

Tom Quinn

January 2021

Using floating offshore wind to power oil and gas platforms

EXECUTIVE SUMMARY

The oil and gas sector is responsible for 3% of the UK's greenhouse gas (GHG) emissions, the majority of which come from gas and diesel power generation on offshore installations. The UK sector of the North Sea has aging infrastructure, leading to a high emissions intensity compared to neighbouring countries. Offshore oil and gas operators regularly pay more than £100/MWh for electricity, and those with high fuel import dependency pay the highest price. Powering the UK's offshore oil and gas assets is therefore a relatively high-carbon and high-cost undertaking.

Floating offshore wind is a developing industry with costs which are currently high relative to fixed-bottom wind farms but which could be competitive with energy prices paid by offshore oil & gas operators. There is therefore an opportunity for electricity-consuming offshore operators who are required to pay higher prices for power, to provide early market development opportunities for floating offshore wind on its journey to full utility-scale deployment. The economic attractiveness depends largely on a combination of power requirements, wind resource and remaining asset life.

There are many technical challenges to address when connecting oil and gas infrastructure to an external power supply, including physical connection methods and the variety of activities for which electricity is required. There is no single solution which is suitable for powering all assets. The development, consenting and construction project can take several years from project definition to investment decision to commissioning, which may not always align with operating requirements.

The UK is in a strong position to develop into the market leader for commercial-scale floating offshore wind project deployment. There is also a significant opportunity to develop expertise and domestic supply chains in the process, creating jobs and export opportunities from this emerging industry. Coupling early industry development with oil & gas decarbonisation can be a win-win.

INTRODUCTION

The purpose of this paper is to analyse the feasibility of powering oil and gas facilities with floating wind and provide a case study for a specific site. This report assesses the feasibility of connecting floating wind turbines to offshore facilities in order to reduce power generation from gas or diesel generators. Three hypothetical sites are analysed with a range of power requirements and asset lifetimes. A detailed case study has also been carried out for the Kraken FPSO (floating production, storage and offloading vessel) to assess its suitability for a demonstrator project.

INDUSTRY BACKGROUND

The oil and gas sector in the UK contributes 3% of total national greenhouse gas emissions, from the production of hydrocarbons. While the sector aims to maximise production, to reduce import dependency for the UK, there is a simultaneous drive to reduce the emissions intensity of that production.

Current emissions intensity for offshore installations is 24,000 tonnes of CO2 equivalent (CO2e) per million barrels of oil equivalent (mmboe) produced. The Committee on Climate Change (CCC) set a target in 2019 of 500,000 tonnes of CO2e in 2050. Using production forecasts, this equates to around 4,000 tonnes CO2e/mmboe, a six-fold reduction in intensity. The majority of these emissions would be from safety flaring, rather than power production.

Despite the ambitions being announced in 2019, there is no framework in place on how to reach these targets. Oil & Gas UK has estimated that a 75% reduction will be required by 2035. 50% will come from the natural decline in production and decommissioning of old, inefficient assets. The remaining 25% will have to be driven by a change in operator behavioural changes and increased electrification.

As part of the work to reduce energy intensity, this report outlines the mechanism and process required to enable medium scale floating offshore wind to power an oil and gas installation.

For the UK to meet net zero by 2050 (and Scotland by 2045), it is estimated that at least 75GW of offshore wind will need to be constructed. In order to deliver this capacity, a significant number of floating wind project sites will have to be developed.

Floating wind is expected to be cost competitive with fixed-bottom sites by the early 2030s. However, for this cost reduction to occur, it is likely that a number of medium-scale floating offshore wind projects will need to be developed and deployed in advance of 2030. This will require investment in floating wind projects providing power at higher prices than from fixed-bottom projects. The oil and gas sector is an ideal candidate to support such deployment as many installations are paying high fuel bills for gas or diesel imports. Coupled with the desire to reduce carbon emissions, and maritime expertise, oil and gas operators will play a vital role in driving cost reduction for floating offshore wind.

The UK has a well-established offshore wind market and is well placed to be an early mover in the floating wind space. Investment in floating wind will allow for career transition for the oil and gas workforce, support existing supply chains in wind and oil and gas, and create opportunities for exporting companies to capture a share the huge global potential for floating wind.

FEASIBILITY STUDY

Three case studies have been assessed for this paper. The projects have been based on actual data from oil & gas operators as much as possible, but the operators and assets have been anonymised. To allow for like-for-like comparisons to be made, several assumptions have been kept static. These include wind speed, water depth, distance from shore, and natural gas opportunity and import costs.

The case studies assume installed wind capacity is roughly double the platform power requirement. This means on average over the year, the wind farm can meet most of the platform's power demand. However, this means that during high winds, the turbines will be producing excess power, which cannot be used without a storage system. This in effect lowers the capacity factor of the wind farm when compared to a regular farm (where broadly all generated power is assumed to be used/sold).

Site Assumptions

The **Alpha** Project has been producing from several platforms and subsea installations since the late 1970s and is now mature. We assume a 10-year life until decommissioning. We assume it is 100% gas deficient and using a mix of imported gas and diesel to meet ongoing power demand. This case study assumes two 8MW floating wind turbines could be sited within the project area, supplying most of the required power over the year.

The **Bravo** Project case study area contains several discovered, undeveloped oil and gas fields, around 200 kilometres northeast of Aberdeen. We have modelled two 10MW floating wind turbines to power a single platform, for the 20-year producing life of the oil field. Being a greenfield site, the integration of wind turbines can be included in the planning and consent stages of the project, potentially saving money and time in the process.

The final scenario assessed was based on discussion with the Oil and Gas Technology Centre (OGTC). There are several sites with clusters of platforms in the North Sea which would benefit from a large-scale floating wind farm. We have modelled a representative example, referred to in this analysis as the **OGTC** Project. The cluster is assumed to have a power requirement of 65MW. As such, a floating offshore wind farm comprising twelve 10MW turbines with an expected lifetime of 30 years is assumed.

	Variable	Unit	Alpha	Bravo	OGTC
Wind farm parameters	Turbine Rating	*MW*	8	10	10
	Turbine Numbers	*Number*	2	2	12
	Site Capacity	*MW*	16	20	120
	Wind Farm Life	*Years*	25	25	30
	First Power	*Year*	2024	2024	2026
	Wind Speed	*m/s*	10.1	10.1	10.1
	Net Capacity Factor	*%*	50.0%	52.5%	52.5%
	Useable Capacity Factor	*%*	35.0%	37.5%	37.5%
	Discount Rate	*%*	10%	10%	6%
Oil field parameters	Power Requirement	*MW*	8.0	11.0	65.0
	Oil & Gas Project Remaining Life	*Years*	10	20	30
	Water Depth	*m*	120	120	120
	Distance to O&M Port	*km*	100	100	100
	Distance to installation Port	*km*	130	130	130
	Gas Opportunity Cost	*£/mcf*[1]	3.50	3.50	3.50
	Gas Import Cost	*£/mcf*	10.00	10.00	10.00

Table 1: Key assumptions for case studies

Cost Assumptions

The cost modelling in this analysis is consistent with the methodology used in the report 'Macroeconomic benefits of floating offshore wind in the UK'[2], using an ORE Catapult in-house Excel-based economic model and reviewed by industry stakeholders. Project costs have been estimated using bottom up analysis based on the site and technology parameters.

The analysis assumes a gas import cost of £10/mcf (based on cost of gas and associated import infrastructure) and an opportunity cost of £3.50/mcf, an assumed price for gas that is sold rather than used for fuelling the facility's power requirement.

[1] mcf = thousand cubic feet
[2] https://www.crownestatescotland.com/maps-and-publications/download/219

Economic Analysis

The ORE Catapult has created a discounted cash flow model to evaluate case studies. The LCOE reduces with turbine size and wind farm size given the economies of scale as shown in Figure 1.

While the overall costs for the Alpha Project are similar to the Bravo Project, the differences in project life (10 vs 20 years) and capacity (16MW vs 20MW) are responsible for most of the difference in LCOE.

The OGTC Project is significantly cheaper on a levelized cost basis. The higher capacity wind farm (120MW) allows for lower capex and opex on a unit basis. The LCOE for this case study is lower than we are anticipating for an average floating wind project in the UK of similar size and timeframe, as this project would not require as many array cables or export cables to shore, if connected to a nearby platform or facility. There may also be savings from shared development and consenting costs with the oil and gas project development.

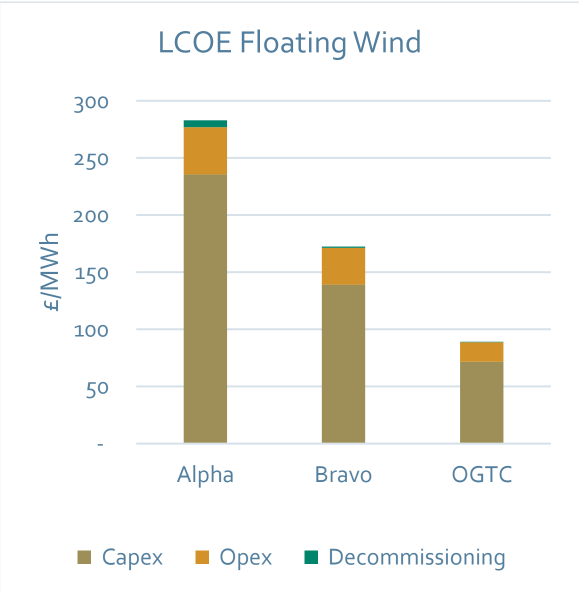

Figure 1: LCOE for case studies in £/MWh

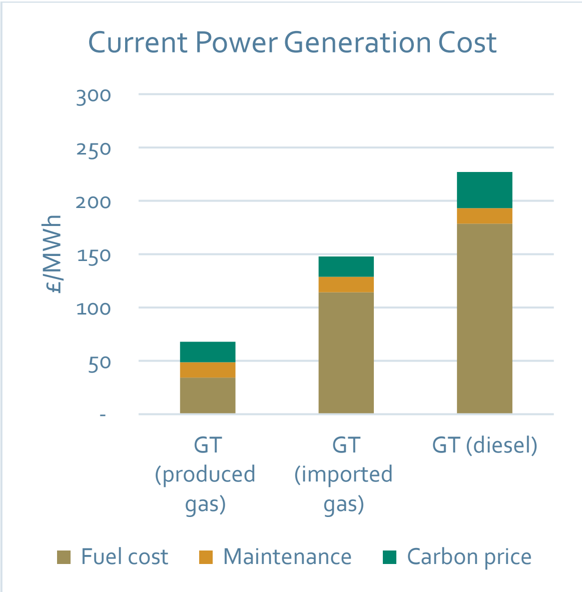

Figure 2: Cost of current power generation by fuel type

Compared against the existing cost for power offshore for gas deficient fields, as shown in Figure 2, projects providing a stable supply of power for under £150/MWh are likely to be attractive to operators. The OGTC cluster, with LCOE of £90/MWh, has sufficient headroom to fit comfortably into this category.

KRAKEN FPSO CASE STUDY

Using criteria defined by the feasibility study, and taking into account availability of data, the Kraken FPSO (floating production, storage and offloading vessel) was selected as a site to install a demonstrator project consisting of five 10MW floating turbines. Combining power demand load data and weather data provided by the operator, the floating offshore wind project is expected to supply just over half of the vessel's electricity demand and offset 143,000 tonnes of CO_2 emissions per year (at current load). The estimated levelised cost of energy (LCOE) is £90/MWh, which is lower than the current diesel fuel cost for electricity generation (£98.50/MWh) on the Kraken FPSO (Figure 3).

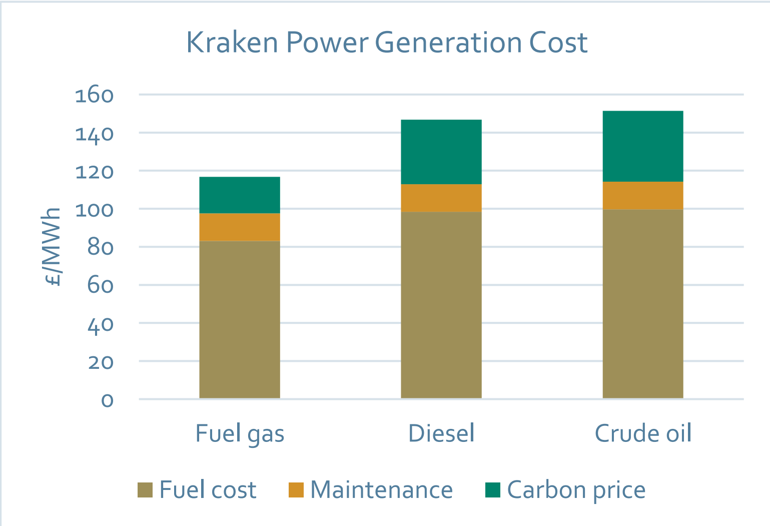

Figure 3: Cost of power generation by fuel type for the Kraken FPSO

The Kraken oil field has produced heavy oil via a FPSO since 2017. The field is operated by EnQuest, which holds a 70.5% stake. The remainder is owned by Cairn Energy (29.5%).

Given the heavy nature of the oil, the FPSO houses three boilers to generate steam for injection, to allow the oil to flow. Electrical power is supplied via four generators which can be run on natural gas, diesel or crude oil. As the field does not produce much gas, the generators mostly run on imported diesel.

Electrical power demand is estimated at 39 MW, while thermal power for steam generation is estimated to be 103 MW. Replacement of electrical power using floating wind would be relatively straight forward (and so is the focus for this case study) compared to replacing steam generation, which would require new electric boilers to be retrofitted.

Economic Feasibility

Given the power requirement of 39MW, four 10MW turbines would meet demand when wind speeds were sufficient to reach rated turbine power. There are periods when wind speed is lower, meaning the project will benefit from additional turbines. However, the project will see diminishing upside, and increased wastage of energy, with each additional turbine added. Beyond 4 turbines, a lower proportion of the output from each additional turbine can be utilised, leading to the increasing amount of excess production shown in Figure 4. As a result, while a larger number of turbines reduces capital and operating costs on a per unit basis, the % of energy produced which can be utilised decreases, leading to an increase in LCOE as shown in Figure 5.

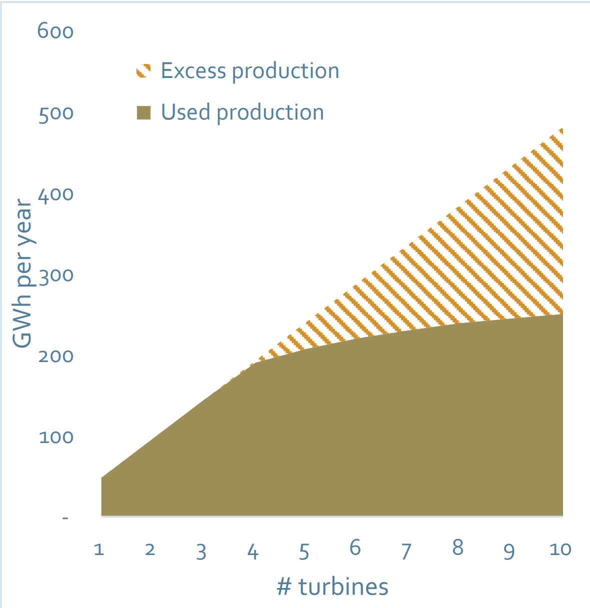

Figure 4: Useable vs excess power generation

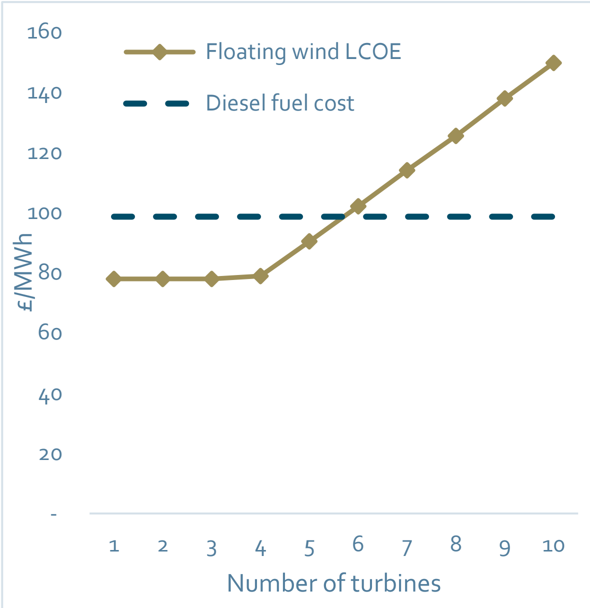

Figure 5: Floating wind LCOE vs current diesel generation fuel cost

This analysis shows the optimal number of turbines is five. This would halve the demand for diesel-fired electricity, allowing for a saving of 106,000 tonnes CO_2 per year, or 2.6 million tonnes over a 25-year period.

Battery storage of excess wind power was assessed. The cost-benefit analysis showed that one 2.3MW battery would reduce diesel-fired power by a further 467 MWh in a year, a saving of £46,000 in fuel cost. However, the battery is expected to cost £1.2 million, not including the space requirement offshore. Hydrogen generation may be a feasible alternative, but this has not been assessed for this study.

Technical Feasibility

Attempts to power oil & gas platforms with floating wind will come up against several technical and commercial challenges. It is crucial to note that understanding and overcoming these challenges will be as critical to enabling the concepts described in this paper as building the economic case.

Oil and gas production units are varied in their power demand, both capacity and type of power required. Some units require purely electrical power to operate pumps, cranes etc. Others require mechanical power or steam generation which is not readily electrified. Brownfield modifications can be complicated and expensive to carry out and the lead times on equipment may be significant.

The Kraken FPSO produces hydrocarbons via an internal turret, which it rotates around due to wind/wave action. Getting power over this turret has proved difficult, with voltage drop-out being experienced.

Oil & gas platforms/vessels currently produce heat as a by-product of electricity generation. The electrification of power systems (away from diesel/gas generation) would require a separate supply of heat to be installed and powered.

CONCLUSIONS

Oil and gas production is responsible for 3% of the UK's GHG emissions. With a high proportion of old fields and assets, emissions intensity is higher for the UK than for other North Sea countries. Norway is the leader in this space, with some platforms powered from shore using clean hydro-electric sources.

Oil and gas operators are ideal candidates to help accelerate the development of floating wind, given the existing cost of energy offshore (usually over £100/MWh), and the operational experience of the operators in offshore environments. Boards of management are also under pressure from investors to reduce emissions and ensure a social licence to operate remains intact.

The UK is in a strong position to develop into the market leader for commercial-scale floating offshore wind project deployment. Development of medium-scale (100-500MW) floating offshore wind projects over the next ten years is essential in order to ensure floating offshore wind can be deployed at large scale (>500MW) around 2030 and to ensure the oil and gas sector can reduce carbon emissions. It also provides a significant opportunity to develop expertise and domestic supply chains in the process, creating jobs and export opportunities from this emerging industry.

AUTHOR PROFILE

Tom Quinn is an Analysis and Insights Manager at ORE Catapult. Tom is responsible for maintaining market intelligence and developing economic and financial models to generate insights from innovative projects. He has worked as an analyst in the energy sector since 2012, mainly in upstream oil & gas market intelligence, with specific expertise in Middle East gas and LNG markets. He helps SMEs to position their offerings in the market and capture funding from investors. He also works closely with partners to understand the impact of the energy transition on the UK's economy.

CONTACT

GLASGOW

Inovo
121 George Street
Glasgow
G1 1RD

+44 (0)333 004 1400

BLYTH

National Renewable Energy Centre
Albert Street, Blyth
NE21 1LZ

+44 (0)1670 359 555

LEVENMOUTH

Fife Renewables Innovation Centre
Ajax Way, Leven
KY8 3RS

+44 (0)1670 357 64

HULL

O&M Centre of Excellence
Ergo Centre
Bridgehead Business Park,
Meadow Road, Hessle
HU13 0GD

ABERDEEN

Subsea UK
30 Ambercrombie Court
Prospect Road, Westhill
Aberdeenshire
AB32 6FE

CORNWALL

Hayle Marine Renewables
Business Park, North Quay,
Hayle, Cornwall
TR27 4DD

PEMBROKESHIRE

Pembroke Dock,
Pembrokeshire
SA72 6TD

CHINA

11th Floor, Lan Se Zhi Gu No.5
Ke Ji Avenue, Hi-Tech Zone
Yantai City
Shandong Province
China

LOWESTOFT

Orbis Energy
Wilde Street
Lowestoft, Suffolk
NR31 1XH