North Sea Wind Power Hub

POWER HUB AS AN ISLAND

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Executive Summary

- Reduction of the total system cost is essential to facilitate large scale offshore wind and interconnection capacity deployment and all options in design, installation and operation should be considered to further reduce cost, including the use of a power hub as an island.

- Realising a power hub as an island located centrally in the North Sea has been assessed to be technically feasible, based on - amongst others - bathymetry, extreme wind speed and hydraulic conditions (wave heights, surge levels, etc.) and geotechnical data.

- In a "lean island" approach the primary - and only - function for the artificial island is to provide a cost efficient support for the electrical infrastructure. This is an option that can be considered given feedback from industry.

- At distances far from shore, additional benefits may result from an expanded power hub island to support offshore wind farm installation and O&M activities and other co-use options.

- A power hub as an island can facilitate power and power-to-gas conversion as well as storage to support short and long term flexibility options to the grid.

Reduction of the total system cost is essential to facilitate large scale offshore wind and interconnection capacity deployment

The Paris Agreement translates into a significant challenge for an accelerated offshore wind and interconnection roll-out for the North Sea from about 9 GW of installed offshore wind capacity today to approximately 70-150 GW of offshore wind in 2040 and possibly 180 GW by 2045 in a specific scenario (COP21) conducted by the consortium. Although the costs for offshore wind have decreased significantly in recent years, it can be expected that there will be a constant upward pressure on the cost of the offshore wind roll-out resulting from moving increasingly further offshore and to deeper waters. While larger distances from shore generally mean higher wind speeds and yields. Costs for connection cables, O&M and foundations will tend to increase sizeably. To counter balance these increased cost levels, all options to reduce the total cost for society need to be considered. These options include the creation an artificial island to support the electrical infrastructure, combining in-feed of offshore wind electricity with interconnection capacity, as well as potentially power-to-gas, with an internationally coordinated roll-out process.

A power hub as an island to support the electrical infrastructure, as well as providing a base for installation and O&M activities can reduce total system cost

The increased scale of offshore wind and interconnection deployment far offshore justifies evaluating in detail the potential cost reduction of having an artificial island in the centre of large offshore wind capacity zones. An island naturally supports the sizeable and heavy electrical infrastructure components without constraints to size and weight that generally result from monopile or jacket foundation technologies. In addition, an island could be expanded further to provide a base for all wind farm installation and operation and maintenance activities in terms of accommodation, assembly, transport and storage. Also, the island may reduce the travel times to the individual wind farm assets. Finally, an artificial island could play an important role in supporting power conversion and storage technologies, such as power-to-gas.

The technical feasibility of an artificial island located far offshore in the North Sea has been proven

To determine the technical feasibility and estimated cost of an artificial island, the consortium have carried out several design option studies both for a relatively small scale (6 GW) island within the IJmuiden Ver potential wind area zone (85-100 km West off the Dutch cost) and for a large scale (30 GW) island located centrally in the North Sea (on/near the Dogger Bank), more than 250 km offshore and with relatively shallow water depths. For the latter location, a concept feasibility study was conducted. Initial design wave and surge conditions of a 1/1,000 year return period and extreme wind speeds were considered to determine boundary design specifications. Geotechnical data (based on boreholes in the area) provided insight into the composition of the subsoil for design specifications with respect to the angle of friction and soil settlement. It is recommended to apply a multilevel safety approach for HVDC and living quarters, where the revetment design is based on a 1/1,000 environmental condition and a second defence line is realised by elevated platforms for HVDC and living quarters.

Four island concepts (sand fill, polder, floating runway and floating facilities and an optional energy reservoir (‘valmeer’) have been qualitatively compared for benefits and drawbacks. Based on the identified benefits and disadvantages it is concluded that the polder, floating runway and energy reservoir concepts are not preferred and the sand fill concept is used as base case.

Additionally, the studies provide insights in different design options, including:

- Runway - Wind conditions at the site show that the usability of a runway ranges from about 70% to 90% depending on runway orientation, wind conditions and size of the airplane. According to expert opinion judgement, the runway implies a 1,800 m exclusion zone from the centreline of the runway for wind turbines. Inclusion of a runway in the design will depend on eventual user requirements of a Power Hub as an Island.

- Cable landing - The large amount of cables and phasing of cable landings requires multiple locations for concentrated landing, either through horizontal directional drilling or installed sleeves through the revetment. On the island AC and DC cables are concentrated in cable galleries of concrete box type.
- Sea defence – Considered to be strong enough to withstand 1/1,000 wave conditions, high enough to limit overtopping in case of extreme water level based on a 1/100 year return period and designed with a "start of damage" criterion, resulting in limited maintenance during its design life of 100 years. Various materials have been considered for revetment and five typical sections are defined for segmentation of the sea defence (*Figure 1*), consisting of Breakwater, Detached Breakwater, Runway Revetment, Super Dike and Gravel Beach. The segmentation of the sea defence around the island depends on the prevailing wave conditions, the acceptable amount of overtopping related to functional area at the rear side of the defence.

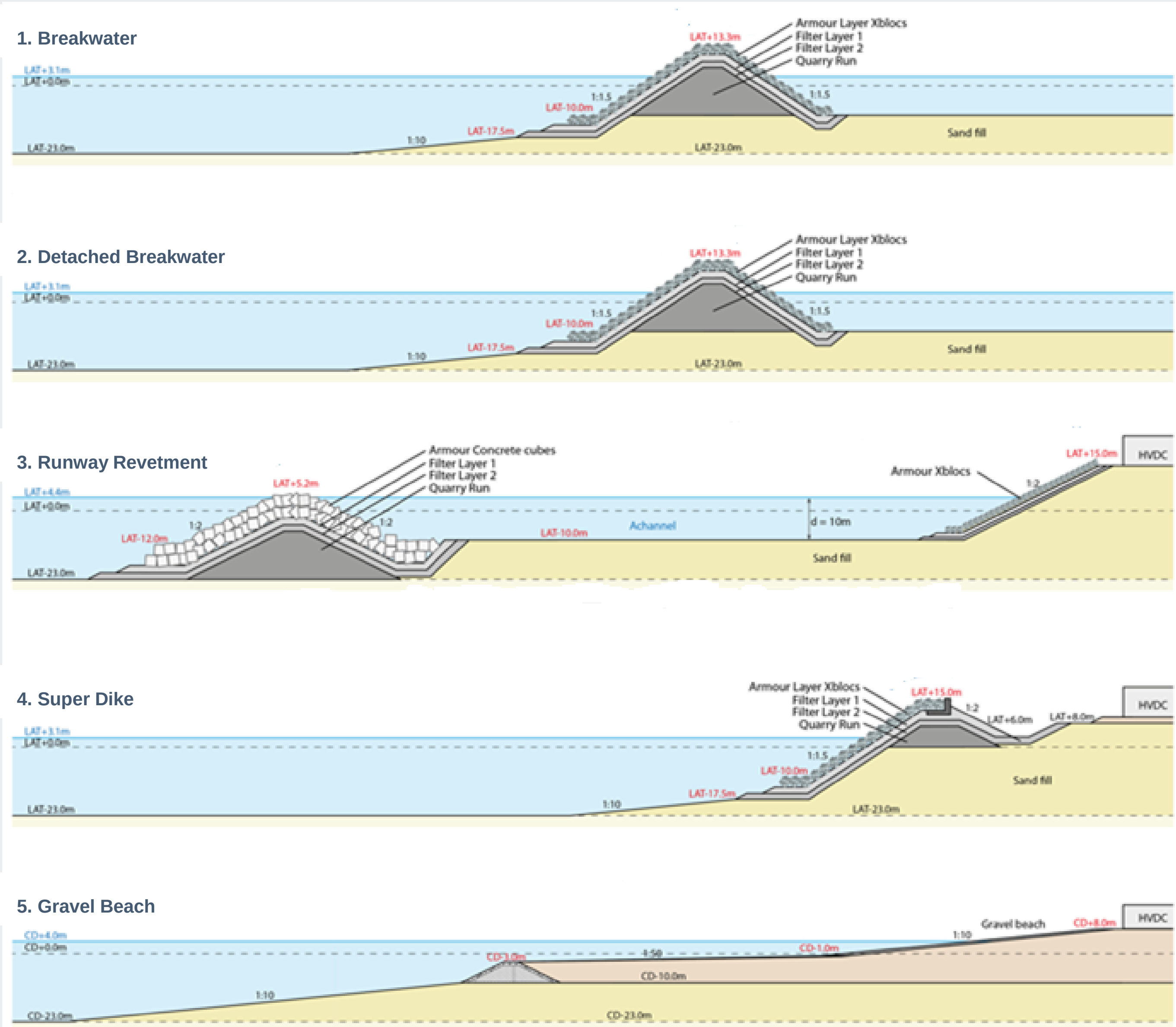

Figure 1 Defined sections of sea defence used in the engineering studies for the potential NSWPH designs.

In a "lean island" approach the primary - and only- function of a Power Hub as an Island is to provide a cost efficient support for the electrical infrastructure (converters, transformers, reactive power compensation, harmonic filters, switch gear, protection, etc.)

Preliminary cost estimates have been prepared for different artificial island designs incorporating either a "lean island" (electrical infrastructure only) or "comprehensive" (larger island with additional facilities to support wind farm installation and O&M) approaches. The total cost of an island is dominated by the cost for revetment (45%-55%) and sand fill (~30%). The choice of safety level for the island has a significant impact on costs. Currently a high level of safety is considered due to the critical function envisaged for the island. An indicative planning shows that construction of the island could take up to 7 years, excluding planning decisions and permitting process.

A first detailed Levelised Cost of Energy (LCoE) calculation for both the IJmuiden Ver zone and a location centrally located in the North Sea indicates that the lowest societal LCoE for connecting 6-10 GW offshore wind areas is realised when using an artificial island in combination with an innovative grid connection concept. In this concept, an innovative A/C grid connection concept is used to transport the capacity from the surrounding wind farms to the artificial island that supports the electrical infrastructure (converters, transformers, reactive power compensation, harmonic filters, switch gear, protection, etc.). For the IJmuiden Ver and further offshore locations, this approach yields a cost reduction of approximately 10%, when compared to a "business as usual" connection scenario using HVDC collector platforms on individual jacket foundations. As the cost for the island is significant, this cost reduction is achieved only when the island is designed using a "lean island" approach to serve its primary function: cost efficient support for the electrical infrastructure.

At distances far from shore, additional benefits may result from an expanded artificial island to support offshore wind farm installation and O&M activities and other co-use options

Depending on the location - especially with respect to distance to shore, wave climate and overall size of the area - alternative installation practices and O&M strategies may become commercially attractive for wind farm operators when an artificial island is extended with facilities such as a harbour, storage, accommodation, runway, etc..

Previously, TenneT conducted a market consultation and an external study in order to assess the potential benefits of - and market interest for - an artificial island for the IJmuiden Ver location. The island considered would be located 85-100 kilometres West off the Dutch coast and would host HVDC equipment for a total of 6 GW of offshore wind energy, accommodation for personnel, a harbour and storage of spare parts. In addition, a runway for airplanes was considered. An important finding of the study is that while travel time from the island to the wind turbines for maintenance conditions is reduced considerably (relative to access from shore), its impact on O&M overall cost is limited. The main reason is that far offshore wave height conditions determine when construction and/or O&M activities can be performed and what vessels can be used. The shortened travel time will not influence this, although the window of opportunity might improve.

Q: What benefits would an artificial island have for wind farm installation and O&M at locations >250 km from shore/port?
Q: What requirements are important to wind farm developers for co-development of such an island to realise these benefits?

Figure 2 Impression of an artificial island in the North Sea, fit to facilitate installation and O&M activities.

The study indicates that an artificial island could provide benefits for offshore wind farm owners to support their O&M strategy if it enables a shift in vessel choice from Surface Operation Vessels (SOVs) to Crew Transfer Vessels (CTVs). To optimise O&M strategies, a more detailed evaluation together with wind farm developers is needed. This more in depth analysis should consider the potential for optimisation of working shifts, the number of technicians needed and the overall trade-off between accessibility and cost.

The cost saving potential for construction and O&M activities may change considerably when considering an artificial island significantly further from shore (250-300 km). At the scale envisaged at this location (about 350-500 hectares) and considering the increased travel times and more severe metrological environmental conditions, alternative installation practices and O&M strategies may become more attractive and economically viable using an artificial island.

Q: Could the design of an artificial island contribute to a 10-15% cost reduction for wind turbine O&M far from shore (>250 km)?

First cost estimates of island cost and impact on its impact on societal LCoE has been derived for both a "lean island" and a "comprehensive" (i.e. large enough to support wind farm operator facilities) far offshore island. This analysis shows that co-use of a comprehensive island, including additional facilities to support installation and O&M activities for the offshore wind farms, should result in a cost reduction for wind farm operation and maintenance in the order of 10-15% to offset the additional investments (~30% in CAPEX) required for a more comprehensive island.

An artificial island can facilitate power conversion and storage to support short and long term flexibility options to the grid

The sharply reduced levels of dispatchable generation in the energy transition from fossil energy to renewables require increased use of cost efficient flexibility options and increased interconnection levels for these flexibility options and the corresponding markets to function. Power-to-gas (e.g. hydrogen) can provide important balancing capacity as well as long term storage options. An artificial island would provide the opportunity to create hydrogen from offshore wind energy on site. In addition, transport of energy from the island to shore could then take place in the form of electricity, gas or both. The consortium is in the process of evaluating these options in more detail, focusing on the need, feasibility and economic benefits of incorporating power conversion into the island concept.

ABOUT THE NORTH SEA WIND POWER HUB

TenneT Netherlands, TenneT Germany, Energinet and Gasunie joined forces to develop a large scale European electricity system for offshore wind in the North Sea. The NSWPH consortium partners consider the project to be an important possible alternative path of an internationally coordinated roll-out towards accomplishing the green energy transition and achieving the Paris Agreement. By developing the North Sea Wind Power Hub project, the consortium endevours to make the energy transition both feasible and affordable. Central to the vision is the construction of one or more hubs at a suitable location in the North Sea with interconnectors to bordering North Sea countries. The whole system may function as a hub for transport of wind energy, an interconnection hub to the connected countries, a working hub for offshore wind developers and a location for possible Power to Gas solutions.

CONTACT DETAILS

The North Sea Wind Power Hub consortium: info@northseawindpowerhub.eu