The Impact of Decarbonising Offshore Fields on Investment Planning of the North Sea Energy System

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Overview

The North Sea region has abundant fossil and renewable energy resources. Fossil energy was largely exploited in the past decades. In recent years, offshore renewable energy has drawn more attention. The EU's target of 300 GW offshore wind in the North Sea makes the region important in the energy transition towards zero emission. During the energy transition, oil and gas may still be needed for many years to come. The emissions from oil and gas production are not negligible. Therefore, the traditional oil and gas industry in the North Sea seeks solutions for the decarbonisation of platforms. The main emissions of platforms come from gas turbines for energy provision. Therefore, switching to clean energy provision of platforms can be an effective way to decarbonise platforms. The need for clean energy from the oil and gas industry may accelerate the deployment of offshore renewable technologies. In addition, to fully replace gas turbines with renewable energy, energy storage may be essential to balance out the volatility of renewable energies. However, due to the weight and space limitation of the offshore platforms, platform located batteries may be infeasible. Offshore energy hubs with an electrolyser fuel-cell hydrogen storage system may, for the purpose of balancing offshore renewable generation, be a better option. The energy hubs can support fields' decarbonisation and serve for energy export in the longer term. An illustration of energy hubs is shown in Figure 1.

In this paper, we analyse (a) the effect of offshore fields' decarbonisation on the acceleration of early investments in offshore low-carbon technologies and offshore grid, and (b) the prospective role of energy hubs in the decarbonisation of offshore fields.

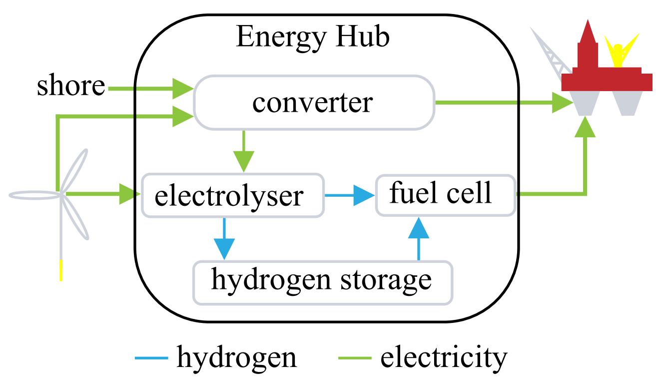

Figure1: Conceptual illustration of offshore energy hubs.

Methods

We use a large-scale stochastic Mixed-Integer Linear Programming (MILP) model [1,2] to analyse the investment planning problem of the North Sea energy system. In the investment planning part, we use integer variables to capture the fixed term of the investment costs to have a more accurate cost model. In the operational part, we include detailed modelling of platforms' operation and scheduling of the entire energy system. Operational uncertainty is essential in an energy system with high penetration of intermittent renewable energies. However, including operational scenarios in traditional multi-stage stochastic programming may lead to a large scenario tree and potentially an intractable problem. Therefore, we use a multi-horizon formulation [3] that can significantly reduce the size of the scenario tree. In addition, we use an enhanced Benders decomposition to efficiently solve the large-scale stochastic MILP model.

Results

The case study is conducted on a North Sea energy system planning problem with a configuration shown in Figure 2 and a 2050 planning horizon. We show results for the investment decisions in the North Sea on this horizon with a 5-year investment step. We compare the results from two cases, one considering the decarbonisation of all fields, and the second one without this requirement.

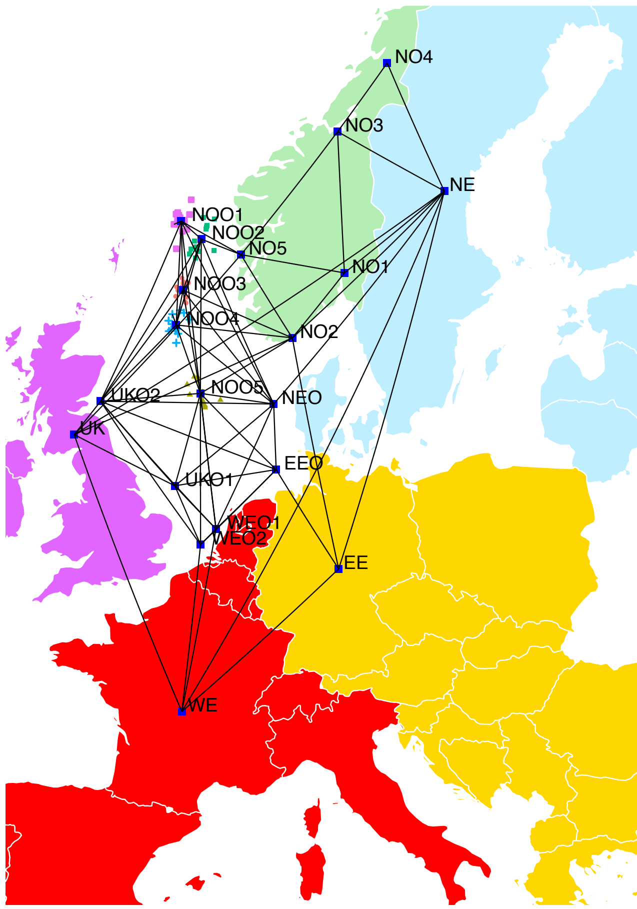

Figure 2: The North Sea grid.

Conclusions

From the results, we show: (a) how fields' decarbonisation affect the deployment of offshore renewable technologies in the North Sea and (b) how offshore energy hubs can facilitate the fields' decarbonisation.

References

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