

## Abstract

There is a growing interest in placing wind farms offshore. 140 GW of offshore wind are currently being planned to reach the EU energy 2020 goal. However, an offshore wind farm occupies a large area and competes with other users of the maritime space. The integration of an offshore wind farm with other marine energy producers such as wave energy and other maritime users such as aquaculture farms may result in significant benefits in terms of economics, optimising spatial utilization, and minimising the environmental impact. In this research project, the integration benefits and disadvantages have been evaluated by the proposed study cases, however these cases are unrelated to Statoil's planned wind projects.

## Objectives

The synergies and disadvantages of a 1000 MW wind farm integration with a wave farm and with an aquaculture farm have been evaluated with regard to the following three criteria.

- **Yield.** The quality and the quantity of the electrical power production, and the aquaculture production.
- **Cost.** The cost synergy including sharing the infrastructure, installation, operation and staff accommodation during installation, operation and maintenance, and decommissioning. The cost increase due to the conflict risks from the integration.
- **Impacts on the marine environment** during the construction, operation and decommission phases.

## Design the integration systems

Firstly, the layout of the 1000 MW wind farm is proposed as shown in Fig. 1. It has 200 floating 5 MW wind turbine units and occupies an area of about 100 km<sup>2</sup>. The wind and wave ratio is assumed to be 10 as a base case and the 100 MW wave farm has three potential concepts:

- A separate 100 MW wave farm consisting of 133 \* 750 kW generators in three rows could be placed at the boundary of the 1000 MW wind farm. The wave farm might reduce the wave loads affecting the wind turbine foundations.
- The wave power generators could be placed within the 1000 MW wind farm area.
- The wave power generator could be fully integrated within the wind power generation turbine.

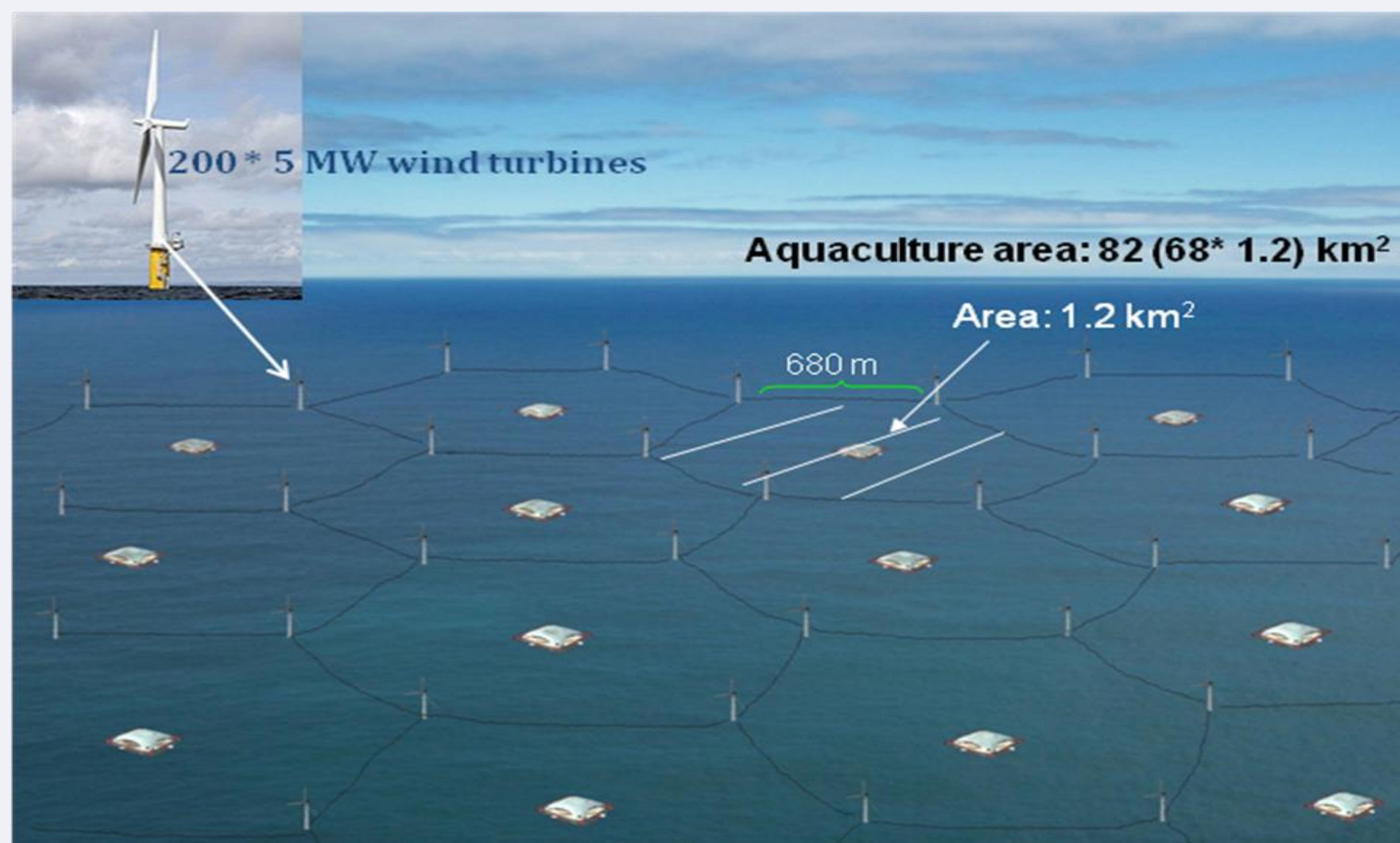


Fig1. An offshore wind farm integration with aquaculture farm

An aquaculture farm could be placed besides or within the 1000 MW wind farm (shown in Fig. 1). Multi-use activities will be assessed through in-situ studies on aquaculture. Three strategies will be applied to enhance finfish, seaweed and shellfish productivity within offshore wind farms. Intensive and extensive aquaculture as well as stock enhancement methods will require additional physical structures added to an offshore platform. This will require that the offshore location is either suited for operations with existing or development of new aquaculture technology.

## Electrical power yield from wind- and wave farm

Firstly, the integration of wind and wave increases the electrical power yield. Fig. 2 shows the power from a 2.3 MW wind turbine and from a wave unit of 750 kW during January 2010. Adding the mean wind power of 809 kW and the mean wave power of 370 kW, the mean power yield reaches 1179 kW.

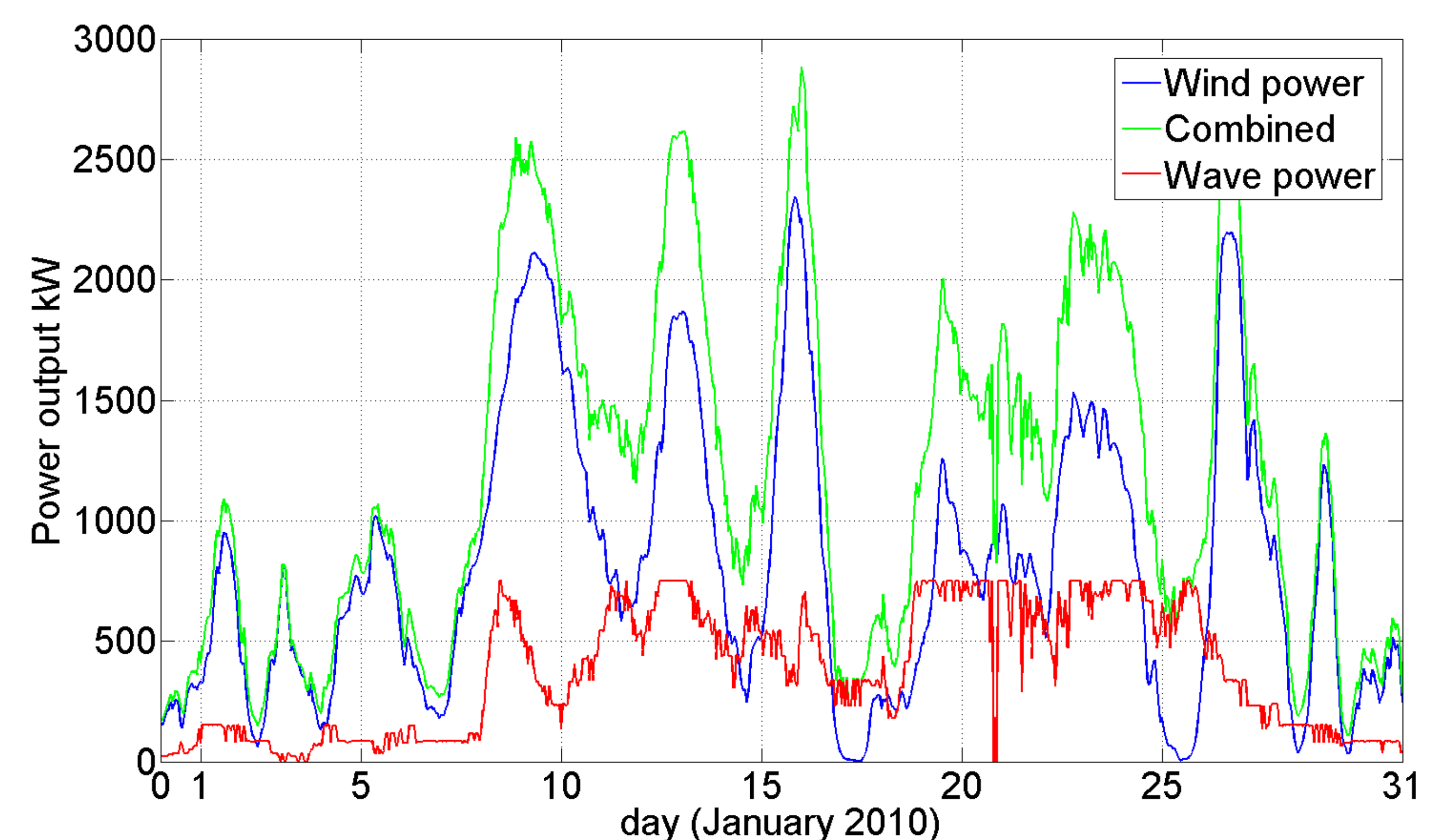


Fig. 2 The power output from the wind turbine and wave device

Secondly, Fig. 3 shows that a lower wind and wave capacity ratio of 1 (100 MW wind and 100 MW wave) results in the system output power more stable than a higher wind and wave ratio of 10 (1000 MW wind and 100 MW wave). The wind and wave integration has potential to give a more stable power output than for the wind farm alone, however, further investigations are required.

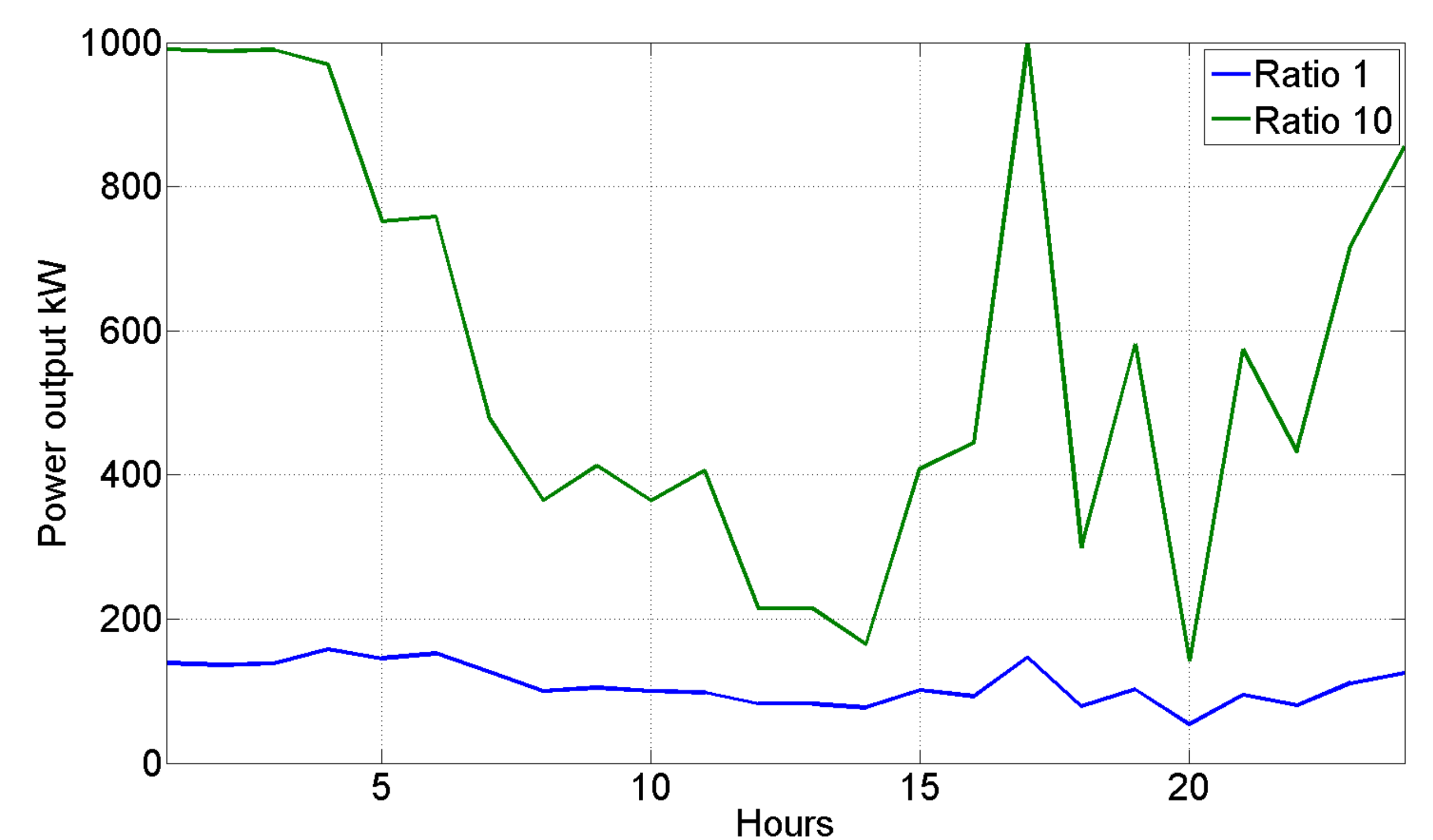


Fig. 3 Simulated power output from wind and wave integration

## Conclusions

This on-going project proposed 1000 MW wind farm integration with both wave and aquaculture. The simulation results show that the wind and wave integration results higher electrical power yield and a more stable power output than for the wind farm alone. The estimation of the aquaculture yield and the costs and the environmental impacts are still under investigation.