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SYNTHESIS REPORT FOR PILOTS

Work Package 7
Implementation of Multi-Use Concepts Within Pilots

December 31st, 2023

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Abstract	This deliverable synthesizes the lessons learnt from the five UNITED pilots, specifically on the implementation of multi-use platforms and/or co-location at platforms (MUCL). This synthesis includes lessons learnt throughout each of the three implementation phases of the project: pre-operational, operational, and post-operational. It reports on site specific needs and challenges, findings from

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ACRONYMS

BBM	Scientific Service Management Unit of the Mathematical Model of the North Sea
CTA	Connection agreement
C-POD	Continuous porpoise detectors
D	Deliverable
EEZ	Exclusive economic zone
DP2	Dynamic positioning 2
HDPE	High-density polyethylene
LTA	Low Trophic Aquaculture
MSL	Mean Sea level
MU	Multi-use
MUCL	Multi-use platform and/or co-location at platform
NS2	North Sea 2 project
PV	Photovoltaic
RIB	Rigid inflatable boat
ROV	Remotely Operated Vehicles
TRL	Technology readiness level
WP	Work package

EXECUTIVE SUMMARY

This deliverable synthesizes the lessons learnt from the five UNITED pilots, specifically on the implementation of multi-use platforms and/or co-location at platforms (MUCL). This synthesis includes lessons learnt throughout each of the three implementation phases of the project: pre-operational, operational, and post-operational. It reports on site specific needs and challenges, findings from the physical installation, monitoring and testing of the solutions at the offshore pilot sites. The synthesis of lessons learnt includes aspects such as monitoring, vessel availability, and staff and it highlights the importance of site-specific understanding, resilient system design, flexibility, effective communication, safety, and comprehensive planning and contingency measures. These lessons can provide a basis for guidelines to design future MUCLs and feed into the Catalogue of multi-use blueprint solutions, the generic roadmap developed in Work Package 1 (WP1).

1. INTRODUCTION

The objective of the UNITED project is to provide evidence of the viability of ocean multi-use (MU). The project considers five different pillars (technology, economics, environment, society, and legal, policy & governance) and the work is centred around five offshore demonstration pilots that have been implemented at offshore locations in the North Sea, Mediterranean Sea, and Baltic Sea, all combining different marine activities:

- German pilot: Offshore wind energy & Aquaculture (blue mussels and seaweed)
- Dutch pilot: Offshore floating solar energy & Aquaculture (seaweed)
- Belgian pilot: Offshore wind energy & Flat oyster aquaculture and restoration & Seaweed cultivation
- Danish pilot: Offshore wind energy & Tourism (boat tours)
- Greek pilot: Aquaculture (finfish) & Tourism (diving)

The implementation of the innovative multi-use solutions in these pilots can be divided into three phases: the pre-operational, operational, and post-operational phase. By going through each of these phases, sometimes facing unexpected challenges, the pilots have gained valuable experience and learnt important lessons that can aid future multi-use endeavours.

This report is the final deliverable of work package 7 (WP7) - Implementation of Multi-Use Concepts Within Pilots. The current deliverable, D7.7, synthesizes the main lessons learnt by the pilots, specifically those on the implementation of MUCLs. The synthesis comprises, for example, information on site-specific needs and findings from the physical installation, monitoring, and testing of the solutions at the offshore pilot sites. The collected information serves as a basis for guidelines to design multi-use combination platform. The output will be used in the creation of the generic roadmap that will be developed in Task 5 of WP1.

The knowledge that was gained by the pilots has been documented in numerous deliverables that have been produced throughout the project, especially those that were part of WP7. A few examples are:

- D1.1: Report on identified risks, challenges and barriers
- D1.2: Report on the State of the art implementation of an integrated pilot approach
- D2.2: Design and construction plans for the pre-operational phase of the pilots
- D2.4: Report on the optimization of scheduling, operations and maintenance
- D2.6: Technical report on design procedure limitations and improvements
- D7.1: Review of pilot TRL, legal aspects, technical solutions and risks
- D7.2: Developing a blueprint for the offshore site operation
- D7.3: Curriculum for offshore course, guideline, and learning manual
- D7.4: Joint production, monitoring, operation and maintenance protocol
- D7.5: Report on harmonized findings from pre-operational and operational phase
- D7.6: Development and implementation of a decommissioning procedure.

Additionally, the pilots have shared their experiences during UNITED Workshops and at conferences.

The aim of the current deliverable is to highlight the most important lessons learnt for each of the three implementation phases, to elaborate on them and to identify the common themes in these lessons across the different multi-use solutions.

2. PILOT OVERVIEW

2.1. German pilot

The offshore research platform FINO3 in the North Sea, operated by FuE-Zentrum, helped the wind farm operators and wind turbine manufacturers in the planning, building, and future operation of offshore wind farms. Meanwhile one focus of FINO3 is the testing of offshore MU activities.

As such, FINO3 was well placed to take up an offshore wind and aquaculture demonstration project and was able to enhance the aquaculture system development to Technology Readiness Level (TRL) 7. The materials, the handling, and the designs were first tested in a nearshore site within a commercial mussel farm and the optimized and adapted solutions were implemented offshore. Within the UNITED project, mussel- and algae aquaculture systems were installed at the FINO3 site. Synergies between active mariculture and offshore wind parks in far offshore cases could be demonstrated pertaining to testing the technology, finances, synergies in health and safety, as well as environmental risk reduction. The dynamic characteristics of this very exposed offshore region, including stormy winters and remote access, made the application of automation and optimization measures between offshore wind parks and mariculture indispensable. Insights into the challenges and solutions of scaling such a combined operation with integrated technological support systems, harvesting requirements, and increased monitoring needs were obtained and helped to generate business case models, blueprint design studies and policy briefs. Information to stakeholders and the public was successfully spread by organizing and taking part in meetings, workshops, fairs, regional and national television broadcasts.

Objectives for the German Pilot at FINO3 were:

Reduce risks and demonstrate tested solutions for multi-use concepts in cooperation with North Sea industries through improved data management, automation, and investigation of interactions between target culture species and the offshore environment.

Demonstrate societal acceptance and benefits of offshore wind and aquaculture developments by exploring business models, cooperative ownership, and fostering positive public perception. Seek shared costs, improved social/environmental image, and increased financial returns. Explore eco-labels and small spatial footprint certification.

Provide opportunities for small and medium-sized companies or EU institutions to establish reference guidelines and showcase their performance capabilities in harsh conditions.

2.2. Dutch pilot

The North Sea Farmers Offshore Test Site (previously called the North Sea Innovation Lab) is an independent test site for research, pilots and the upscaling of innovations in the field of seaweed cultivation, floating solar and other renewable energy innovations, and co-use of wind farms. It is located 12 kilometres off the coast of The Hague and therefore subject to the rough offshore conditions of the North Sea. The water depth is 18-20m, the area is officially demarcated by cardinal buoys and with its total area of 600ha / 6km^2 the largest offshore test site in Europe.

The Dutch pilot was installed at this location. UNITED partner “The Seaweed Company” installed together with “North Sea Farmers” two seaweed cultivation systems for two growing seasons. Next, a floating solar pilot (the first offshore floating solar installation in the world) was installed by UNITED partner “Oceans of Energy”. Additionally, a few measuring devices were installed. Both as part of the pilots (for example force measurement on the system) as well as several data buoys.

The objectives of the Dutch pilot were:

- Demonstration of offshore solar integration in offshore wind farms;
- Demonstration of a safe operational plan for the commercial roll-out of integrated aquaculture in offshore wind farms;
- Demonstrate and quantify the wave dampening of floating solar array;
- Demonstrate Remote Monitoring.

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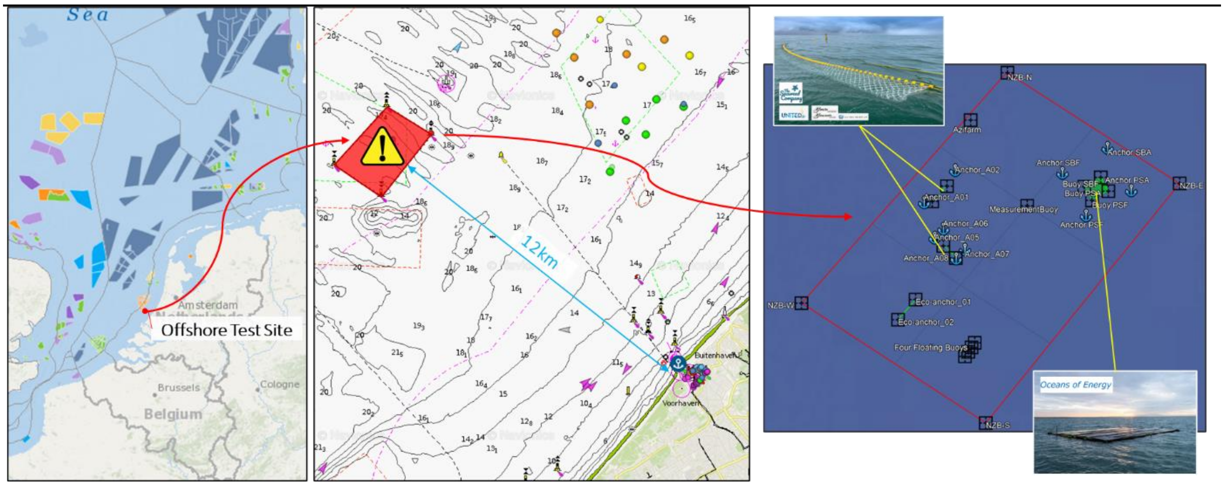

Figure 1: Dutch pilot location "North Sea Farmers Offshore Test Site"

2.3. Belgian pilot

The Belgian pilot is situated at two test locations in the Southern North Sea. The nearshore test site 5 km off the coast at Nieuwpoort (Westdiep) facilitated optimizing cultivation techniques of the European flat oyster (Ostrea edulis) and sugar kelp (Saccharina latissima) as well as improving restoration procedures. The best performing methods were then implemented at the offshore test site within the operating wind farm Belwind (operated by Parkwind), 46 km off the Belgian coastline (Figure 2), with a total capacity of 165 MW, powering up to 175 000 households.

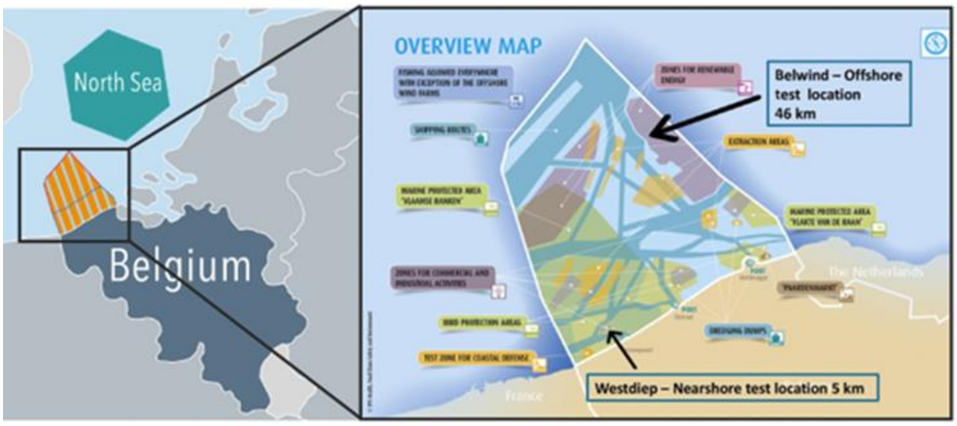

Figure 2: Belgian pilot test locations the Westdiep (nearshore test site) and Belwind (offshore test site) and marine spatial plan of the Belgian part of the North Sea

In 2022, two separate longline systems were installed in the offshore Belwind site: one system for oyster cultivation and the other for seaweed cultivation. Several different types of cultivation structures were dispersed along the oyster backbone to determine best practices for oyster grow out offshore. The seaweed longline used a net system for grow out and tested two different methods of seeding.

The Belgian pilot also conducted a feasibility study for oyster restoration by installing four restoration tables on the sea floor in the Belwind concession area. These four restoration tables were installed on the existing scour protection around two monopiles. Tables were placed on the sea floor at a safe distance from the wind turbines. Moreover, the non-exclusion site around the monopile (= e.g. landing and cable site) was avoided.

Per monopile, two tables were installed: 1 structure in SW-NE axis and one on SE-NW axis, to estimate whether the place around the monopile could influence the settlement of oysters. Per table, 6 smaller compartment called “gabions” were filled with scour protection materials.

The objectives of the Belgian pilot were:

- Improve design and installation methods for offshore low trophic aquaculture (LTA) systems
- Demonstrate integration of LTA systems within an offshore wind farm
- Identify optimal seaweed and bivalve cultivation equipment for offshore conditions
- Optimize scheduling of multi-use activities
- Develop business cases and financial analysis of integrating the offshore wind and aquaculture activities.
- To test whether adult oysters could spawn in offshore conditions in the Belgian part of the North Sea
- To see whether or not self-recruitment (= settlement of oyster larvae on the substrates at the same spot as where they were released from) was possible
- To investigate whether or not the oyster larvae could colonize the substrates in the tables downstream.

2.4. Danish pilot

The Danish pilot is combining the production of wind energy with tourism. One or two of the existing wind turbines of Middelgrunden Wind Farm – in total 20 turbines (Bonus today Siemens Gamesa each 2 MW from 2000) – is used for visiting. In 2000 Middelgrunden Wind Farm was the largest offshore wind farm in the World.

From the beginning – 20 years ago – the kind of visits were following an old Danish tradition made available at the annual wind day – 3rd Sunday in June – for the 8500 shareholders. Slowly the opportunity for getting up in a wind turbine was getting known by universities and developers and since 2012 the number of visits has slowly been growing.

Middelgrunden Wind Farm is Denmark's premier offshore wind and tourism destination located right off the coast of Copenhagen. Middelgrunden consists of 20 turbines, each 2 MW, a total power of 40 MW delivering 3% of the power used in Copenhagen. Not only is the wind farm a vital source of renewable energy for the city, it is also a major city landmark, voted as the second most important by the locals.

Middelgrunden is much more than just a wind farm. It is a place where you can experience the beauty and power of offshore wind up close and personally. Visitors can join guided tours led by the local cooperative that owns and manages 50% of the farm. These tours and visits offer a unique and extraordinary opportunity for offshore experts, investors, wind developers, universities and students, and the general public to learn about the importance of renewables and their sustainable integration into the local socio-economic context.

Figure 3: Students and developers visiting Middelgrunden Wind Farm

It is a once in a lifetime experience that will change your perspective and give you a first-hand insight into the role of renewables at a time when so much effort is being taken globally to reduce the impacts of climate change.

The objectives of the Danish Pilot were:

- Develop the combination of wind production and tourism from TRL 6 to TRL 9.
- Establish knowledge to be used by offshore wind farm owners to enable them to combine with tourism.
- Investigate the opportunity for adding other forms of MU like diving and fishing.

Figure 4: Students and developers visiting Middelgrunden Wind Farm

2.5. Greek pilot

The pilot is situated in the marine area near the 59th km Athens- Sounio Ave., Gaidouronisi strait (Patroklos), Saronikos municipality, Eastern Attika district, Greece. The pilot expands tourism activities (leisure scuba-diving) at aquaculture site. KASTELORIZO AQUACULTURE SA operates a fish-farming unit, on floating facilities in the marine area near islet “Patroklos”. KASTELORIZO provides the aquaculture unit that shares the same marine space with the touristic diving activities of Planet Blue Dive Center.

The objectives of the Greek pilots are to facilitate touristic growth in combination with social acceptance of aquaculture activities by offering scuba diving expeditions around the marine area and aquaculture facilities and guided boat tours, informing about sustainable aquaculture. Furthermore, innovative technologies are applied for a more efficient aquaculture production and increased fish welfare management, such as monitoring environmental parameters (salinity, water quality) as well as fish behaviour and stress levels.

3. LESSONS LEARNT – PRE-OPERATIONAL PHASE

3.1. Site specific needs and challenges

3.1.1. German Pilot

The Pre-operational phase involved designing and validating the systems, planning the monitoring of environmental factors, planning a monitoring lander and implementing remote operation capabilities. However, several challenges were encountered during this phase, and the project team learnt important lessons along the way.

Permitting Delays: One of the greatest challenges faced during the pre-operational phase was the permitting process. Officially stated to take eight weeks, it unexpectedly stretched to eight months. This delay highlighted the importance of such MU pilot projects. One is well advised to start the permitting process well in advance and account for potential bureaucratic hurdles and unforeseen complexities. Proactive engagement with regulatory authorities and obtaining the necessary approvals early on can help avoid significant delays.

Nearshore Testing: Conducting tests in a nearshore environment proved crucial in assessing equipment functionality, workflow efficiency, and monitoring equipment performance. This step allowed the project team to identify and rectify issues before deploying the systems in the offshore environment. Utilizing a controlled test site near the project location is an essential prerequisite, can provide valuable insights and mitigate potential risks associated with system operation. One example regarding the underwater cameras: A test camera was provided by the supplier as this model is a comparably cheap version and the quality of the photos had to be ensured before the offshore deployment. The attachment to the longline proved to be insufficient even for the protected nearshore site and was enforced for the offshore operation.

COVID-19 Impact: The outbreak of the COVID-19 pandemic coincided with the project's pre-operational phase, introducing unforeseen challenges. Lockdowns, disruptions in manufacturing, and delays in material delivery created additional hurdles. To mitigate the impact of such external factors, project planners should consider incorporating contingency plans, preparing alternatives and building flexibility into the project timeline and supply chain management. As an example, all team members were trained to handle the offshore equipment and have a detailed knowledge of design plans. In case of absence due to illness any other team member could take over the sea mission.

Insurance Considerations: Obtaining insurance coverage for offshore operations posed challenges, primarily due to the unique nature of the aquaculture multi-use project. Understanding the specific insurance requirements for offshore aquaculture ventures and engaging with insurance providers early in the project can help navigate these complexities and ensure adequate coverage.

System Behaviour Modelling: To enhance system performance and minimize risks, modelling the behaviour of the mussel and algae aquaculture system was crucial. Different international standards, described in UNITED D7.2 (2022), needed to be achieved with the design. By simulating different scenarios, the project team could anticipate potential challenges, optimize system design, and fine-tune operational parameters. Collaborating with partners and external experts in aquaculture system modelling can greatly assist in achieving desired outcomes. So, the “weak links” were detected and at specific points other shackles were chosen to increase the safety of the system.

Remote Monitoring and Operation: The inclusion of webcams offered valuable insights into the surface and subsea conditions. However, the project team learnt the importance of robust and reliable communication infrastructure for remote operation. Ensuring stable and efficient data transmission from the monitoring equipment to the control centre is essential for real-time decision-making and system management. Therefore, test runs of all transmitting pathways, like sensor to transmitter, transmitter to the offshore server and from the offshore platform to the onshore server, were done before the installation of the system to ensure the complete functioning from day 1 of the operational time.

In conclusion, the pre-operational phase of the offshore aquaculture multi-use project provided valuable lessons for the successful deployment and operation of the mussel and algae aquaculture system. Overcoming permitting delays, conducting nearshore testing, adapting to external disruptions, addressing insurance challenges, modelling system behaviour, and optimizing remote monitoring and operation capabilities were key takeaways. Implementing these lessons can enhance the efficiency, resilience, and sustainability of future offshore aquaculture projects.

3.1.2. Dutch pilot

For the Dutch pilot, North Sea Farmers had already a permit for the Offshore Test Site. Therefore, no permit application was needed, which saved a lot of time compared to other pilots. Part of the pre-operational phase were: design of the installations and procedures for the installation, O&M, and decommissioning. In general, it is important to know upfront what the focus / objective of the pilot is, to make sure this can be indeed validated during the operation. This includes for example choices in the design or monitoring equipment.

The following lessons learnt are interesting to share.

- Monitoring approach: the type of monitoring should be considered in the pre-operational phase, as the structures, monitoring equipment and the corresponding vessels need to be designed and chosen in such a way that they correlate to each other. For example: if a sensor needs to be cleaned, a decision needs to be made up front whether this will be done on land, offshore on deck of a vessel or offshore in the water from a vessel / RIB. It turned out that a small data buoy that can be installed with a small vessel (and can be carried by hand) is much more convenient than a large data buoy that needs a heavy crane. This is way more costly and more difficult to operate. See comparison in Figure 5 below.
- Supply of materials: due to covid, but also in general the supply of certain materials is more difficult than before. Within the Dutch pilot there were no issues with the materials for the pilot installations, but it took longer to get the right sensor equipment for the data buoy(s). Lesson learnt is to start as soon as possible with the procurement of all the elements needed in the pilot, also when it isn't necessary right from the start.
- Offshore grade sensor equipment: another lesson learnt is that most sensor equipment is not offshore grade, even though the supplier says so. Therefor it is important to take into account that you might need to develop your own sensor housing. The battery lifetime of sensor equipment in winter offshore conditions is also an element that needs to be sorted out before installation.
- Temporary "storage" space: especially for seaweed, but in general as well, it is useful to have a back-up temporary storage space when due to unforeseen circumstances the offshore installation has to be cancelled. For seaweed, it's important to seed and install the nets in the water within a timeframe of a few days "after the seeds are ready". In the second growing season within UNITED, the seeded seaweed nets had to be installed, when it turned out an additional maintenance operation on the installation offshore was necessary. Fortunately, a spot in the harbour could be used for putting the seeded nets into the seawater, but this wasn't an ideal situation.
- Soil conditions: when an anchor is used that penetrates (partly) in the seabed, it can be useful to check the soil conditions prior to the installation and design of the anchor. Within the Dutch pilot drag embedment anchors were used. Finally, it worked to install them, but both for the floating solar as well as for the seaweed cultivation pilot it was more challenging than expected.
- Legal and contractual framework: UNITED partner Ventolines provided a report on the regulatory and legal framework for integrated offshore wind and solar energy projects. This report addresses the legal and contractual implications of integrating an offshore floating solar farm into an offshore wind farm, with a specific focus on the Dutch exclusive economic zone (EEZ). Six scenarios, based on designs provided by our partner TNO, ranging from standalone to integrated concepts, have been analysed, incorporating both green- and brownfield developments. The assumption for this report is that future solar farms will be situated in proximity to existing and upcoming wind farm plots in the Dutch EEZ.
- Key regulatory findings reveal that the Offshore Wind Energy Act applies within the EEZ but lacks a framework for energy project integration. Offshore solar farms require a water permit under the Water Act, as direct connection to the offshore grid is not currently permitted. The current legal framework favours greenfield offshore wind and solar farms over brownfield projects. In the Ventolines report, a case study illustrates different integration scenarios, emphasizing the challenges in brownfield situations where the wind farm tender process has concluded.

- The recommendations in the aforementioned report include overhauling the Dutch regulatory framework to create a comprehensive legislative package for integrated offshore projects. This proposed law should cover designated solar farm areas, integrated permitting processes, and conditions for integrating solar farms with existing wind farms.
- For comprehensive information regarding the legal and contractual framework for offshore integrated wind and solar energy projects within the Dutch part of the North Sea, please be referred to the Ventolines report. The executive summary of the report is included in Annex I and the full report is included in Annex II.

Figure 5: Difference between installation of the large data buoy with large vessel (left) and small data buoy with smaller vessel (right) at the Dutch pilot.

3.1.3. Belgian pilot

The Belwind offshore wind farm is located at the Bligh Bank and its surrounding gullies where the sea depth varies between 15 and 37 meters. The area is characterized by sandbanks and gullies that are formed and sustained by the tidal currents. The pilot multi-use combines seaweed and European flat oyster (Ostrea edulis) aquaculture, and oyster reef restoration within an offshore wind farm.

The Belgian pilot's challenges for design and construction have been mainly related to: 1) its relatively long distance (46 km) from the coast; 2) rough conditions with 6 m waves not being an exception; 3) its location in a wind farm, posing requirements on risk assessments.

To make sure the installations envisaged would comply with and resist to the challenging nature in these offshore circumstances, engineering teams have modelled the structures which were implemented. Moreover, installation methods were adapted for oceanic conditions and to mitigate environmental impacts.

In the Belgian pilot, two aquaculture longlines and oyster restoration tables were installed offshore.

For the aquaculture longlines, one was destined for seaweed and one for oyster cultivation. To make sure the systems were as adapted to the rough offshore environment as possible, numerical modelling has been conducted by Gent University Department of Civil Engineering, Maritime Technology Division and simulated under 50-year storm conditions. This has helped to inform the construction of the two submersed longlines.

Dynamic analysis of mooring setups for the oyster and seaweed longlines are performed by utilizing a lumped-mass based mooring dynamic solver (Hall & Goupee, 2015; Pribadi, Donatini & Lataire, 2019). Hydrodynamic forces are modelled using the Morison Equation (Morison et al., 1950). Consequently, the Morison coefficients used are taken from DNV OS301 (DNVGL, 2018). The Norwegian Standard NS9415 (Norwegian Standard, 2010) defined the ultimate limit state (ULS) as a combination of:

- 50-year return period of wave and 10-year return period of current
- 10-year return period of wave and 50-year return period of current

In Table 1, the 50-year return period of wave and current are presented, which will be used in the numerical calculations. The properties of lines and buoys are to be defined once the ULS numerical calculations are performed. The diameter of the inflatable backbone still needs to be determined based on its floating capacity and breaking strength (BS) (Hall & Goupee, 2015). Maximum tension on the line, based on the ULS numerical simulations, should not exceed line's BS divided by 3.45, which is a combination of material factor (Synthetic rope = 3.0) and type of analysis (dynamic analysis = 1.15) (Norwegian Standard, 2010).

Table 1: Load combinations used in the simulation.

Wave				Current (depth-averaged)	
input	height	period	direction	speed	direction
[-]	[m]	[s]	[going-to]	[m/s]	[going-to]
Regular wave	11.8	9	North-East	1.4	North-East

Detailed info on the numerical modelling can be found in UNITED D7.2 – Developing a blueprint for the offshore site operation (2022).

Lessons learnt during the pre-operational phase:

The pre-operational phase required the obtaining the correct permits for aquaculture and restoration operations for research purposes, establishing an insurance policy, designing and modelling offshore cultivation systems for flat oysters and seaweed, and testing designs in the nearshore environment. There were challenges faced and lessons learnt in the process of following these steps.

- Permitting: as this was a scientific project, an environmental permit did not need to be requested. If this would have been the case, an environmental assessment must have been carried out by the Scientific Service Management Unit of the Mathematical Model of the North Sea (BBM). Buoys marking the area were already in place via other research activities in this area, hence there was no extra need for that. For installing the restoration tables however, we needed to make a notification of the activities to be performed in a "passende beoordeling" that had to be sent to BMM for approval. Concretely, we had to describe the project, describe whether and how we would disturb the bottom, how much square metres was going to be installed at the bottom and for how long. The authorities responsible for evaluating proposals and granting permits do so on a case-by-case basis. For offshore permitting, we needed approval of the concession holder in order to be allowed to carry out activities in the area and we needed to provide method statements before the activities to be performed could be approved by Parkwind.

- Insurance: nearshore, the insurance was covered under other scientific activities which were already negotiated on before the start of UNITED. For offshore, negotiating insurance coverage for an offshore aquaculture multi-use project proved to be quite difficult. An independent party was subcontractor to estimate the risks that the activities at sea offshore in a windfarm would entail. This risk assessment was necessary to have as to be able to get the activities approved by the concession owner and by the wind farm operator.

- Modelling and industry advice: before installing an offshore system, it is crucial to ensure that the infrastructure can withstand the harsh conditions of the North Sea. Modelling is an essential tool for this, but it should be supplemented and validated by the experience of industry members who can provide practical advice, which was done so in the preparation of going offshore.

- Nearshore testing: The preoperational nearshore tests were essential for identification and development of suitable cultivation techniques for oyster and seaweed aquaculture and restoration offshore. Trial and error was necessary to determine effective methodology and revise designs for the offshore environment.

3.1.4. Danish pilot

The Danish Pilot operator, SPOK ApS organises guided tours to Middelgrunden Wind Farm on behalf of the Cooperative Owners.

Boats used for the activities within this pilot need to be booked and are not owned by the pilot operator. The pilot operator works normally with two boat companies. The tourism consists of a cooperation between commercial boat operators, which are booked for the date of the trip, and the wind park operator represented by the Pilot operator. The boat operator is selected depending on the number of visitors and on the wishes from the visitors related to the exciting experience wanted. Both boat operators have their own insurance.

Legal rules and insurance related to the risk during the visit were not studied in depth when the project started as the visits by turbine owners were automatically covered by their share ownership.

3.1.5. Greek pilot

Choice of ROVs: During the pre-operational phase, it was important to carefully select ROVs (Remotely Operated Vehicles) based on specific requirements. Lessons learnt include:

- Reduced staff exposure to diving dangers: By using ROVs instead of human divers, the risks associated with diving, such as decompression sickness and underwater hazards, can be minimized. This ensures the safety of the staff involved in the operations.
- Operation under any weather conditions day and night: ROVs offer the advantage of being able to operate in various weather conditions, including rough seas and low visibility. This flexibility allows for continuous monitoring and data collection regardless of the time or weather.
- Ability to approach great depths: ROVs equipped with advanced technology can reach significant depths in the water, providing access to areas that may be difficult or dangerous for divers. This capability is crucial for comprehensive monitoring and inspection of aquaculture infrastructure.
- Small size and portability: Choosing ROVs that are compact and easily transferable allows for efficient deployment and flexibility in different locations. This ensures adaptability to the specific needs of the aquaculture site.

Impact of COVID-19: The COVID-19 pandemic brought several challenges related to the provision of cameras and sensors from foreign countries. Lessons learnt include:

- Supply chain disruptions: Restrictions on international travel and logistics affected the timely delivery of equipment, including cameras and sensors, from foreign suppliers. Building resilience in the supply chain and exploring local sourcing options can help mitigate future disruptions.
- Importance of local capacity: Developing local capacity for the production and maintenance of cameras and sensors can provide more reliable and accessible options during times of crisis.

4. LESSONS LEARNT – OPERATIONAL PHASE

4.1. Site specific needs and challenges

4.1.1. German Pilot

During the operational phase of the offshore aquaculture multi-use project, specific needs and challenges associated with the project site were identified. These factors played a crucial role in shaping the project's approach and outcomes.

COVID-19 Impact: The ongoing COVID-19 pandemic continued to disrupt project operations, leading to delays and limited availability of materials and long delays in delivery. This necessitated the development of contingency plans.

Ship Availability: Ships were not always readily available when good weather windows were present. Hence close coordination with shipping companies and within the pilot team to navigate these challenges effectively was necessary. Safe decisions for or against a sea mission could be made only 24 hours in advance. The suitability of the available ships is often limited which led to wider adaption of the installation procedures. The conclusion is that demand clearly exceeds the supply situation of suitable vessels. So, several discussions with different stakeholders were undertaken to present the present and future situation of offshore aquaculture activists and to highlight the opportunities to be one of the first experienced and specialized providers for MU research and commercial projects. The need for a clear definition of the legal status of offshore MU projects for investors became obvious. As it takes time for the current situation to change, major adjustments for materials and gear suitable for smaller vessels are recommended for future projects. Also, a new mindset and greater acceptance of the offshore industry are needed to use more synergy effects like sharing vessels.

Adverse Weather Conditions: The offshore site was prone to adverse weather conditions, including storms and rough seas. These conditions significantly affected ship operations, emphasizing the need for accurate weather forecasting, flexible scheduling, and resilience in system design to withstand extreme offshore conditions. The central data platform for UNITED, HISEA, was constantly “fed” with detailed information on site-specific conditions and experiences. As a result, HISEA forecasts improved throughout UNITED and became an increasingly important tool in the decision-making process.

Ship and only short-term weather forecast availability resulted in strong permanent commitment of the employees like partly 24h standby, holidays of a maximum duration of 4 days, and permanent research for ships and alternatives. This led to increased ambitions to create additional synergy effects with other offshore users of the location or nearby wind parks. Weather forecasts and site-specific experiences with them were more closely exchanged, offshore personal was trained to cover some maintenance activities. New opportunities and also limits for these cooperations were discovered as an outcome. More staff to reduce the workload is advisable.

4.1.2. Dutch pilot

In general flexibility is the key in the operational phase. Due to the combination of the dependency of both good weather conditions to go offshore as well as the availability of the right vessels, it is necessary to be flexible. It is advisable to have the necessary equipment and enough people that can and are allowed to work offshore ready, so that in case it’s necessary to go offshore ánd the weather is okay ánd the right vessel is available, you can act immediately. An example is that you would like to do an inspection of the installation after a heavy storm. Another example for seaweed cultivation is that you want to be able to do the harvest at the right moment, to make most out of the harvest.

Having a large network for the procurement of the necessary equipment and the rental of multiple vessels is an advantage. As well it is advised to have a good weather forecast model specific for the location. Or, in case this is not available, know which models for areas close by are the best fit for the pilot location. For example: the current, and especially the moment of the turnaround where the current is the lowest, is an important factor for the planning of the offshore work. This moment in time differs per location, so it is useful to know exactly when this is at your pilot location to safe "waiting time" offshore.

4.1.3. Belgian pilot

The Belgian part of the North Sea is a high energy environment with strong offshore currents and often adverse weather conditions. Safety precautions are of the utmost importance in this environment and the Belgian pilot location within an offshore wind farm only adds to the possible complications of rough seas. These site-specific conditions led to challenges in the operational phase of the pilot. For example, sea missions for installation, monitoring, and harvests proved to be particularly difficult to plan. Operational limits were set to waves <1 m, currents of <0.5 m s-1 which occur during tidal changes around neap tides as well as low wind conditions of preferably <5 m s-1 to ensure safe operation within the offshore wind farm. Additionally, there are a limited number of vessels equipped to work with the long line cultivation systems in the Belgian pilot which also meet the safety standards required by Parkwind, the operator of the Belwind offshore wind farm. Vessels must be vetted by Parkwind before a contract for the sea mission can be finalized. As the vetting takes a minimum of two days, the administrative process can limit the flexibility needed to take advantage of favourable weather windows. Therefore, the offshore missions require careful planning and are subject to delays.

4.1.4. Danish pilot

During the UNITED project period the visits have been professionalized.

We were at TRL 6 when the project started. Visits were organised as an add to the visits organised every two years for the shareholders. Visits were organised having one board member from the Wind turbine cooperative joining a group of visitors. When climbing the turbines, which were only 30% of the tours, one specific boat from one operator was available (it was the only boat able to get into the shallow water). For the rest of the tours more boats were available as we don't need to get into shallow water.

Following the high demand of tours experienced in the spring and summer of 2022 – especially the visits including climbing the turbine were increasing – two new guides have been trained. A guide manual was developed as part of UNITED (Danish pilot manual for guides, 2023). It shall be noted that guides work on a demand-basis, depending on the number of booked tours. This can be a bit challenging and requires flexibility, as some tours are booked with several months´ notice, whereas others with very short time e.g., two weeks in advance.

We have established insurance and legal rules and have been improving the overall security and risk assessment by the operations, which specially include access from the sea level using Zodiacs.

Both boat tour operators have now expanded their activities to now also promote tours to Middelgrunden Wind Farm. These tours are advertised on their website and can be directly booked there. The boat operators are then asking the Pilot operator to deliver a guide for the visit.

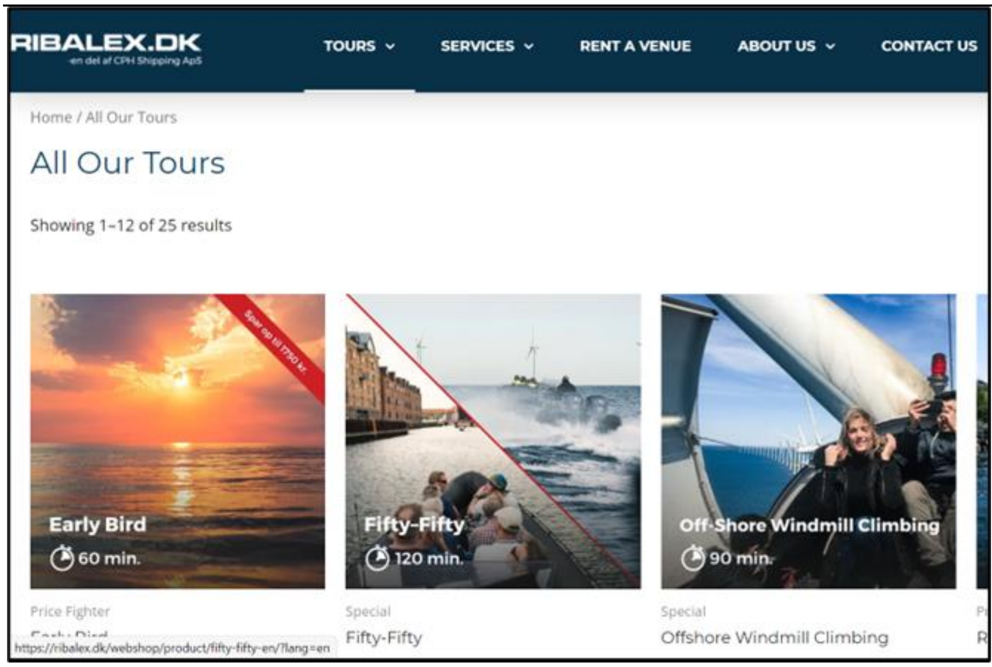

Figure 6: The website from the boat operator offering tours to Middelgrunden Wind using Zodiacs

*Table 2: The development of number of visits from 2017-2023 (*only ½ year)*

Business	2017	2018	2019	2020	2021	2022	2023*
Trips	31	35	48	4	13	75	67
Guests	676	930	1117	130	246	1687	1569
1.000 €	38,9	44,3	55,6	4,4	19,5	102,1	111,7

To cope with the lack of visitors during Covid and to expand the guided tours to *onshore* visitors in the city of Copenhagen, we have created a set of virtual tours (in both Danish and UK version) that aim to show the citizens of Copenhagen and tourists what happens at sea and for example how Middelgrunden Wind Farm was built. The virtual tours can be accessed via a QR code placed at several landmarks of Copenhagen, from which the wind farm can be seen. It shall be noted that Middelgrunden Wind Farm is visible from many places of the capital.

4.1.5. Greek pilot

COVID19 restrictions posed a great issue in the carrying out of the touristic activities during the operational period, but we managed to have the touristic expeditions once the lockdown restrictions were withdrawn. The tourist diving was 60% lower than the period before COVID19, which means that even though some tourist expeditions took place they were much less than the number of them would be during a normal period.

Fuel prices: Summer of 2022 was extraordinarily "low" due to the increase in fuel charges which have increased the diving fees by almost 20%. Furthermore, Lavrio, being at 60 kms away from Athens, adds an extra increase in divers' commuting, esp. local ones which would need to pay 20 euros (fuel and toll fees) to get here. For this reason, an increase in shore diving and a decrease in boat diving have been observed.

For the technological implications, WINGS has proceeded with the installation of solar panels for power supply, attached to the mooring system. To solve the internet issue, the WINGS Smart Gateway device has been adjusted accordingly to get internet connectivity with the use of a SIM card.

4.2. Physical installation at the offshore site

4.2.1. German Pilot

The physical installation phase of the project involved deploying the mussel and algae aquaculture systems in the offshore environment.

System Resilience: Despite challenging offshore conditions characterized by strong currents and high waves, the mussel system demonstrated resilience and successfully withstood winter storms. Contrary to the major scepticism of stakeholders at the beginning of the project, this is a huge success. This underscored the importance of designing aquaculture systems to withstand harsh environments and incorporating resilience features into system design. Nevertheless, adaptions towards lighter and smaller components are needed (see section 4.1.1).

Equipment malfunctions and accidents: An equipment malfunction resulted in interrupted or failing monitoring. These incidents emphasized the significance of thorough equipment testing, regular maintenance, and quality control measures to minimize the risk of accidents and equipment failures.

The ship crews became more and more familiar with handling offshore aquaculture equipment and the installation procedure. Experienced and established ship crews increase the safety and accelerate the time of offshore installations. The setting up of such teams is highly recommended and could be a competitive advantage in the offshore market if MU is expended in the future.

4.2.2. Dutch pilot

At the Dutch pilot the physical installations at the offshore site included:

- Two seaweed cultivation systems (one parallel and one perpendicular to the current)
- Floating solar installation
- Data buoys

In general, there is a lot of movement in the offshore structures due to the heavy conditions. This needs to be considered in the design. Sharp edges need to be avoided and parts that can move loosely will wear out quickly. Therefore, monitoring of the installations, both by inspections trips as well as via remote monitoring, is the key.

It is advisable to design the installations in such a way that there is no single point of failure. In case off any damage, for example after a storm, action can be taken to repair the installation. The installations in the Dutch pilot have demonstrated great robustness in the rough weather conditions of the North Sea. For the next steps in multi-use, aiming for a lifetime of ~25 years, the robustness of the installations needs to be further studied and monitored during the coming years in long-term pilots. Designs of the installations is expected to be improved the coming years with all the lessons learnt.

4.2.3. Belgian pilot

The installation phase of the Belgian pilot included installation of four screw anchors, and two longline systems for oyster and seaweed cultivation. In addition, oyster restoration tables were installed on the sea floor near the wind turbines.

The installation procedures carried out in the Belwind site would normally require a vessel with Dynamic Positioning 2 (DP2). However, due to vessel availability, a contingency plan was reached in which the contracted vessel used a four-point anchoring system to maintain position during the installation. All screw anchors and both longline systems with cultivation structures were successfully installed.

4.2.4. Danish pilot

The Danish pilot did not install any additional structures at the pilot location.

4.2.5. Greek pilot

The aquaculture farm of the Greek pilot was already in operation before the start of the UNITED project. The pilot did not install any large-scale infrastructure during the project and has, thus, no lessons to share except those already reported in section 4.1.5.

4.3. Monitoring at the offshore site

4.3.1. German Pilot

Monitoring the environmental factors and the growth of mussels, algae, and other aquatic life was a crucial aspect of the project to validate the pilot's technical and ecological setup and to find recommendations.

Technical aspects:

- Lander Data Connection Issues: The project faced a setback when the connection to the lander, responsible for transmitting data, was interrupted. We had to switch to the preinstalled backup system and rely on data collected at the FINO3 platform. This highlighted the importance of implementing redundancy measures and robust communication infrastructure to ensure uninterrupted data transmission and monitoring capabilities.
- The offshore graded and implemented load cells turned out not to be offshore suitable and all data was lost due to leaking. This underlines the need to simulate offshore conditions and test even graded equipment. See also Dutch pilot recommendations.
- The remote monitoring setup, as described in former deliverables of WP7 (sensor to transducer to data buoys to offshore structures to servers to onshore base), passed all tested parameters and turned out to be a feasible solution for remote locations with the high potential for commercial applications. This is a good example for further MU synergy effects.
- Even comparably cheap solutions like an adapted data buoy served well until a storm destroyed important parts. Further improvements can lead to even better suitability of this buoy. Close feedback and discussions with the offshore industry suppliers are taking place.
- Remote monitoring option of the system in heavy weather is essential. It is too expensive and even impossible to check the system by ship. A webcam installed on a nearby offshore structure, like a windmill, research platform or a transverter platform, as well as visual inspection by other offshore staff can replace those trips and create and use new synergy effects (Figure 7).
- Power supply is a limiting factor offshore and determines maintenance intervals. Therefore, the combination of other energy sources like wave energy plants with aquaculture should be analysed.
- The echosounder was also used to deliver important data about the behaviour of the net in the water (angle of back scatter) column when linked to tides, wave heights and current.
- GPS trackers proved to be a very valuable remote monitoring method to check the position of important and expensive equipment offshore as well as to plan the recovery in the event of loss.

Ecological aspects:

- Monitoring of highly protected species: Harbour porpoises are protected by Council directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. They experience a high degree of recognition and great sympathy from the public which often leads to emotive and non-fact-based debates. This is one reason why an enhanced monitoring of the eventual impact on this species was implemented. The only officially allowed method is based on standardized continuous porpoise detectors C-PODs. The mooring of these C-PODs demands a large sway circle as well as very short maintenance intervals of six weeks. These requirements turned out to be not suitable for a necessary remote offshore monitoring technique. See "weather conditions and ship availability" in section 4.1.1.

- Alternative Monitoring Methods: Challenges in obtaining mussel samples led to the utilization of a handheld underwater camera for monitoring mussel growth. This adaptive approach showcased the importance of flexibility and innovative solutions in overcoming operational obstacles and achieving project objectives.
- The independently operating echosounder (Figure 8) proved to be very suitable to monitor both technical aspects of the aquaculture design and biological questions such as mussel growth, impact on the marine environment and food availability. Figure 10 shows the expected decrease of biofouling on the mussel net in October compared to August (well defined boundaries), a bigger back scatter during summer due to more growth and more organisms like food for mussels, in the water column. Also, behaviour of fish and mammals can be detected with this method.
- All options for gathering needed data from already existing sources, like public data platforms or access to other offshore monitoring applications, need to be intensively checked in the planning phase to save costs and time.

Figure 7: Webcam photo taken from FINO3, North Sea on March 23, 2022 to monitor the status of the aquaculture systems remotely.

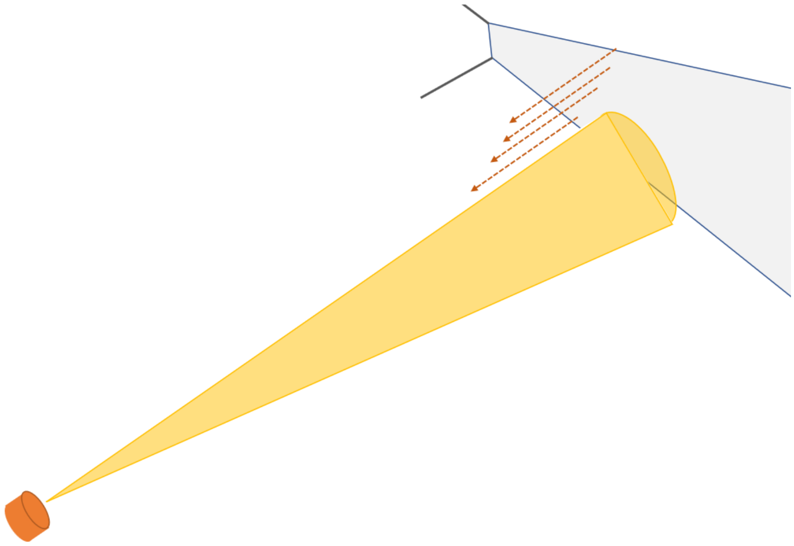

Figure 8: Echosounder placed on the seabed monitoring the mussel net.

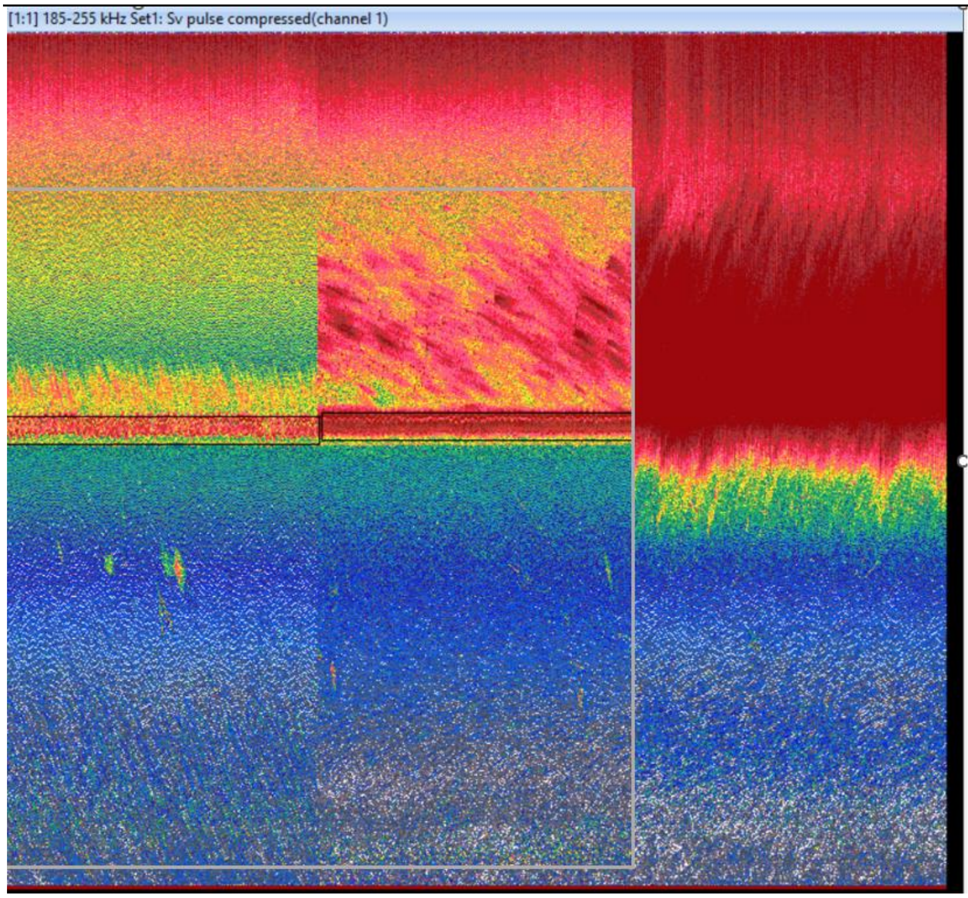

Figure 9: Echogram of mussel net at FINO3, North Sea, Germany in summer 2022. The beam in the middle represents the mussel net. Left picture: As the tide changes, the drift speed changes and water flow almost stops. Middle: Waves have a strong effect and lead to turbulent echograms. Right: Net is taken outside of the echosounder beam due to a storm

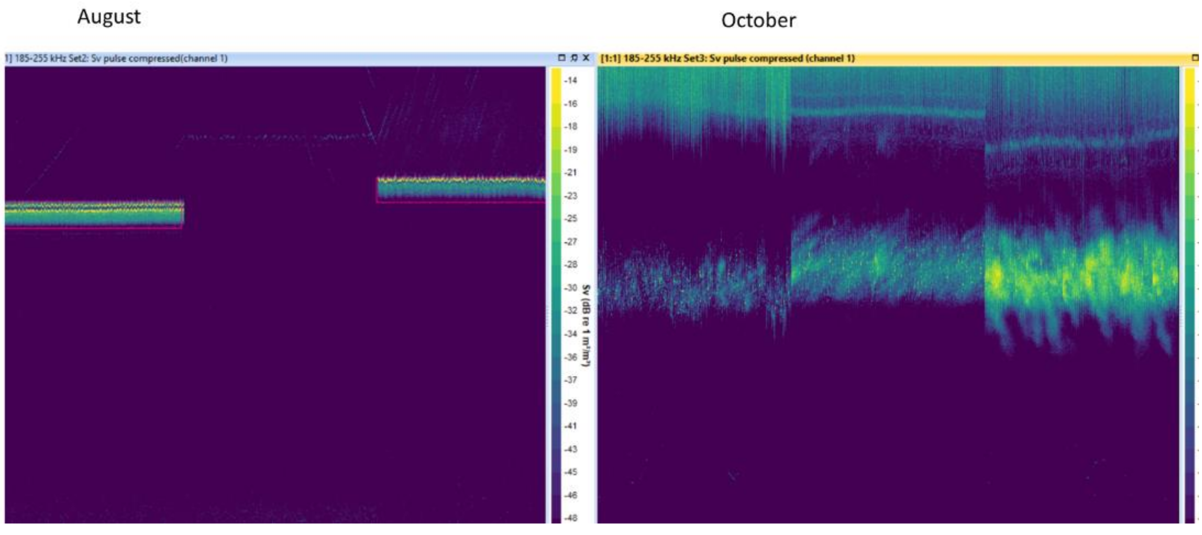

Figure 10: Echograms of the mussel net at FINO3, North Sea Germany in August and October 2022. Heavy biofouling leading to a clear beam in August. Wave action and decrease of biofouling are shown in a turbulent echogram in October.

4.3.2. Dutch pilot

Monitoring during the pilot is essential. Both for retrieving the right research data to learn from and improve the design as well as for the operation. Therefore, this needs to be considered carefully upfront (as mentioned in paragraph 3.1.2) both in pilot projects as well in the commercial phase. Depending on the objectives, different types of monitoring are relevant.

Within the Dutch pilot, two different types of monitoring were considered. These are the lessons learnt:

- Monitoring equipment installed offshore in/at/near the installations:
    - Also mentioned in paragraph 3.1.2 it is important to check whether the sensor equipment is really offshore graded.
    - For certain sensors it turned out that they needed to be cleaned and calibrated during the operational phase of the pilot. Fouling can become an issue. This is something to consider in the choice for the type of sensor and/or the maintenance planning.
    - It is important to make a wise choice between what parameters need to be monitored remote with live connection and from which parameters the data can be logged and retrieved after the pilot. The last will be more applicable for research purposes and the first for operational goals.
    - With the logging of the data, a connection with other data sets must be able to be made. For example: you want to be able to link the data of load sensors in the mooring to the exact waves and current conditions. Therefore, both a time stamp as well as the right measurement interval are of importance.
- Inspection trips to the site
    - These inspections trips will take place when the weather is okay. This holds for everyone having a pilot offshore at the same location. Therefore, it is advisable to share vessels for those offshore inspections and thereby saving money.
    - During a pilot, it is advised to go on an inspection trip after a heavy storm to check the state of the installations. Part of this condition can be checked with remote monitoring, for a commercial multi-use installation it is expected that this will fulfil. In the early stage of development, the pilot phase, it is advisable to use this monitoring methodology to validate the remote monitoring data. As well additional visual checks can be performed.

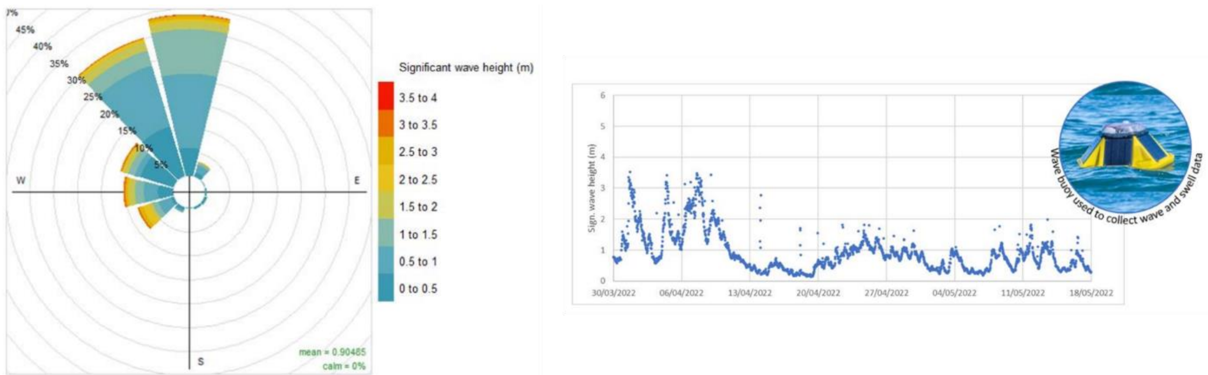

Figure 11: Example monitoring data Dutch pilot - These figures show some data of the wave buoy collected in 2022 by Oceans of Energy

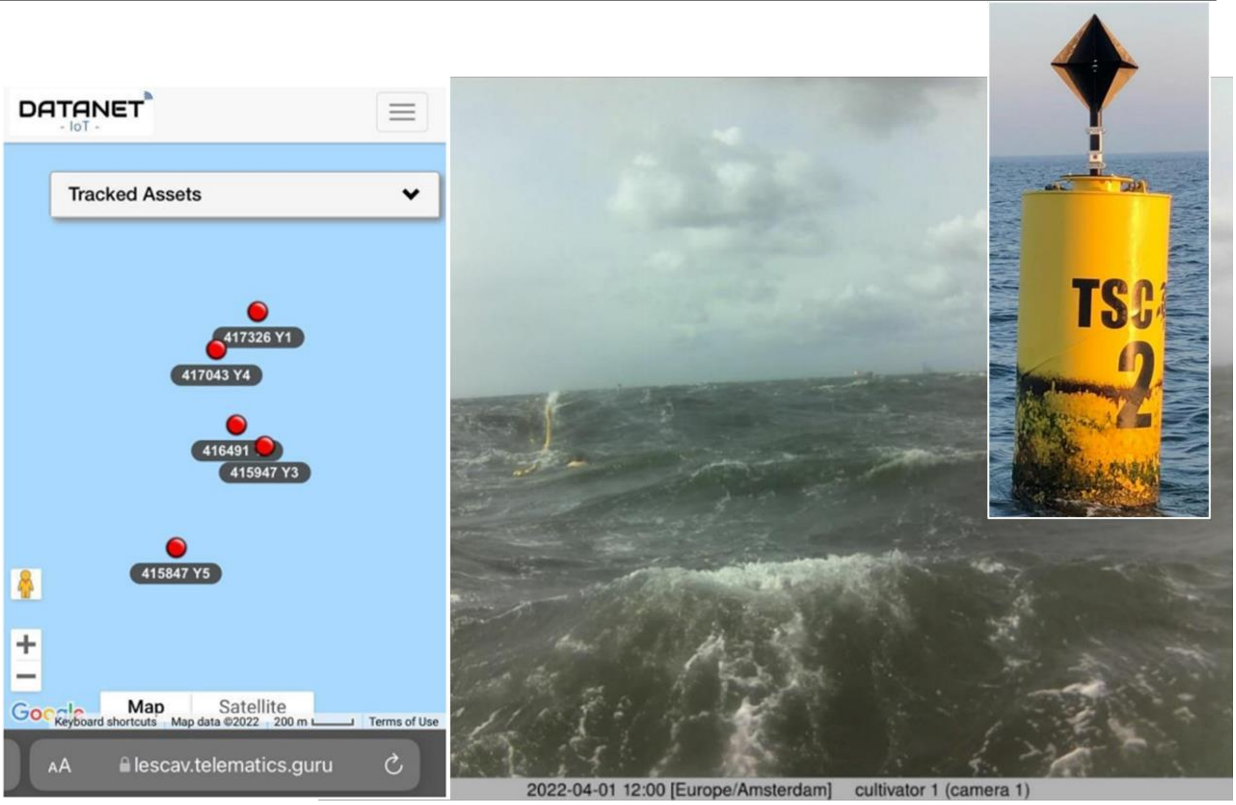

Figure 12: Example monitoring Dutch pilot - combination of GPS and cameras on the seaweed installations.

Figure 13: Example of footage of the latest installed data buoy with HD camera (left "bad" weather, right "good" weather)

4.3.3. Belgian pilot

One advantage of the pilot location within the Belwind site is the monitoring capability of Parkwind. Continuous video monitoring of the site allows Parkwind personnel to monitor weather conditions and any vessel traffic. Parkwind can then alert the pilot partners of any concerns or abnormalities. This allowed for quick, decisive action when the oyster cultivation system became unmoored.

Due to the limited number of sea missions possible for this project, monitoring of biometric data was only possible after harvesting the oysters and seaweeds. Both oysters and seaweeds were successfully grown at the offshore site. Samples are still being processed and measurements are still being analysed.

4.3.4. Danish pilot

The Danish pilot did not use any monitoring equipment. The only parameters that have been monitored are the number of visitors and the turnover, as seen in Table 2.

4.3.5. Greek pilot

Wired Connection Challenges: Lessons learnt during the operational phase include the limitations of a wired connection between cameras and sensors. Some challenges encountered include:

- Operational vessels cutting the wire: The wired connection between cameras and sensors may be prone to accidental damage by operational vessels. This can disrupt data transmission and monitoring activities. Alternative solutions or protective measures need to be explored to ensure uninterrupted connectivity.
- Power supply management: Aquaculture operators may turn off the power at times, leading to interruptions in the operation of cameras and sensors. Reliable power backup systems or alternative power sources should be considered to maintain continuous monitoring.

4.4. Testing of solutions at the offshore site

4.4.1. German Pilot

The testing phase at the offshore site involved collecting data and assessing the performance of the aquaculture systems.

Mussel and seaweed system: Both systems proved to be robust and functioning reliably to withstand 16m waves and currents of 1.5m/sec. The design, materials and mooring solutions were stable throughout the entire offshore phase. The installation procedure required specific vessels and an experienced crew (Figure 15). Four different commercial net types were tested for their suitability to cultivate mussels offshore. One net type turned out to be well applicable for offshore conditions. One net type was not fitting the requirements for mussel settlement, but biofouling was incredibly high. Details of the system are described in former deliverables of WP7.

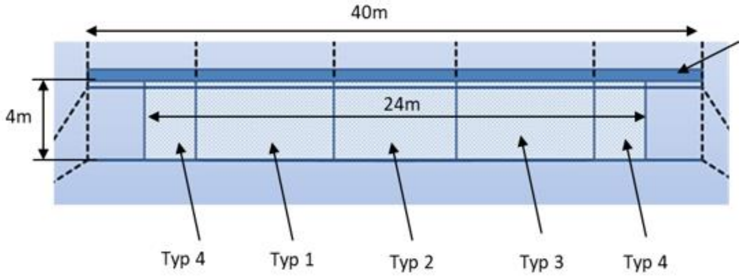

Figure 14: A sketch of the mussel system with four different net types. Typ1: Mesh size 90x90mm 210/600 and 12mm wide bands; Typ2: 135x135mm 210/500 and 6,5mm wide bands; Typ3: 200x200mm 210/600 and 12mm wide bands, Typ4: 200x200mm "Christmas tree" 65 diameter.

The seaweed net performed well for the growth of algae, but it was a big challenge to install and decommission it. Both more suitable vessels and experienced crew are needed but have not been available. Alternatively, more modular systems need to be tested in the future. An established standardized seeding method is not present in the industry. This decisive step of the production chain could be moved forward by the UNITED pilots but needs further exploration like one step or two step, twine or direct seeding and mobile seeding machines for upscaled operations.

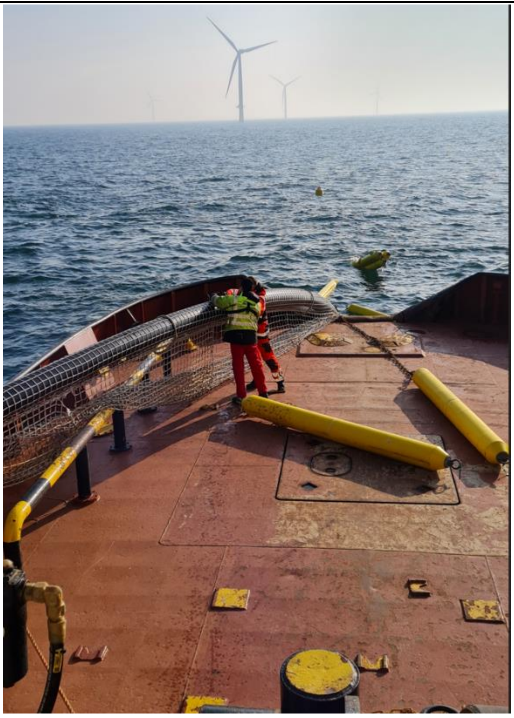

Figure 15: Installation of the mussel system offshore

Biofouling: Comprehensive nearshore tests were conducted to find an effective and approved-for-food-production antifouling solution. Extensive literature research and tests with external suppliers, start-ups and projects were implemented. The best material was chosen for the offshore site and proved to resist the high biofouling pressure in the North Sea.

Marking buoys combined with C-PODs: No chains to secure the marking buoys were allowed to avoid noise affecting the recording of the C-PODs. There was not enough additional unplanned space for separate anchors for each C-POD in this MU area. The C-PODs were an unplanned requirement from the authorities to obtain the license. The marking buoys were lost several times in storms which resulted in additional costs to recover and install them again. Five different mooring systems were developed within this project. The conclusion is that chains are unavoidable in order to achieve secure anchoring.

Tests for monitoring solutions are described in section 4.3.1.

Figure 16: Seeding the seaweed net by hand.

Algae System Deployment Challenges: Unfavourable weather conditions in the first year delayed the deployment of the algae system. As a result, the algae system had to be cultivated in the harbour as an interim solution before moving offshore. This highlighted the need for adaptability and flexibility in project execution, being prepared to adjust plans based on prevailing conditions.

Importance of Preparing for External Factors: The project encountered ongoing challenges related to COVID-19, ship availability, and adverse weather conditions. These external factors emphasized the need for comprehensive contingency plans, effective communication with stakeholders, and the ability to adapt to unforeseen circumstances.

Synergy effects: Different synergy effects were tested offshore. Sharing vessels with other offshore operators revealed to be possible for some missions. The cost reduction is a convincing fact. Some materials and some components need to become lighter and smaller to be able to expand and standardize this solution. Sharing personal also revealed to be a benefit for all offshore users for some tasks like maintenance, visual inspections and installing and operating any equipment on other offshore structures like webcams and data receivers. Some tasks like installation procedures or larger maintenance cannot be shared with other staff. One important point is the missing experience of the offshore aquaculture sector for standardized materials, designs and procedures. No blueprints nor suitable materials, sensors, designs existed for such harsh and remote locations. The available partial solutions had to be adapted or turned out to fail already in the nearshore site. See also Dutch pilot. Most of the achieved solutions were based on very specific created plans, close exchange with the other pilots and were adapted even during the operational phase according to the always existing difference between theory and practice.

4.4.2. Dutch pilot

Both the seaweed cultivation installation, the floating solar and the (wave) buoys with remote monitoring have been successfully tested at the offshore test site. During the UNITED project several severe storms have crossed the North Sea, making it a perfect test for these installations. It was favourable to have year-round tests to make sure the installations have been tested in all the different seasons. In this Dutch pilot even twice (two years)! By testing for two years, for the seaweed cultivation pilot, taking the nets out of the water for harvest and putting them back seeded several months later could be tested as well. This was an important step towards the goals of more large-scale operation of seaweed farms within wind farms.

Another interesting part that is developed during the UNITED project for the pilots at the offshore test site is a permit to work system. Before an offshore activity takes place, an automatic application form is used to get the permission to go to the Offshore Test Site. All the approved work permits are logged in a database including date, partner, plot, type of activity, vessel, captain, crew, visitors, offshore & onshore standby contacts, etc. This improves the safety of working offshore and is advised for all offshore pilots and projects.

4.4.3. Belgian pilot

Solutions designed for offshore testing were derived from lessons learnt in the nearshore, pre-operational phase.

Oyster cultivation: Flat oysters were successfully cultivated in the offshore pilot site, and a comparison of four different cultivation structures yielded useful results. Cylindrical lantern baskets, ropes with oysters cemented, heavy metal cages, metal frames each containing 4 SEAPA baskets were distributed along the longline system. Survival rates were high across all cultivation methods except for the ropes. Clear differences were noticed between the different structures in terms of structural integrity, biofouling, and influence on shell morphology. Among these options, the frames containing SEAPA baskets appeared to be the best combination of low internal biofouling, higher structural integrity, and practical convenience.

Seaweed cultivation: Seeding techniques proved to be crucial for successful cultivation in a highly exposed, offshore environment. Initially, there were poor results with direct seeding. However, there was a significant improvement with 2-step direct seeding methodology. The nursery period was also observed to be important for growth.

Aquaculture longlines installed in the offshore windfarm Belwind

Seaweed longline

The longline consists of 2 screw anchors, 2 mooring chains, 2 mooring ropes and 2 600 L corner buoys as can be seen in Figure 17 and Figure 18 below.

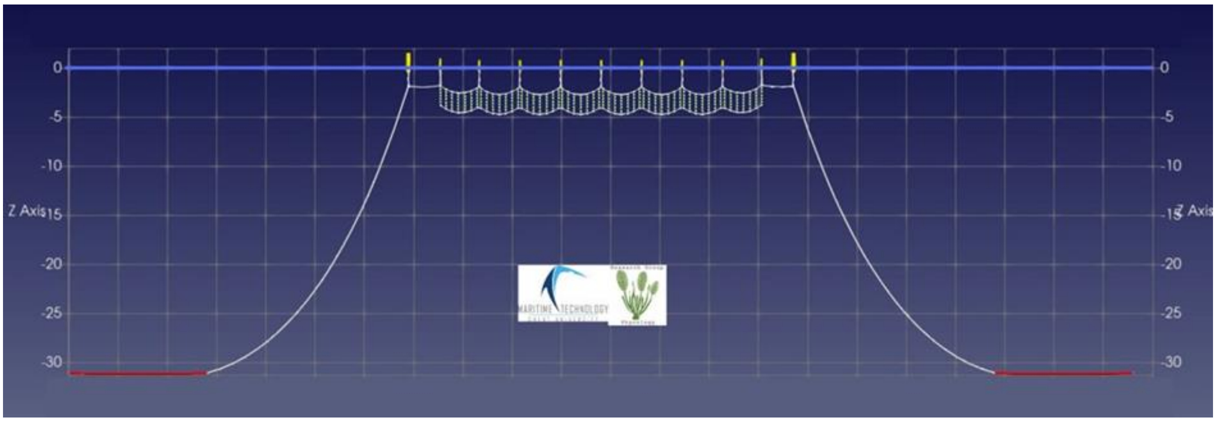

Figure 17: The seaweed cultivation structure of the UNITED project, modelling.

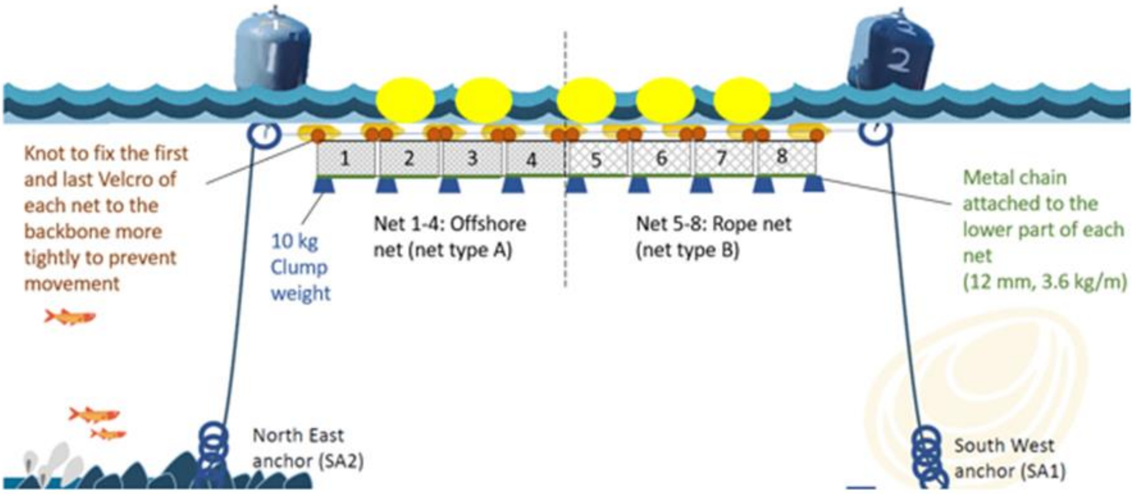

Figure 18: Illustration of seaweed longline.

Installation offshore was done December 2022 and retrieval of the nets in early summer (May 2023).

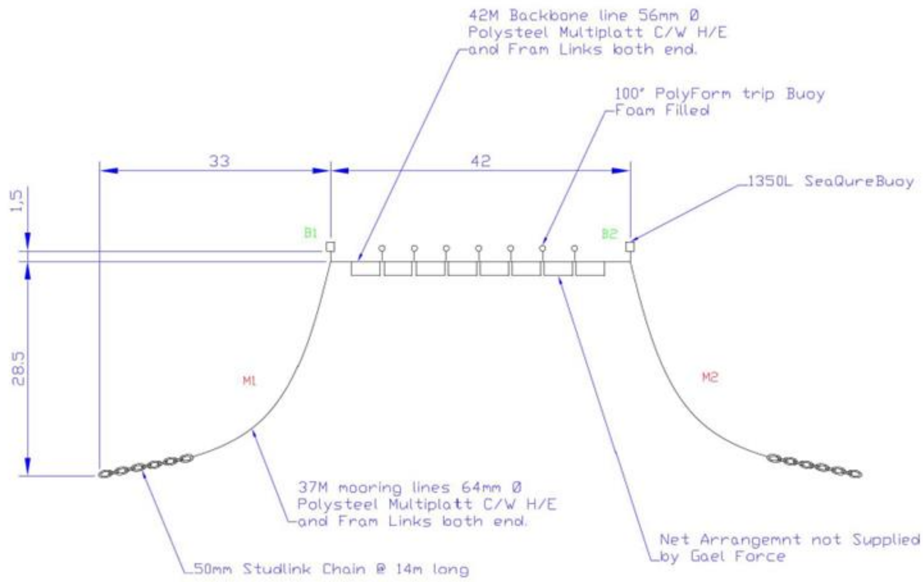

Figure 19: Technical drawing of a similar seaweed line with 8 nets hung next to each other.

Nets were used for the seaweed grow-out systems as they provide a larger cultivation surface in comparison to a single line. Different net types, appropriate for the attachment of seaweed rhizoids, as well as different seeding techniques were tested nearshore. Strong differences between the net types in terms of their durability to with-stand the harsh conditions were observed nearshore and adjustments were conducted in preparation of the off-shore installation. Some of the experimental treatments included the intermediate step of a hatchery where the gametophytes were allowed to attach and develop into sporophytes before deployment in the sea. This step ap-peared to be crucial for the successful attachment of the juvenile seaweed.

The nets were hung from the backbone via velcro adjusted to the diameter of the backbone with a distance of 0.5m between the nets. A chain running was attached to the lower part of the nets to ensure a stable vertical orientation of the nets in the water column.

An example of the seaweed net types used nearshore is given in Figure 20 below.

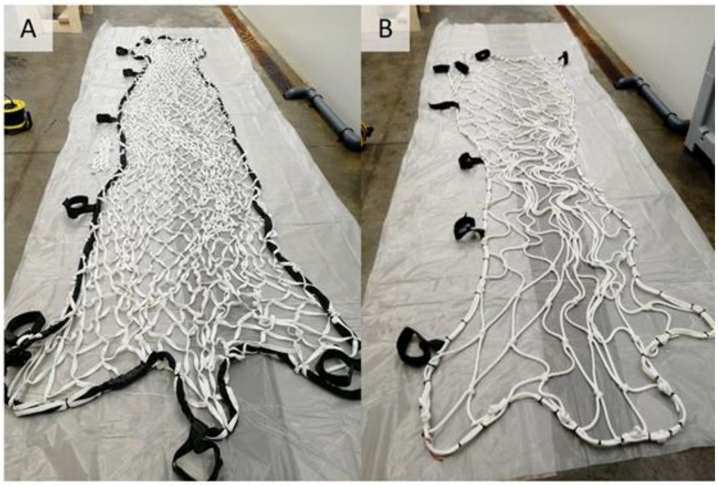

Figure 20: Overview of net type 1 (A) and net type 2 (B) before installation

As one of the net types tested nearshore proved to be too light for offshore use, the net type applied was adjusted for offshore use (see Figure 21).

Figure 21: Seaweed nets (offshore type)

Oyster longline

The installed oyster longline (Figure 22 and Figure 23) is fully submerged at -9m under MSL and consists of a 119m long submerged backbone (64 mm Polysteel multiplatt). The mooring lines consist of the same rope (30m) connected to 50mm Studlink chain (14m). All floaters are made of high-density polyethylene (HDPE). There are 5 large surface buoys (corner buoys with a light) installed and 10 smaller buoys at 9 m depth below surface.

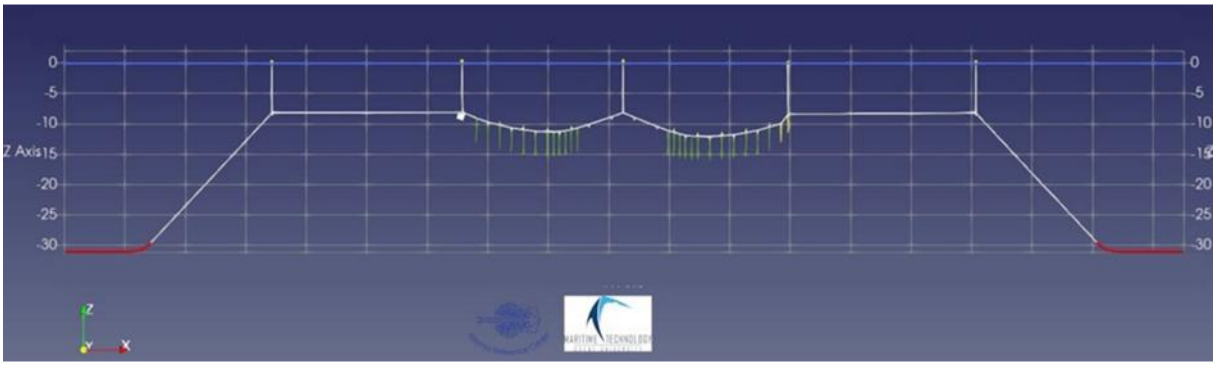

Figure 22: Schematic of oyster backbone structure in the water column

Figure 23: Surface view of H2020 UNITED oyster aquaculture backbone

Grow-out oyster systems installed offshore

Figure 24 below gives an illustration of oyster structures that were attached to the backbones.

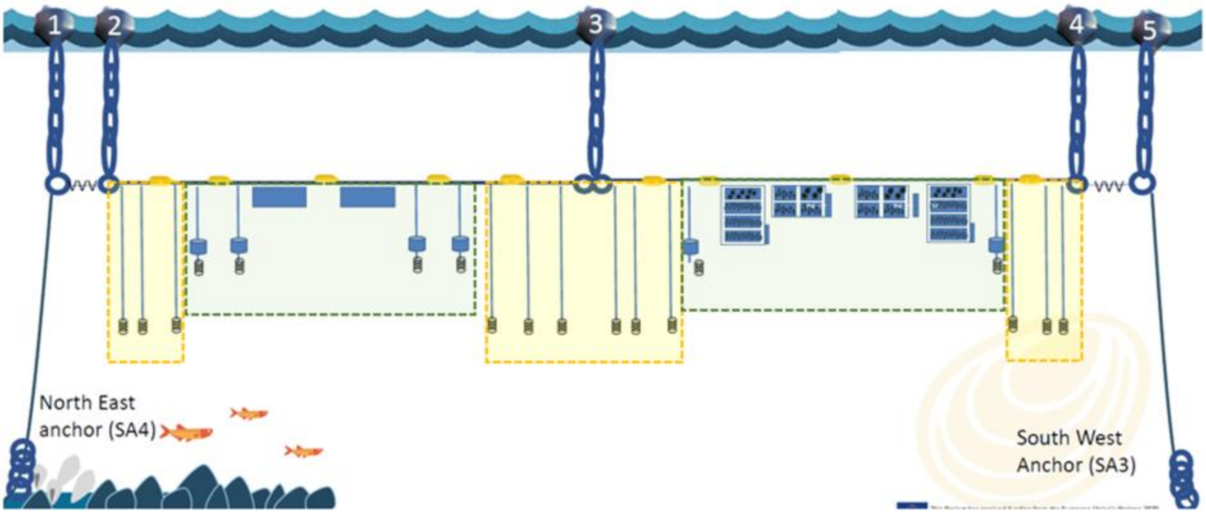

Figure 24: Illustration of oyster structures to be removed from the backbones. Yellow background: ropes seeded with oysters, Blue background: metal structures.

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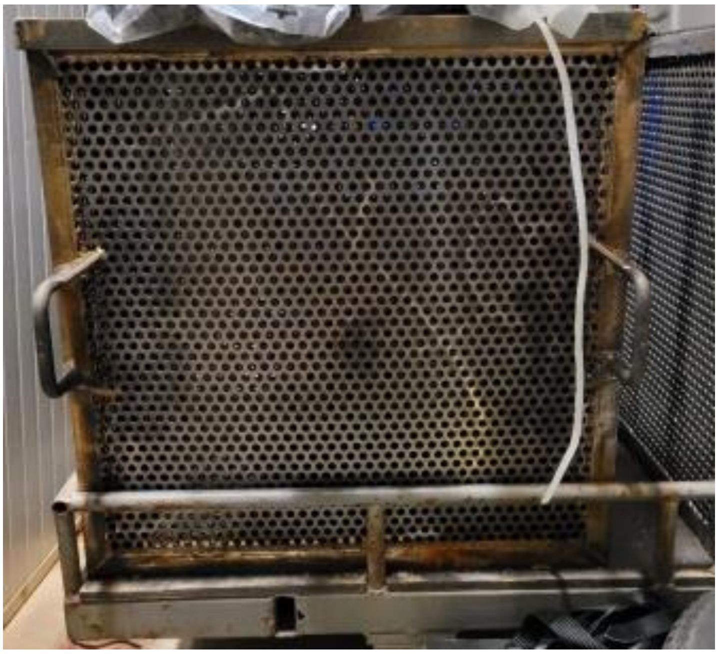
Structures attached to the backbone of the oyster longline installed August 2022:

1. Baskets in frames: tailor-made racks were developed and installed.
   Metal frames custom-made with SEAPA-baskets (+ attach zinc block of 1000g)

<table>
<tr>
<td>
https://seapa.co.jp/wp-content/uploads/2014/07/SEAPA-OysterBasket-brochure_5-14.pdf</td>
<td>
<table>
<tr><td>Dimension frames</td><td>L75*W68*H33 (cm)</td></tr>
<tr><td>Weight frame</td><td>30 kg</td></tr>
<tr><td>Number of SEPA baskets</td><td>4</td></tr>
<tr><td>Total weight system</td><td>70 kg</td></tr>
</table>
</td>
</tr>
<tr>
<td></td>
<td>Different designs:
• 1x4 system; dimensions: L : 74cm; W = 38cm; H = 67cm. The loop is attached to the structure at W = 34cm (hence middle of the width). Inner diameter of the loop = 4cm
• 2x2; dimensions: L : 75cm; W = 68cm; H = 33cm. The loop is attached to the structure at W = 34cm (hence middle of the width). Inner diameter of the loop = 4cm</td>
</tr>
</table>

2. As a second option of cages, very heavy oyster cages with 3 levels have been tested. A zinc-block was attached to prevent corrosion to take place.



Final stocking density	10kg/level
Total levels	3
Dimension basket	100(H) * 100(depth) * 100(length)
Weight empty	50 kg
Final weight + oyster + fouling weight	100 kg
L = 66cm; W = 65cm; H = 46cm. The handles are attached in the middle of the height and width (hence four handles for practical use) and are positioned from 26cm to 39cm of the length, the inner diameter of a handle is 11 cm. This allows the ropes to be able to pass the handles several times (at least three is needed, here four or five times can be taken for extra attaching to the backbone as these are heavier structures compared to the first four	

3. Ropes: oysters were lost in the lower part of the 4m ropes. A heavier weight or larger distance between the ropes offshore may solve this problem. Cementing oysters to ropes worked better than gluing the animals. Fouling did not seem to harm the oysters, although growth comparison between the different systems is still under analysis.

Type rope	Polyester 10mm
Length rope	4 m
Weight rope	3.1 kg
Number of oysters	3 oysters/7cm so total 171 oysters
Final size of oysters	75 mm
Weight of oysters	171 * 0.09 kg = 15.4 kg
Total weight rope	18.5 kg

4. Lantern baskets: nearshore, these were hung at three different levels, where we saw that the lower two levels had several compartments which were seriously damaged. This probably as a result of the shallow nearshore location (15m), leading to collisions between baskets or with the sea floor during stormy weather. Also, the mesh size was not appropriate, so quite a lot of spats were lost. Hence why the lantern baskets applied offshore, had one level of three layers and the mesh size was adjusted by adding an extra layer of small mesh inside the baskets. Six blue lantern baskets were connected to the backbone with Typtylon 12 or 14 mm rope (Deltaflex as possible alternative). Per rope, 1 stack consisting of 3 layers per blue basket as seen in Figure 25. Structures were connected to the longline using a mast throw (mastknoop). Weights were connected to the lower side of the ropes using mast throws.

Figure 25: Blue lantern basket

https://www.intermas.com/our-activities/aquaculture/oyster-farming/ostriga-lanterns.html

Trays per system (H10cm; circumference 60cm; mesh 10mm)	3
Total oyster weight	9 kg / tray
Final oyster weight	0.09 kg / oyster
Total oysters	100 oysters / tray of 300 per system
Oyster final size expected	75 mm (commercial)
Stack weight	1.2 kg / tray
Total weight	1.2 kg + (0.09 kg x 300 oysters) kg = 28.2 kg, without fouling

The Table 3 below shows the oyster backbone as prepared on land and just after installation.

Table 3: Pictures of oyster longline used in UNITED.

Oyster backbone before deployment	Oyster backbone just deployed (summer 2022)
	

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Restoration structures installed in the offshore windfarms Belwind

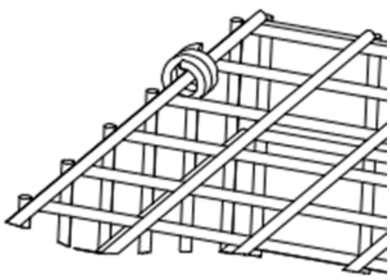
In the nearshore activities, the design and deployment of four restoration tables (Figure 26) filled with different scour protection materials as substrate for flat oyster spat was tested. This in the presence or absence of flat oyster adults (for detailed info, please see UNITED D7.2 (2022). The restoration tables proved to be successful nearshore for installation on a sandy bottom, however, the table design did not allow for fast intermediate sampling by divers. Hence, the Jan De Nul engineering team redesigned the tables to be placed on the scour protection stones offshore, this together with the input from the different Belgian pilot partners. It was important to come to a practical solution for intermediate sampling, since the diving window offshore is very short.

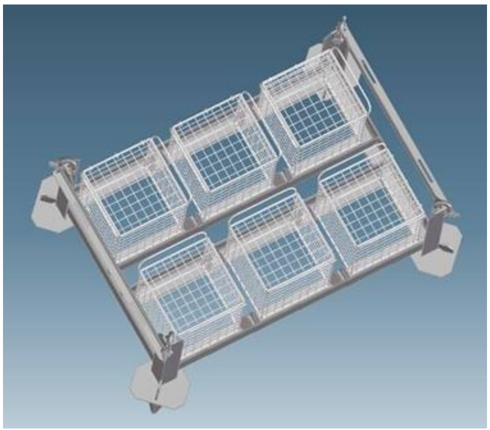
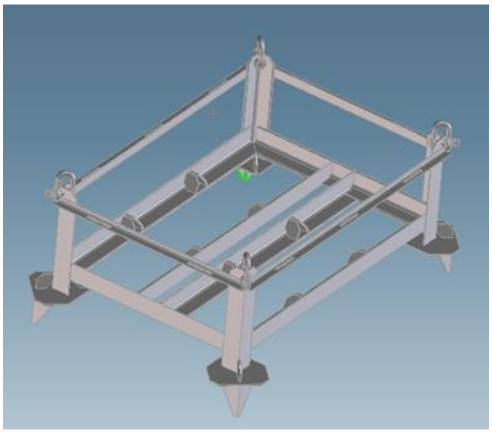
Four restoration tables were installed on the existing scour protection around two monopiles. Tables were placed on the sea floor at a safe distance from the wind turbines. Moreover, the non-exclusion site around the monopile (= e.g. landing and cable site) was avoided.

Figure 26: Restoration tables being installed near the wind farm site.

Per monopile, two tables were installed: 1 structure in SW-NE axis and one on SE-NW axis, to estimate whether the place around the monopile could influence the settlement of oysters. The material choice of the tables remained the same due to good experience with this nearshore. The tables for offshore were made in galvanized stainless steel. Per table, 6 smaller compartment called “gabions” were filled with scour protection materials.

Table 4: Bottom culture system for flat oyster

 	Gabion dimensions 32 x 32x 32 cm; can lift 70kg; weight gabion 5.7kg With an estimated density of 1600kg/m³ for the stones, this gives 51.2kg stones. The lid will be closed with sort of spiral

	6 gabions in 1 frame with 10mm distance between them
	Design of the frame for the offshore gabions. Dimensions 1200mm x 750mm H=650mm – Weight 120 kg. A total of 4 bars will keep the gabions together

Because the difference in settlement of flat oyster seed nearshore on the four different scour materials were minimal, it was decided to use only 1 type of stone (Norwegian granite) for allowing the settlement of oysters in the offshore site. Next to that, mussel shells were added as positive control for oyster settlement and to attract oyster larvae from the environment. The table most upstream contained adult Ostrea edulis which were ready to spawn, while the table downstream did not contain oysters. The hypothesis was to test 1) whether adult oysters could spawn in offshore conditions in the Belgian part of the North Sea, 2) whether self-recruitment (= settlement of oyster larvae on the substrates at the same spot as where they were released from) was possible 3) whether the oyster larvae could also colonize the substrates in the table downstream.

4.4.4. Danish pilot

In the project proposal we have proposed to expand with fishing and diver activities.

The project has shown the fishing activity does not fit with the visit as it takes several hours extra. The fishing activity is handled by one of the boat operators but on a separate tour.

During a few of the tours we do fishing when two groups of people are waiting for each other. Maximum 15-18 people can enter the turbine at the same time and the boat can take 30 people. During the period waiting for the first group some of the guests are using the opportunity for fishing, as can be seen on Figure 27.

Figure 27: A group of US students get their evening meal while waiting to start climbing.

The diving activity turned out to be too complicated. Further on it was based on the wrong assumption: that you need power from the turbine during the diving. In fact, a diving boat all the time need for safety reasons to have a transportable generator to be sure that the compressed air can get to the diver. Therefore, the synergy was non existing.

4.4.5. Greek pilot

The operational phase has seen the successful implementation of on-site infrastructure improvements to enhance internet and power connectivity. A 4G access point now provides WiFi and Ethernet access, ensuring seamless communication and data transmission on-site. Photovoltaic (PV) panels have been installed in the floating ware-house, generating a stable 7V output to sustainably power on-site operations (Figure 28).

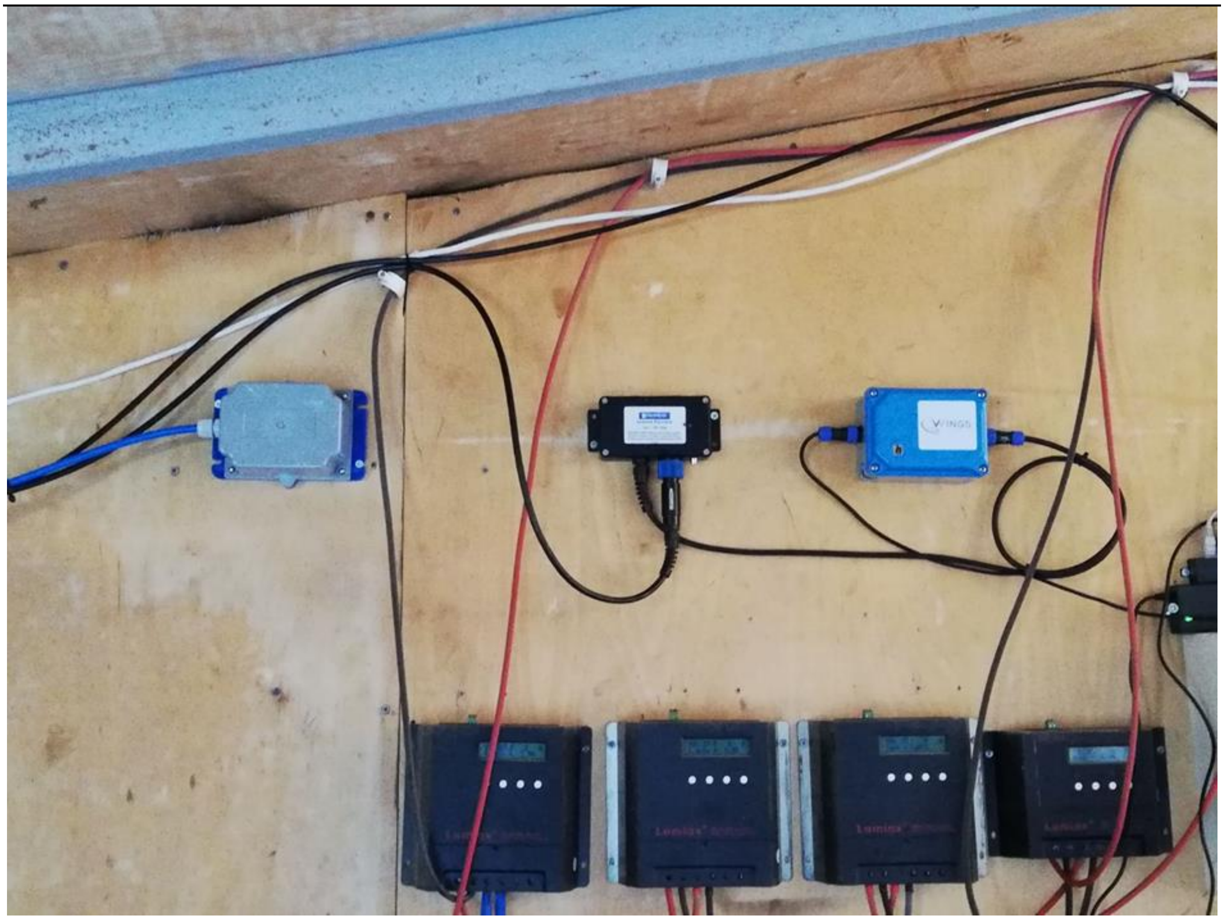


Figure 28: Installations in the floating warehouse.

The sensor device was connected directly to the power source (PV) for energy and WiFi for internet connectivity. This strategic setup aimed to optimize data acquisition capabilities and further enhance the monitoring system.

For the camera and current sensor device, a waterproof PoE cable has been positioned 15 meters away from the local switch. Power was provided through autonomous panels (Figure 29).

The device was securely installed in a custom structure at the periphery of the fish cage, ensuring reliable power and data connectivity for continuous monitoring and data collection.

Moreover, the deployment of cameras in additional geographical locations beyond the pilot site has been a crucial step in ensuring the scientific validity and robustness of the experiments. Tests conducted under diverse conditions have allowed capturing a wide range of environmental factors and their impact on fish behaviour and aquaculture activities. Utilizing the same camera system across different areas has established consistent data collection protocols, enhancing the reliability of gathered information. Incorporating data from these additional locations has provided valuable baseline conditions and comparative insights, enabling a more comprehensive understanding of the aquaculture environment. This multi-site approach has also facilitated the development and optimization of camera systems, ensuring their effectiveness and performance during both the pre-operational and operational phases of the project.

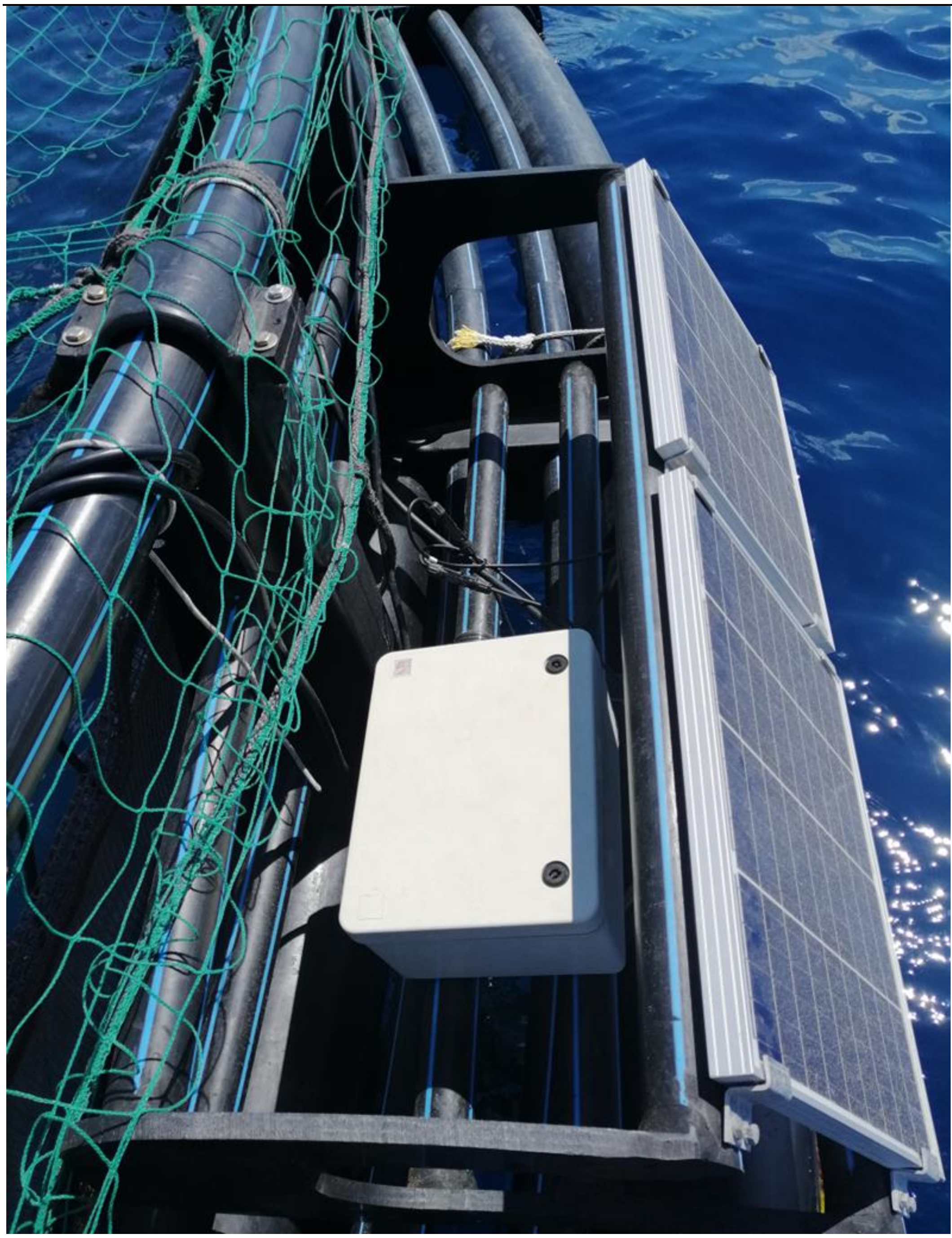


Figure 29: The panels for autonomous power supply have been installed in the periphery of the cage.

5. LESSONS LEARNT – POST-OPERATIONAL PHASE

5.1. Site specific needs and challenges

5.1.1. German Pilot

During the post-operational phase of the offshore aquaculture multi-use project, site-specific needs and challenges played a significant role in shaping the outcomes and learnings of the project.

Lander Data Retrieval Issues: The project encountered difficulties in retrieving data from the lander. However, data from the FINO3 platform and backup systems on the mussel and algae net were available and could be used instead. This highlighted the importance of implementing redundant data collection systems to ensure data integrity and minimize the risk of data loss.

Successful Algae and Mussel Cultivation: Despite the challenges faced, the project achieved successful cultivation of both algae and mussels. This success emphasized the importance of meticulous planning, implementation of appropriate cultivation techniques, and adaptation to site-specific conditions for the optimal growth and development of aquaculture systems. Further detailed lessons learnt were realised during the post-operational phase but are described in the chapters above.

Resilience to Winter Storms: The aquaculture systems showcased remarkable resilience by withstanding winter storms in the North Sea. This demonstrated the effectiveness of robust system design, considering factors such as strong currents and high waves prevalent in offshore environments. Understanding and accounting for site-specific challenges is crucial for ensuring the longevity and success of aquaculture operations.

5.1.2. Dutch pilot

The post operational phase is used to evaluate all the lessons learnt in the pilot. Based on these lessons learnt improvements in the design and operation could be made and implemented for the next phase. This next phase is already ongoing. For the seaweed cultivation a permit application is submitted for a seaweed farm with a current Dutch wind farm installed in 2023. In addition, Oceans of Energy will install a floating solar system in a to-be-build Dutch wind farm in 2025. In both projects, remote monitoring will be an important element in the operation.

So, it has been demonstrated that that offshore solar and seaweed cultivation can be integrated and rolled-out in offshore wind farms.

5.1.3. Belgian pilot

In the post operational phase, lessons learnt from the installation, monitoring and harvesting of the oyster and seaweed cultivation systems are contributing to the next iteration of Belgian pilot. Results from seeding techniques and comparison of cultivation structures are already informing infrastructure design and methodology in the follow up project Horizon Europe ULTFARMS. The challenging environmental conditions faced in the Belgian pilot have also inspired new solutions for offshore low trophic aquaculture going forward.

In the post operational phase, it is also important to synthesize information in order to effectively communicate the lessons learnt. As the UNITED project is coming to a close, the focus is now on communication, collaboration, and moving towards commercialization.

5.1.4. Danish pilot

Based on the lessons learnt by the Danish pilot within the UNITED project, there are some recommendations for opportunities to expand tourism to other wind farms:

- Develop comprehensive safety guidelines and protocols for tourists during windmill tours.

- Collaborate with local tourism authorities to promote windmill tours and educate visitors about renewable energy.
- Only wind turbines of the old type from before 2007 where there are more floors in the turbine, are suitable for tourism where you want to climb the turbine. In modern turbines it is only possible to climb with safety equipment (8 meters between the floors is the maximum without).
- Visiting (climbing the turbine) is only possible when the turbine owners allow it.
- Visiting without climbing is used by 50% of the guests and here you can do it just by boat ride usually without having permits from the turbine owner – it depends how close you want to go.

A training manual for new guides has been developed (Danish pilot manual for guides, 2023). This manual can be used as a guide for developing similar activities in other countries.

5.1.5. Greek pilot

The post-operational phase of the project provided valuable lessons and insights, particularly in navigating external challenges and refining technological solutions. Despite the hurdles posed by COVID-19 restrictions, strategic planning and adaptability allowed for the resumption of tourist diving after the withdrawal of lockdown measures. The experience highlighted the need for contingency plans and a flexible approach to handle unforeseen circumstances.

The summer of 2022 presented an unexpected challenge with a considerable increase in fuel charges, leading to a nearly 20% rise in diving fees. This economic aspect emphasized the importance of financial resilience and proactive cost management in sustaining project activities. Conversely, the summer of 2023 showcased a positive turnaround, with all scheduled dives completed successfully and no cancellations reported. The absence of COVID restrictions allowed for a more fluid interaction among divers, contributing to a robust and successful summer season.

From a technological perspective, addressing power supply concerns by installing solar panels attached to the mooring system showcased the project's commitment to sustainable and reliable energy solutions. Additionally, adjustments made to the WINGS Smart Gateway device to ensure internet connectivity through a SIM card underscored the importance of versatile and adaptable technology.

One crucial lesson learnt is the importance of foresight and adaptability in anticipating and navigating unforeseen challenges. Whether dealing with global health crises or economic fluctuations, having contingency plans in place is essential for project continuity. The successful deployment of cameras in additional geographical locations beyond the pilot site reinforced the project's dedication to scientific validity and experiment robustness, emphasizing the need for a comprehensive and adaptable research approach.

5.2. Decommissioning

UNITED D7.6 (2023) describes the decommissioning plans and procedures for each of the UNITED pilots and contains a list of recommendations for decommissioning multi-use zones. The sections below describe some key lessons learnt from the decommissioning process of the pilots.

5.2.1. German Pilot

The decommissioning phase of the offshore aquaculture multi-use project involved the removal of equipment and infrastructure from the site.

- Extended Decommissioning Time: The decommissioning process took longer than initially expected due to limited vessel availability, indicating the importance of accounting for potential delays and challenges in the project timeline. Proper planning, resource allocation, and coordination with relevant stakeholders are vital to ensure a smooth and efficient decommissioning process.

- Diver Intervention and Lander Recovery: During decommissioning, divers had to be used to decommission the lander. Offshore diving operations always include additional risks and costs. This highlighted the need for more advanced decommissioning procedures without divers. Automatically releasable inflatable devices with connection points would be a way forward.
- All decommissioned parts should be reusable to save effort, cost and minimize waste. If waste cannot be avoided the choice of materials should consider to be recyclable and not hazardous waste.

More details of the decommissioning phase and lessons learnt are described in UNITED D7.6 (2023).

5.2.2. Dutch pilot

The lessons learnt from decommissioning are separated per installation:

- The seaweed cultivation installations have been decommissioned successfully. There was a lot of mussel growth. The additional weight on the structure and cleaning of the installation need to be considered. Per element was checked whether reuse was possible, to make sure the materials would be reused in the best way possible. This should be considered in the design phase as well.
- The big data buoy has been decommissioned twice. As mentioned before, this was quite an operation for a data buoy as a large crane (due to the weight) and therefore a large vessel was necessary. A second smaller data buoy was developed and installed, which until now turned out to be way more favourable. The same small vessel and crane can be used when this small data buoy will be decommissioned at the end of the project. The installation & decommissioning costs are roughly 10% of the big data buoy.
- The floating solar installation is used as start for a new project (North Sea 2). At the end of NS2 the solar farm will be decommissioned.

In general, it is favourable to explore the synergies of combining decommissioning activities of the multi-use installations together with the offshore wind farm at the end of the lifetime. And, as said above, also explore the reuse of the different elements, for example floating devices and anchor chains. This can be considered already in the design of the installations.

5.2.3. Belgian pilot

The decommissioning phase of the Belgian pilot was extended due to the overlap with the follow up ULTFARMS project. The cultivations systems installed during UNITED were planned to be under continuous use over the lifespan of the ULTFARMS project, and therefore the decommissioning originally planned for the end of the UNITED project would be postponed. Nevertheless, the oyster longline has been effectively decommissioned and it will soon be determined whether the long line will be re-attached to the screw anchors, or the corresponding screw anchors will also be decommissioned. This impromptu decommissioning of the oyster cultivation system has highlighted some important concerns:

- Sea missions in general are expensive, and the technical aspects of the decommissioning process increase the price considerably – if an ROV (working class 2) mission is necessary, for example.
- Any gear lost from the original infrastructure must be recovered, even at great cost. Therefore, it is important for lost gear to be trackable (e.g. tagged or ideally fitted with a pinger which emits a frequency that can be used to locate the lost gear)
- Insurance providers may play a crucial role in the decommissioning process when an incident has occurred.

In the Belgian part of the North Sea, policy states that all elements of an installation must be decommissioned at the end of the project life span. Unless there is a further continuation of the Belgian pilot beyond ULTFARMS, the remaining UNITED equipment will be decommissioned by the end of the project in 2026. This includes screw anchors, the seaweed longline, and restoration tables.

5.2.4. Danish pilot

The Danish pilot was not required to decommission any structures during the UNITED project. Consequently, nothing has been decommissioned. As described in UNITED D7.6 (2023), the Danish pilot does not foresee the need for the complete removal or dismantling of the wind turbines of Middelgrunden Wind Farm, instead, it has a vision of repowering, i.e. refurbishing and upgrading the turbines to extend their lifetime.

5.2.5. Greek pilot

The Greek pilot was not required to decommission any structures during the UNITED project. Consequently, nothing has been decommissioned.

6. SYNTHESIS OF LESSONS LEARNT

The synthesis of the lessons learnt from the pre-operational, operational, and post-operational phases of the offshore multi-use project provides valuable insights and opportunities for improvement in future endeavours. By combining the knowledge gained from each phase, stakeholders can maximize the project's success and sustainability.

6.1. Site specific understanding

The project highlighted the importance of comprehensively understanding the site-specific needs and challenges. This knowledge informs decision-making processes, allowing stakeholders to develop tailored solutions that consider factors such as adverse weather conditions, COVID-19 disruptions, and the resilience required to withstand offshore environments. Another important aspect to consider are the specific insurance requirements, as the project revealed that obtaining insurance coverage was challenging, especially for offshore aquaculture multi-use. Integrating site-specific considerations from step1 into project planning is mandatory to obtain useful outcomes practicable for next steps like upscaling, improved systems and concepts as well as commercialization.

6.2. Resilient system design

The project underscored the significance of resilient system design. Building systems that can withstand extreme conditions, including strong currents, high waves, and winter storms, ensures their long-term functionality and success. During the design phase it is recommended to make sure that the design has no single point of failure. In addition, avoiding both sharp edges and loosely moving parts and incorporating robust materials, redundancy measures, and adaptability in system design minimizes risks and increases operational efficiency. Nearshore testing sites are highly recommended as an intermediate step from lab to offshore. Expensive offshore time and money can be saved by ruling out not useful equipment, weak points and unfavourable material combinations.

6.3. System behaviour modelling and nearshore testing

Both modelling of the behaviour of designed systems under different scenarios and conducting pre-operational tests at a nearshore location can be used to identify and resolve issues before deployment offshore. The results of model runs and nearshore tests can, for example, provide knowledge on the functionality of the design and monitoring equipment, workflow efficiency, and suitability of cultivation techniques. Although modelling is a useful tool, it should be supplemented and validated by the experience of industry members. The testing and subsequent redesigning can enhance the performance and can mitigate potential risks related to system operation.

6.4. Flexibility and adaptability

The project's experiences emphasized the need for flexibility and adaptability throughout all phases. Unforeseen circumstances, such as COVID-19 restrictions or delays due to unfavourable weather conditions, require project teams to adjust plans and find alternative approaches. The need for flexibility has also been highlighted for the activities related to tourism, for example with guides working on an on-demand basis. Being prepared to adapt and employing innovative solutions can help overcome obstacles and maintain progress towards project goals.

6.5. Accurate weather forecasts

The pilots have presented challenges related to adverse weather conditions and have highlighted the need for accurate weather forecasting models. The central data platform of the project, the HiSea data platform, was continuously "fed" with detailed information on site-specific conditions for the German pilot. The HiSea forecasts improved over the course of the project and became an increasingly important source of information for the German pilot. The Dutch pilot highlighted that accurate forecast of the currents, especially the turnaround moment when the current is the lowest, can prevent additional time waiting offshore.

6.6. Ship availability and suitability

The project experienced several challenges related to the availability and suitability of ships. Sea missions do not only depend on good weather windows but also on availability of ships and specifically ones that are suited for the activities to be performed. One should aim to have a large network for the rental of vessels. The challenges highlighted a need for close collaboration between stakeholders of the offshore shipping industry, demonstrated the options of MU, and highlighted a need for future developments to improve the situation.

6.7. Monitoring, including redundancy and data integrity

Several pilots have highlighted the importance of monitoring. The monitoring approach should be considered during the pre-operational phase. Several aspects to be considered are (I) whether the planned system design, monitoring equipment and vessels are compatible (II) whether the equipment needs to be cleaned or calibrated during operation (III) whether there needs to be a live connection to land or whether data logging is sufficient (IV) whether it will be possible to compare the collected data to external data sources, e.g., through time stamps and matching measurement intervals (V). Experiences from the pilots revealed that monitoring equipment may not be offshore grade even when the supplier says it is, which means that additional sensor housing might be needed. In addition, wired connections might be susceptible to damage by operating vessels, so alternative solution or protective measures should be explored. With two marine activities at one location, an activity can benefit from the monitoring capability of another activity, as was for example the case for the Belgian pilot. The project also brought to light the importance of redundancy in data collection systems. Having (power) backup systems and multiple data sources mitigates the risk of data loss and ensures the availability of valuable information for monitoring and analysis. Implementing robust communication infrastructure and regular maintenance of equipment safeguards data integrity.

6.8. Effective communication and collaboration

The project's challenges underscored the significance of effective communication and collaboration among stakeholders. Establishing open lines of communication, maintaining regular contact, and fostering collaboration enhance project coordination, enable quick response to changes, and facilitate problem-solving.

6.9. Safety and equipment maintenance

Safety protocols and regular equipment maintenance are critical in offshore aquaculture projects, especially for locations inside a wind farm. It is useful to have alternative options besides divers during decommissioning and it is important to make sure that any gear that could be lost is trackable (e.g., with a tracker that emits a signal that can be used to locate lost gear). The lander incidents encountered in the German pilot during the operational phase emphasized the importance of thorough equipment testing, quality control measures, and regular inspections. Prioritizing safety and implementing maintenance routines ensure the well-being of personnel and equipment integrity.

6.10. Trained staff

Trained staff is of utmost importance when dealing with heavy equipment in offshore operations to ensure the highest possible safety standard and to minimize offshore time and costs. A useful tool to improve the safety of working offshore is a permit to work system, as developed by the Dutch pilot, which has automatic application forms to get permission to go offshore and logs of all approved work permits.

6.11. Comprehensive planning and contingency measures

The project's lessons highlighted the necessity of comprehensive planning and the integration of contingency measures. Accounting for potential delays, external disruptions, and unforeseen challenges during all project phases allows stakeholders to develop robust contingency plans, allocate resources effectively, and mitigate risks.

By synergizing these lessons, stakeholders can improve the efficiency, sustainability, and success of future offshore aquaculture multi-use projects. A holistic approach that considers site-specific factors, resilient system design, flexibility, effective communication, safety, and comprehensive planning lays the foundation for projects that thrive in dynamic offshore environments while minimizing potential risks and maximizing outcomes.

7. SUMMARY AND CONCLUSION

The UNITED project provided valuable lessons learnt across its pre-operational, operational, and post-operational phases. These lessons highlighted, among other things, the significance of site-specific understanding, resilient system design, flexibility, accurate weather forecasts, monitoring, effective communication, safety, and comprehensive planning and contingency measures. By synergizing these lessons, stakeholders can enhance the efficiency, sustainability, and success of future projects in offshore aquaculture multi-use systems.

Furthermore, we suggest implementing modular systems that are easier to install. Modular systems offer advantages such as simplified installation processes, scalability, and adaptability to changing environmental conditions. Their ease of installation reduces project timelines and enhances operational efficiency, promoting the growth and expansion of offshore aquaculture multi-use systems.

Another crucial aspect learnt during the project was the scarcity of trained skilled workers in the field of multi-use systems. The specialized nature of these systems necessitates the training of personnel with a specific skill set. The project generated manuals and training materials to address this scarcity, providing a foundation for training programs and ensuring the availability of skilled workers for future endeavours.

UNITED serves as a pioneering initiative in the development of sustainable aquaculture practices in offshore environments. Through its various phases, the project demonstrated the importance of adapting to site-specific needs, designing resilient systems, fostering effective communication, prioritizing safety, and comprehensive planning.

The lessons learnt from the project have far-reaching implications for future multi-use systems. As the first-of-its-kind project, the insights gained from this endeavour will serve as a valuable basis for future multi-use projects.

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ANNEX I – EXECUTIVE SUMMARY OF VENTOLINES REPORT

Background of the report

This report addresses the legal and contractual implications of integrating an offshore floating solar farm into an offshore wind farm. Six scenarios based on various combinations of standalone, semi-standalone, and integrated design concepts (provided by our partner TNO), along with green- or brownfield development have been analysed. The majority of Dutch wind farms, both current and projected, will be situated within the Dutch exclusive economic zone (EEZ). For the purpose of this report, it is assumed that future floating solar farms will be realized in the vicinity of existing and future offshore wind farm plots.

Key regulatory findings

The Offshore Wind Energy Act is applicable within the Exclusive Economic Zone. This Act provides for a comprehensive tender procedure for offshore wind and solar energy projects. However, the Offshore Wind Energy Act does not include a framework for other types of energy projects, or for integration of wind and other forms of energy production. A framework specifically developed for offshore solar farms and other types of multi-use is currently lacking. As a result, for offshore solar projects in the Dutch EEZ a fragmented framework is applicable. To operate a solar farm (and to integrate it with a wind farm) in the North Sea, a permit must (separately) be obtained under the Water Act, covering the presence and operation of the floating installation.

One important issue is that, under the current regulation offshore solar farms cannot connect directly to the offshore grid. Solar farms will not be able to get their own connection agreement (CTA) with grid operator TenneT unless the Electricity Act and/or the future Energy Act (which will consolidate the prevailing Electricity Act and Gas Act into a single Act) are amended. This means that the current regulatory framework does not allow for the standalone design concept for solar farms on the North Sea, except for small-scale experiments. The other concepts (semi-stand alone and turbine integrated) are possible, as solar farms connecting to wind farms and supplying energy through them is left open as an option. This does however cause potential bankability issues as it makes the solar farm dependent on the CTA between the wind farm and TenneT.

The current legal framework provides for more room for the integration of greenfield offshore wind farms and solar farms than for the integration of brownfield offshore wind farms and solar farms. This is the case because the offshore solar farm is not subject to the regulatory framework of a permit issued for the offshore wind farm under the Offshore Wind Energy Act. Consequently, a separate water permit will need to be obtained for the offshore solar farm. As opposed to what is the case for permits under the Offshore Wind Energy Act for offshore windfarms, a tender procedure does not apply for this water permit.

In the case of a greenfield wind farm, the offshore solar farm can be included in the tender for the offshore wind farm. The winner of the tender for the combined wind and solar farm is expected to be granted the water permit. Even if specific conditions will be attached to this permit, and the relationship between these conditions and the conditions of the permit based on de Offshore Wind Energy Act is uncertain (notably, in the event of multiple applicants seeking a water permit for the operation of an offshore solar farm, the government lacks legal criteria to ascertain the party to whom the water permit should be awarded). The greenfield scenario would seem to be easier to fit into the existing offshore wind regulatory framework.

However, in brownfield situations the tender process for the wind farm has already been concluded. The report addresses, among other things, whether a brownfield wind farm can be compelled to accommodate an offshore solar farm on the grid connection of the wind farm. The fact that the tender procedure has already been concluded, results in a scenario in which any person desiring to establish an offshore solar farm could apply for a water permit. Of course, they would also need (private law) permission from the offshore wind farm to connect to its infrastructure, meaning that in seeking a permit without such permission, considerable expenses may be incurred without a guarantee of project feasibility. But, as feasibility is not a criterion for obtaining a water permit, it is conceivable that multiple parties will apply for a water permit to realize an offshore solar farm, irrespective of whether they have obtained cooperation from the relevant offshore wind farm. This raises legal and commercial issues as, without legislative amendment, the wind farm cannot, as a general rule, be forced to allow the integration of an offshore solar farm into its grid connection.

Bankability issues

The bankability of offshore integrated projects within the Dutch EEZ is problematic under the current regulations. Ownership and security rights are not expected to be major concerns, as project finance parties can deal with legal uncertainties through financing documents. However, the larger issue lies with grid connection scenarios for offshore floating solar assets, due to regulatory gaps and uncertainties. In such cases, solar farms may need to connect to the offshore grid indirectly through wind farms. Financing parties will require thorough due diligence on wind farms and all other installations involved, insurance, warranties and credit support for internal settlement of grid connection costs and tariffs, and set high standards for their long-term viability. This could increase transaction costs and raise concerns about commercial and technical proprietary information.

Case study

Included in this report is a case study, which delves into three different scenarios for integration of wind and solar energy in the North Sea. In the first scenario, a park under construction includes a 50 MW solar farm connected to an offshore wind farm, assuming the solar farm is included in the Area Passport for Shared Use. The second scenario involves a 50 MW solar farm that can connect to TenneT's offshore substation, where it is assumed that the solar farm is not included in the Area Passport for shared use. In this scenario, a brownfield situation is assumed, meaning that the wind farm is already fully constructed and operational. The third scenario entails a situation in which a 50 MW solar farm is connected to a wind farm and the tender for the wind farm incorporates criteria that enable (or even require) the establishment of a solar farm.

The outcome of this case study reflect once again that the prevailing legal framework holds out more favourable prospects for the integration of offshore solar farms and greenfield offshore wind farms, than to the integration of offshore solar farms and brownfield offshore wind farms.

Recommendations

To address the bankability issues identified in the report and to solve the issues mentioned in the paragraph "Key regulatory findings" above, an overhaul of the Dutch regulatory offshore integration framework is needed. We recommend the governmental institutions to create a comprehensive legislative package for integrated offshore (energy) projects. This new comprehensive law (for example: the Dutch Offshore Act for Energy projects and Multi-use) should, in our opinion, at least encompass the following: designation of offshore solar farm areas (including tender procedures), integrated permitting processes, and conditions for integrating offshore solar farms with brownfield wind farms.

ANNEX II – FULL VENTOLINES REPORT

The external report of UNITED Partner Ventolines, written as part of UNITED WP7 and discussed in section 3.1.2 above, is attached below.

Ventolines

United Report

The legal, regulatory and contractual framework for integrated solar and offshore wind

Project name	UNITED Task WP7
Author	Redmar Damsma & Pelle van den Heuvel
Date	December 21 2023
Status	Public

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1 Executive summary

1.1 Background of the report

This report addresses the legal and contractual implications of integrating an offshore floating solar farm into an offshore wind farm. Six scenarios based on various combinations of standalone, semi-standalone, and integrated design concepts (provided by our partner TNO), along with green- or brownfield development have been analyzed. The majority of Dutch wind farms, both current and projected, will be situated within the Dutch exclusive economic zone (EEZ). For the purpose of this report, it is assumed that future floating solar farms will be realized in the vicinity of existing and future offshore wind farm plots.

1.2 Key regulatory findings

The Offshore Wind Energy Act is applicable within the Exclusive Economic Zone. This Act provides for a comprehensive tender procedure for offshore wind and solar energy projects. However, the Offshore Wind Energy Act does not include a framework for other types of energy projects, or for integration of wind and other forms of energy production. A framework specifically developed for offshore solar farms and other types of multi-use is currently lacking. As a result, for offshore solar projects in the Dutch EEZ a fragmented framework is applicable. To operate a solar farm (and to integrate it with a wind farm) in the North Sea, a permit must (separately) be obtained under the Water Act, covering the presence and operation of the floating installation.

One important issue is that, under the current regulation offshore solar farms cannot connect directly to the offshore grid. Solar farms will not be able to get their own connection agreement (CTA) with grid operator TenneT unless the Electricity Act and/or the future Energy Act (which will consolidate the prevailing Electricity Act and Gas Act into a single Act) are amended. This means that the current regulatory framework does not allow for the standalone design concept for solar farms on the North Sea, except for small-scale experiments. The other concepts (semi-stand alone and turbine integrated) are possible, as solar farms connecting to wind farms and supplying energy through them is left open as an option. This does however cause potential bankability issues as it makes the solar farm dependent on the CTA between the wind farm and TenneT.

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In the case of a greenfield wind farm, the offshore solar farm can be included in the tender for the offshore wind farm. The winner of the tender for the combined wind and solar farm is expected to be granted the water permit. Even if specific conditions will be attached to this permit, and the relationship between these conditions and the conditions of the permit based on de Offshore Wind Energy Act is uncertain (notably, in the event of multiple applicants seeking a water permit for the operation of an offshore solar farm, the government lacks legal criteria to ascertain the party to whom the water permit should be awarded). The greenfield scenario would seem to be easier to fit into the existing offshore wind regulatory framework.

However, in brownfield situations the tender process for the wind farm has already been concluded. The report addresses, among other things, whether a brownfield wind farm can be compelled to accommodate an offshore solar farm on the grid connection of the wind farm. The fact that the tender procedure has already been concluded, results in a scenario in which any person desiring to establish an offshore solar farm could apply for a water permit. Of course, they would also need (private law) permission from the offshore wind farm to connect to its infrastructure, meaning that in seeking a permit without such permission ,considerable expenses may be incurred without a guarantee of project feasibility. But, as feasibility is not a criterion for obtaining a water permit, it is conceivable that multiple parties will apply for a water permit to realize an offshore solar farm, irrespective of whether they have obtained cooperation from the relevant offshore wind farm. This raises legal and commercial issues as, without legislative amendment, the wind farm cannot, as a general rule, be forced to allow the integration of an offshore solar farm into its grid connection.

1.3 Bankability issues

The bankability of offshore integrated projects within the Dutch EEZ is problematic under the current regulations. Ownership and security rights are not expected to be major concerns, as project finance parties can deal with legal uncertainties through financing documents. However, the larger issue lies with grid connection scenarios for offshore floating solar assets, due to regulatory gaps and uncertainties. In such cases, solar farms may need to connect to the offshore grid indirectly through wind farms. Financing parties will require thorough due diligence on wind farms and all other installations involved, insurance, warranties and credit support for internal settlement of grid connection costs and tariffs, and set high standards for their long-term viability. This could increase transaction costs and raise concerns about commercial and technical proprietary information.

1.4 Case study

Included in this report is a case study, which delves into three different scenarios for integration of wind and solar energy in the North Sea. In the first scenario, a park under construction includes a 50 MW solar farm connected to an offshore wind farm, assuming the solar farm is included in the Area Passport for Shared Use. The second scenario involves a 50 MW solar farm that can connect to TenneT's offshore substation, where it is assumed that the solar farm is not included in the Area

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Passport for shared use. In this scenario, a brownfield situation is assumed, meaning that the wind farm is already fully constructed and operational. The third scenario entails a situation in which a 50 MW solar farm is connected to a wind farm and the tender for the wind farm incorporates criteria that enable (or even require) the establishment of a solar farm.
The outcome of this case study reflect once again that the prevailing legal framework holds out more favourable prospects for the integration of offshore solar farms and greenfield offshore wind farms, than to the integration of offshore solar farms and brownfield offshore wind farms.

1.5 Recommendations

To address the bankability issues identified in the report and to solve the issues in paragraph 1.2, an overhaul of the Dutch regulatory offshore integration framework is needed. We recommend the governmental institutions to create a comprehensive legislative package for integrated offshore (energy) projects. This new comprehensive law (for example: the Dutch Offshore Act for Energy projects and Multi-use) should, in our opinion, at least encompass the following: designation of offshore solar farm areas (including tender procedures), integrated permitting processes, and conditions for integrating offshore solar farms with brownfield wind farms.

2 Introduction

Ventolines is a partner in the UNITED, a research project co-financed by the European Union Horizon 2020 program. The UNITED project runs from 2020 to 2023 to provide evidence for the viability of ocean multi-use through a variety of research and pilot projects. Ventolines is a partner in the Dutch pilot project along with Oceans of Energy (floating solar developer) and TNO (research organization).

Specifically, Ventolines is assigned Work Package 7 (WP7), Pilot 7.2, Task 7.2.1, Deliverable D7.2.1.9. The deliverable is a report on the legal and contractual framework for an integrated floating solar and offshore wind farm.

The contractual and legal implications of integrating a floating solar farm into an offshore wind farm are dependent on multiple factors. Two important categories to consider are the design concept and whether the solar and wind assets are developed in coordination. Some of these characteristics may also impact the regulatory and legal requirements for an integrated floating solar and offshore wind farm.

This document outlines six scenarios based on different combinations of on the one hand standalone, semi-standalone and integrated designs, and on the other hand green- and brownfield development. For example, one scenario is a design concept that connects the solar plant at the TenneT offshore substation (standalone) to an existing offshore wind farm (brownfield development). In all scenarios, it is assumed that solar plants and wind farms belong to different owners. The contractual, legal and regulatory implications of an integrated solar and offshore wind farm with these characteristics will be explored.

3 Project Characteristics

3.1 Design Concept

There are many potential design concepts for integrating floating wind into an offshore wind farm. Given that all existing and planned offshore wind farms in the Netherlands use bottom-fixed foundations, this report only considers the integration of floating solar with bottom-fixed foundation offshore wind farms. In TNO report R10444, TNO has outlined 10 concepts for the electrical integration of floating solar with offshore wind farms. All 10 of those concepts (and potentially many others) can be grouped into three main categories: Standalone, Semi-standalone, Turbine-integrated. Here we use the same terminology as TNO for consistency. The table provides a summary of the design concepts, which are elaborated on in sections 3.1.1 through 3.1.3.

	Location of connection	Voltage level of connection
Standalone	TenneT substation	66 kV[1]
Semi-standalone	WTG switchgear	66 kV
Turbine integrated	WTG LV side of transformer	voltage at LV side of transformer (500 – 1000 V)

3.1.1 Standalone

Standalone designs all interconnect the solar farm at the TenneT offshore substation at the array cable voltage. In the case of the TNO paper, it was assumed to be a 66 kV array (the first offshore wind farms in the Netherlands have a 33 kV[2] array, but 66 kV has now become the standard). The solar farm has its own inverters, transformer(s), and array cabling that ties in to the 66 kV switchgear at the offshore substation. This would require the availability of a connection field at the offshore substation, which is very rare in the case of the existing 700 MW platforms. In the case of the new 2 GW platforms, a connection field with a maximum of 415 MW would be possible. First of all, it will have to be determined who will be guaranteed the transport capacity. Subsequently, a legal framework would have to be developed for non-guaranteed (non-firm) use of the transport capacity by the additional renewable energy generator. This will be discussed in Chapter 4.

[1] Or 33 kV for some older Dutch offshore wind farms

[2] OWEZ, Prinses Amalia, Gemini and Luchterduinen use 33 kV array cables (OWEZ directly to shore, no substation).

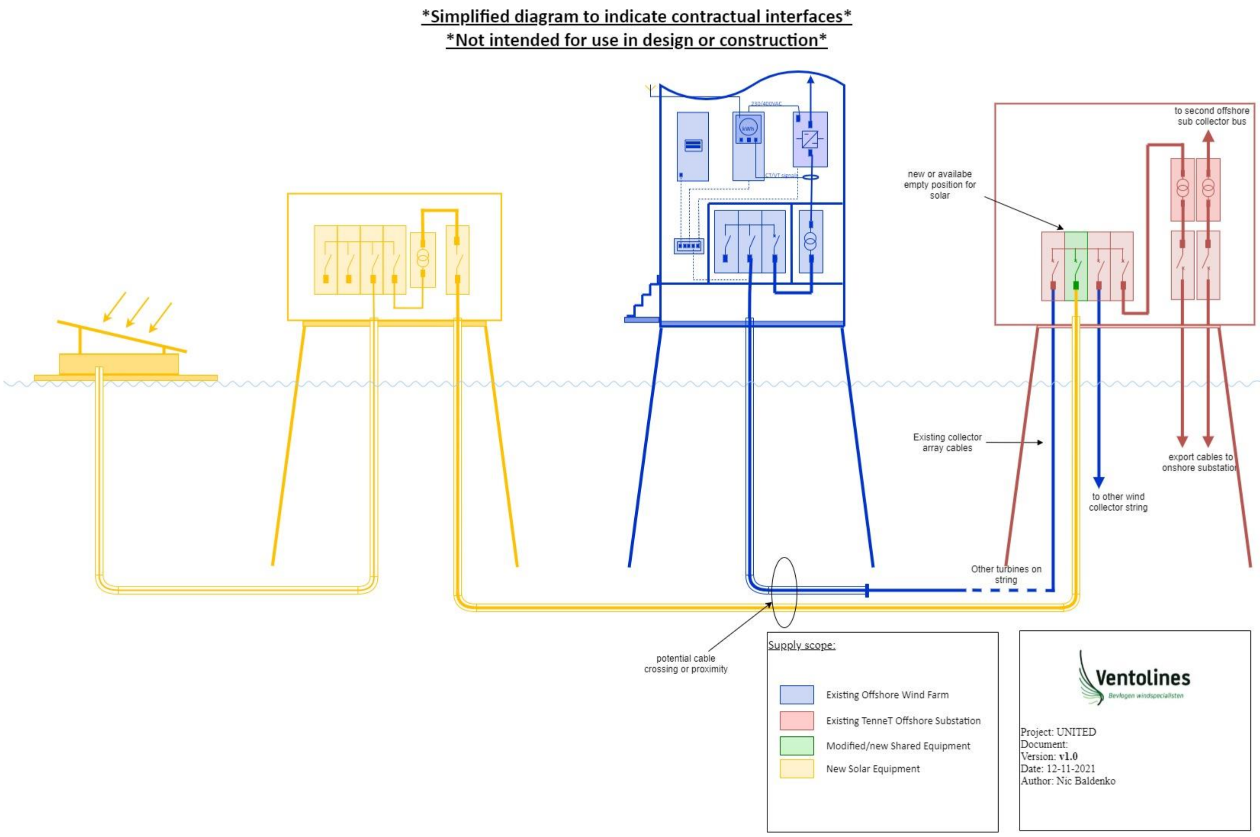

Figure 1 - Simplified diagram of the standalone design concept to indicate contractual and ownership interfaces

3.1.2 Semi-standalone

Semi-standalone designs interconnect the solar farm to the existing offshore wind farm collector array, with each solar module sized to connect at the end of an existing string of wind turbines. The solar farm has its own inverters and transformer(s) to connect at the array cable voltage (66 kV in the case of the TNO paper).

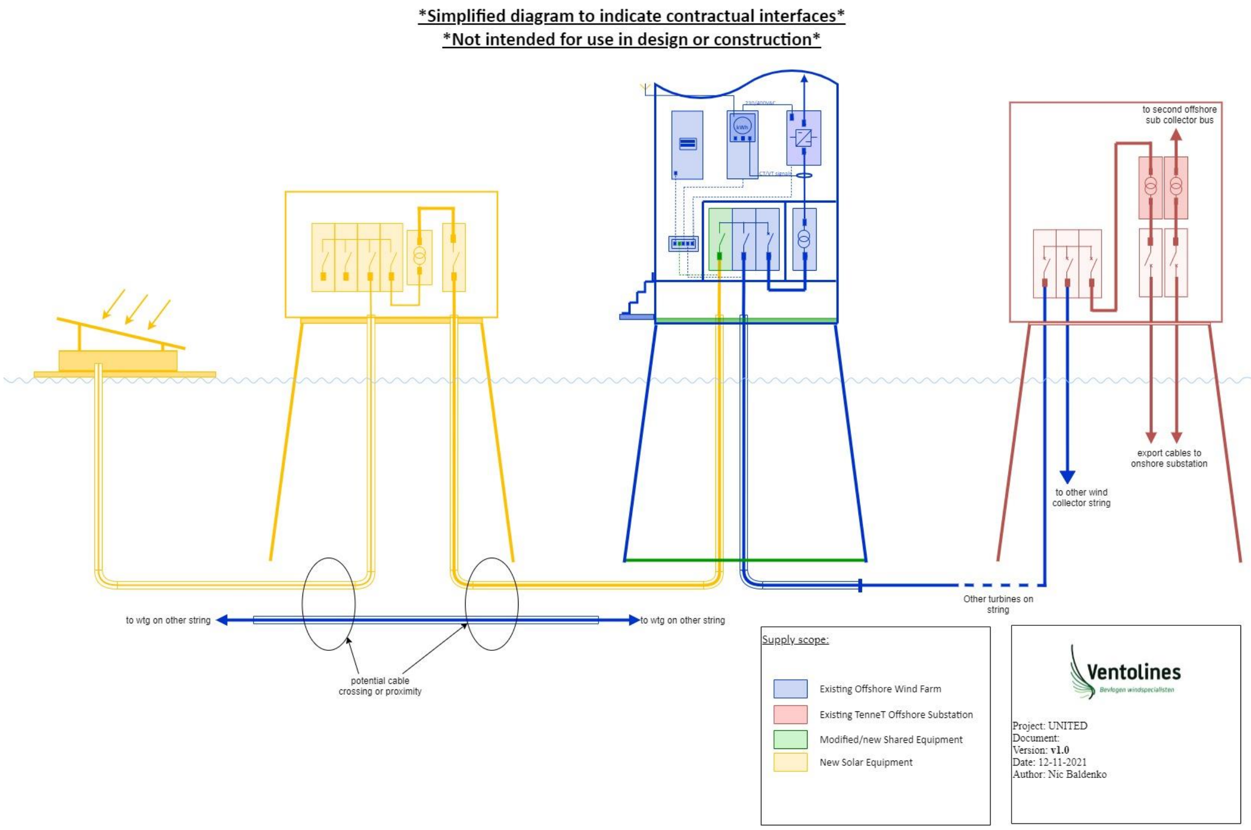

Figure 2 - Simplified diagram of the semi-standalone concept to indicate contractual and ownership interfaces

3.1.3 Turbine-integrated

Turbine-integrated designs interconnect smaller modules of the solar farm directly into multiple existing wind turbines along each array string. Generally, the solar farm is broken up into reasonably sized modules that tie in directly with the turbine transformer or a new transformer at the wind turbine. This design concept differs from the semi-standalone design concept due to the larger number of smaller PV modules. The contractual and ownership interfaces look similar to those shown in Figure 2.

3.2 Development Coordination

Two forms of development coordination are considered in this paper as they have different implications for contractual and regulatory requirements. In one case, a combined offshore wind and floating solar project may be developed in a coordinated manner on a greenfield site with no existing assets. Such a situation will be referred to as Greenfield development.

In the second case, there may be an existing offshore wind asset to which floating solar may be added. Such a situation will be referred to as Brownfield development. In either case, it is possible that the total facility may consist of more than one wind and one solar development. While this paper considers the case with one wind farm and one solar farm, the conclusions will likely be similar for facilities with more developments.

4 Contractual considerations

4.1 TenneT connection agreements

In order to connect to the offshore substation, customers must enter into a Connection and Transmission Agreement ("CTA"; in Dutch *"Aansluit- and Transport Overeenkomst"* or *"ATO"*) with the offshore grid operator TenneT. In some cases (for example, semi-standalone or turbine integrated design), only one of the farms will have a CTA with TenneT. For new connections, a Realisation Agreement (*"REA"*), to have the network operator construct the required infrastructure, is required as well. Existing offshore wind farms will have an existing CTA.

4.2 Cable sharing/cable pooling

This section considers the situations in which a contractual solution is required to facilitate the use of shared cables (and other shared electrical equipment) between the wind and solar facilities. Cable pooling is a term associated with existing agreements that facilitate the shared use of cables for onshore wind and solar facilities, and therefore it is used in this paper. However, this paper also uses the term cable sharing to more broadly address the topic of shared electrical infrastructure.

Regardless of design concept, all designs will share the export cable from the offshore substation to the onshore substation. For existing wind farms, the export cable has likely been sized for the windfarm alone. The wind farm likely has a higher maximum capacity than the nominal capacity of the export cable, as a large wind farm almost never runs at full capacity, due to unavailability of one or more wind turbines (hereinafter also referred to as: "WTGs") and wind conditions ("overplanting"). The solar farm will attempt to efficiently utilize spare capacity. Also, in green field developments the export cable will most likely not be sized to export the full capacity of the wind and solar farm simultaneously.

Two situations can be distinguished:

1. Solar and wind farms have individual connection and transmission agreements (CTAs) with TenneT. While it is possible to have a standalone design with separate CTAs, it is also feasible to share a single CTA with TenneT to reduce costs. However, it is important to note that offshore wind farms cannot have a separate CTA as per current legislation, since it is not possible for offshore solar farms to connect to the offshore grid. This means that concluding a CTA is not possible for offshore solar energy projects (this will be outlined below in Chapters 5-6).

2. In all other situations there will be one CTA with TenneT. It will depend on the regulatory and commercial context whether both farms will be a party to this CTA, or only one of them (most likely the wind farm).

In situation 1, a solution will be needed to determine priority for using shared TenneT facilities. For example, a three-party agreement between TenneT, the wind farm owner, and the solar farm owner may be used to determine priority. Such a solution would be new, to the best of our knowledge, as it has not been done before. Alternatively, there may be legal or regulatory solutions that more broadly cover the shared use of offshore facilities. Whichever solution, or combination of solutions is developed, such a solution must inter alia cover the following topics:

- Maximum capacity of export cable (firm and excess)
- Minimum and maximum capacity allocated to each owner (if any)
- Priorities of usage and curtailment (by TenneT, by producers/PPA offtakers), including detailed procedure

It must be emphasized that on the basis of current Dutch legislation, situation 1 is not possible for offshore solar energy projects on the North Sea, because solar farms are not able to connect to the offshore grid. This means that, based on the current legislation, concluding a CTA is not possible for offshore solar farms. For more details, please refer to our findings in Chapter 5 and 6.

For situation 2, the cable pooling agreement developed by Ventolines could be used as a basis in addition to the CTA with TenneT, a summary of which is provided in paragraph 4.2.1 below. This is especially the case if both farms are a party to the CTA. In case only one of the farms (most likely the wind farm) is a party to the CTA, additional clauses in the cable pooling agreement are necessary to ensure the solar farm's access to the grid as this is not guaranteed by a CTA.

In the case of semi standalone and turbine-integrated designs, congestion will likely occur in the array cables, as most likely they are not designed to transport full wind plus solar capacity at the same time. This issue may also be solved via a form of cable pooling agreement, as the wind and solar farm will share a single grid connection with TenneT in all semi-standalone and turbine-integrated designs.

4.2.1 Cable pooling agreement

The cable pooling agreement is a contract between two (or more) entities that want to connect their wind- or solar farms to the grid via a single connection. The parties apply for a grid connection together, and the connection and meters are co-owned. The main objective of the cable pooling agreement is to optimize the available capacity.

The cable pooling agreement covers, inter alia, the following topics:

- Construction, operation and maintenance of the commonly owned grid connection and meters, including distribution of costs.
- Exchange of information, e.g., with balancing responsible parties.
- Curtailment of the wind and solar farms in case of congestion.
- Clauses on financing, insurance, decommissioning, termination etc.
- Ownership of shared equipment.
- Coordination and cooperation between farms; risk mitigation; liabilities in case damages are caused.

As explained above, two cases need to be distinguished: (1) both farms (possibly via a general partnership (*vennootschap onder firma*), or a similar construction, depending on the outcome of ongoing legal debates) are party to a CTA with TenneT and (2) only the wind farm has a CTA with

TenneT. In the latter case, additionally, there is need to ensure the solar farm's access to the grid in case the wind farm ceases to function.

4.3 Cable crossing & proximity agreements

In the project site, three types of cables will be installed:

1. TenneT owned cable(s) connecting the offshore substation to shore and possibly to other offshore substations
2. Inter array cables connecting wind turbines to the offshore substation
3. Cables interconnecting solar panels, solar transformer platform (if applicable) and wind turbines (semi-standalone and turbine integrated) or offshore substation (standalone)

In general, greenfield designs should be able to avoid all cable crossings. Depending on the lay-out brownfield development might require crossing wind farm inter array cables; crossing TenneT cables will normally be avoidable but might be necessary in brownfield standalone situations. Obviously, when wind and solar farms are owned by the same company, no crossing or proximity agreement is required in relation to these assets (but, of course, TenneT would still be relevant).

A cable proximity agreement with TenneT would normally only be required in the standalone layout, as the solar cables will necessarily be close to the TenneT cables near the offshore substation. Cable proximity agreements would be necessary in all designs with the wind farm owner (if different from the solar farm owner).

If solar panels are installed within the safety zones around the TenneT and wind farm cables, the solar panels may hinder or prevent repairs on the cables. If that situation can be avoided, no proximity agreements would be necessary. If the solar farm can be designed such that the panels can be (re)moved in case of repair on seabed cables, solar panels could be installed in the safety zones. A specific proximity agreement would need to be developed which would provide for the temporary removal of solar panels from the safety zone.

4.4 Turbine maintenance & service contract

Integrated design concepts will require modifications to turbine equipment, varying from simply tying in the solar array cables into the WTG (semi-standalone), to co-usage of the transformer (integrated) and potentially adding metering and IT equipment. Solar farms should be designed such that accessibility of the WTG (for CTVs, SOVs and heavy lift vessels) is not impacted.

The additional and/or modified equipment of course needs to be maintained (but given the nature of this equipment, the scope will be rather small). In principle, two main options are possible:

1. Inclusion of maintenance and service of additional equipment installed in the WTG (cables, metering, IT) in the WTG maintenance and service contract. Compared to a standard WTG service contract, the following must be added or modified:
    - Addition / modification of scope (e.g., Modified transformer, additional cable, additional meters) to the WTG service contract

- Maintenance strategy, scope of standard service activities (preventive, reactive), reaction times
- Performance criteria
- Liabilities, in particular related to:
  - Damage to third party equipment (which would be more or less a standard clause), and
  - Compensation of down time caused by the o&m contractor to the solar farm (which needs to be elaborated, in line with standard o&m contracts for wind farms);
- Access to confidential information

Furthermore, additional agreement is needed between the wind farm owner and the solar farm owner, covering payment for the additional maintenance under the WTG service contract, liabilities for downtime of the solar wind farm as a result of failure to perform preventative maintenance or break down of the serviced equipment, and liabilities for downtime of the wind farm caused by the solar farm. This can be laid down in a separate agreement or a CPA.

2. A separate maintenance and service contract for the additional equipment installed in the WTG. In this situation, the following should be agreed between the parties (service providers and owners):
   - Scope division
   - Access to the WTG (not working at the same time, access to proprietary equipment)
   - Liabilities in case of damage third party property

For both situations, the following applies: in case the solar farm equipment hinders access to the WTGs (for CTVs, SOVs or heavy lift vessels), WTG maintenance and service contract may need amendments.

4.5 Warranties on and certification of WTGs

In the semi-standalone and integrated scenarios, especially in brown field situations with an existing wind farm, warranties by the WTG and BoP supplier might be impacted. Depending on the exact lay-out, the solar farm uses WTG equipment, in particular switchgear or transformers. Warranty provisions in supply contracts normally specify that the WTG supplier is obliged to repair a defect, but that the cost of the repair is to be borne by the Employer if the cause of the defect is external. Theoretically it could be possible a switchgear or transformer defect is caused by the solar farm. Amendments to existing contracts are not necessary, but it is recommended that new contracts include a specific clause on the impact of the solar farm on warranties. Other WTG warranties, like power curve and noise warranties are unlikely to be affected by the solar farm.

Specific consideration should be given to the IEC certification of the WTGs. Although the solar farm does not impact the core characteristics of the WTGs, it is recommended to further investigate this topic with certification bodies. This does not apply in standalone scenarios.

4.6 Financing and insurance

Project finance and insurance policies for standalone offshore wind farms are readily available at reasonable terms. This is not (yet) the case for offshore solar farms, simply because no offshore solar farm (other than smaller, experimental farms) has ever been constructed. The financing and insurance market will need to go through a learning curve with the first few offshore solar farms, just as it went through a learning curve with the first offshore wind farms.

When that step has been taken, the next step of financing and insuring a greenfield combined offshore wind/solar farm with one owner in one financing agreement and one insurance policy appears to be relatively easy. Combining a wind and solar farm with different owners, and thus under different financing agreements and insurance policies adds another level of complexity.

4.7 Key Findings

1. All design concepts will share a TenneT export cable and therefore must determine priority for curtailment based on substation and export capacity.
2. Ensuring that the floating solar panels do not hinder ability to work on existing TenneT and/or wind farm cables will help minimize cable proximity agreements and modifications to service and maintenance contracts.
3. In integrated and semi-standalone concepts additional equipment is installed in the WTGs and/or existing equipment is modified, that needs to be maintained. The additional maintenance can either be included in the existing WTG maintenance agreement, or a separate agreement can be concluded.
4. WTG warranties and certification of the wind farm need to be taken into consideration but are not likely to be materially impacted.
5. Insurance and project finance of combined wind- and solar farms is new, and it is expected that a few projects need to be developed before the finance and insurance world has a full understanding of the risk profile of combined wind- and solar farms.

Ventolines

5 Grid connection within the Dutch Exclusive Economic Zone

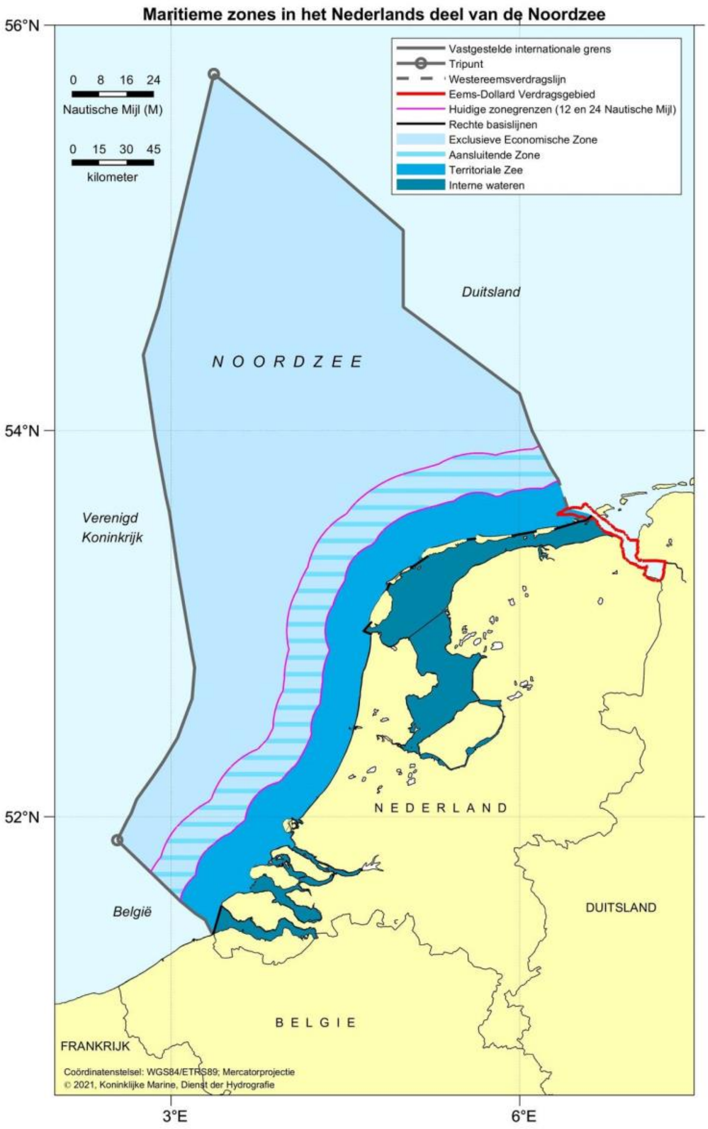

Figure 3 – the Dutch Maritime Zones in the North Sea

5.1 Introduction

Many of the legal and regulatory aspects are location-specific and will differ from country to country. This applies even within the EU because, even if many of the regulatory aspects such as environmental law and electricity regulation have EU origins, regulatory regimes differ widely from member state to member state. In addition, many other (private law) legal aspects (such as ownership, rights in rem and security rights (pledge, mortgage and contractual security rights)) are fully a competence of the EU member states and thus can be completely different between member states.

As this report is drafted as a part of the Dutch pilot project, it is assumed that the offshore integration between solar and wind farms takes place under (some form of) jurisdiction of The Netherlands. Concretely, this means that the offshore wind and solar farms concerned must be located either in the territorial seas of The Netherlands or in the Dutch EEZ, as explained in the next paragraph. If the wind and solar farms are in neither of these regions, but instead in the territorial seas or EEZ of another state or on the high seas, The Netherlands has no jurisdiction and, consequently, Dutch law does not apply.

5.2 Dutch territorial seas and Dutch Exclusive Economic Zone

The scope of jurisdiction of states on the surrounding seas is defined in the United Nations Convention on the Laws of the Sea from 1982 (UNCLOS). Currently, 133 states have ratified UNCLOS, among which The Netherlands and virtually all European states, meaning that all states bordering the North Sea will recognize and apply UNCLOS to determine which state has jurisdiction.

The Dutch territorial seas have their limit of 12 nautical miles out of the coast of The Netherlands (article 3 UNCLOS). In the Dutch territorial seas, the Netherlands have full jurisdiction – meaning that all Acts and regulations apply there fully (unless explicitly mentioned otherwise). The figure above illustrates the Dutch maritime zones in the North Sea.[3]

Almost all windfarms that are planned and/or are currently under construction in front of the Dutch coastline, however, are located outside the 12-mile zone.[4] The illustration below shows the locations of the prospected windfarms. This means they will fall into the Dutch EEZ as introduced by UNCLOS. In the EEZ, a state does not have full jurisdiction, but instead *"(…) the coastal State shall have the exclusive right to construct and to authorize and regulate the construction, operation and use of: (a) artificial islands; (b) installations and structures for the purposes provided for in article 56 and other economic purposes; (c) installations and structures which may interfere with the exercise of the rights of the coastal State in the zone. 2. The coastal State shall have exclusive jurisdiction over such artificial islands, installations and structures, including jurisdiction with regard to customs, fiscal, health, safety and immigration laws and regulations."*

In The Netherlands, acts do not automatically apply in the Dutch EEZ; an act must explicitly declare it is applicable in the Dutch EEZ. In the subsequent paragraphs, it will be indicated whether acts/regulations apply in the EEZ or not.

5.3 Electricity, cable pooling and grid connection regulation

Before we delve deeper into the various spatial aspects of integrated offshore wind/solar projects, in this paragraph the relevant legal framework around obtaining a grid connection in the North Sea will be presented.

5.3.1 The offshore grid

The Dutch Electricity Act (*Elektriciteitswet 1998*) regulates the production, supply and transport of electricity in the Netherlands. Recently, a draft proposal for a new Energy Act – combining regulatory regimes for both the electricity and the gas markets – has been made public for consultation. The proposal for a new Energy act is currently going through legislative procedure. It was sent to the (Second Chamber of) the Dutch Parliament in June 2023. If enacted, the Energy Act will replace several acts related to energy, among which the Electricity Act. Whether and at what date the Energy Act will enter into force and replace the Electricity Act will depend on the outcome of the legislative process. The Electricity Act and the future Energy Act are applicable in the EEZ – although with some limitations as will be explained later on.

The Electricity Act qualifies the offshore grid as separate from the national (onshore) grid. Currently, only offshore wind farms can apply for a connection to the offshore grid, meaning solar farms are excluded from access to the offshore grid. In the explanatory memorandum

[3] Noordzeeloket, "Maritime and incident control zones North Sea"
[4] OWEZ is located entirely and HKZ III & IV are partly located within the 12 nautical mile zone.

accompanying the new Energy Act, certain indications are provided that suggest the possibility of connecting solar farms to the Offshore Electricity Transmission System. [5]

This serves to emphasize that the offshore solar technology can be considered a mature technology ready for large-scale deployment at sea. In this context, the Explanatory Memorandum accompanying the Energy Act indicates that solar and wind are, first and foremost, highly complementary techniques for electricity generation, which is expected to result in minimal competition between offshore solar energy and wind energy on the offshore electricity transmission system. It is also stated that the technological development of offshore solar energy is progressing rapidly. For these reasons, it is considered plausible and desirable in the Explanatory Memorandum that (large-scale) pilot projects for offshore solar energy in the North Sea can be developed in the coming years. The Energy Act therefore proposes to enable the integration of solar energy and other generators into the offshore electricity transmission system.

However, upon closer examination of the statutory text, Article 3.86 of the Energy Act reveals that the opportunity for solar farms to autonomously feed into the offshore electricity grid is not ensured under the new Energy Act. The Energy Act proposal's explanatory memorandum outlines regulations for offshore integrated energy projects in the North Sea. According to the proposal, the Transmission System Operator (TSO) is only required to connect offshore wind farms that have permits under the Offshore Wind Energy Act, as well as end-users of electricity. However, this does not necessarily mean that offshore solar energy installations cannot be connected to existing wind energy installations. If such a connection is made, the two installations will share the connection to the offshore electricity transmission system. In the event that a solar energy installation is linked to an existing wind farm, the wind farm will be responsible for ensuring that a new Connection and Transmission Agreement is reached with the TSO for offshore electricity. It should be noted that regulations similar to those in place for wind farms do not currently apply to PV-installations. This does however not entail a situation in which the offshore solar farm has an independent grid connection.

Given that the statutory text of the Energy Act does not allow solar farms to independently connect to the offshore grid, an amendment is required to allow offshore solar farms access to the offshore grid (except for experiments, as explained above).

5.3.2 An obligation to assign a grid operator?

A complicated regulatory question is whether the connections between offshore assets (e.g. wind and solar farms) qualify as a grid within the meaning of the Dutch legislation (the Electricity Act/the Energy Act). In this regard, we remark that connections between onshore assets do qualify as a grid within the meaning of the Electricity Act. This has as its consequence that there will be an obligation, on the basis of article 10 (9) Electricity Act, to assign a grid operator. The question is whether this obligation also applies to the offshore grid and more specifically the connection between offshore assets. First of all, it is clear that the connections between integrated offshore assets do not constitute part of the offshore grid (as defined in article 15a Electricity Act):

> *"The offshore grid comprises the grids that are intended for the transmission of electricity and that connect one or more offshore wind farms to the national high-voltage grid, with the*

[5] Paragraph 3.3 of the Explanatory memorandum of the Energy Act

> *exception of pipelines and connected equipment for the transmission of electricity that connects one or more offshore wind farms to the national high-voltage grid and for which a permit has been granted before 1 January 2016 under the Public Works Management Act (Wet beheer rijkswaterstaatswerken) or under Article 6.5 of the Water Act".*

This means that the offshore grid only applies to connection between offshore wind farms and the national (onshore) grid. Therefore, connections between integrated offshore assets do not fall under the scope of "the offshore grid" within the meaning of the Dutch Electricity Act. However, that still leaves open the possibility that these connections qualify as a (non-specified) "grid" in the meaning of the Electricity Act. For this, it becomes relevant how the scope of the Electricity Act within the EEZ is described:

> *"This Act and the provisions based on it also apply on the offshore grid located within the Dutch EZZ, cross-border grids located within the Dutch EEZ and to installations for the generation of electricity located within the Dutch EEZ, as well as the electricity generated by it."*

This definition does not include connections/grids between two production-installations. A production-installation is defined in the Electricity Act as: "an installation for the production of renewable energy". A production installation can consist of multiple production units. A production unit can be qualified as the smallest possible entity that produces renewable energy. An example of multiple production units that together form an entire production-installation, are multiple wind turbines in one wind farm. The infrastructure between these productions units will qualify as production-installation. However, it seems unlikely to us that an integrated wind and solar farm will qualify as a single production-installation. If this is indeed not the case, then connections between solar and wind farms in the EEZ will not be regulated by the Electricity Act (and by the Energy Act neither, as this Act applies in the EEZ in a similar way to the current Electricity Act, as will be explained below).

The foregoing means in turn, that there is no "grid" and therefore no obligation to appoint a grid operator (as normally would be required on the basis of article 10 (9) of the Electricity Act). The explanatory memorandum of the Electricity Act does mention that the "connection obligation" (*aansluitplicht*) of the offshore grid operator will follow the onshore regulations for grid connection as much as possible, although the connection obligation only applies to holders of a permit for an offshore wind farm. Furthermore, the definition of "offshore grid" in the Electricity Act (see above) is only applicable to offshore wind farms.

As mentioned above, from the text of the explanatory memorandum of the Energy Act also follows that TSO TenneT is only obliged to connect offshore wind farms. The new Energy Act proposal provides some clarity with regard to legal classification of the connections between offshore assets. The scope of the Energy Act within the Dutch EEZ is regulated in article 1.6. This article regulates that the Energy Act is applicable within the Dutch EEZ to offshore transmission systems.

> The definition of "offshore transmission system" is laid down in article 1.1 of the Energy Act: *"system of pipes and connected devices for the transport of electricity at a voltage level*

> *equal to or greater than 110 kilovolts that primarily connect one or more offshore wind farms to an electricity transmission system".*

The explanatory memorandum discusses the possibility of connecting other types of users to the offshore transmission system (e.g. solar farms). In case of connection to the offshore wind farms, the offshore solar farms and their connection(s) to the offshore transmission system will not qualify as being part of the offshore transmission system. This would mean that, based on the Energy Act, the connections between offshore solar farms and offshore wind farms will not fall within the scope of the EEZ, and therefore, there will be no requirement to appoint an operator for these connections.

5.3.3 Connecting to an offshore TenneT platform

As mentioned in paragraph 3.1 above, the additional generation of (solar) energy within an offshore wind farm would either require the solar farm to connect to the array strings of the wind farm (semi-standalone concept), or an individual connection field to one of TSO TenneT's offshore high-voltage stations (standalone concept). The latter case is very rare in the case of the existing 700 MW platforms. In case of the new 2 GW platforms, a connection field with a maximum of 415 MW would be possible. First of all, it will have to be determined who will be guaranteed the transport capacity. Since it is not possible for solar farms to connect directly to the offshore grid, the wind farm will be the party that will be guaranteed transport capacity. Subsequently, a legal framework would have to be developed for non-guaranteed (non-firm) use of the transport capacity by the additional renewable energy generator. As long as legal framework is not developed, contractual agreements must be made between the wind and solar farm, which will share the cable that connects the offshore substation to the onshore substation.

It is worth noting that at Hollandse Kust Noord, additional connections have been established at the substation for gas and oil electrification. It has been indicated that these connections, in theory, could also be utilized for offshore solar projects. This effectively creates the physical possibility for the offshore solar farm to connect to TenneT's substation. However, practical limitations arise due to the provisions of the Electricity Act, as solar farms are unable to independently enter into a Connection and Transportation Agreement (ATO) with TenneT.

5.4 Key findings

1. Currently, only offshore wind farms have access to the Dutch offshore electricity grid, and this is expected to remain the case under the current version of the Energy Act. In principle, solar farms are excluded, except for the option to connect to an offshore wind farm and supply energy to it instead of directly to the grid.

2. The offshore semi-standalone and offshore turbine-integrated design concepts require a single CTA with TenneT because solar farms cannot connect directly to the offshore grid. As a result, the current and anticipated future legislation does not allow for offshore solar farms to operate in a standalone concept.

3. To enable offshore solar farms to enter into a CTA with TenneT, an amendment to the Electricity Act and/or the Energy Act will be required in the future. We propose that this be included in the legislative package necessary to introduce offshore solar and offshore integration.

6 Spatial planning of offshore projects

This paragraph explores the practical implications of spatial planning rules for offshore wind farms, floating solar farms and offshore integrated projects (the latter in both brownfield, and greenfield situations).

6.1 Offshore wind

Specifically for development of offshore wind farms at the North Sea, the legislator has adopted the Offshore Wind Energy Act (*Wet windenergie op zee*). One of the instruments introduced with adoption of the Offshore Wind Energy Act is the "plot decision" (*kavelbesluit*), through which the competent authority can designate areas in the North Sea (including the EEZ) for offshore wind farms and cable routes between wind farms and (onshore) substations. Plot decisions provide a regulatory framework for prospective wind farms, indicating the square footage of a windfarm and the capacity and power of the wind turbines. While the authorities remain competent to set up a (national) zoning plan for areas of the North Sea, the adoption of the Offshore Wind Energy Act by the legislator suggests a preference for the plot decision when it concerns the spatial arrangements for offshore wind farms.

Naturally, ecological interests play an important role in the preparatory procedures of plot decisions. Specifically for offshore wind farms, the legislator has introduced an integrated implementation of the assessment of aspects of nature (laid down in further detail in Sections 5 and 7 of the Offshore Wind Energy Act). Assessments regarding protection of threatened species and habitats are no longer performed separately under the Nature Preservation Act (*Wet natuurbescherming*) but are integrated in the preparatory procedure of the plot decision.

In almost all cases, more in-depth environmental research will be required during the preparatory stage of a plot decision in addition to the assessments on habitat and species protection. Most likely, the competent authority will also explore whether an environmental impact assessment and a so-called *"passende beoordeling"* are to be performed. If these assessments show that construction and/or operation of the relevant offshore wind farm have any unacceptable negative effects on the environment, the competent authority will explore if and how these effects can be sufficiently mitigated by additional measures and – if so – how these mitigating measures should be translated to site-specific regulations as part of the plot decision.

After laying down the starting points and basic principles for an offshore wind farm in a plot decision for a specific location in the North Sea, the plans for the wind project will materialize through a permit for its construction and offshore operations. Only one permit will be granted per location – to the winner of the to be organized tender (see next paragraph). The period for which the activities that are specified in the permit can be carried out is determined in the plot decision. This permit replaces the "traditional" permit requirements regarding construction and environmental aspects (*Wet algemene bepalingen omgevingsrecht*) and the permit based on the Water Act (*Waterwet*), as the permitting-framework that is pursuant from each act is not applicable when it comes to offshore wind farms (provided it does not concern a near-shore wind farm that is situated within the territory of a municipality or province).

When the plot decision is final, the Netherlands Enterprise Agency (*RVO*), commissioned by the Ministry of Economic Affairs and Climate, will organize a tender procedure for the allocation of the plot(s) and the associated permit(s). The winner of the tender will (exclusively) be entitled to obtain a permit. The Offshore Wind Energy Act provides the framework for the tender (such as a summing up of the criteria that can potentially be set in the tender); the precise wording and weighting of the criteria will be worked out in a tender specific regulation. In this way, the specifics of the tender vary (slightly) from tender to tender.

When the tender regulation is final, commercial parties with an interest in the plot can submit proposals/permit applications with regard to the construction and operation of the wind farm. The government will decide which party will build and operate the wind farm. This party will receive a permit for the construction and operation of the wind farm in the relevant site.

6.2 Integrated projects

By contrast to the regime for wind energy (as described in the previous paragraph), no specific legislation for other types of offshore renewable energy/installations (such as solar, energy storage etc.) exist, let alone for integration between different types of energy. Zooming in on floating solar farms and integrated wind/solar projects with cable pooling between the projects, we see that specific regulation equivalent to the Offshore Wind Energy Act is yet to be created and adopted. Regarding constructing and having a PV-installation and/or a shared cable network in the EEZ, this leads to a situation in which we fall back on the following general zoning and environmental regulations for offshore activities within the EEZ, which will be briefly outlined in the paragraphs below.

A clear trend is visible: system integration is playing an increasingly large role in the outcome of the wind tenders (described in the previous paragraph). In the draft-tender regulation for the most recent IJmuiden Ver tender plot Beta, the applicant's contribution to the adaption of the offshore wind farm to the Dutch energy system is one of the award criteria. A total maximum of 168 points can be divided between (1) onshore investments in order to adapt the offshore wind energy plot to the Dutch national (onshore) grid, and (2) the integration of offshore solar farms and the wind farms within the IJmuiden Ver Beta plot. The stimulation of investments in integrated offshore solar farms will contribute to more efficient use of the available offshore (wind) energy infrastructure. According to this points awarding system, a solar farm of at least 50 MWp can be integrated into the offshore wind farm in the IJmuiden Ver Alpha plot. The fact that a solar farm of 50 MWp (or even more) can be included in a plot that is originally designed and determined for wind energy indicates that the solar farm can be considered subordinate to the offshore wind farm that it connects to.

The full offshore solar farm must be taken into use no later than 60 months after the permit has become irrevocable. Parties grant unlimited access to the entire solar farm at sea to parties designated by the State for ecological monitoring and allow the necessary equipment to be installed in the park. The results of this research will be made public. In their proposal, the parties include a description of how the collaboration with these parties designated by the State will be established and how they will facilitate this ecological research. Parties will monitor the practical applicability of solar energy at sea and the way in which electricity production from solar energy and wind energy function together. They make this knowledge publicly available. The parties will make every effort to keep the entire offshore solar farm operational for at least ten years. Requirements for the configuration of the set-up with regard to safety and ecology are to be determined.

The current draft tender regulations for other offshore wind areas do not include a specific awarding system for system integration. However, for example in the Hollandse Kust West VII plot, integrated solar projects are planned to be operated. The fact that award criteria are not included in the draft tender regulation does not prevent the realization of offshore integrated solar farms.

Based on the information provided above, it appears that offshore wind farms are predominantly regulated through plot decisions under the Offshore Wind Energy Act. This raises the question of how this affects brownfield wind farms that have existing plot decisions which lack criteria for combined use and system integration. Is it possible to amend these existing plot decisions? Additionally, is it feasible to require existing wind farms to share their cables with offshore solar farms?

6.3 The Area Passport for Shared Use

Before delving into the required water permit for offshore zone energy projects, we will first introduce an offshore-specific government instrument: the Area Passport for shared use. The Area Passport is a guide that serves as the basis for spatial zoning of initiatives within wind farms. When assessing the water permit applications (which will be discussed in the following paragraph) from potential shared users of the wind farm's spatial zone, Rijkswaterstaat consults the Area Passport. The Area Passport serves as a tool for zoning initiatives within wind farms and indicates the lay-out of a wind energy zone. This entails that the Area Passport will provide an overview of the WTGs exact locations, the cable circuits, the routes for shipping traffic, and where there is still room for other activities, such as fishing, marine farming, animals/plants protection, other renewable energy projects and recreation.

Recently, Area Passports have been introduced to provide interested parties with information on where activities other than wind energy, such as solar energy, can be carried out. Integrated solar energy is an example of combined use of a wind farm's spatial zone, and parties that want to generate energy within the wind farm may deviate from the Area Passport.

Although the legal status of the Area Passport is not entirely clear; what is clear is that they will have an impact on the assessment of the application of a water permit.[6] The Area Passport system has been outlined in the Program North Sea 2022-2027. This program qualifies as a national water program, which plays an important role when deciding whether a water permit can be granted,

[6] Article 6.22 jo. 2.1 Water Act and article 8.84 Environmental Activities Decree

this will be outlined in the next paragraph. As the Area Passports follow from this national water program, it is to be expected they will also play a major role in deciding whether a water permit can be granted.

It is possible that the preparations for an Area Passport will start after the tender for the offshore wind farm. Therefore, it is advisable to consider the integrated offshore solar farm when designing and positioning the wind turbines for the wind farm. This provides clarity about the position of the solar farm within the wind farm zone and the cable locations. As a result, the location(s) included in the area passport for the solar farm will most likely align with the preferred location for the operator of the offshore solar farm. If the location that is designated for solar in the permit application, corresponds with the solar area in the Area Passport, this will reinforce the water permit application.

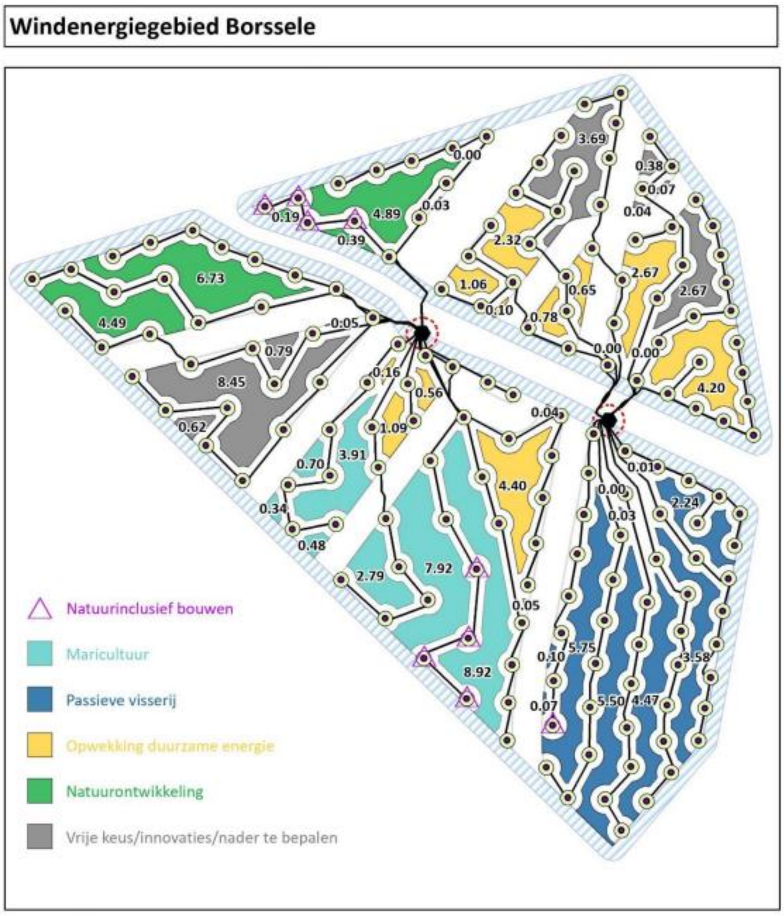

Figure 4 - The Area Passport for Shared Use for Offshore Wind Energy Area Borssele. The area dedicated to renewable energy (other than wind) is indicated in yellow.

6.4 The water permit for offshore solar

It is prohibited to carry out activities in a water body and to erect construction works in that water body without a so-called water permit (Section 6.5 (c) of the Water Act (*Waterwet*) in conjunction with Section 6.13 of the Water Decree (*Waterbesluit*)). The North Sea is considered a water body in that sense too and, therefore, projects that are to be developed and operated at the North Sea must possess a water permit. This applies both to the solar farm itself and to the cables that are required to integrate wind and solar farms, although this raises questions regarding overlap with the permit granted based on the Offshore Wind Energy Act – on which more below.

A water permit can be granted with a view to the applications of the Water Act. The applications of the Water Act can be summarized as follows: preserving water quality, maintaining water quantity, and fulfilling societal functions through water systems. This last aspect pertains, for example, to infrastructure (including considerations for maritime transport), economic interests such as water for businesses and water for agriculture, and ensuring adequate drinking water provisions. "Protection of water quality" includes both chemical and ecological quality of the body water (article 6.21 jo. 2.1 Water Act).

For the sake of its completeness, we note that from January 1st, 2024, the permit under the Water Act will be indicated as an environmental permit under the Environment and Planning Act (*Omgevingswet*). Under the Environment and Planning Act, a water permit will be replaced by the environmental permit for limitation area activities regarding water management structures (*beperkingengebiedactiviteiten met betrekking tot waterstaatswerken*). This environmental permit will be assessed against the same criteria as the aforementioned criteria under the Water Act. Under the Environment and Planning Act the protection of the physical environment (one of the main objectives of this Act[7]) is an additional criterion for the assessment of the permit application. However, we do not expect this criteria to result in an issue regarding permit application, as the government seeks to facilitate offshore solar projects.

Water permit conditions can only be established in accordance with the aforementioned applications of the Water Act (or in the near future the Environment and Planning Act). In this report, the permit for an offshore solar farm will be referred to as: "the water permit".

The criteria mentioned above from the Water Act (water quality, water quantity, and societal functions of water systems) will be assessed by the government when reviewing a water permit application. The latter criterion pertains to the maintenance of a sound water infrastructure and places significant emphasis on maritime navigation. Additionally, other economic interests are considered in the evaluation of this criterion. For instance, this may include the allocation of available water resources among different enterprises, such as sustainable energy projects or fisheries.

Article 8.84, subsection 2 of the Environmental Quality Decree[8] further dictates that the competent authority, when assessing a water permit application, shall take into account water management programs, regional water programs, river basin management plans, flood risk management plans, and the national water programs. The shared-use area passport, as outlined above in Section 6.3, is derived from the national program North Sea. This program constitutes a national water program. Consequently, the shared-use area passport will factor into the evaluation of a water permit application for an offshore solar energy project. The shared-use area passport designates

[7] Article 8.90 of the Environmental Quality Decree
[8] The Environmental Quality Decree is one of the four implementation Decrees on the Environment and Planning Act

areas within a wind farm for various forms of multi-use. This will de facto mean that obtaining a permit in an area not designated for solar energy in a shared-use area passport will be challenging. If it is designated, then a significant hurdle is cleared for the "societal functions of water systems" evaluation criterion. In such cases, the assessment of the water permit will primarily focus on the protection of chemical and ecological water quality.

The Water permit will be assessed against the assessment framework for multi-use, derived from the North Sea program.[9] The framework for this purpose is intended, on the one hand, for the permit issuers to assess permit applications for these activities in offshore wind farms and to carefully weigh the interests. On the other hand, the framework provides permit applicants with insight into the steps to be taken to obtain a permit, as well as the required documentation and resources.

In evaluating the admissibility of the activity, a fixed legal procedure is followed. The framework provides guidance for steering towards efficient and multi-use spatial planning in wind farms. In this regard, the principle of 'first come, first serve' is partially applied, and the initiative lies with the market. The framework for assessing the water permit for shared use follows the steps outlined below:

STEP 1: Preliminary Consultation and Description of Activity and Spatial Needs

In the initial phase of the process for co-use in offshore wind farms, it is advisable to engage in preliminary discussions with the competent authority before submitting a permit application. This preliminary discussion, considered as the initiation of the integration process, involves deliberations on the proposed activity and may, when necessary, involve other stakeholders such as wind farm operators. The description of the activity and spatial requirements necessitates specific information regarding the activity, spatial claim, potential effects, and the intended location within the wind farm. Evaluation encompasses various aspects, including nature conservation, the effects on the ecosystem, and an assessment of potential impacts based on the best available knowledge. The ecosystem approach and the precautionary principle are applied in this context.

A pivotal consideration in the relationship between the co-use initiator and the wind farm operator is that co-use must not impede the generation of wind energy. Consultation between co-use initiative-takers and wind farm operators is highly recommended to identify potential effects and prevent objections to the co-use permit.

STEP 2: Pre-assessment of Intended Activity and Spatial Requirements

In the second step, the pre-assessment of the intended activity and spatial requirements, the activity is evaluated by the competent authority based on preferences outlined for each offshore wind energy area. If the activity is designated as a preferred activity, the process proceeds directly to the third step. If the activity is not designated as a preferred activity, the competent authority

[9] North Sea program, p. 129

may announce an intention to issue a permit for the specific location. Other initiators then have the opportunity to declare within six weeks that they also intend to deploy a co-use activity in the area in the short term. If no other initiators come forward within this period, the formal permitting process can commence. If another initiator emerges within this timeframe with a preferred activity for the intended location, consultation will determine if there is room for both initiatives and whether the activities can be combined. The "first come, first serve" principle applies when there are no preferred activities, with priority given to the initial activity.

STEP 3: Assessment of Effects of Activity and Location Selection

In the third step, the evaluation of the effects of the activity and location choice after the submission of the formal permit application, the application is assessed based on various criteria. This includes aspects such as spatial and operational effects on the wind farm and other activities in the area. Attention is also given to safety, liability, and financial security. Specific requirements apply to the permit duration, clean-up obligation after the permit term, and ensuring a good environmental state according to the North Sea Program 2022-2027. The text also underscores the consideration of archaeological and cultural-historical values, which are factored into permit issuance for activities in the North Sea.

The aforementioned criteria for the assessment of a water permit do not include any criteria designating a location to the entity granted the water permit to construct and operate an offshore solar farm. In this context, it is interesting to note that the government (the Ministry of Internal Affairs in collaboration with Rijkswaterstaat) has established a tool that can contribute to designating areas for offshore solar farms: the Area Passport for shared use which will be elaborated in paragraph 6.3.

Furthermore, in our view, the criteria for the assessment of a water permit on the basis of the Water Act (as stated in Article 2.1 of the Water Act)[10] do not allow the competent authority responsible for granting water permits to differentiate between multiple parties applying for a permit to build and operate a solar farm at the same location. This results in some issues regarding the tender procedure for offshore solar projects. These issues will be addressed in the following subparagraph.

6.5 Awarding offshore solar

In practice, operators of an offshore solar farm will only seek a water permit when they secure the tender for the integrated solar farm within the offshore greenfield wind project. If the solar farm operator does not win the tender, the project will not be feasible. Although, from a legal standpoint, the government cannot discriminate among the various parties applying for a water permit for an offshore solar farm, there still exists a situation wherein the party applying for a water permit will distinguish itself from the other applicants for the offshore solar farm permit. This

[10] Article 8.84 of the Environmental Quality Decree under the new Environment and Planning Act

distinction arises due to the fact that this party has won the tender for offshore solar, which is integrated in the tender for the greenfield offshore wind farm.

In brownfield situations, the tender procedure has already been concluded. Consequently, a scenario can be imagined in which any entity desiring to establish an offshore solar farm could apply for a water permit. However, it is worth noting that it remains uncertain whether many entities will initiate the application process without having obtained permission from the offshore wind farm to connect to its infrastructure. In such cases, considerable expenses are incurred in the permit process without a guarantee of project feasibility. Nevertheless, it is imperative to underscore that project feasibility is not a criterion for obtaining a water permit. From a legal perspective, it is therefore feasible for multiple parties to apply for a water permit to realize an offshore solar farm, irrespective of whether they have obtained cooperation from the offshore wind farm. An intriguing question arises as to whether the wind farm, under such circumstances, can be compelled to allow the integration of an offshore solar farm into its grid connection. Solar farms are entirely reliant on the ability to connect to the grid connection of an offshore wind farm since they cannot independently connect to the offshore grid (as discussed in Section 5.3). This raises the possibility that the grid connection of an offshore wind farm may be considered an essential facility.[11]

Currently, there is no provision within the Offshore Wind Energy Act that obliges an offshore wind farm to admit an offshore solar farm to its grid connection. This would necessitate an amendment to the Offshore Wind Energy Act. What is particularly problematic in this regard is the fact that compelling a brownfield wind farm to incorporate an offshore solar farm would require a retroactive provision, since the brownfield wind farm is already constructed (or at least tendered). This presents a challenge in light of the 1st Protocol of the European Convention on Human Rights (ECHR): “the protection of the peaceful enjoyment of property”. The wind farm, after all, is owned by the wind farm operator, and compelling the admission of a solar farm to the wind farm's connection would constitute an interference with that property. As a result, we would expect that, in such a case, compensation for damages would need to be offered to the wind farm, as a matter of principle. In practice, however, one may question whether the wind farm would indeed suffer any harm. In practice, it is expected that the wind and solar farms would agree that the solar farm would curtail its generation when there is insufficient grid capacity.[12] This is a situation commonly observed onshore for wind and solar farms that share a grid connection through cable pooling. The fact that the solar farm would curtail its generation means that, in practice, the wind farm would not suffer production losses due to the connection of the solar farm.

Furthermore, both the Offshore Wind Energy Act and the Water Act lack provisions determining which party should be granted a water permit when multiple applicants seek such a permit for an offshore solar farm at the same location. This appears to be inconsistent with judgments from the

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[11] It could be argued that the offshore electricity grid can be considered an essential facility under European law. By denying direct access to the offshore electricity grid for offshore solar farms, these solar farms are placed in a dependent position relative to the offshore wind farm. However, it is uncertain whether the essential facilities doctrine provides room for the solar farm to compel a connection to the offshore electricity grid through the wind farm, since there are no precedents.

[12] Since the solar farm is the secondary party that connects to this offshore grid connection

Court of Justice of the European Union (ECJ).[13] According to European law, there should be a transboundary interest for its application. We anticipate that such an interest exists since foreign entities may also express interest in operating an offshore solar farm in the North Sea. The European case law cited above indicates that rights cannot be allocated without some form of tender procedure, as this would contravene the prohibition of discrimination and the principle of transparency. It is essential to emphasize that the situation in the case of a greenfield wind farm is evident due to the tender procedure for the wind and solar farms in that scenario. The winner of this tender, provided they meet the relevant legal evaluation criteria, will be granted a water permit. As a result, we anticipate that there is no violation of European law in a greenfield scenario.

The situation becomes intriguing when dealing with a brownfield offshore wind farm. In such a case, multiple operators of offshore solar farms can theoretically apply for a water permit. When the wind farm cannot be compelled to cooperate in connecting a specific solar farm, it places the wind farm in a highly privileged position. This would result in a scenario where the offshore wind farm, by winning the offshore wind tender, also gains the exclusive right to choose whether, and if so, which solar farm may connect to the offshore wind farm. This is in contrast to the case of a brownfield wind farm where no tender for an offshore solar farm has taken place. While the wind farm may have won the tender for wind energy, solar energy was not included in that tender at the time. Consequently, considering the prohibition of unfair competition and the concept of scarce permits, it appears unjust that an offshore wind farm has the exclusive authority to determine which solar farm may connect to it. Furthermore, in our opinion offshore solar is a development that should be stimulated by the government. This makes that solar farms should have a stronger position in order to be able to operate offshore, that both in greenfield and in brownfield situations.

From the above, it is evident that the operator of an offshore wind farm could potentially gain a disproportionately privileged position when connecting offshore solar farms without a tender procedure. Therefore, it is expected that the government will organize a tender when multiple parties apply for a water permit for the operation of an offshore solar farm that wishes to use the grid connection of an offshore wind farm. An alternative is that the government holds the applications and waits for new policy in this area, which could possibly involve the aforementioned amendment to the Offshore Wind Energy Act.

6.6 Environmental impact assessments

Different from the regime for offshore wind farms (where the plot decision, and, therefore also, permit on the basis of the Offshore Wind Energy Act cover environmental aspects), the relevant assessments regarding protection of threatened species and habitats are to be performed separately under the Nature Preservation Act if applicable (the Nature Preservation Act is applicable within the Dutch Exclusive Economic Zone). Likewise, an EIA (hereinafter also referred to as: "EIA") must be performed if this is required on the basis of the regulation regarding Environmental impact assessments. However, as self-explanatory performance of EIAs are in

[13] ECJ, ECLI:EU:C:2010:506 (Engelmann) en HvJEU, ECLI:EU:C:2000:669 (Telaustria); Moreover, we also examined the national Dutch jurisprudence concerning this matter (ABRvS 6 juni 2018, ECLI:NL:RVS:2018:1847), but it is less relevant in this context

developing (offshore) wind farms (for wind turbine installations and high voltage cable routes), this is not the same for offshore solar farms. Unless a project is expected to have significant consequences for a Natura-2000 area in its vicinity, EIAs are not mandatory for offshore solar farms, because floating solar is not mentioned in the lists in the appendix of the EIA regulation (*Besluit-mer*).

The option that an EIA has to be carried out, because the project has potential significant consequences for a Natura-2000 area, is only relevant when a project is situated near one of the Natura-2000 areas in the North Sea (article 7.2a Environmental Management Act jo. article 2.8 Nature Preservation Act).[14]

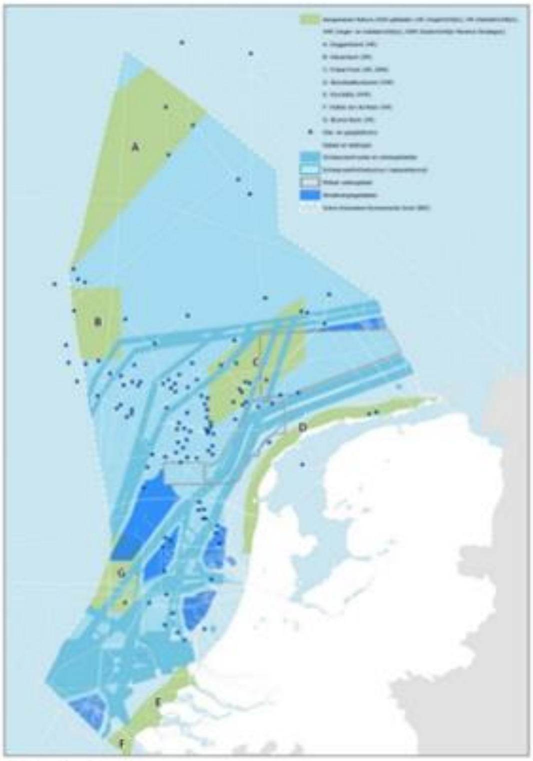
As indicated on the map below, the plots for Windarea IJmuiden Ver (and potentially Hollandse Kust West) are located near the Natura-2000 area Bruine Bank. The original plot for IJmuiden Ver is amended, in order to not overlap with the Bruine Bank Natura-2000 area. However, the fact that both the wind area and the Natura-2000 area are located close to each other, results in the fact that an estimation of potential significant consequences pursuant to article 2.8 Nature Preservation Act (and thus and EIA) will probably have to be carried out. Protected species in the relevant Natura-2000 areas are marine mammals, birds and bats. For wind-energy projects mammals are mostly affected through noise of pile driving and flying species are affected by the rotor. The solar farm substation equipment will require foundations. As such, there may be an impact on protected species. Also, the effect of the reduction of solar radiation that penetrates the surface of the North Sea - due to the installation of (floating) solar panels on the surface of the water - on flora and fauna needs to be examined.

As a result, EIAs are only mandatory for plans or programs that are constituted for the preparation of offshore solar projects, if the offshore solar project has significant consequences for one of the Natura-2000 areas which are indicated in the map below. The water permit for an offshore solar farm will not qualify as “plan” or as “program”. This means that there will be no EIA required for the water permit for an offshore solar farm. The Area Passport does however qualify as a plan or program, since it provides with a framework for the assessment of the water permit for the offshore solar farm. This means that the Area Passport will possibly have to be submitted to an EIA.

The wish to expand operations by adding a floating solar farm to an existing wind farm (brownfield situation) could raise the question whether the ecological and environmental studies that were performed in the preparatory stages of the plot decision and permit based on the Offshore Energy Act are still accurate and whether the new project design is expected to cause any additional environmental impact compared to the original design. Assuming that the expected environmental and ecological impact of the new project increases as the project scale increases, we believe that the authorities may set a higher standard and, therefore, may require a more elaborate

[14] Or article 16.36 (2) jo. 16.53c (1) under the Environment and Planning Act

substantiation regarding ecological and environmental aspects.



Figures 5 and 6 – Offshore Wind Energy Areas and offshore Natura 2000 protected areas

6.7 Key findings

1. Nearly all of the current and projected Dutch wind farms will be located in the Dutch EEZ. Most of the relevant regulation applies to the EEZ, with the notable exception of the Dutch Civil Code (see Key finding 5 below).

2. For offshore wind farms, the Offshore Wind Energy Act provides an extensive regulatory framework. Interested parties can obtain a permit for construction and operation of a wind farm by winning a tender for a specific location designated as suitable for wind energy by the Minister of Economic Affairs. Such a permit covers all the environmental and spatial planning aspects.

3. For offshore solar farms, by contrast such a framework is lacking. Solar farms will mainly have to apply for a water permit for the construction and operation of the solar farm on the basis of the Water Act. This permit covers the presence and operations of the floating installation at the North Sea. Such a permit will be awarded if it can be shown that the solar PV system or cable network will not interfere with maintaining or achieving a "good condition" of the water body (water quality). This "protection of water quality" includes both chemical and ecological quality of the body water (article 6.21 jo. 2.1 Water Act).

4. Tailored regulations for the integration of offshore wind and solar have not yet been created. Currently, neither the Offshore Wind Energy Act, nor the Water Act explicitly

facilitate expansion of wind-operations in the sense that new activities that are complementary to existing operations can be assessed and permitted based on a set framework. For clarification purposes, we propose to expand the scope of the Offshore Wind Energy Act to include other renewable energy projects.

5. Despite the challenges surrounding permit applications, there is a clear trend emerging: system integration is becoming increasingly important in tender outcomes. In the draft tender regulations for the IJmuiden Ver Alpha plot, points are given for the integration of solar projects. This means that a solar farm with a capacity of up to or even exceeding 50 MWp can be integrated into the plot, which was originally intended for wind energy.

6. In brownfield situations, the tender procedure for the offshore wind farm has already been concluded. When an offshore solar farm subsequently seeks to connect to the brownfield offshore wind farm, there is no legally prescribed tender procedure for obtaining a water permit for the offshore solar farm. In our opinion, it is entirely conceivable that the government may organize a tender procedure in such a case to obtain the water permit for offshore solar.

7. The preceding key finding raises the interesting question of whether the wind farm can be compelled, in such a situation, to allow the winner of the tender for this water permit access to its grid connection (as the offshore solar farm cannot independently connect to the offshore electricity grid, as discussed in Chapter 5.3). The Offshore Wind Energy Act currently lacks a legal basis to compel wind farms to permit offshore solar farms onto their grid connection. Since it appears legally impossible to force wind farms in this regard, operators of brownfield wind farms appear to be in a privileged position. They can independently decide whether, and if so, which offshore solar farm may connect to their grid connection. Addressing this privileged situation would require amendments to the Offshore Wind Energy Act. Such amendments would need to be accompanied by a compensation scheme for any damages incurred by the offshore wind farm as a result of allowing the offshore solar farm onto the grid connection of the offshore wind farm.

8. Based on the current legal framework (and the future framework of the Environment and Planning Act) the is no EIA required for the water permits for an offshore solar farm. However, the Area Passport for Shared Use may qualify as a “plan” or “program”, since it provides a framework for the assessment of water permits. Article 7.2a of the Environment Management Act states that an EIA will be required when a suited estimation of environmental impacts (“*passende beoordeling*”) will have to take place. [15] We expect that the preparation of the Area Passport will need a “*passende beoordeling*”, and therefore an EIA will be demanded.

[15] And article 16.36 (2) jo. article 16.53c (1) Environment and Planning Act

6.8 Recommendations based on the foregoing

Even though development of integrated offshore activities is still in its early stages, as also noted above, we observe that regulatory bodies have not acted on the need and desire for regulation facilitating new developments in this field. The market's interest in such structures is evident, as illustrated by the joint advocacy of Holland Solar and the Dutch Marine Energy Centre. They recently submitted a shared perspective, advocating for increased opportunities to conduct experimental initiatives at sea, including other sustainable technologies such as large-scale offshore solar power systems.

We believe the most efficient way to address this is through expansion of the scope of the Offshore Wind Energy Act to include other renewable energy projects (for example, solar, storage, integrated projects etc.). One of the major advantages of this would be that, as with wind energy currently, one permit for the solar farm including integration with the wind farm will suffice, without the need to perform individual EIAs (see the previous paragraph for details). Another advantage of expansion of the scope of the Offshore Wind Energy Act to other types of renewable energy is that this will also allow for the Minister to set rules on how the integration will take place. For example, it can be regulated whether wind farms are free to build their own solar farms next to them or whether the solar farms will be (publicly) tendered. And in case the solar farms are tendered, are wind farms then required to share cables and so on?

The absence of a tender procedure in the Water Act makes it difficult to distinguish between multiple parties applying for a water permit for an offshore solar farm in the same location. In greenfield situations, this problem could be resolved by stipulating in the law that the winner of the integrated tender for the offshore solar farm, that is concluded in the tender for offshore wind, is the only party eligible to apply for a water permit. However, in such a greenfield scenario, we anticipate that in practice only a party winning the offshore solar tender, that is integrated in the tender for offshore wind, will apply for a water permit. Should the tender not be secured by a solar farm operator, the project would, in practice, be unfeasible for that solar farm operator.

In brownfield situations, the tender procedure has already concluded. When offshore solar was not included in this the tender for the brownfield wind farm, it is legally possible for multiple parties to submit water permit applications for the establishment of an offshore solar farm. There is, in principle, no tender procedure associated with the issuance of the water permit for offshore solar. In this Chapter, we have examined whether such a situation is desirable. The wind farm is placed in a highly privileged position as it has the ability to determine whether and, if so, which solar farm has the opportunity to connect to the grid connection of the offshore wind farm. We believe it is entirely possible that, in practice, the government may still organize a tender procedure for the issuance of the water permit for offshore solar in a brownfield situation. Also on this topic, we recommend the government to provide clarity by expanding the Offshore Wind Act to other types of energy and to system integration and regulate such issues as described above in comprehensive legislation.

Preparation of a plot decision requires an EIA. In this EIA, multiple variants in terms of turbine types, foundation techniques and cable locations will be assessed for their environmental effects.

As long as the permit application shows that the proposed project fits within the project outlines provided by the plot decision, the party to whom the permit is ultimately granted does not need to draw up a new environmental impact report. This is also applicable to other aspects that were not considered in the plot decision but are taken into account in the permit application. Of course, it would be preferential to draft plot decisions in such a way that a certain margin for future expansions of offshore activities is maintained. However, because performed environmental research is only valid for a certain amount of time, we doubt that this leads to future proof plot decisions. The desired flexibility that encourages to look beyond offshore wind should therefore have its own position in the Offshore Wind Energy Act. It will provide clarity and certainty for project initiators regarding the question whether an integrated project is compliant with the applicable legal obligations when it is only in possession of a permit pursuant to the Offshore Wind Energy Act. Furthermore, the suggested change ensures that project initiators are well informed about their possibilities regarding integration of offshore wind and other renewable techniques, such as solar activities. Our expectation is that this permanent solution will be provided for when authorities have new incentives to provide a regulatory response to developments in the field of sustainable energy.

7 Ownership

7.1 Ownership in relation to legal and permit requirements

Under Dutch administrative law, non-compliance with legal requirements can in principle be cause for the competent authorities to issue enforcement measures, such as a periodic penalty payment (*last onder dwangsom*) or an administrative enforcement action (*last onder bestuursdwang*). A precondition for issuing enforcement measures is that the legal entity that has failed to be compliant, is able to put an end to the illegal situation. Decisive in this respect is not whether the entity that receives the enforcement measure for example owns the challenged structure, but whether it can comply with the order. If two components of a project are each owned by different parties, that would be a strong indication that the competent authority can only take enforcements action against the owner of the relevant component.

Which legal entity operates the project (or for which part), which entities share in of the project is a matter of legal structuring. Parties can work these aspects out in the relevant contractual arrangements. In case of a brown field situation, parties can make additional arrangements for aspects that are relevant when expanding operational activities.

7.2 pledging for offshore assets

The Dutch Civil Code applies to wind and solar farms in the Dutch territorial seas. This makes it possible to establish security rights (mortgage, pledge, as applicable) over all installations used for offshore integration in the Dutch territorial seas in an identical way as for onshore installations. This will enable financing parties to create the security they need to provide loans to finance projects in the Dutch territorial seas.

Whether or not (or to what extent) the Dutch Civil Code applies in the EEZ is subject of legal discussion. The prevailing opinion is that the Dutch Civil Code does apply. There is no debate as to ownership of (parts of) the Dutch part of the EEZ: (parts of) the EEZ cannot be the subject of ownership rights, whether by private persons or entities or the Dutch State. Nor does the UNCLOS Treaty (see paragraph 5.2) include any provisions relating to ownership. Forgoing a discussion of the fine legal points, we observe that it is generally accepted that (if only for that reason) a right of mortgage cannot be established over assets in the EEZ even if they would unambiguously qualify as immovable property (*onroerende zaken*) when present in the Dutch territorial sea. Conversely, *communis opinio* seems to exist that title and rights of pledge can be created over such assets, qualifying as movable property. Based on Dutch international private law the Dutch Civil Code is the most likely (if not the only available) legal regime to apply to such title and rights of pledge.

Determining the plot for offshore solar farms is an issue in general. While a plot decision procedure is applicable to offshore windfarms on the basis of the Offshore Wind Energy Act, there is no similar procedure for solar farms. This means that to offshore solar farms the regular water-permit procedure on basis of the Dutch Water Act applies. This water-permit procedure however does not include designating a plot for the offshore energy-project. This makes it complicated - if not impossible – for operators of offshore wind farms to claim ownership of a certain area on the North Sea, in order to operate the solar farm. A procedure where the solar farm is integrated in the wind farm, in a way that the plot decision for the offshore wind farm could be shared by the offshore solar farm, could be a solution for this problem. The answer to the question, whether a plot decision can be shared, depends on the different design concepts/scenarios of the integration of offshore wind and solar farms. The different concepts/scenarios with regard to the characteristics of each integrated project will be discussed in more detail in Chapters 8 and 8.

7.3 Bankability and ownership

Based on our findings in the previous paragraphs we do not expect ownership and the possibility to create security rights (notably rights of pledge; mortgage rights are excluded due the fact that the Dutch EEZ cannot be owned) over wind farm and solar farm assets to raise major bankability concerns. It is established practice for project finance parties to deal with any legal uncertainties through the introduction in financing documents of clauses that enable financing parties to unilaterally vest, or have placeholder rights automatically convert into, security rights as possible under applicable law. In addition, in line with project finance practice, rights of pledge will be established over shares in the relevant project companies, ensuring that lenders will be able to assume control of the project through the exercise of voting rights well before commercial or financial degradation of the project threatens to evolve into insolvency scenarios. The impact of residual legal uncertainties with regard to the overall security package on commercial terms of senior debt facilities (such as gearing and risk premium) is outside the scope of this study.

If we look at bankability from a project risks perspective, the larger issues lie with the grid connection scenarios for offshore floating solar assets, prompted by the current gaps and uncertainties in the regulatory regime that governs access to the offshore grid. Under the prevailing regulatory regime floating solar will need to connect to the offshore grid indirectly, either through a turbine-integrated configuration or by connecting to the windfarm's inter-array cabling. If we assume that each production asset is developed, financed and operated in a separate special purpose company, then the solar-SPC will depend on the windfarm-SPC for the continuity of its grid connection. Banks would normally look for intercreditor arrangements, containing informational covenants, cross-default provisions, cross-control mechanisms to manage reserved discretions, and step-in rights. It is to be noted that, under prevailing regulatory law a right for the solar-SPC to step into the grid connection agreement – a common solution in onshore constellations – would not be exercisable because the offshore grid is not available for connection of generation facilities other than wind turbines. It can be expected that, particularly in greenfield situations, in order to assess financing risks of offshore floating solar farms, banks will instruct thorough technical and commercial due diligence on the offshore windfarm that the solar project is to connect to, and set high standards for the long-term robustness of the windfarm's business case. This will cause a significant increase in transaction costs and raise intricacies on how to deal with commercial and technical proprietary information.

8 Contractual and legal implications for six scenarios with varying project characteristics

Projects with different combinations of design concept, development coordination, and ownership will have different contractual implications. There are 6 scenarios with different combinations of characteristics which are outlined below in Table 1. In this Chapter, each scenario will be described.

Table 1 - Scenario Definitions

Identifier	Design Concept	Development
1 (standalone-green)	Standalone	Greenfield
2 (standalone-brown)	Standalone	Brownfield
3 (semi-green)	Semi-Standalone	Greenfield
4 (semi-brown)	Semi-Standalone	Brownfield
5 (turbine-green)	Turbine integrated	Greenfield
6 (turbine-brown)	Turbine integrated	Brownfield

8.1 Scenario 1 Review (standalone - greenfield)

Scenario 1 contemplates a standalone design on a greenfield site. In other words, the solar and wind farms will each have independent owners, on a site with no previous development, and connect them separately into a single TenneT offshore substation that is constructed for the combined wind and solar project.

8.1.1 TenneT CTAs

In this scenario, both the wind farm and solar farm will require their CTAs with TenneT. As mentioned above (in paragraph 4.2), entering into a CTA with TenneT is not possible for offshore solar farms, since the connection obligation for TenneT on the North Sea is only applicable to wind farms. See also 8.1.5 below.

8.1.2 Cable pooling

In this scenario, as a minimum, the only shared cable(s) will be the export cable(s) from the TenneT offshore substation to the onshore substation. A cable pooling agreement needs to be concluded between wind farm and solar farm, as described in paragraph 4.2.

8.1.3 Cable crossing and proximity

Cable crossings should be avoidable in this scenario, given that the wind, solar, and offshore substation are being developed in a coordinated manner. However, cable proximity agreements between the wind farm, solar farm, and TenneT will likely be necessary since they will all have cables tying into the same offshore substation.

8.1.4 Turbine maintenance

No amendment necessary.

8.1.5 Regulatory implications

This scenario involves a greenfield situation and requires the entire project to undergo the permitting process. Assuming that the solar and wind projects have different owners and that liability issues are isolated to the respective parties responsible for the operations of their installations, the initiators of the solar and wind projects must each secure the necessary permits for their offshore activities. The wind component requires a permit based on the Offshore Wind Energy Act, while the solar component requires a Water permit for shared use under the Dutch Water Act.

Taking this perspective into account, choosing a plot for offshore solar farms would pose a challenge since the water permit process does not entail designating a specific location, nor does it include a tender procedure. Additionally, current legislation does not allow solar farms to connect to the offshore grid. Consequently, the standalone scenario is not a viable option for offshore solar farms to link up with the North Sea grid.

8.2 Scenario 2 Review (standalone - brownfield)

Scenario 2 contemplates a standalone design on a brownfield site. In other words, a solar farm will be constructed on a site that already has an offshore wind farm, by a different owner than the offshore wind farm, and it will connect directly to the TenneT offshore substation that was built for the offshore wind farm.

8.2.1 TenneT CTAs

In this scenario, both the wind farm and solar farm will require their own CTAs with TenneT. As mentioned above, concluding a CTA with TenneT is not possible for solar farms, since solar farms are not able to connect directly to the offshore grid. See also 8.2.5 below.

8.2.2 Cable pooling

In this scenario, the only shared cable(s) necessary are the export cable(s) from the TenneT offshore substation to the onshore substation. A cable pooling agreement needs to be concluded between wind farm and solar farm, as described in paragraph 4.2.

Cable crossings may not be avoidable in this scenario, depending on the original lay-out of the wind farm. However, cable proximity agreements between the wind farm, solar farm, and TenneT will likely be necessary since they will all have cables tying into the same offshore substation.

8.2.3 Cable crossing and proximity

Cable crossings should be avoidable in this scenario, given that the wind, solar, and offshore substation are being developed in a coordinated manner. However, cable proximity agreements between the wind farm, solar farm, and TenneT will likely be necessary since they will all have cables tying into the same offshore substation.

8.2.4 Turbine maintenance

No amendment necessary.

8.2.5 Regulatory implications

The first regulatory issue pertains to the lack of access for solar farms to the offshore grid, as explained in Chapter 5 above. This means that a standalone scenario is currently not feasible, since a CTA between the solar farm and TenneT is required, which TenneT cannot establish with the solar farm.

In this scenario, a new offshore solar farm will be integrated with an existing offshore wind farm. The solar project will have its own cable route between the PV-installation and the TenneT substation to deliver the produced electricity. The wind component will require a permit based on the Offshore Wind Energy Act, while the solar component will require a Water permit for shared use based on the Dutch Water Act. It is worth noting that under current Dutch legislation, the standalone scenario is not an option for connecting a solar farm to the offshore grid.

8.3 Scenario 3 Review (semi-standalone - greenfield)

Scenario 3 contemplates a semi-standalone design on a greenfield site. In other words, the solar and wind farms will each have independent owners, on a site with no previous development, and the solar farm will tie into the offshore wind farm strings. The connection to the TenneT offshore substation will come from the array strings that contain both wind turbines and solar panels.

The wind farm owner will need to conclude a REA and CTA with TenneT. Assuming the cable pooling exception in the Electricity Act has been amended to include offshore situations as described in Section 4.4, an exemption as network operator is not required.

8.3.1 TenneT CTAs

The wind farm owner will need to conclude a REA and CTA with TenneT.

8.3.2 Cable pooling

In this scenario, both the wind farm array cables and the export cable(s) from the TenneT offshore substation to the onshore substation will be shared. A cable pooling agreement needs to be concluded between wind farm and solar farm, as described in paragraph 4.2. Furthermore, a sharing agreement is necessary (which can be arranged by including paragraphs on sharing in the CPO) between wind and solar farm owner to regulate capacity sharing of the array cables, covering the following topics:

- Maximum capacity of array cable (guaranteed and excess)
- Minimum and maximum capacity allocated to each owner (if any)
- Priorities of usage and curtailment (by TenneT, by PPA offtakers), including detailed procedure.

8.3.3 Cable crossing and proximity

Cable crossings should be avoidable in this scenario, given that the wind, solar, and offshore substation are being developed in a coordinated manner. However, cable proximity agreements between the wind farm and solar farm will likely be necessary since they will both have cables tied into the same WTG.

8.3.4 Turbine maintenance

The design of wind- and solar farms should be optimized to avoid impact on access to the WTG, and no specific arrangements need to be included in the WTG service and maintenance contract. The additional solar farm equipment could be serviced by the WTG service provider (in which case the WTG service contract need to include this scope) or could be serviced by a third party (in which case access to the WTG should be arranged for in both service contracts).

8.3.5 Regulatory implications

In this scenario, the solar project and the wind project will share the cable between the wind farm and the TenneT substation to deliver produced electricity to the grid from the start. As the shared cable-infrastructure will also serve energy production by means of wind, the cable route between the wind farm and the TenneT substation and between the PV-installation and the TenneT substation, can both be included in the plot decision procedure and permitting procedure pursuant from the Offshore Wind Energy Act.

The wind component will require a permit as per the Offshore Wind Energy Act, while the solar component will require a Water permit for shared use based on the Dutch Water Act. The water permit application does not involve a tender procedure. However, in this case, the solar farm will be included in the tender for the offshore wind farm. Therefore, we anticipate that the winner of the integrated tender for the offshore wind farm, including the offshore solar component, will be the sole entity to whom a water permit for the construction of the offshore solar farm will be granted.

As solar farms cannot connect directly to the offshore grid, it is not feasible for them to conclude a CTA with TenneT, even in an integrated scenario. In a greenfield situation, the wind farm will be responsible for concluding a CTA with TenneT, and the solar farm will depend on the provisions agreed upon in this CTA. Of course, the wind and solar farms can make their own arrangements between themselves.

8.4 Scenario 4 Review (semi-standalone - brownfield)

Scenario 4 contemplates a semi-standalone design on a brownfield site. In other words, a solar farm will be constructed on a site that already has an offshore wind farm, by a different owner than the offshore wind farm, and it will connect to the offshore wind array strings.

8.4.1 TenneT CTAs

The wind farm owner will have a CTA with TenneT. The solar farm will plug into the wind farm and supply its energy to the wind farm, instead of supplying directly to the grid. This means that the wind farm's CTA will need to be amended.

8.4.2 Cable pooling

In this scenario, both the wind farm array cables and the export cable(s) from the TenneT offshore substation to the onshore substation will be shared. A cable pooling agreement needs to be concluded between wind farm and solar farm, as described in paragraph 4.2. Furthermore, a sharing agreement is necessary between wind and solar farm owners.

8.4.3 Cable crossing and proximity

Cable crossings should be avoidable in this scenario, depending on the original layout of the wind farm. However, cable proximity agreements between the wind farm and solar farm will likely be necessary since they will all have cables tied into the same WTG.

8.4.4 Turbine maintenance

It may not be possible to design the solar farm such that there is no impact on access to the WTG, so an amendment of the WTG service contract may be necessary. The additional solar farm equipment could be serviced by the WTG service provider (in which case the WTG service contract need to include this scope) or could be serviced by a third party (in which case access to the WTG should be arranged for in both service contracts), as detailed in paragraph 4.4.

8.4.5 Regulatory implications

In this scenario, the wind project will no longer have sole use of its cable infrastructure to the TenneT substation, because the addition of the PV-installation to the offshore project will lead to the situation that the solar project also uses the cable between the wind farm and the TenneT substation to deliver produced electricity to the grid. However, as the shared cable-infrastructure keeps serving the energy production by means of wind, the cable route between the wind farm and the TenneT substation remains within the scope of the plot decision procedure and permitting procedure pursuant from the Offshore Wind Energy Act.

The construction and operation of the PV-installation in the water body, along with the cable infrastructure between the solar farm and the wind farm, will also require a Water permit for shared use. However, the absence of instruments like the plot decision and the tender procedure (as found in the Offshore Wind Energy Act) in the Water permit process remains an issue.

Similarly to the semi-standalone greenfield scenario, in this brownfield scenario, the solar farm will connect to the offshore wind farm's array strings. In this case, the solar farm will not establish an individual or separate CTA with TenneT. Instead, the solar farm will rely on the provisions outlined in the CTA between TenneT and the wind farm it connects to.

Finally, the solar farm will require a water permit. In this case, the absence of a tender procedure for the issuance of this water permit does present an issue. The lack of a tender procedure means that it is not clear to which party the water permit will be granted when multiple parties apply. We anticipate that the government may organize a tender procedure. However, this raises the question of whether the brownfield offshore wind farm can be compelled to allow an offshore solar farm to connect to its grid. Forcing such admission does not appear to be justifiable in light of the offshore wind farm's right to undisturbed enjoyment of property. Allowing an offshore solar farm would necessitate adjustments to the (business) structure of the wind farm. Furthermore, the guarantees of the wind farm will be at risk due to the addition of the offshore solar farm. In our view, it is not possible under current laws and regulations to compel an offshore wind farm to admit an offshore solar farm.

8.5 Scenario 5 Review (turbine integrated - greenfield)

Scenario 5 contemplates a turbine integrated design on a greenfield site. In other words, the solar and wind farms will each have independent owners, on a site with no previous development, and the solar farm will tie in with the offshore wind turbine transformers. The connection to the TenneT offshore substation will come from the array strings that contain both wind turbines and solar panels.

8.5.1 TenneT CTAs

The wind farm owner will need to conclude a REA and CTA with TenneT.

8.5.2 Cable pooling

In this scenario, both the wind farm array cables and the export cable(s) from the TenneT offshore substation to the onshore substation will be shared. A three-party agreement is necessary between TenneT, the owner of the wind farm, and the owner of the solar farm for the sharing of the export cable and the grid connection. Furthermore, a sharing agreement is necessary between wind and solar farm owners.

8.5.3 Cable crossing and proximity

Cable crossings should be avoidable in this scenario, given that the wind, solar, and offshore substation are being developed in a coordinated manner. However, cable proximity agreements between the wind farm and solar farm will likely be necessary since they will both have cables tying into the same WTG.

8.5.4 Turbine maintenance

The design of wind- and solar farms should be optimized to avoid impact on access to the WTG, and no specific arrangements need to be included in the WTG service and maintenance contract. The additional solar farm equipment could be serviced by the WTG service provider (in which case the WTG service contract need to include this scope), or could be serviced by a third party (in which case access to the WTG should be arranged for in both service contracts)

8.5.5 Regulatory implications

In this scenario, PV-installations will be integrated with separate wind turbines. As a result, the solar and wind projects will share cables between the wind turbines and the cable between the wind farm and the TenneT substation. However, the wind component will require a permit based on the Offshore Wind Energy Act, while the solar component will require a permit based on the Dutch Water Act.

As solar farms cannot connect directly to the offshore grid, it is not possible for them to establish a CTA with TenneT, even in an integrated scenario. In a greenfield situation, the wind farm will be responsible for concluding a CTA with TenneT, and the solar farm will depend on the provisions agreed upon in this CTA. Of course, the wind and solar farms can make their own arrangements between themselves.

Finally, the solar farm will need a water permit. The application for and granting of the water permit do not involve a tender procedure. However, in this case, the solar farm will be included in the tender for the offshore wind farm. Therefore, we expect that the winner of the integrated tender for the offshore solar component within the wind farm tender will be the sole entity to whom a water permit for the construction of the offshore solar farm will be granted. Please be referred to Chapter 6 for more detailed information on this matter.

8.6 Scenario 6 Review (turbine integrated - brownfield)

Scenario 6 contemplates a turbine integrated design on a brownfield site. In other words, a solar farm will be constructed on a site that already has an offshore wind farm, by a different owner than the offshore wind farm, and it will connect to the offshore wind turbine transformers.

8.6.1 TenneT CTAs

The wind farm owner will have a CTA with TenneT. The solar farm will plug into the wind farm and export energy via the wind farm, instead of supplying directly to the grid. This means that the wind farm's CTA will need to be amended.

8.6.2 Cable pooling

In this scenario, both the wind farm array cables and the export cable(s) from the TenneT offshore substation to the onshore substation will be shared. A cable pooling agreement needs to be concluded between wind farm and solar farm, as described in paragraph 4.2. Furthermore, a sharing agreement is necessary between wind and solar farm owner.

8.6.3 Cable crossing and proximity

Cable crossings should be avoidable in this scenario, depending on the original lay-out of the wind farm. However, cable proximity agreements between the wind farm and solar farm will likely be necessary since they will all have cables tying into the same WTG.

8.6.4 Turbine maintenance

It may not be possible to design the solar farm such that there is no impact on the access to the WTG, so an amendment of the WTG service contract may be necessary. The additional solar farm equipment could be serviced by the WTG service provider (in which case the WTG service contract need to include this scope), or could be serviced by a third party (in which case access to the WTG should be arranged for in both service contracts), as detailed in paragraph 4.4.

8.6.5 Regulatory implications

In this scenario, new PV-installations will tie into existing separate wind turbines. This will lead to a situation in which the solar and wind project will from that moment on share the cables between the wind turbines and the cable between the wind farm and the TenneT substation.

However, the wind energy component will be subject to regulation through a permit based on the Offshore Wind Energy Act, while the solar component will be regulated by a Water permit for shared use. As mentioned earlier, the latter may result in some issues with plot designation and selecting among multiple solar farm operators who apply for a Water permit to operate at the same location.

As solar farms cannot connect directly to the offshore grid, it is not feasible for them to establish a CTA with TenneT, even in an integrated scenario. In the brownfield scenario, the wind farm will already have a CTA with TenneT. Since the solar farm cannot establish a CTA with TenneT, it will have to rely on the provisions outlined in the existing CTA that have already been agreed upon.

Finally, the solar farm will need a water permit. In this case as well, the absence of a tender procedure for the granting of this water permit raises concerns. The lack of a tender procedure means that it is not clear to which party the water permit will be granted when multiple parties apply. We anticipate that the government may organize a tender procedure. However, this raises the question of whether the brownfield offshore wind farm can be compelled to allow an offshore solar farm to connect to its grid. Forcing such admission does not appear to be justifiable in light of the offshore wind farm's right to undisturbed enjoyment of property. Allowing an offshore solar farm would necessitate adjustments to the (business) structure of the wind farm. Furthermore, the guarantees of the wind farm will be at risk due to the addition of the offshore solar farm. In our view, it is not possible under current laws and regulations to compel an offshore wind farm to admit an offshore solar farm.

9 Table and key findings

	TenneT agreements	Cable Pooling	Cable crossing agreements	Proximity agreements	Turbine maintenance	Environmental/spatial planning	Electricity Regulation
1. stand alone green	Requires separate CTA's for wind and solar. Problematic: no CTA possible between solar farm and TenneT.	Three party agreement / legal framework	TenneT & wind Farm: Avoidable, but may be required	TenneT & wind farm: likely	Turbine access coordinated between wind and solar MSAs	Permit based on the Offshore Wind Energy Act will be required for wind energy component; Water permit will be required for floating solar PV.	Amendment required to allow solar farms access to national offshore grid.
2. stand alone brown	Requires separate CTA's for wind and solar. Problematic: no CTA possible between solar farm and TenneT.	Three party agreement / legal framework	TenneT & wind farm: Likely	TenneT & wind farm: likely	Modify wind MSA based on accessibility impact from solar panels	Permit based on the Offshore Wind Energy Act will be required for wind energy component; Water permit will be required for floating solar PV.	Amendment required to allow solar farms access to national offshore grid.
3. semi green	Wind farm concludes CTA, solar farm will depend on provisions CTA between wind farm and TenneT; Shared REA	Two party agreement. Extra provisions needed to cover for access to the national grid for solar farm.	TenneT & wind farm: Avoidable/ minimized	TenneT: Avoidable/ minimized; Wind farm: Likely	Coordinated access and shared equipment in wind and solar MSAs	Permit based on the Offshore Wind Energy Act will be required for wind energy component; Water permit will be required for floating solar PV.	Possible to share connection with Windfarm. Amendment required for solar farm to be a party to a CTA with TenneT.
4. semi brown	Wind farm's CTA must be amended, No new REA	Two party agreement. Extra provisions needed to cover for access to the national grid for solar farm in case only wind farm has CTA with TenneT	TenneT: Avoidable/ minimized; Wind farm: likely	TenneT: Avoidable/ minimized; Wind farm: Likely	Modify wind MSA based on accessibility and shared equipment	Permit based on the Offshore Wind Energy Act will be required for wind energy component; Water permit will be required for floating solar PV.	Possible to share connection with Windfarm. Amendment required for solar farm to be a party to a CTA with TenneT.

5. **WTG** **green**	Wind farm concludes CTA, solar farm will depend on provisions CTA between wind farm and TenneT; Shared REA	Two party agreement. Extra provisions needed to cover for access to the national grid for solar farm.	TenneT & Wind farm: Avoidable/ minimized	TenneT: Avoidable/ minimized Wind farm: Likely	Coordinated access and shared equipment in wind and solar MSAs	Permit based on the Offshore Wind Energy Act will be required for wind energy component; Water permit will be required for floating solar PV.	Possible to share connection with Windfarm. Amendment required for solar farm to be a party to a CTA with TenneT.
6. **WTG** **brown**	Wind farm's CTA must be amended, No new REA	Two party agreement. Extra provisions needed to cover for access to the national grid for solar farm in case only wind farm has CTA with TenneT	TenneT: Avoidable/ minimized Wind farm: Likely	TenneT: Avoidable/ minimized Wind farm: Likely	Modify wind MSA based on accessibility and shared equipment	Permit based on the Offshore Wind Energy Act will be required for wind energy component; Water permit will be required for floating solar PV.	Possible to share connection with Windfarm. Amendment required for solar farm to be a party to a CTA with TenneT.

Table 2 - Key findings for each scenario

1. The standalone design concept (Scenarios 1 and 2), in which the wind farm and solar farm directly connect their own cables to the TenneT offshore substation is not possible under the current electricity regulation in case of solar farms on the North Sea, safe for small-scale experiments. Connecting to the offshore grid is only possible for wind farms – and for now it is foreseen that this will stay this way also after entry into force of the new Energy Act. The foregoing does however not exclude the option for solar farms to connect to the wind farm and supply energy via the wind farm, instead of supplying directly to the grid. This would mean that the wind farm concludes a CTA with TenneT. This means the solar farm will depend on the wind farm for its grid connection, which (if the solar farm is to be financed separately) may cause bankability issues (see next Chapter), especially when it concerns large scale solar farms.

2. The regulatory hurdle explained in the previous point (only wind farms have access to the offshore grid) prohibits solar farms from having their own CTAs with TenneT. Instead, the wind farm will have or enter into a (revised) CTA with TenneT and the solar farm will enter into a cable pooling agreement with the wind farm (see the next point).

3. For offshore wind farms, the Offshore Wind Energy Act provides an extensive regulatory framework. Interested parties can obtain a permit for construction and operation of a wind farm by winning a tender for a specific location designated as suitable for wind energy by the Minister of Economic Affairs. Such a permit covers all the environmental and spatial planning aspects. By contrast, such a framework is lacking for offshore solar farms. Solar farms will have to apply for a permit for the construction and operation of the solar farm on the basis of the Water Act. This permit covers the presence and operations of the floating installation on the North Sea. Such a permit will be awarded if it can be shown that the solar PV system or cable network will not interfere with maintaining or achieving a "good condition" of the water body (water quality). Additionally, project initiators have to check how the actual and new project plans relate to the project as it was envisioned in the preparatory stages of the (Offshore Wind Energy Act) plot decision and, specifically, whether all aspects of the project were considered in the different studies that were performed, or whether conducted reports must be renewed or amended. Tailored regulations for the integration of offshore wind and solar have not yet been created. Currently, neither the Offshore Wind Energy Act, nor the Water Act explicitly facilitate expansion of wind-operations in the sense that new activities that are complementary to existing operations can be assessed and permitted based on a set framework. For clarification purposes, we propose to expand the scope of the Offshore Wind Energy Act to include other renewable energy projects.

4. All scenarios will require some form of cable pooling due to the fact that electrical equipment will be shared between the wind and solar farms. The model onshore cable pooling agreement as developed by Ventolines (current version: April 2022) can form the basis for such an agreement. However, if it is assumed, based on the previous parts of this study, that under prevailing legislation the CTA cannot not be shared but only entered into by just the wind farm, certain amendments of the model cable pooling agreement will be

necessary with a view to mitigating the risks for the solar farm that result from its dependency on the wind farm for its connection.

5. There is a notable difference in potential cable crossing and proximity between greenfield and brownfield scenarios. Given that brownfield developments already have an existing wind farm where a solar farm will be co-located, there are existing subsea wind cables that cannot be moved or optimized with the new solar farm cables. Therefore, there is a significantly higher chance of cable crossings and cables in close proximity to each other. In a brownfield standalone design (Scenario 2), these additional crossings may occur with TenneT cables because the new solar farm cable(s) will extend directly to the TenneT substation. All brownfield design concepts (Scenarios 2, 4, and 6) will have an increased chance of cable crossings within the wind farm array cables.

6. Based on the above concepts, it can be concluded that current legislation provides better opportunities for the integration of greenfield offshore wind farms and offshore solar farms than for brownfield offshore wind farms and offshore solar farms. In this Chapter, we have described using various concepts that, based on current laws and regulations, it is not possible to compel wind farms to admit offshore solar farms to their grid connections. We recommend amending the Offshore Wind Energy Act to enable this possibility. In this context, consideration should also be given to provisions for compensating the damage that the wind farm incurs due to the addition of the offshore solar farm (such as capacity loss, etc.). Refer to sections 6-7 for a more detailed description of the above.

7. The permit for the wind farm will be granted in accordance with the Offshore Wind Energy Act, but the offshore solar component is not covered by this legislation. Instead, the (integrated) offshore solar farm will be regulated through a Water permit for shared use. Please be referred to Chapter 6 for a more detailed explanation regarding the water permit.

8. Zooming in on the shared equipment and cables after system integration, we see no relevant difference between the greenfield and brownfield situation (other than that the scope of the permits may vary, but the relevant regulation does not change). Other than the frameworks in the Offshore Energy Act and the Water act, the cables of offshore wind farms and of offshore integrated projects are not subject to specific environmental and zoning regulations. The cables and shared equipment are considered in the applicable legal procedure that facilitates the new development (the plot decision, the permit based on the Offshore Wind Energy Act, or the permit based on the Water Act).

10 Case study

This Chapter will apply the findings from the previous Chapters to three distinct scenarios concerning the connection of a 50 MW solar farm to an offshore wind farm.

10.1 Scenario 1 (wind farm under construction, solar farm included in Area Passport)

In this case, we consider a park under construction, where a 50 MW solar farm is being connected to an offshore wind farm. In this scenario, it is assumed that the solar farm is included in the Area Passport for Shared Use (as explained in Chapter 6 above). Since the wind farm is already under construction, cooperation from the wind farm is expected to be necessary to enable the connection of the solar farm. Based on the current law, there appear to be no possibilities to compel the wind farm to connect to the solar farm.

The Area Passport for Shared Use is a document in which the government indicates, based on area-specific characteristics, the most favorable prospects and best ways to integrate various forms of shared use within each wind area. Consequently, these forms of shared use are given preference. The "Guidelines for Area Passports for Shared use in Wind Energy Areas in the North Sea" enable differentiation between permit applications from different potential shared users using the Framework for Shared Use of Offshore Wind Farms.

Since it is not possible on the basis of current legislation to connect to TenneT's offshore substation, the solar farm will need to connect directly to the wind farm (see semi-standalone and turbine integrated concepts paragraphs 3.1.2 and 3.1.3). In this case, the wind farm will enter into the Connection and Transmission Agreement with TenneT, and the solar farm will depend on the agreement between the wind farm and TenneT. Private agreements can also be made between the wind and solar farms, but it remains problematic if the wind farm were to disappear (e.g., when it goes bankrupt). This is because the solar farm cannot enter into an agreement with TenneT independently.

We assume that a water permit can be obtained in any case. The public uniform preparation procedure under the General Administrative Law Act (*Algemene wet bestuursrecht*) will apply to this water permit. The Minister of Infrastructure and Water Management is expected to be the competent authority for granting a water permit for an offshore solar farm.

However, it is not entirely clear how this legal system will function in practice, and there are still some questions in this area (see section 6). The lack of precedents makes it unclear whether water permits will be granted and under what conditions. Nevertheless, we anticipate that, when it is indicated that shared use is possible, there will have been an assessment of whether shared use is indeed feasible at the relevant location. In addition to the foregoing, we recommend operators of offshore solar farms to consider the integrated offshore solar farm when designing and positioning the wind turbines for the wind farm. This provides clarity about the position of the solar farm within the wind farm zone and the cable locations. As a result, the location(s) included in the area passport for the solar farm will most likely align with the preferred location for the operator of the offshore solar farm. If the location that is designated for solar in the permit application, corresponds with the solar area in the Area Passport, this will reinforce the water permit application.

Moreover, it is unclear how the application for the water permit compares to other applications by solar farms seeking to operate in the same location. This is because the water permit does not involve a site decision procedure or a tender procedure. It is essential for the government to provide clarity on these matters. However, as mentioned in 6.4 above, we do not expect operators of offshore solar farms to seek for a water permit when the wind farm does not want to cooperate with them, since in that case the project will not be feasible.

In this situation we expect that a brownfield wind farm could in principle not be compelled to cooperate with the offshore solar farm that desires to connect. This would change when the government organizes a tender procedure for the application of a water permit for offshore solar. In that case, the question arises whether a brownfield wind farm can be forced to cooperate with the winner of that tender for the water permit for offshore solar. In our opinion, this possibility would require an amendment of the Offshore Wind Energy Act. Additionally, a compensation arrangement shall be required to address any damages incurred by the wind farm due to the inclusion of the offshore solar farm in its connection.

Finally, based on the current legislation (and the future framework of the Environment and Planning Act) an EIA will not be required for the water permit of the offshore solar farm. In case the project has potential negative effects on Natura2000 protected areas, the Area Passport may have to be submitted to an EIA.

10.2 Scenario 2 (wind farm under construction, solar farm included in Area Passport)

The second scenario involves a 50 MW solar farm that connects to a brownfield offshore wind farm, assuming that the solar farm is not included in the Area Passport for shared use. In this scenario, a brownfield situation is assumed, meaning that the wind farm is already fully constructed and operational. The solar farm in this situation appears to always require cooperation from the wind farm to connect.

In the brownfield scenario, unlike the greenfield situation (see scenario 3), the solar farm has not been included in the tender for the offshore wind farm. Consequently, we anticipate that the government will initiate a tender procedure for the issuance of a water permit for an offshore solar farm seeking to connect to a brownfield offshore wind farm.

Under the current legislation, however, it is not possible to compel the wind farm operator to permit the connection of the offshore solar farm to the grid. Enabling the enforcement of such a connection for an offshore solar farm that successfully wins the tender for the water permit would necessitate an amendment to the Offshore Wind Energy Act. This would also involve considering potential compensation for any harm incurred by the offshore wind farm due to the addition of the offshore solar farm.

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Furthermore, when connecting an offshore solar farm to an offshore wind farm in a brownfield situation, consideration must also be given to the fact that adding a solar farm to the wind farm will require adjustments to the infrastructure. This will probably affect the warranties of the offshore wind farm, and thus result in issues with regard to bankability. Based on the foregoing, we expect that the current legal framework does not constitute a possibility to compel existing offshore wind farms to integrate an offshore solar farm.

The fact that the solar farm is in this case not included in the Area Passport for shared use means that no specific area has been designated for the generation of sustainable energy through solar power. This means that the water permit cannot be assessed on the basis of the Area Passport and will thus solely be assessed on the criteria which are given in the Water Act.[16]

Granting a water permit for an integrated offshore solar farm is a new topic and there are no precedents. This, combined with the absence of an Area Passport for Shared Use in this scenario, makes it less clear whether a water permit will be issued and under what conditions. However it is clear that the chemical and ecological water quality and fulfilling societal functions through water systems will form the assessment criteria for the water permit.

Water permit requirements are expected to be more stringent than in the situation where the solar farm is included in an Area Passport for Shared Use, as the latter case already undergoes an assessment of the "suitability" of the designated location for the solar farm as per the Area Passport.

Finally, based on the current legislation (and the future framework of the Environment and Planning Act) an EIA will not be required for the water permit of the offshore solar farm.

10.3 Scenario 3 (greenfield, integrated tender)

The third scenario entails a situation in which a 50 MW solar farm is connected to a wind farm where the tender for the wind farm incorporates criteria that enable (or even require) the establishment of a solar farm. It is assumed that in the tender documentation, points are allocated for various capacities of proposed investments in integrated offshore solar farms (ranging from 0-20 MWp to equal to or greater than 50 MWp). In this case as well, the solar farm cannot directly connect to the offshore electricity grid. The solar farm must connect to the wind farm and thus relies on the agreements made in the Connection and Transportation Agreement between the wind farm and TenneT.

Furthermore, a water permit must also be obtained for the solar farm. The application procedure of a water permit does not entail a tender procedure. However, we expect that the winner of the integrated tender for offshore wind and solar will always be the party to which a water permit will be granted. This does, in our view, not seem to be in conflict with the relevant European and national legislation with regard to scarce permits, which we discussed in more detail in Chapter 6.

We recommend operators of offshore wind farms to consider the integrated offshore solar farm when designing and positioning the wind turbines for the wind farm. This provides clarity about the position of the solar farm within the wind farm zone and the cable locations. As a result, the

[16] Or in the Environment and Planning Act, as from 2024 onward this Act will replace the Water Act

location(s) included in the area passport for the solar farm will most likely align with the preferred location for the operator of the offshore solar farm. If the location that is designated for solar in the permit application, corresponds with the solar area in the Area Passport, this will reinforce the water permit application.

Finally, based on the current legislation (and the future framework of the Environment and Planning Act) an EIA will not be required for the water permit of the offshore solar farm.

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