE CHALLENGE

Urgent action is needed to
reach a low-carbon society in time

The Consortium

The North Sea Wind Power Hub consortium has joined forces to realise climate goals. The consortium her work is based on research, stakeholder interaction and experience from earlier projects.

Port of Rotterdam

Biggest port in Europe with a strong ambition 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

gasunie

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.

Executive Summary

The transition of the North Sea countries to a low-carbon society requires swift and massive changes in the energy system. Decarbonising the energy system requires large scale offshore wind deployment in the North Sea, at an accelerated deployment rate, to meet the Paris Agreement. This introduces several challenges including:

- Moving from short term and fragmented towards long term and holistic energy system planning
- Developing far and large-scale offshore wind within the limited available area in the North Sea
- Developing a cost-efficient integrated energy infrastructure to maximise supply of North Sea offshore wind energy to energy markets
- Integrating offshore wind in an already constrained onshore electricity system
- Maintaining security of supply across various time scales, geographic locations, sectors and markets, and developing flexibility options at scale and across all time scales to support strongly increasing shares of variable renewable energy sources in the energy system
- Designing appropriate regulatory frameworks and markets to allow for anticipatory investments in the required energy infrastructure, generating benefits beyond single project boundaries, and robust incentives throughout the energy transition

A strong domestic and cross border energy transmission infrastructure, and flexibility options at scale and across all time scales (including sector coupling and storage), are required to successfully integrate large scale offshore wind energy in the energy system. Urgent action and international coordination are required to move to a low-carbon society in time.

Six concept papers, one storyline

The goal of the concept papers is to inform North Sea stakeholders, and the general public, of the results the NSWPH has obtained working on the modular Hub-and-Spoke concept over the last two years. The six concept papers tell one story: from the challenge to meet the Paris Agreement, through the solution building on the modular Hub-and-Spoke concept, to the next steps required to meet the Paris Agreement timely and in a cost-effective manner.

The challenge is enormous as today's energy use is largely fossil fuel based resulting in significant carbon emissions.

The transition of the North Sea countries to a low-carbon society requires swift and massive changes in the energy system

At COP21 in December 2015 a global, legally binding climate deal was reached. This Paris Agreement sets out a global action plan of both national and international effort-sharing ambitions to put the world on track to address climate change by limiting global warming to well below 2 °C, with an aim to limit the increase to 1.5 °C. The EU formally ratified this agreement, and it entered into force on 4 November 2016. With the political will and mandate to act, the EU is fully focused on the practical implementation of this agreement.

Limiting global warming to well below two degrees, requires net zero greenhouse gas emissions by 2050. The challenge for the energy system is enormous as today's energy use is largely fossil fuel based resulting in significant carbon emissions, and the renewable energy share (renewable electricity, fuels, gases and heat) in the EU is still below 20%[i]. Several energy scenarios[ii, iii, iv], indicate that a 2050 energy system will see levels of electrification double from 23%[v] today to approximately half of final energy demand in 2050. This implies the other half of final energy demand should be supplied in the form of low-carbon or renewable fuels, gases, or heat. Hydrogen is considered to be an important energy carrier in several future energy system scenarios, both globally[vi] and specifically for the EU[ii,vii]. Decarbonising the power sector is generally considered to be a first step[ii], as it is cost effective, has significant impact on CO_2 emission reduction and is considered possible well before 2050. Key in the decarbonisation of the power sector is an increased and efficient deployment of renewables, sufficient roll-out of interconnection capacity between countries, development of flexibility options (to address mismatches between supply and demand) and a smart design of markets to ensure free flow of energy across borders and market boundaries. In parallel, options need to be developed to decarbonise non-electric final energy demand e.g. for industry and mobility. This can be achieved through sector coupling and leveraging the complementary role of gasses and electricity in the energy system[viii]. This requires the upscaling of P2X[1] conversion technologies, re-use of existing gas infrastructure and utilisation of storage facilities. Note that energy imports are likely to remain a significant source of energy in the future, although they are expected to drop from 55% today to 20-38% in 2050[ii]. This indicates domestic (renewable) energy production in the EU is expected to become increasingly important towards 2050.

With increasing deployment of non-dispatchable renewables (e.g. solar and wind), energy production is becoming progressively variable while at the same time dispatchable energy sources (such as fossil fuelled power plants) are phased out of the system by a combination of policy measures, CO2-emission costs and availability of lower cost renewables. This requires the energy system to become more flexible to ensure energy demand can be met across various time scales, geographical regions, across sectors and markets. A wave of technical, market design and organizational challenges is coming.

Offshore wind energy has a major potential for cost-efficient decarbonisation, as cost levels have declined rapidly evidenced by new offshore wind projects with limited subsidies. However, deployment rates need to accelerate significantly, which requires a stable market framework and collaboration efforts from suppliers, developers and system operators to keep progress. Furthermore, authorities need to collaborate in coordinating spatial use and offshore concessions across the region and over time.

[1] *P2X includes power-to-gas (mainly H2 as well as methane) and other options (such as fuels, feedstock, food, oxygen, residual heat, etc.)*

A continuation of today's offshore wind deployment rate clearly is insufficient to realise the targets implied by the Paris Agreement.

In the past, the integration of smaller shares of variable renewable energy sources and incrementally shifting demand patterns could be accommodated in the existing electricity transmission infrastructure. However, new supply and demand patterns require radical overhauls of the onshore electricity transmission infrastructure, which is already facing difficulties in expanding and reinforcing onshore electricity corridors due to permitting challenges. Existing gas infrastructure is well developed and has significant energy transmission capacity available, but innovative technologies such as P2X conversion should be further developed to unlock it's potential. Present business cases for hybrid projects (combining interconnection and wind farm transmission asset infrastructure) are already under pressure due to uncertainty, short-term focus and lack of coordination in optimising use of the infrastructure for maximum social economic benefits. Decentralised renewable generation such as onshore wind and solar PV will also contribute significantly to meeting the Paris Agreement climate goals, but their potential will be insufficient to completely decarbonise the energy system of the North Sea countries[2] due to onshore spatial constraints and limited social acceptance[ix].

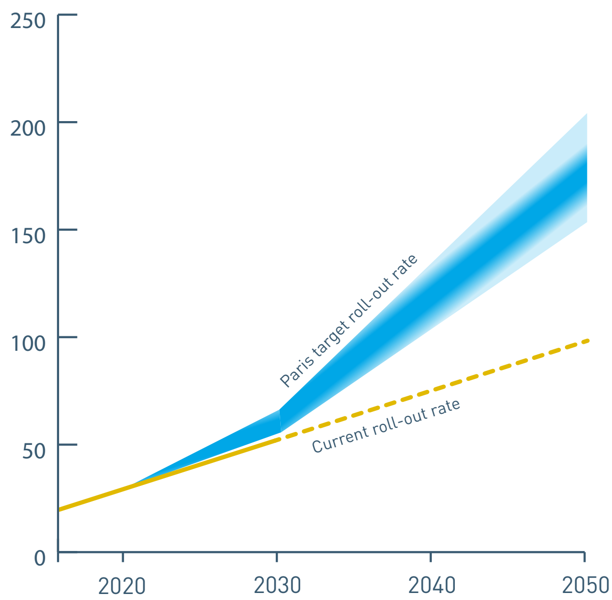
Decarbonising the energy system requires large scale offshore wind deployment in the North Sea, at an accelerated deployment rate, to meet the Paris Agreement

Several long-term scenarios (e.g. European Commission, Fraunhofer, PRIMES, Greenpeace, WindEurope, ENTSO-E, IEA) point to wind in general - and offshore wind in the North Sea in particular - as a major contributor to renewable energy generation for the North Sea countries. The long-term scenarios set out a range of 70 GW to 150 GW of future deployment of offshore wind power in the North Sea already in 2040. The most recent European Commission scenarios[x] show a range of 140 to 450 GW of offshore wind in the EU towards 2050.

Clearly, independent of the specific scenario used, all forecasts indicate a significant increase in offshore wind in the coming decades. At the end of 2018 approximately 13 GW of offshore wind capacity was installed in the North Sea; while the roll-out rate in 2018 was approximately 2 GW/year[xi]. A continuation of today's offshore wind deployment rate clearly is insufficient to realise the targets implied by the Paris Agreement. Thus, a great leap in offshore wind deployment is needed. As an example, to reach an installed offshore wind capacity between 70-150 GW for the North Sea by 2040, an average deployment rate up to 7 GW/year over the period 2023-2040 is required. A well-timed steady rollout of offshore wind is key to ensure industry is prepared and can realise offshore wind at the lowest cost for society.

Current roll-out rate of offshore wind is insufficient to meet Paris target.

Projected installed offshore wind capacity range in the North Sea [GW]



[2] North Sea countries consist of Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden and the United Kingdom. https://ec.europa.eu/energy/en/topics/infrastructure/high-level-groups/north-seas-energy-cooperation

The energy system of the future should be internationally coordinated and developed today

A strong domestic and cross border energy transmission infrastructure, and flexibility options at scale and across all time scales (including sector coupling and storage), are required to successfully integrate large scale offshore wind energy in the energy system

A higher share of variable sources in the energy system (e.g. offshore wind generation, hydrogen production from renewables, renewable power to heat), with strongly reduced levels of dispatchable energy generation and increased levels of non-dispatchable generation capacity introduces new challenges to the energy system. In the past, additional transmission capacity was the go-to solution to accommodate additional generation capacity in the grid. Whilst this is still an important component of the tools required to maintain security of supply, other flexibility options and means for integrating fluctuating renewable energy sources, such as demand response, small/large-scale storage and P2X, will become essential in the future energy system. A combination of all of these integration measures will most likely be needed.

Large scale electricity and gas infrastructure projects, both offshore and onshore, domestic and cross border, are required to enable the large-scale roll-out and accelerated deployment rates of offshore wind energy. These type of projects (e.g. combined transmission assets and interconnectors, or development of large scale P2X conversion capacity) typically have lead times of more than 10 years, while the full energy transition must be accomplished within 30 years. Several of these projects should be developed in parallel to accommodate these vast amounts of offshore wind capacity. Therefore, the energy system of the future should be internationally coordinated and developed today.

Markets and regulatory frameworks need to be adapted with clear long-term needs and sense of urgency in mind. The frameworks should provide the appropriate incentives to offshore wind developers to enable offshore wind developments in a "post subsidy" environment. A stable market outlook on offshore wind developments is essential for a significant build-up of supply chain capacity in the industry. The same holds for the development of sector coupling and flexibility options using conversion, transport and storage of molecules like hydrogen or derivatives. The regulatory framework should enable parties to develop, build and operate these assets while the market design should ensure the appropriate incentives are there to develop viable business cases. Key here is also to ensure these technologies are scaled up sufficiently in time.

The North Sea countries' combined maritime spatial plans cannot yet accommodate the envisaged offshore wind capacity additions, mainly by the lack of appointed offshore wind farm areas after 2030. The available offshore area in the southern part of the North Sea is limited (about 14,000 km^2, providing space for up to 50-90 GW depending on power density[xii] and scattered due to exclusion zones. An alternative approach is required to allow for a full deployment of the future energy system including offshore wind capacity, green hydrogen facilities, hubs and grid connections. The approach must consider co-utilization with e.g. nature, shipping and fisheries and take a long-term, international and multi-stakeholder perspective (e.g. use of areas after decommissioning of oil and gas rigs).

Urgent action and international coordination are required to move to a low-carbon society in time

As the energy system will undergo a swift and massive change to meet the Paris Agreement climate goals, the developments and requirements as listed above show the need for an internationally coordinated approach towards large scale offshore wind development and energy system integration. ***Therefore, a concerted action and cooperation across all North Sea stakeholders***[3] is required now to enable this internationally coordinated roll-out and integration of offshore wind, which is pivotal in reaching the Paris Agreement. The discussion should also aim for a detailed P2X implementation strategy (including technical and economic feasibility), with special consideration of the corresponding implications it will have on electricity and gas grids.

The consortium stands ready to initiate and facilitate discussions between policy makers and North Sea Stakeholders. The consortium can add the techno-economic perspective from grid developments and system impact to the discussion on actions considered by policy makers and other stakeholders.

[3] *Including e.g. policy makers, spatial planners, TSOs, offshore wind developers, environmental NGOs etc.*

Sources

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[x] "The share of renewables in gross electricity generation is very similar across scenarios getting to 81%-85% in 2050. (...) Among renewables, wind is clearly the dominant technology, representing in 2050 51-56% of the power production in all decarbonisation scenarios." This corresponds to 700 to 1200GW wind of which about one third offshore. (Source: EC, 2018. In-depth analysis in support of the commission communication com (2018) 773)

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