CHAPTER 1

OFFSHORE RENEWABLE ENERGY IN THE BELGIAN PART OF THE NORTH SEA

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Abstract

Eight offshore wind farms are operational in the Belgian part of the North Sea (BPNS), totaling an installed capacity of 2.26 Gigawatt (GW) and consisting of 399 offshore wind turbines. They produce an average of 8 TWh annually, accounting for ~1/3 of gross electricity production from renewable energy sources in Belgium (FPS Economy, 2022). An additional zone for offshore renewable energy has been designated in the marine spatial plan 2020–2026 and is anticipating an installed capacity ranging between 3.15 and 3.5 GW with an expansion of the Belgian offshore transmission network scheduled to start in 2024. To reduce spatial competition in the marine economy options for sustainable offshore multi-use are being investigated. As "Blue Growth" matures to a sustainable blue economy, it has been tasked with ensuring the environmental sustainability of the natural capital of the oceans and seas (EU, 2021).

With 523 km² reserved for operational and planned offshore wind farms in Belgium, 344 km² in the adjacent Dutch Borssele zone, and 50 km² in the French Dunkerque zone, cumulative ecological impacts continue to be a major concern. These anticipated impacts, both positive and negative, triggered an environmental monitoring program focusing on various aspects of the marine ecosystem components, but also on the human appreciation of offshore wind farms. This introductory chapter provides an overview of the status and recent developments in offshore renewable energy in the BPNS.

1. Offshore wind energy in Belgium

With the Royal Decree of 17 May 2004, a 264 km² area within the BPNS was reserved for the production of electricity from water, currents or wind. It is located between two major shipping routes: the north and south traffic separation schemes. In 2011, the zone was adjusted on its Northern and Southern side in order to ensure safe shipping traffic in the vicinity of the wind farms. After this adjustment the total surface of the area amounted to 238 km². A second area of 285 km² is reserved in the revised marine spatial plan that came in force on March 20th, 2020. In the neighboring Dutch Borssele zone two wind farms are operational and totaling an installed capacity of 1.5 GW on an area of 344 km². In front of Dunkerque, in the French part of the North Sea, 50 km² is reserved for offshore wind development (Fig. 1). On 24 April 2023, a North Sea coalition of nine countries committed to combined targets for offshore wind of at least 300 GW by 2050 (https://northseasummit23.be/en/ostend-declaration).

The European Directive 2018/2001 on the promotion of the use of energy produced from renewable sources, imposes a binding target of 32% for the overall share of energy from renewable sources in the EU's gross final consumption of energy in 2030. In 2021, the share of energy from renewable energy in Belgium was 13%, up from 1.9% and 7.7% in 2004 and 2013 respectively (Eurostat, 2023)

On 31 December 2019, Belgium submitted a National Energy and Climate Plan to the European Commission which envisions a target figure of 17.5% for the contribution of the production of electricity from renewable energy sources by 2030. This plan includes 4 GW of operational offshore wind energy by 2030 (Belgische Overheid, 2019).

Prior to installing a renewable energy project, a developer must obtain (1) a domain concession and (2) an environmental permit. Without an environmental permit, a project developer is not allowed to build and exploit a wind farm, even if a domain concession was granted.

When a project developer applies for an environmental permit an administrative procedure, mandatory by law, starts. This procedure has several steps, including a public consultation during which the public and other stakeholders can express any comments or objections based on the environmental impact study (EIS) that is set up by the project developer. Later on, during the permit

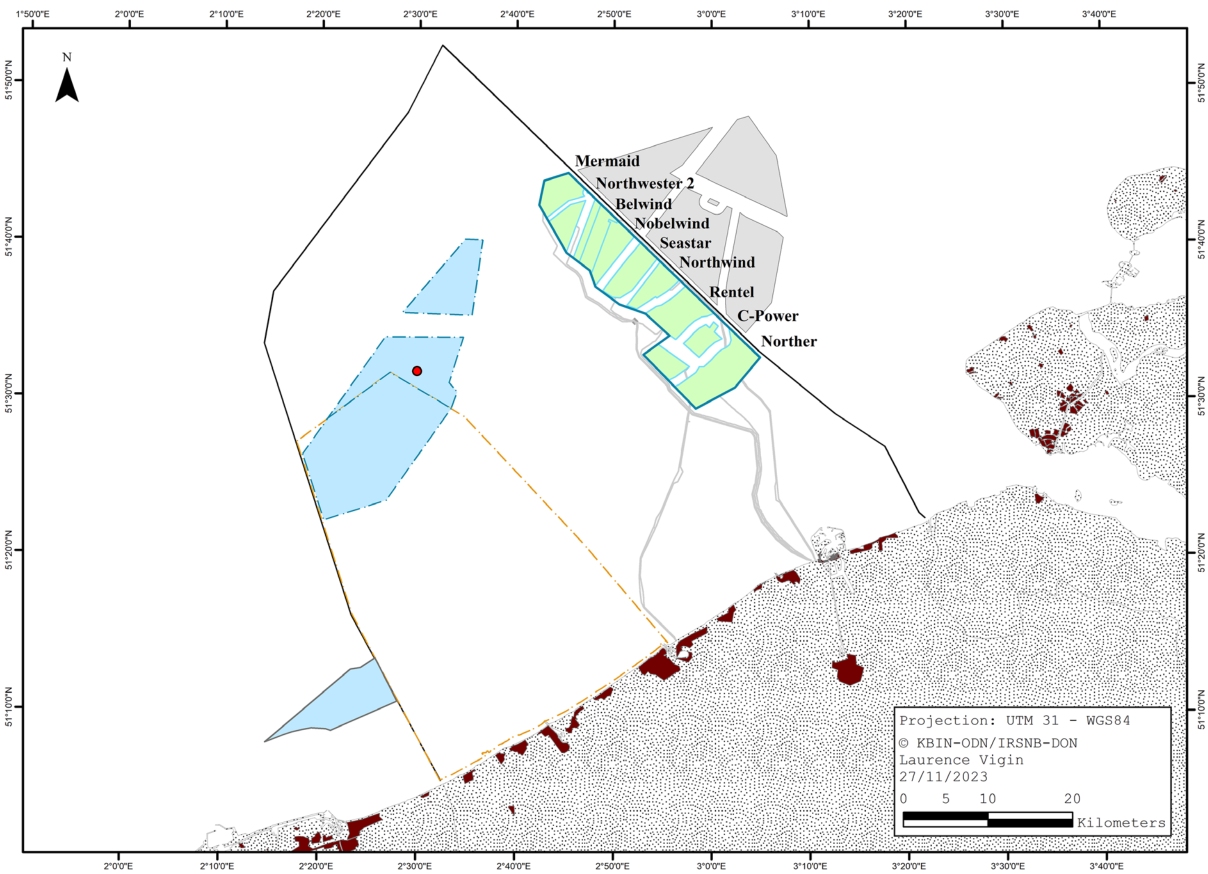

Figure 1. Current and planned zones for renewable energy in and around the Belgian Part of the North Sea. Operational wind farms in Belgian waters are shown in green. Operational wind farms in the Dutch Borssele area are in grey. The blue areas in the NW of the Belgian part of the North Sea are the Princess Elisabeth zone, an area for renewable energy development as delineated in the revised marine spatial plan 2020–2026. Also in blue is the proposed Dunkerque offshore wind farm in French waters. The orange dashed line is the Belgian Natura 2000 area 'Vlaamse banken'. The red dot is the location of the modular offshore grid 2.

procedure, the Management Unit of the North Sea Mathematical Models (MUMM), a Scientific Service of the Operational Directorate Natural Environment (OD Nature) of the Royal Belgian Institute of Natural Sciences, gives advice on the acceptability of expected environmental impacts of the future project to the Minister responsible for the marine environment. MUMM's advice includes an environmental impact assessment, based on the EIS. The Minister then grants or denies the environmental permit in a duly motivated decree.

At present, nine projects were granted a domain concession and an environmental permit (from South to North: Norther, C-Power, Rentel, Northwind, Seastar, Nobelwind, Belwind, Northwester II & Mermaid (Table 1 and Fig. 1). On July 20th, 2018, the merger between the Seastar and Mermaid projects was finalized and the resulting merged project was named Seamade NV. 399 wind turbines are operational in the Belgian part of the North Sea (Fig. 2). The entire first area has a capacity of 2262 MW and can cover up to 10% of the total electricity needs of Belgium or nearly 50% of the electricity needs of all Belgian households. The capacity density of the first wind energy zone, defined as the ratio of the wind energy zone rated capacity to its ground area, is at 9.5 MW/km² among the highest in Europe. Over the last decade, turbine size, rotor diameter and installed capacity per turbine has gradually increased (Table 1) with extra-large monopiles (i.e., with a diameter larger than 7 m) becoming the dominant foundation type in our (shallow) waters (Fig. 2).

The environmental permit includes a number of terms and conditions intended to mitigate and/or minimize the impact of the project on the marine ecosystem. Furthermore, as required by law, the permit imposes an environmental monitoring programme to assess the effects of the project on the marine environment. Based on the results of the

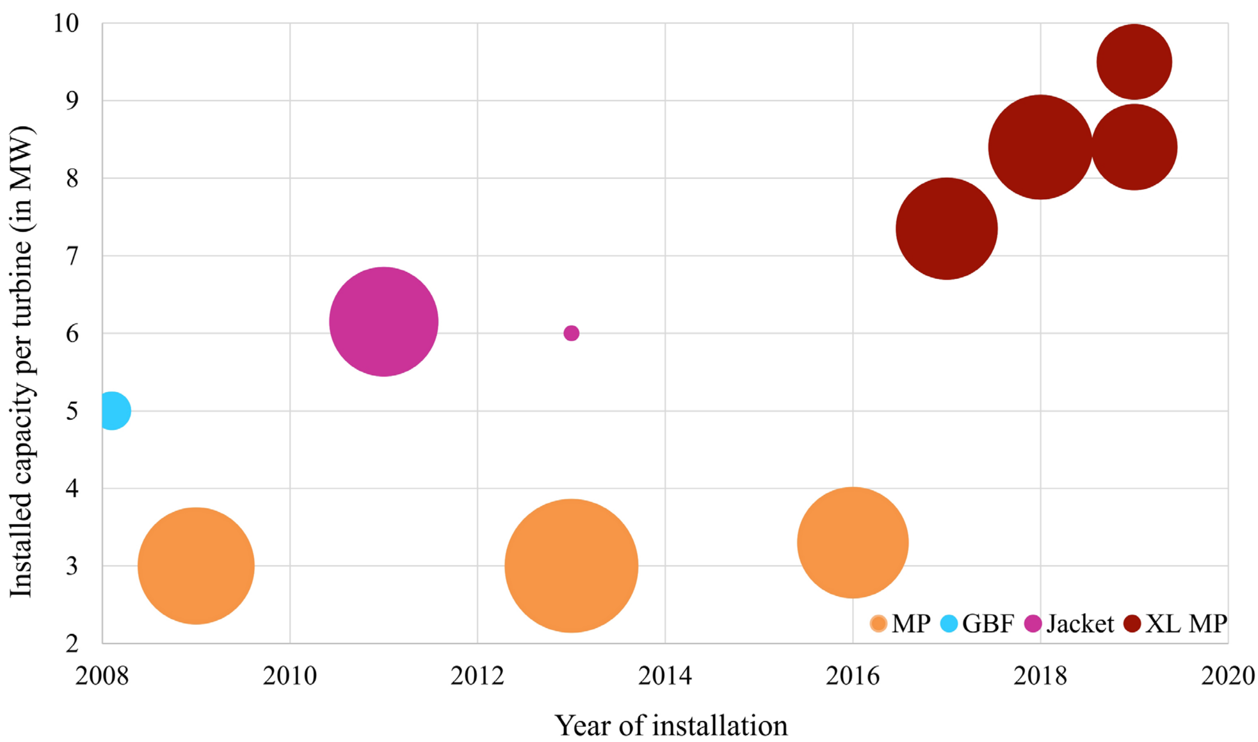

Figure 2. Overview of the timing, individual capacity and foundation type of offshore wind turbines installed in the Belgian Part of the North Sea since 2008. The size of the bubbles is proportional to the number of turbines installed per project of phase (Table 1). Abbreviations: GBF = Gravity based foundation; Jacket = Jacket foundation; MP = monopile foundation; XL MP = monopile foundations exceeding approximately 7 m in diameter.

monitoring programme, and recent scientific insights or technical developments, permit conditions can be adjusted.

On 20 March 2020, the second marine spatial plan for the BPNS (Royal Decree of May 22nd, 2019, establishing the marine spatial planning for the period 2020 to 2026 in the Belgian sea-areas) came into force. This plan lays out principles, goals, objectives, a long-term vision and spatial policy choices for the management of the Belgian territorial sea and the Exclusive Economic Zone (EEZ) for the period 2020–2026. Management actions, indicators and targets addressing marine protected areas and the management of human uses including commercial fishing, offshore aquaculture, offshore renewable energy, shipping, dredging, sand and gravel extraction, pipelines and cables, military activities, tourism and recreation, and scientific research are included. In this revision of the marine spatial plan, the Belgian federal government has delineated a second zone for renewable energy of 285 km² located at 35–40 km offshore (Fig. 1). This second zone, called the Princess Elisabeth zone (PEZ), will be suitable for an additional 3.15–3.5 GW of installed capacity. Storage of energy and grid reinforcement continue to be major hindrances to the further integration of marine renewables into the electricity grid. In 2023, Elia was granted an environmental permit for the Modular Offshore Grid 2 to reinforce the offshore electricity grid (see below).

The PEZ is partly located inside the designated Natura 2000 marine protected area 'Vlaamse banken' (Fig. 1). To determine whether and how the new offshore wind farms can be designed and operated with respect to the existing and aspired ecological values as defined by the conservation objectives for the area, a targeted research programme was set up. The EDEN2000 project on "Exploring options for a nature-proof DEvelopment of offshore wind farms inside a Natura 2000 area" aimed at filling knowledge gaps of prime relevance to and advice for an environment friendly development of the spatial overlap of the PEZ and the Special Area of Conservation "Vlaamse Banken". These knowledge gaps linking societal concerns with research questions, were identified based on iterative roundtable consultations of environmental NGOs active in the BPNS, the Belgian Offshore Platform representing the Belgian offshore renewables industry, the Federal Public Service Environment responsible for the implementation of environmental policies in the BPNS, the Cabinet of the Minister of the North Sea and the Royal Belgian Institute of Natural Sciences. Filling these gaps necessitated either a summary of existing knowledge, a dedicated analysis of existing data or newly designed research. The EDEN2000 studies span the mitigation of negative impacts and the promotion of positive impacts, and touch upon (1) the ecological context of the area, (2) the artificial reef effect in its widest sense, (3) the effects of fisheries exclusion inside the area and (4) the effects of the introduction of energy. This programme commenced in 2019 and results were published in 2023 (Degraer *et al*. 2023). All studies, conclusions and recommendations are publicly available at https://www.health.belgium.be/nl/eden2000-studies.

2. Elia Modular Offshore Grid 2

On January 9th, 2023, ELIA applied for an environmental license for the construction and operation of Modular Offshore Grid 2 (MOG2). This MOG2 project aims to expand the Belgian offshore transmission network by developing and constructing additional offshore substations and export cables. MOG2 thus provides the connection between the new wind farms in the PEZ and the onshore Belgian transmission network. Additionally, facilities will be created for new HVDC interconnections, such as the Nautilus project with the United Kingdom and the Triton Link project with Denmark. The MOG2 project comprises the construction of an artificial island or multiple platforms for AC (Alternating Current) and HVDC (High Voltage Direct Current) substations (Fig. 3)

Table 1. Overview of operational wind farms in the Belgian part of the North Sea.

Project		Number of turbines	Capacity (MW)	Foundation type	Rotor diameter (m)	Hub height (m LAT *)	Total capacity (MW)	Operational since	Depth (m LAT)	Monopile diameter (m)	Average distance to the coast (km)
Norther		44	8.4	monopile	164	107	370	2019	20–35	8–9 m	25
C-Power	phase 1	6	5	gravity based	126	94	325	2009	14–18	NA	27
	phases 2 & 3	48	6.2	jacket	126	94		2013		NA	
Rentel		42	7.4	monopile	154	106	309	2019	22–36	8 m	34
Northwind		72	3	monopile	90	72	216	2014	16–29	6–7 m	38
SeaMade	Seastar	30	8.4	monopile	167	109	487	2020	22–38	8.3	38
	Mermaid	28							24–40		53
Belwind	phase 1	55	3.1	monopile	90	72	171	2011	15–37	4.3	49
	Alstom Demo project	1	6	jacket	150	100		2013		NA	
Nobelwind		50	3.3	monopile	90	72	165	2017	26–38	6–7	46
Northwester 2		23	9.5	monopile	164	106	219	2020	25–40	8–9	51

* lowest astronomical tide

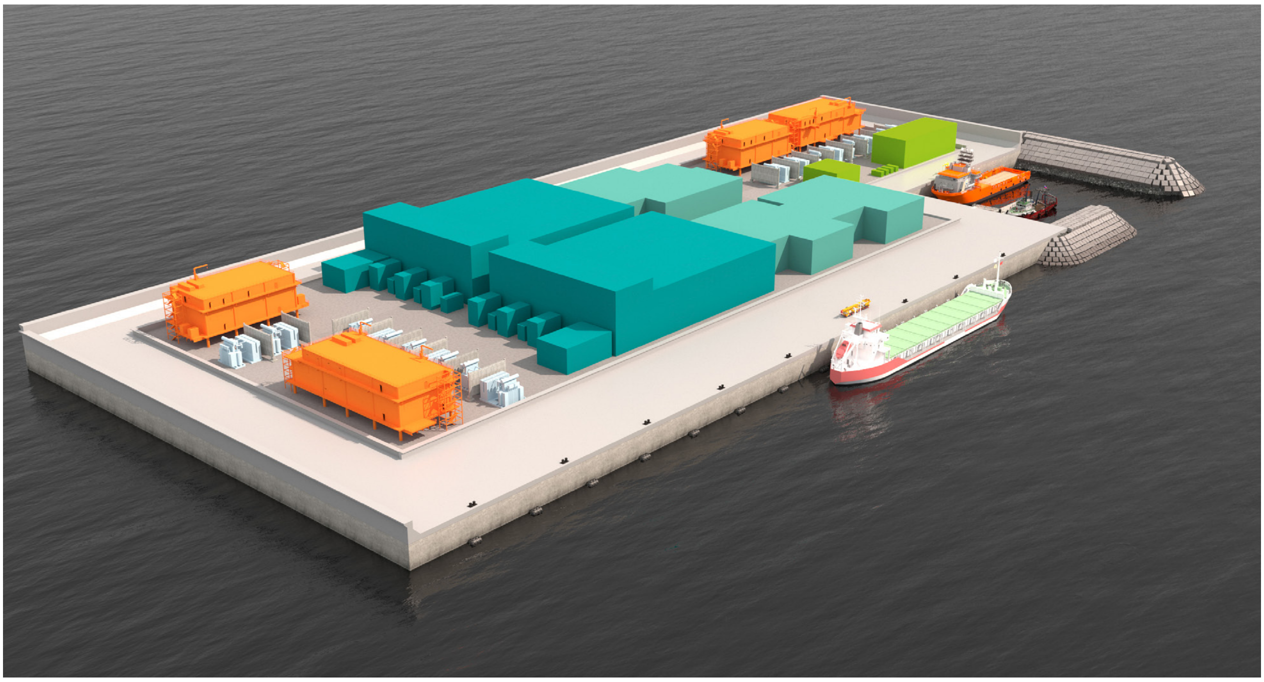

Figure 3. Visualisation of the energy-island MOG2 (Source: Elia).

and the connection of these substations to the mainland through six 220 kV three-phase AC export cables and one HVDC cable system. In the EIA, the environmental impacts of various alternatives regarding location, cable route and execution were investigated and the alternative with multiple platforms rather than a caisson-type artificial island was found to have the smallest impact for most aspects of the marine environment (Haelters *et al.*, 2023). On September 26th, 2023, ELIA was granted their environmental license for the construction and operation of MOG 2 and construction is expected to start in summer 2024. Because of the additional functionalities of an island compared to platforms, the island alternative will be constructed. The location is shown on Fig. 1. A dedicated environmental monitoring programme was drafted to validate the predicted impacts of this project. This will also be the first offshore construction project in Belgium where Nature Inclusive Design measures are broadly applied aimed at offsetting some of its negative impacts on the marine environment.

3. Decommissioning of the first offshore wind farms

The first offshore wind farms in Belgian waters were constructed in 2008 and 2009. As the decommissioning of this first generation of wind farms is approaching, many questions are raised about the phased decommissioning process in the period 2034–2047. On the one hand, new technologies are providing new options for decommissioning. For example, options for repurposing and recycling blades and ways to remove foundations in their entirety from the ground are being explored. On the other hand, new insights surrounding the interaction between wind farms and biodiversity are constantly emerging. Monitoring the ecological effects of wind farms has shown that additional biodiversity has been created in and around offshore wind turbines, the so-called artificial reef effect. These new hard substrates underpin a rich underwater fauna of invertebrates, which in turn attracts various fish species, bird species and possibly marine mammals.

To decommission offshore wind farm infrastructure, there are theoretically several options. The foundations can either be

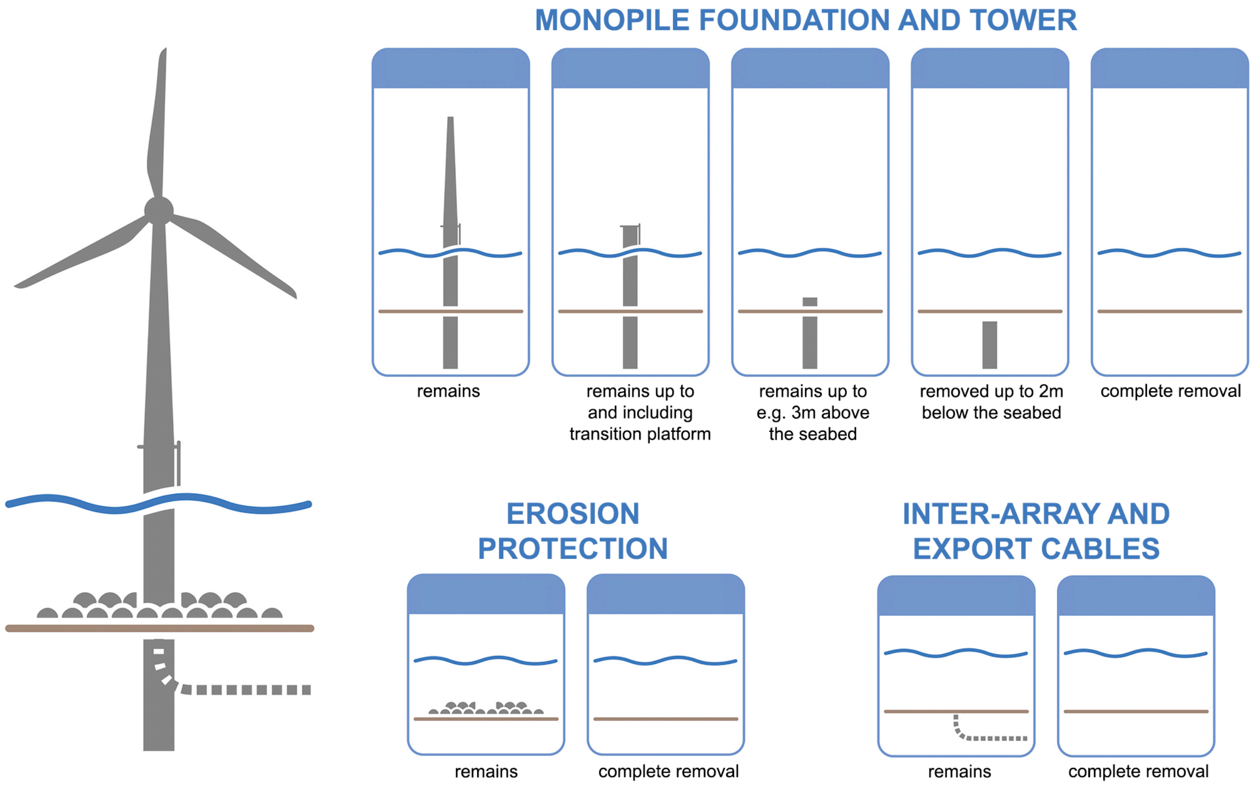

Figure 4. Different options of offshore wind farm infrastructure decommissioning (after Van Maele *et al.* 2023a).

completely or partially removed or remain entirely on site. Erosion protection layers and cabling can also be removed or remain on site (Fig. 4). Of the more than 40 organisations that were consulted during a stakeholder participation process, the majority favoured complete removal of all man-made structures.

The naturally occurring and desirable fauna of dynamic sandy substrates is adapted to high dynamics, allowing it to withstand and quickly recover from temporary disturbance caused by decommissioning activities.The new biodiversity created as a result of the artificial reef effect is not considered of such interest in a naturally dynamic sandy-bank ecosystem to be left untouched because it is a habitat that does not naturally occur at that site. Moreover, decommissioning in the context of repowering will re-provide hard substrate in the form of a new wind farm, so that those additional habitat, shelter and resting opportunities will recover in the short term and in phases.

Leaving some of the infrastructure in place could be useful for attaching structures for aquaculture, passive fishing or as a research base (sensors, testing new technologies, etc.), for example, but these functionalities could equally be envisaged for yet-to-be-built wind turbines. In addition, retaining (part of) the foundation and leaving erosion barriers and cables in place do not outweigh the disadvantages such as e.g. insecurity and the missed opportunity to reuse materials.

The wind farm operators, on the other hand, who have to carry out and pay for the decommissioning, are rightly concerned whether it will be both feasible and affordable in engineering terms to completely remove the foundations. Also, removing the erosion protection, even if it is to be reused for the same purpose when repowering, is a costly and time-consuming activity. Thus, further research and consultations still appear necessary to identify the feasibility and the advantages and disadvantages of the alternative decommissioning scenarios (complete or partial removal of wind farm infrastructure, including erosion protection layers). By starting this in time, there is time for the public and private partners involved to prepare.

The findings from the stakeholder consultation process also offer insights into how future wind farms can be optimally designed, taking into account the decommissioning phase. In particular, promoting circular use of materials offers sustainability opportunities.

The Princess Elisabeth zone contains zones with natural hard substrate, a low-dynamic habitat with high ecological value. Decommissioning activities will therefore have a greater impact here than on the dynamic sandy soils where the current wind farms are located. On the other hand, in the gravel beds of the Princess Elisabeth zone, many win-wins can be achieved by implanting artificial hard substrate such as wind turbines and erosion protection layers. Whereas in the first zone it is advised, for reasons of natural value, to remove everything when decommissioning, in the Princess Elisabeth zone it remains to be seen how to avoid disturbance of the gravel beds during decommissioning as much as possible, and how to preserve the natural value of the artificial hard substrate in the vicinity of the gravel beds as much as possible.

4. Aquaculture

For the stakeholders consulted in the participation project, the primary goal of aquaculture in the Belgian part of the North Sea is sustainable food production. Despite a current focus on oysters and mussels, a broad spectrum of organisms is suitable for this purpose including algae, whelks, scallops, fish, jellyfish, sea cucumbers, sea urchins, sea grasses and even bacteria. Whether offshore (integrated) multitrophic aquaculture is technically possible in the Belgian North Sea needs further investigation.

Given the limited extent of the BPNS, optimal use of available space remains one of the main concerns highlighting the opportunities for multiple use of space. The stakeholder process for aquaculture in the Belgian part of the North Sea, highlights the potential for aquaculture in the zones for wind energy, though linked to predefined basic and boundary conditions. However, where possible, facilitating aquaculture in these offshore wind farms, should be taken into account already at the design stage of the wind farms which is unlikely to happen without policy support and a suitable regulatory framework (Van Maele *et al.* 2023b)

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