

Deliverable Report

D3.2 Grid-connection architecture



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List of abbreviations

- SEC Sustainable Energy Catapult
- FWT Floating Wind Turbine
- IA Inter Array (cable)

1. Executive Summary

The objective of task 3.1 (which is connected to deliverable 3.2) is to define the architecture needed for safe and cost-efficient grid connection for FLAGSHIP at the Metcenter / Sustainable Energy Catapult Test site.

The preferred option is to connect to the 66 kV onshore grid and by using UNITECH Zefyros (former Hywind Demo) as a hub. Zefyros is located 10 km from shore and 3 km from the FLAGSHIP location.

Utilizing ZEFYROS as a hub for FLAGSHIP will also give increased export capacity for the Test site.

While the HUB solution is preferred, 2 alternatives with and without the offshore HUB is being reviewed until end of January 2021.

2. Introduction

2.1 Purpose

In general, the FWT can be fitted for any grid connection or be part of a larger string of turbines into a hub or export point. The turbine will be equipped with the equipment needed to transform the local power production to the same standard of the array cable or the grid. In the Design Basis for the power export, investigation of alternative end users for the power production and their requirements will be done to ensure flexibility in the “after test” life. For the test period, the FWT will be located in the MET test site outside Karmøy and grid connection will be to the central 66 kV grid. Modifications have to be done to the local grid to be able to connect to the 66 kV, however this is the preferred voltage for wind farms and therefore preferred in this project to demonstrate cable and turbine. IBR, MET and UNITECH will develop a plan for the grid connection architecture. This task aims to deliver the plan including a system overview (SO) item list and design basis for all the elements included in the overall grid connection architecture.

2.2 Laws and regulations

The laws and regulation concerning grid connection is handled by Task 7.6 and given in Deliverable 7.6 by MetCentre.

3. Grid connection location

3.1 Offshore location

The location of FLAGSHIP installation is in Metcentre outside Karmøy, Norway.

Today there is one FWT installed; UNITECH Zefyros installed approx. 10 km (5,4 nm) outside the coast of Karmøy illustrated in figure 3.1

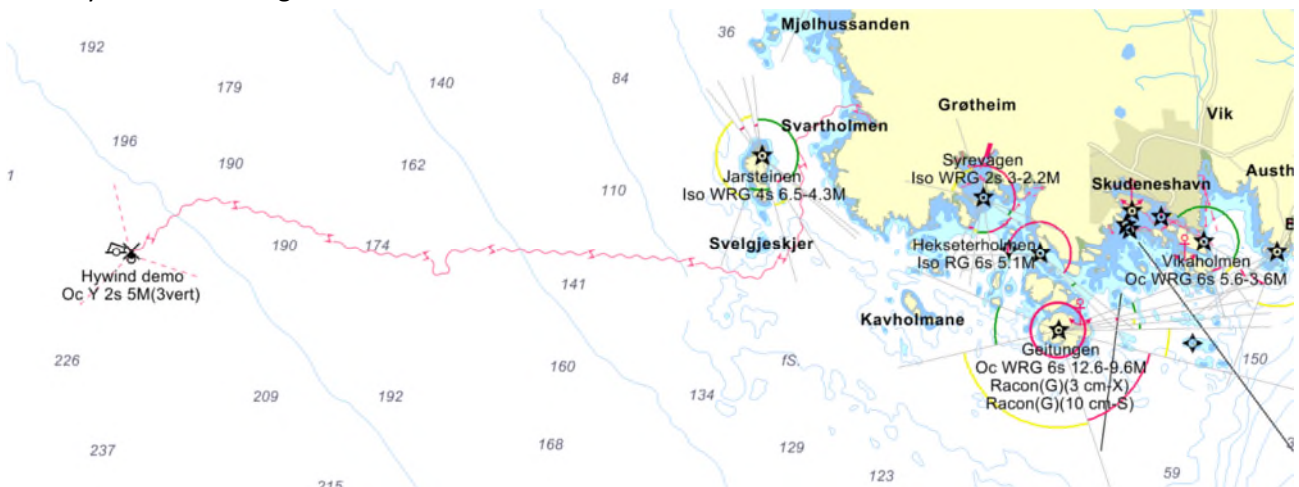


Figure 3.1 Map of Zefyros and 22 kV cable route

The world’s first floating wind turbine “Hywind Demo” was installed by Equinor in 2009. The turbine is now renamed UNITECH Zefyros and is owned and operated by UNITECH Offshore. Zefyros is today part of a National Test Center “Sustainable Energy Catapult” and serves as a hub for future FWT pilots to the Metcentre and as a test infrastructure for new technology. Zefyros as a hub is reducing the footprint on the environment by more pilots using same export cables to land and contributes to overall cost reduction for new turbines to be connected to the onshore grid.

3.2 Onshore grid connection and capacity

The onshore grid connection is located at Rørvika close to Skudeneshavn city on the south-west side of Karmøy island. Rørvika keeps today a kiosk for the 22 kV grid connection of the existing export cable at Metcentre.

There is a 66 kV connection point to the grid a short distance from Rørvika kiosk planned to be extended to the Rørvika connection point. The design of the onshore grid extension of the 66 kV line is ongoing and to be concluded by end of January 2021.

The 22 kV grid at Zefyros has a 12 MW export cable. Present reserved capacity is 2,3 MW for Zefyros and 3,6 MW for Tetraspar, leaving a rest capacity of approx. 6 MW.

FLAGSHIP is planned connected to the 66 kV grid via Zefyros as a HUB or by a separate export cable from FLAGSHIP to the onshore connection point. The preferred option is via Zefyros as it provides cost reduction, less overall footprint and opens for more FWT piloting at Metcentre and hence potential further cost savings for the FWT industry.

There is an ongoing process of establishing a joint project for a new export cable to Zefyros for the 66 kV grid between Metcentre, Sustainable Energy Catapult, UNITECH and FLAGSHIP. This project will conclude by end of December 2020 and the 2 alternative cable routes will be kept open; however, priority is on the Zefyros connection point.

Final decision on the cable routing will be end of January 2021.

4. Grid connection architecture alternatives

There are 2 alternative main architectures for grid connection. Via Zefyros as a hub or directly to the onshore grid connection point.

4.1 Grid connection by Zefyros

The preferred architecture is via Zefyros as indicated in figure 4.1 and described in 3.2

The new approx. 13 km export cable to Zefyros will be shared by multiple FWT pilots. The IA cable between Zefyros and FLAGSHIP will be of approx. 3 km long (pending survey and detailed engineering).

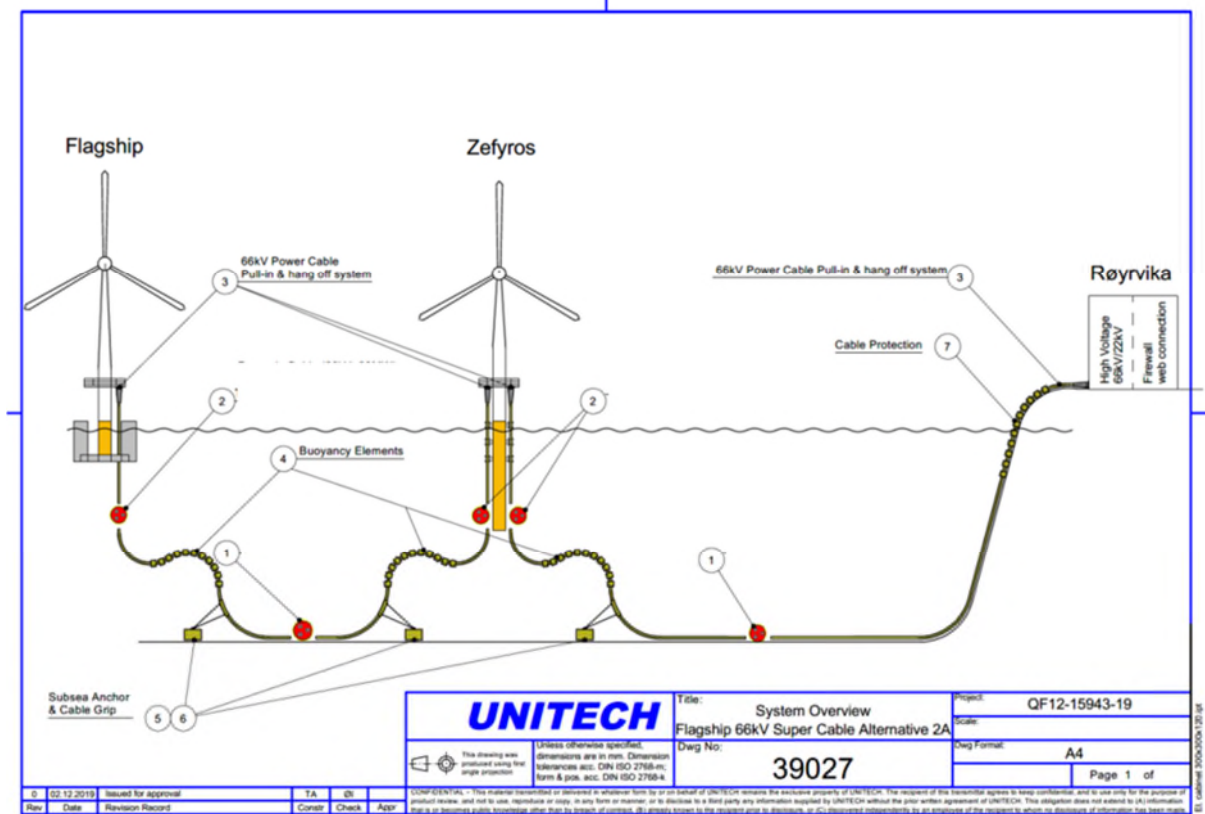


Figure 4.1 Zefyros HUB solution

4.2 Grid connection by separate export cable for FLAGSHIP

Alternative grid connection is with separate export cable for FLAGSHIP only as indicated in figure 4.2.

The export cable will be approx. 15 km long (pending survey and detailed engineering).

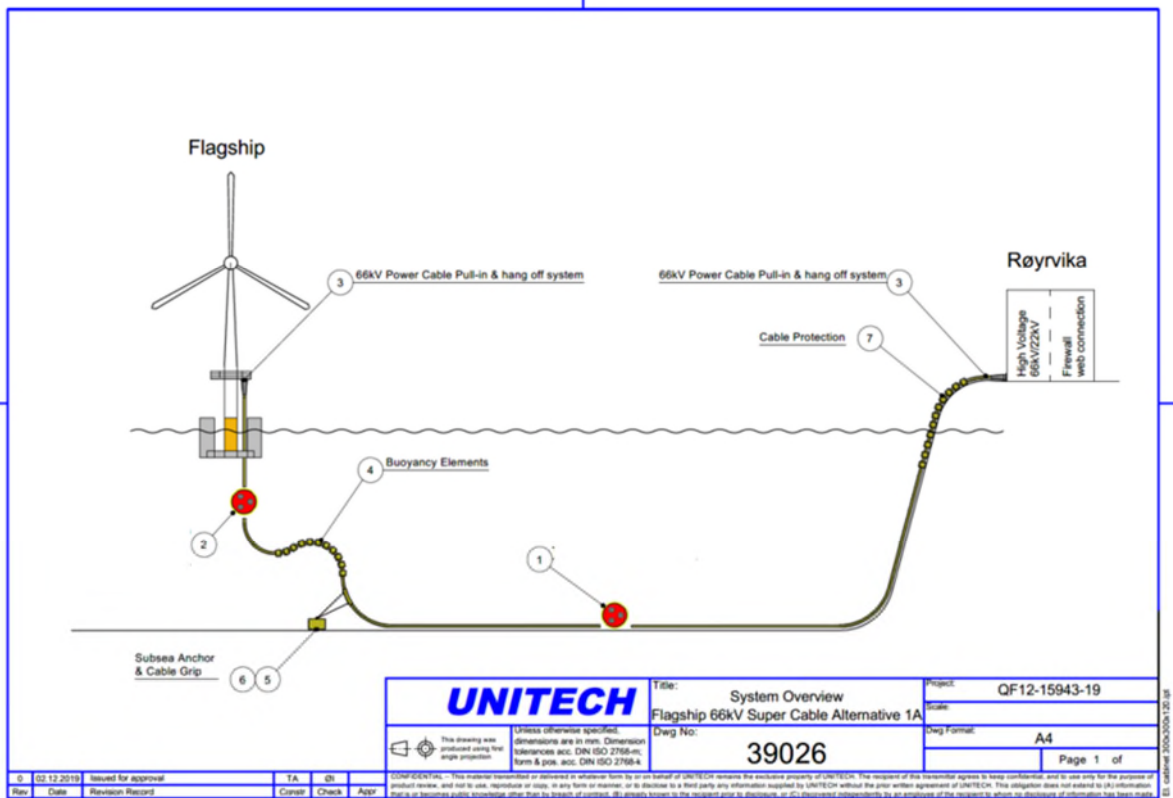


Figure 4.2 Grid connection by new export cable

4.3 Cable pull-in side FLAGSHIP

In a workshop Oct 22nd and Nov 5th between UNITECH, Kværner, Olav Olsen and Iberdrola orientation of the floater was defined based on the given Metocean Design Basis of the area. The entry point for the cable at FLAGSHIP was decided to be on the East side of the turbine as shown in the Figure 4.3

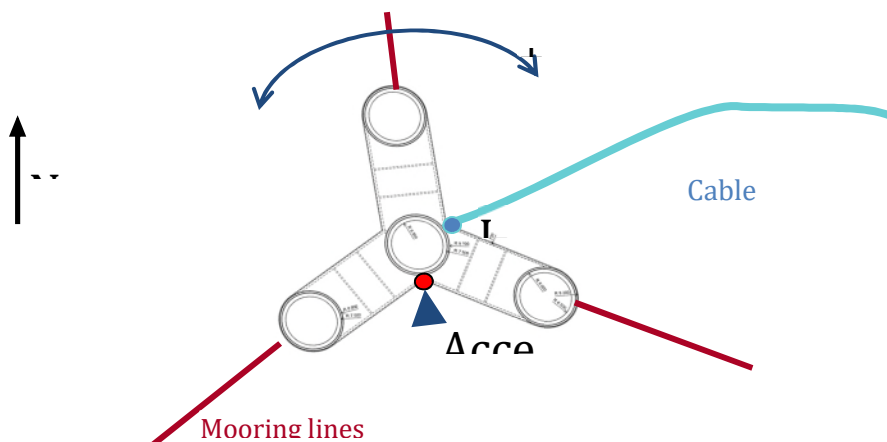


Figure 4.3 entry point for cable at floater (by Kværner).

In 2021 Tetraspar Demonstrator (3,6 MW) FWT Pilot will be installed on the north side of Zefyros and connected to Zefyros 22 kV grid.

The cable route from FLAGSHIP must go on the east side of the turbines due to restrictions on the west side. Because of this there is an ongoing clarification of the cable route between the Tetraspar and Zefyros to reduce the load on the East side entry point of Zefyros.

The Tetraspar and FLAGSHIP entry points to the hub will be defined in December 2020.

4.4 Cable pull-in side ONSHORE

Onshore location for the grid connection for both a direct cable and a new export cable to Zefyros is at Rørvika ref. figure 4.4

The engineering of the grid connection between Rørvika entry point and the 66 kV line is in progress and will be concluded by mid-January 2021.

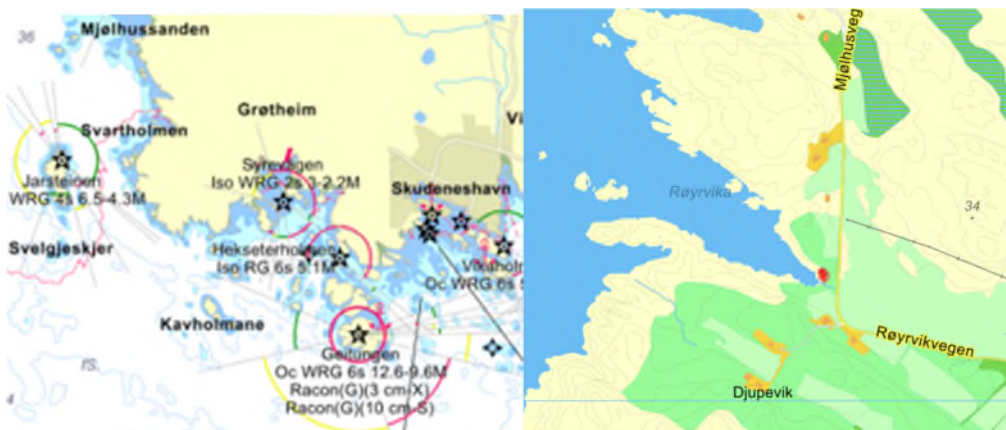


Figure 4.4 Rørvika grid connection point. Red dot indicates the existing kiosk for 22 kV export cable termination.

5. Grid connection by Zefyros

The hub solution requires a new export cable for Sustainable Energy Catapult. The new export cable will hold a capacity of 50-60 MW where 60 MW is likely to be the max capacity the 66 kV grid connection can take. The IA cable between the 2 floaters will be of 12 MW capacity. This is a cable that both meets the requirement of FLAGSHIP and is a dimension expected to be asked for in the coming marked of FWTs.

The alternative solution with separate export cable for FLAGSHIP only is investigated in parallel as contingency, and for cost and risk comparison.

5.1 System Overview Zefyros HUB solution

The figure 5.1 is illustrating the system overview of the grid connection utilizing Zefyros as a HUB for FLAGSHIP and future FWT pilots.

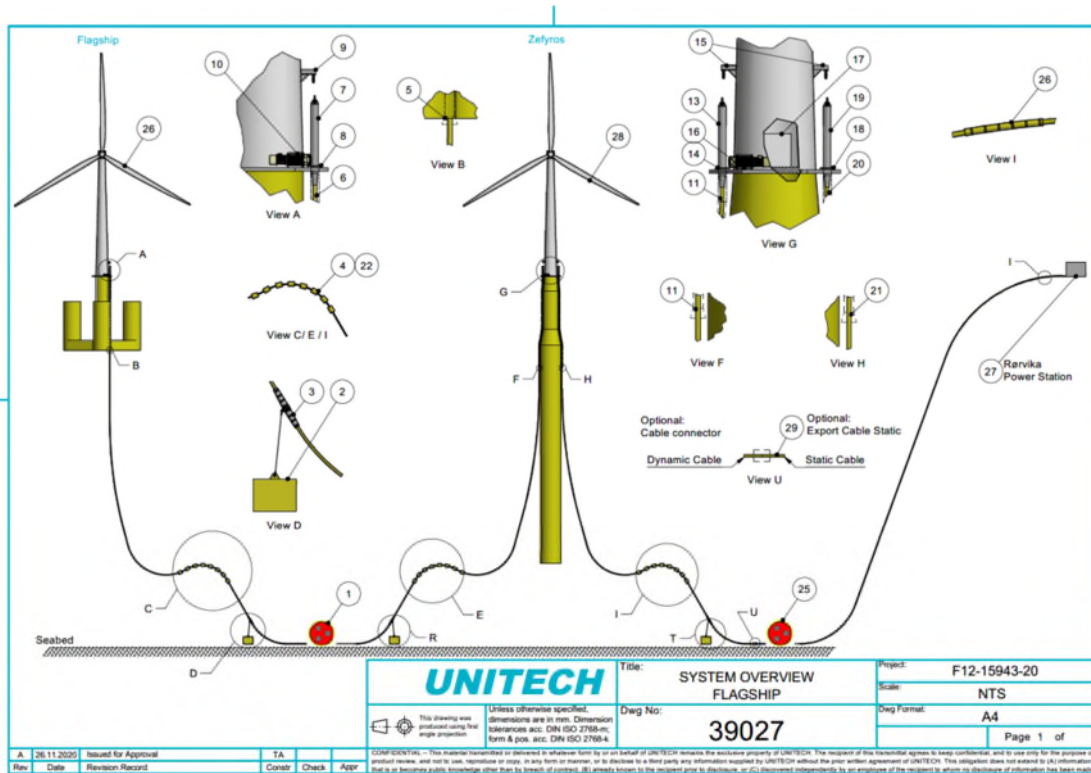


Figure 5.1 System Overview of Zefyros HUB solution

6. Conclusion and next steps

There are 2 options for grid connection investigated either with separate export cable to FLAGSHIP or by doing a joint project with SEC and connect to Zephyros as a hub for multiple FWT pilots.

Both options are technical possible and will be investigated further and concluded pending information from Turbine Supplier and capacity requirement by SEC.

The conclusion for final Cable architecture for FLAGSHIP will by end of January 2021.

The detailed overview of the architecture and budgets is pending input from D3.1 Cable Design Base and input from Turbine Supplier and Floater design. A preliminary dynamic analysis investigation has been started by Core Marine for input.

The delivery and manufacturing schedule require the grid architecture to be concluded no later than end of January 2021.

Next steps (to be concluded by end of January 2021):

- Receive Turbine Manufacture data
- Preliminary Design (ref 31. Design Base report)
- Preliminary Dynamic Analysis
- Receive onshore grid connection upgrade system overview by Metcentre/Haugaland Kraft
- Complete the detailed System Overview for both grid connection alternatives.
- Conclusive decision meeting with stake holders by end of January.