

A case study of multi-use platform: Aquaculture in offshore wind farms

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Abstract

Ever increasing marine construction and human activities in the European seas necessitates more judicious planning in the use of ocean space. This planning must consider multi-use the ocean space to minimize the environmental impacts. Within this concept, the EU-funded research project “Innovative Multi-purpose off-shore platforms: planning, design and operation (MERMAID)” aims to integrate energy extraction and aquaculture activities in a multi-use platform (MUP). Two study cases at different water depths are presented to address the bottlenecks related to deployment and operational activities of MUPs. The innovative transport technologies are investigated to maximize the synergies and reduce the risks of MUPs.

Approach

The annual electricity yield of the 1000 MW offshore wind farm is estimated, along with an integrated aquaculture production. The 1000 MW wind farm consists of 100 units of 10 MW wind turbine with two configurations: 1) jacket foundation; 2) floating sub-structure. The aquaculture unit will culture a multi-trophic ecosystem of fish, mussel and seaweed. A novel and expeditious method for the jacket foundation installation uses a new vessel with dynamic positioning capabilities. The feasibility is assessed by numerical simulations of the jacket foundation lifting. The floating 10 MW wind turbine is fully assembled and towed to final operation site.

A MUP case at North Sea site

First, in Figure 1, the combined mussel, seaweed and salmon production systems are suggested within the 1000 MW wind farm. The annual electricity production is estimated to be 3300 GWh at an annual average wind speed of 9.2 m/s and the annual salmon production is predicted to be 60,000 to 70,000 tons. This increased annual financial yield from salmon production accounts to 240-280 M€ at a price of €4/kg, which accounts for 73 to 85% of the annual electricity yield (0,10 €/kWh). In addition, the mussels and seaweed production systems will further increase the yields.

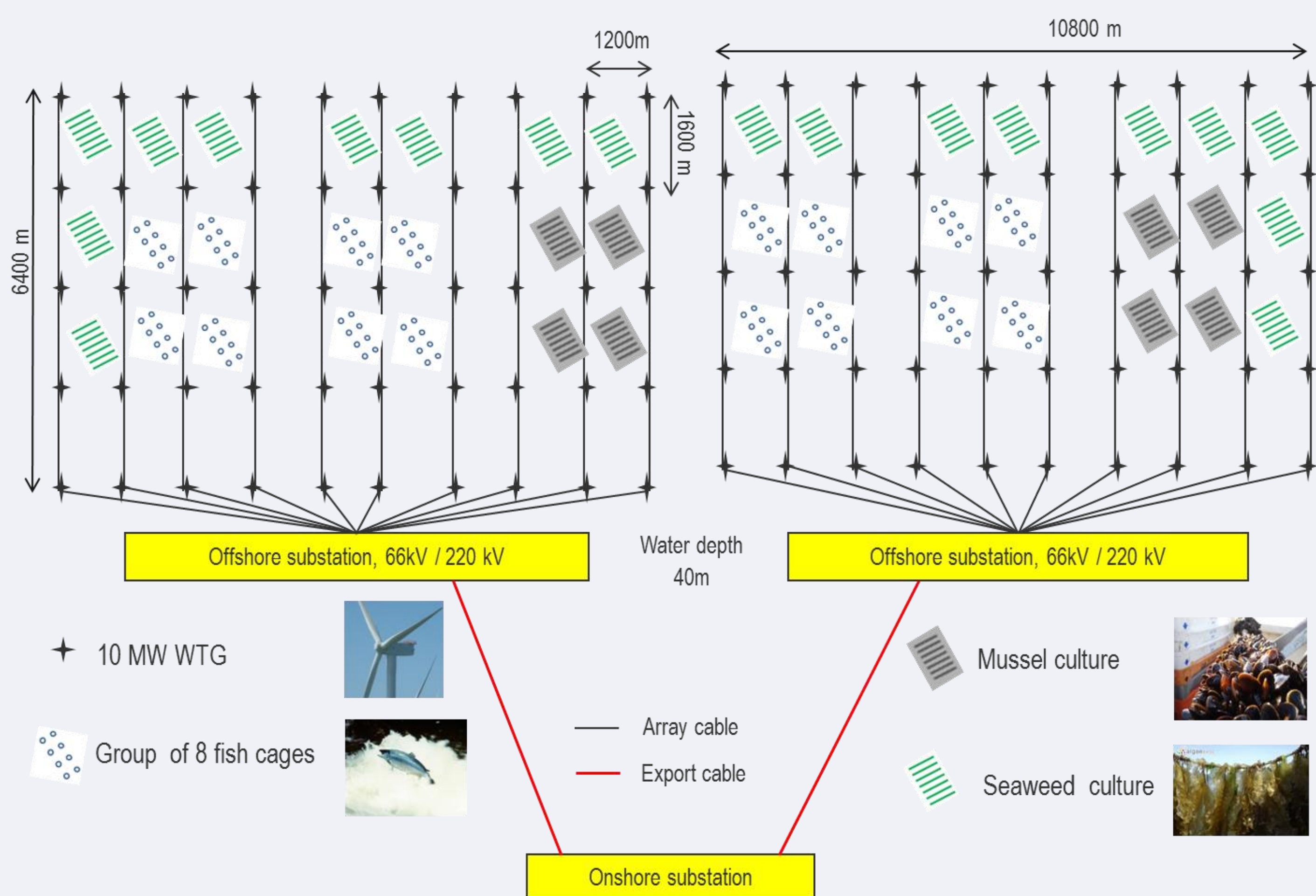


Figure 1 Layout of a MUP case at North Sea site

Second, the ambitious goal of this MUP study case is to finish the installation period in one year. A floating installation vessel was selected as an example in order to conduct the installation of the 10 MW wind turbine foundation. A numerical model of lowering and landing a 10 MW offshore wind turbine jacket foundation by a floating installation vessel was established in order to check vessel workability.

Third, the fish cages for the aquaculture farming usually have a much smaller weight compared to the component of the offshore wind farm. The installation of a group of eight fish cages (circular: circumference 120 m, depth 25 m) is assumed to take a one-month offshore work duration.

Fourth, there are at least three major risks related to the implementation of conventional large fish cages within the offshore wind farm: (i) most conventional fish cages and their mooring systems have been designed for operation at inshore protected sites; (ii) the fish cages with their mooring systems placed within the wind farm might increase collision risks with the operation, service and large maintenance vessels; (iii) there are conflicts between the offshore wind and aquaculture farms during the installation and operation phases.

A MUP case at Atlantic Ocean site

In this MUP case, the 10 MW floating Hywind is used as an example. The Hywind mooring system consists of three mooring lines and needs three anchors. An innovative hexagonal layout of 100 units of floating 10 MW Hywind is presented in Figure 2. The three mooring lines from the nearby three wind turbines share one anchor point on the sea bed to achieve cost reduction, which results the distance between two nearby wind turbines being 1600 m. The hexagonal layout in Figure 2 with sharing the mooring line anchor points requires an area of 228 km² (The North Sea site case needs 138 km²). Consequently, an offshore wind farm with floating WTGs might have more space for aquaculture farming than the wind farm fixed foundations.

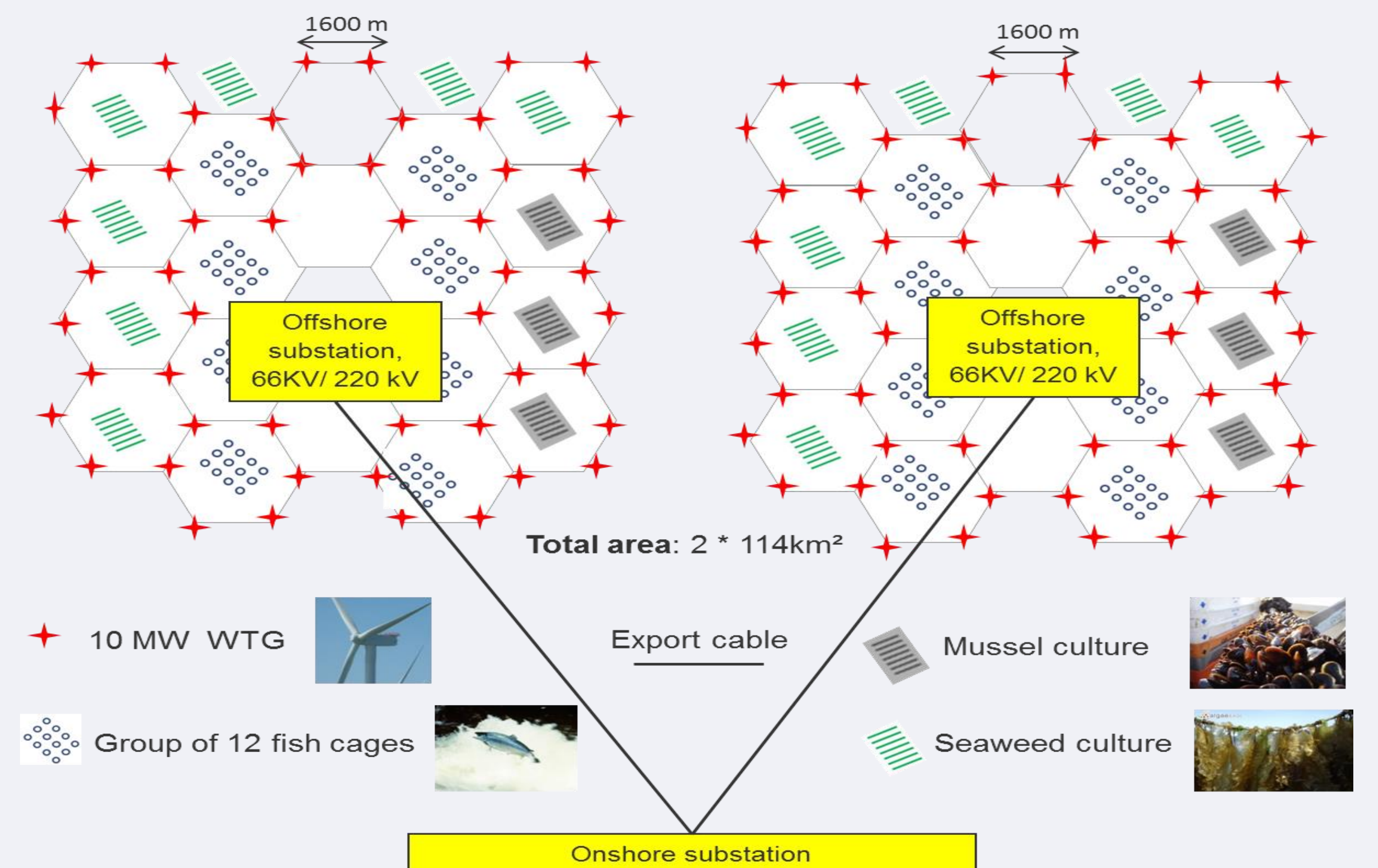


Figure 2 Layout of a MUP case at Atlantic Ocean site

The installation phases of 10 MW floating wind turbine are illustrated in Figure 3. A sub-structure must be manufactured at a suitable yard, transported to the assembly site and up-ended. The tower sections, nacelle and rotor must be manufactured by the turbine supplier, transported to the assembly site and lifted onto the sub-structure in a number of (typically four) lifting operations. Because of the large lifting heights, the operations will then become weather sensitive.

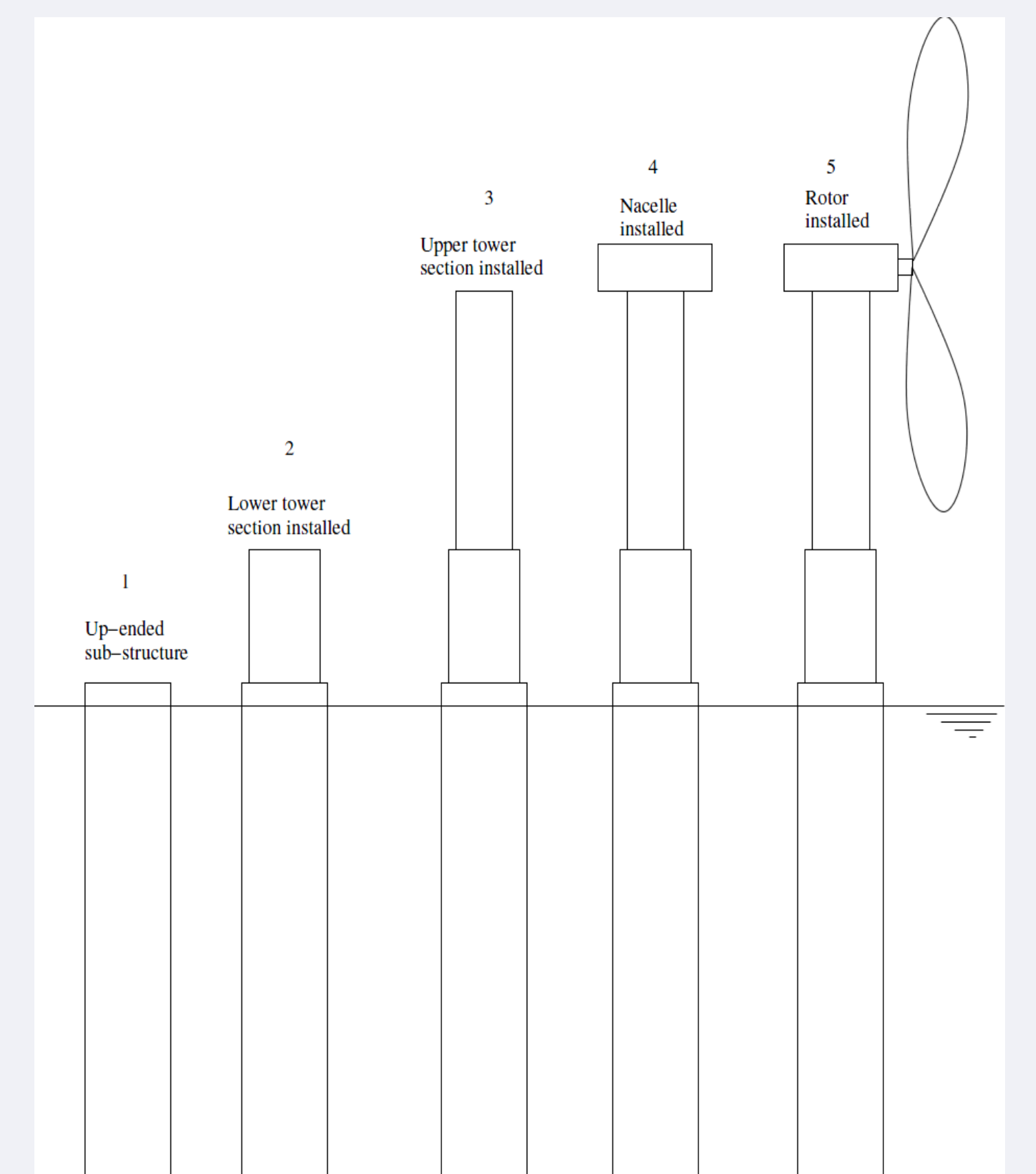


Figure 3 Installation phases of 10 MW floating wind turbine

Conclusions

The two MUP layout analyses demonstrate that the aquaculture within wind farms has potential to produce significant annual yields of commercial species. It will enable annual production of 60-70.000 tons of salmon and accounts for 73-85% of the electricity yield (North Sea case). The synergies and the risks of the MUP integrated installation and operational technologies have been identified. Based on the defined operational criteria and the simulated results of the jacket lifting operation, a workability analysis has been performed to identify sea conditions suitable for the installation process. In conclusion, the study cases present promising examples of future innovative MUPs..