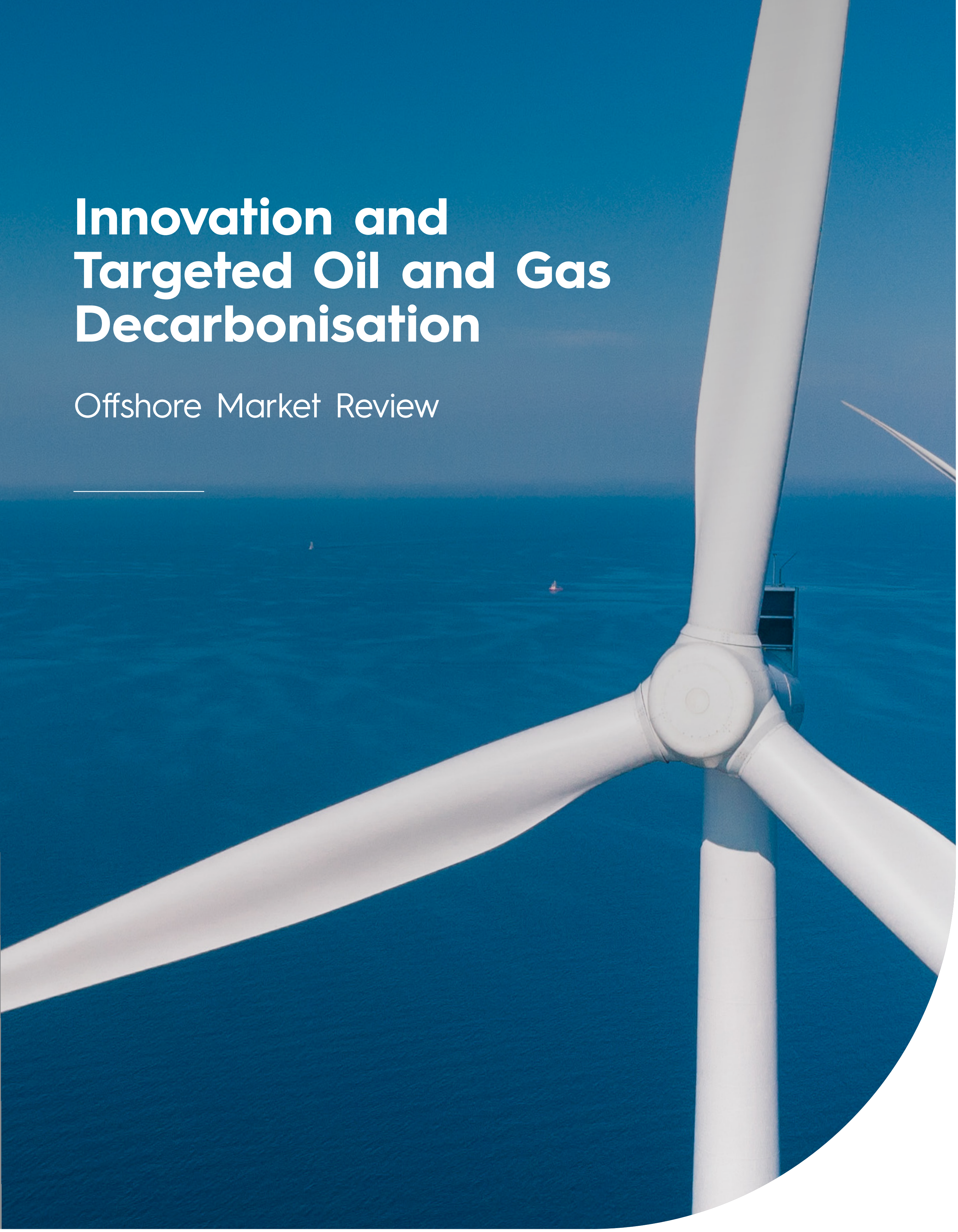

Innovation and Targeted Oil and Gas Decarbonisation

Offshore Market Review

Crown Estate Scotland
Oighreachd a' Chrùin Alba

natural power

Document history

Author	Iain Corrigan, Advisory Lead – Offshore Wind & Duncan McLachlan, Director Systems Engineering	30 March, 2022
Checked	Rick Campbell, *Head of Offshore*	1 April, 2022
Approved	Hannah Staab, *Head of Advisory - Europe*	1 April, 2022

Client Details	
Contact	Scott Ross
Client Name	Crown Estate Scotland
Address	2nd Floor, Quartermile Two, 2 Lister Square, Edinburgh EH3 9GL

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Local Office:

Ochil House
Springkerse Business Park
Stirling
FK7 7XE
SCOTLAND
UK
Tel: +44 (0) 1786 542

Registered Office:

The Natural Power Consultants Limited
The Green House
Forrest Estate, Dalry
Castle Douglas, Kirkcudbrightshire
DG7 3XS

Reg No: SC177881

VAT No: GB 243 6926 48

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Executive Summary

Offshore wind has been a major success story for the UK, with an established policy framework combining with long term, strategic private sector investment leading to significant cost reduction and decarbonisation of the economy. Following the ScotWind announcements in January 2022, Scotland now has a development and construction pipeline of over 30 GW of offshore wind.

The Innovation and Targeted Oil and Gas (INTOG) leasing round, announced by Crown Estate Scotland in February 2022 presents an opportunity to secure seabed rights to develop offshore wind projects specifically for the purpose of providing low carbon electricity to power oil and gas installations.

This aligns with the Scottish Government's objective to deliver a Just Transition (Just Transition Commission, 2020) to a net zero economy and society, as well as the UK Government's Offshore Wind Industrial Strategy and Ten Point Plan for a Green Industrial Revolution (UK Government, 2021) (HM Government, 2019) (HM Government, 2020).

The key positive features of the INTOG leasing round for the offshore wind industry are:

1. **Opportunity to secure seabed rights** for commercially viable, consentable offshore wind projects in an established market with strong natural resources and a mature policy regime.
2. Potential for **full or partial offtake agreement with oil and gas installations**, enabling financial stability and potentially avoiding the need for OFTO, TNUoS costs, network reinforcement and associated timing constraints.
3. Opportunity to **deploy innovative offshore wind infrastructure**, demonstrating technology and readying the supply chain in anticipation of deployment for commercial-scale ScotWind projects.
4. Introduction of **new participants in the offshore wind market**, with opportunity for cross-sector learning and novel approaches to financing, ownership, operations and maintenance.
5. Opportunity for **offshore wind to play a part in the decarbonisation of oil and gas infrastructure**; a major step in the delivery of a net zero economy.
6. Enhanced **pipeline of projects** for Scotland's floating wind supply chain.

Offshore Market Review

The oil and gas industry is moving towards electrification, with the INTOG leasing round providing a meaningful opportunity to support this process through integration with floating offshore wind technology. By considering a number of potential approaches to floating wind integration, including a range of technology solutions, this report seeks to demonstrate the benefits of this leasing round to the offshore wind industry.

Integration of offshore wind and oil and gas infrastructure presents some unique and complex technical challenges. It also presents opportunities for cost reduction and novel offtake solutions, which are considered throughout. For example, an off-grid solution would provide a floating wind project with a 100% electrical offtake from an oil and gas installation; however, this would likely require integration with a storage solution or alternative means of electricity production.

ScotWind has seen meaningful commitment to Scotland's offshore wind supply chain, with 11 of 17 awarded sites seeking to deliver floating wind projects. The INTOG leasing round has similar commitment requirements, and the timescales associated with the projects provide Scotland's supply chain with further opportunity to support major project activities.

This report considers opportunities within the scope of the Just Transition Commission for both the oil and gas sector and the wind sector. The Scottish Government has stated that support for the oil and gas industry is "conditional upon a sustainable, secure and inclusive energy transition".

1. Introduction

The Natural Power Consultants Limited ("Natural Power") has been commissioned by the Crown Estate Scotland (the "Client") to carry out a study in regards the opportunity for Innovation and Targeted Oil and Gas (INTOG) leasing opportunity. This electrification replaces the platforms' traditional energy supply from diesel generators and gas turbines. A recent report (Oil & Gas Authority, 2021) highlighted that oil and gas power generation CO_2 emissions were in the region of 10 Mt per annum. To put this into context, this is approximately 21% of the total greenhouse gas emissions in Scotland (as of 2019 – latest figures available) (statista, 2019).

Oil and Gas Decarbonisation

The United Kingdom Continental Shelf (UKCS) is a significant element of the United Kingdom's (UK's) emissions footprint, contributing 4% of the UK's total Green House Gases (GHG) emissions in 2018.

The UK Government's net zero strategy has identified the decarbonisation of the UKCS oil and gas industry as a strategic aim. Representatives of the oil and gas industry including Offshore Energies UK (OEUK) and the Oil & Gas Authority (OGA), all fully support this aim and have established approaches to achieving it. One of the most significant approaches is a recognition that electrification is fundamental to achieving the targets and that electrification of both existing and future developments must take place to meet the UK net zero target.

The use of offshore wind to serve these electrification projects is not without technical challenges, but case studies from the electrification of the Norwegian sector and technical studies from the UKCS oil and gas sector have sought to address these.

Economic analysis in the OGA's UKCS Energy Integration Final Report, evaluating four alternative schemes for brownfield electrification and two for greenfield electrification, considered alongside the Department for Business, Energy & Industrial Strategy (BEIS) updated traded carbon values for modelling purposes (real 2018), suggests clear economic incentives for operators to electrify their installations.

By examining greenfield developments West of Shetland and brownfield developments both West of Shetland (WoS) and Central North Sea (CNS), the demand for renewable power from oil and gas operators will likely exceed 1 GW. Due to technical considerations, this will result in up to 4 GW of installed wind power being offered seabed rights.

High level Terms and Definitions

Throughout this report the following key terms and their definitions are used.

Installation	An oil and gas facility: floating platform, FPSO, bridge platform, etc
Asset	An offshore wind asset: floating wind generator.
Greenfield	A newbuild oil and gas installation which is not constrained by prior works
Brownfield	An existing installation with established means of electricity production

A complete list of definitions and terms is provided in Appendix 9.2.

Offshore Wind Development in Scotland and INTOG

Several factors have combined to make Scotland an attractive market for investment in and the development of offshore wind:

- positive policy approaches to planning consent and renewable energy support mechanisms by the Scottish and UK Governments;
- a physical environment well suited to offshore wind; and
- expert knowledge in both regulators and development organisations.

INTOG is a new offshore wind leasing round specifically designed for offshore wind farms that support the decarbonisation of the oil and gas sector, as well as small scale innovation projects of less than 100 MW. INTOG will form an important role in delivering the North Sea Transition Deal's Supply Decarbonisation policy (UK Government, 2021).

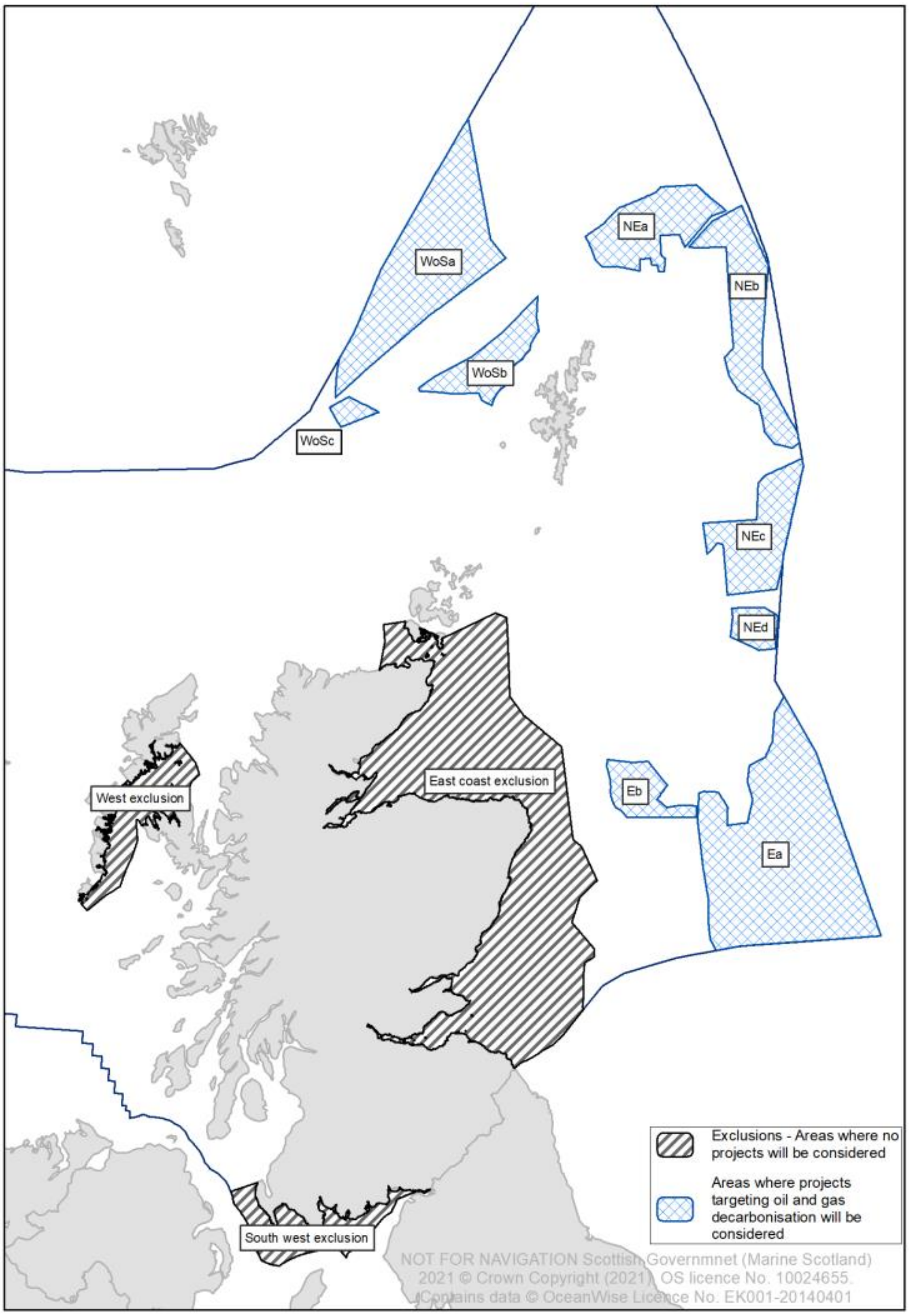

Figure 1.1: Initial Plan Framework Targeted Oil and Gas Areas Decarbonisation options and Exclusions (Scottish Government, 2022)

The objective of this report is to provide a qualified opinion on the opportunity that offshore wind brings in the decarbonisation of oil and gas supply. In doing so, the report seeks to investigate the following principal considerations surrounding the electrification of oil and gas production:

1. The nature and potential benefits of electrification to the offshore wind industry, as well as the offshore wind supply chain opportunities

This report explores the unique challenges surrounding electrification, including integration with brownfield and greenfield oil and gas, requirement for storage and/or alternative generation facility, use of deep-water floating wind and integration with other Scottish offshore wind projects. In doing so, several example opportunities are explored, such as coordination of multiple oil and gas installations with floating wind projects, and integration with ScotWind projects to facilitate connection with the National Grid.

The INTOG leasing round has supply chain requirements comparable to the successful ScotWind leasing round. Additional floating offshore wind development at both innovation-scale and commercial-scale, on timelines which are expected to integrate with the ScotWind projects, provide opportunity for Scottish-based manufacturers to further establish a pipeline, and this is explored throughout the report.

2. The role of electrification in delivering a Just Transition

Alongside the North Sea Transition Deal, the INTOG initiative provides an opportunity or catalyst in developing and delivering on Just Transition (Just Transition Commission, 2020). The Just Transition Commission's role is ensuring a levelling up across Scotland and a focus on people's day to day lives as change becomes more challenging, as well as ensuring that this transition addresses skills and employment as an integral part of the net zero journey.

> **Oil and Gas Authority** (OGA)'s role is to regulate and influence the UK oil and gas industry and carbon storage industry offshore. It aims to maximise economic recovery from the UK's hydrocarbon resources and help meet the UK's energy demands while supporting the industry's energy transition.
>
> **Offshore Energies UK (OEUK)** is a representative body for the UK offshore oil and gas industry. Its aim is to inform, engage and champion the UK offshore oil and gas industry as part of a diverse energy mix, incorporating hydrogen, carbon capture and storage and offshore wind.

The North Sea Transition includes:

- The sector committing to early targets for the reduction of greenhouse gas emissions from production against a 2018 baseline.
- Achieving a 60 Mt reduction in greenhouse gas emissions, including 15 Mt through the progressive decarbonisation of UKCS production over the period to 2030, as well as emission saving from Carbon Capture Utilisation and Storage (CCUS) and utilisation of hydrogen.
- Moving away from unabated greenhouse gas emissions resulting from combustion of fossil fuels will be achieved through a combination of energy efficiency, electrification, alternative decarbonised energy and the use of carbon capture technology.

This commitment is fully supported by the OGA which states full commitment "to enabling the achievement of the UK Government's commitment to reach net zero emissions by 2050 (Oil & Gas Authority, 2022)" and has published a report on the electrification of offshore installations (Oil & Gas Authority, 2020). This report concluded:

- The oil and gas industry could significantly reduce GHG emissions (by ~2–3MtCO_2e pa, equivalent to ~11-16% of the 2018 total GHG emissions from upstream oil and gas operations were 14 MtCO2e) by sourcing power for its UKCS installations either from the shore or from offshore renewables (OGUK, 2020).
- Economics of converting existing installations (brownfield electrification) could potentially be improved through cross-industry projects that supply power from offshore windfarms.
- CO_2 abatement costs for brownfield sites, in the range of £23–43/tCO_2 could be enabled by these synergies, making electrification potentially attractive compared to other options to reduce emissions. This is 25%-70% less

than the OGA's estimated levelized cost of Carbon Capture and Storage (CCS) in the range of £58-£76 tCO2 based on an assumed onshore carbon capture cost of £46/tCO2 (OGA, 2020)

- Electrification of newbuild installations (greenfield) would be more attractive (£6–15/tCO_2) due to CAPEX savings derived from designing installations for electrification from the outset and the associated equipment simplification.

3. Wider effects of electrification on the offshore wind industry, notably in terms of market participation and investment

By examining the OGA report and other relevant industry documentation, this report identifies how electrification projects can enhance the attractiveness of the offshore wind sector to the oil and gas sector, stimulating increased interest and investment.

Given the net zero commitments of the oil and gas industry, electrification of installations has been identified as a key strategy. This is not without technical challenges, including proximity to power and variability of renewable sources. Locating INTOG leasing sites relatively close to areas of oil and gas operation, offers mitigation to these challenges and makes offshore wind more attractive to oil and gas operators.

4. Wider opportunities surrounding offshore wind electrical offtake, for INTOG and other offshore windfarms.

Unique in offshore wind development to date, INTOG presents a viable route to market which does not require a connection to existing grid infrastructure. That is, by connecting to an off-grid solution (i.e., an oil and gas installation), an offshore wind farm could feasibly secure a 100% power purchase agreement with the asset owner. As is explored in the report, this may be amalgamated with connections to other offshore wind farms, other forms of generation or storage, or potentially form part of a coordinated network with the National Grid.

Depending on the design life of oil and gas installations, INTOG also provides an opportunity to consider secondary deployment of offshore wind infrastructure, subject to appropriate planning and infrastructure requirements. Again, this is novel to the INTOG process and is considered within the report.

This report is primarily focused on the scenario where offshore wind provides the primary decarbonisation and electrification solution, though other technologies are considered in Section 6. Due to bathymetry considered the report considers floating offshore wind to be the primary technology. It should be noted that hydrogen does not form the primary focus of the INTOG leasing process; however, integration with oil and gas installations could open opportunities for hydrogen production.

2. Offshore Wind in Scotland

Scotland has over 900MW of operational offshore windfarm projects with a consented, pre-construction pipeline of approximately 5GW and a further 4-5GW progressing through the consent process.

On 17 January 2022, Crown Estate Scotland awarded 17 sites around Scotland for development of almost 25GW of offshore wind projects. Eleven of these sites have potential for floating offshore wind to be installed, placing Scotland at the forefront of the floating wind industry globally, which presents a clear advantage to INTOG projects.

2.1. ScotWind

Successful applicants in the leasing process committed to meaningful investment in Scotland's offshore wind supply chain. A map of the option areas awarded is provided in Figure 2.1.

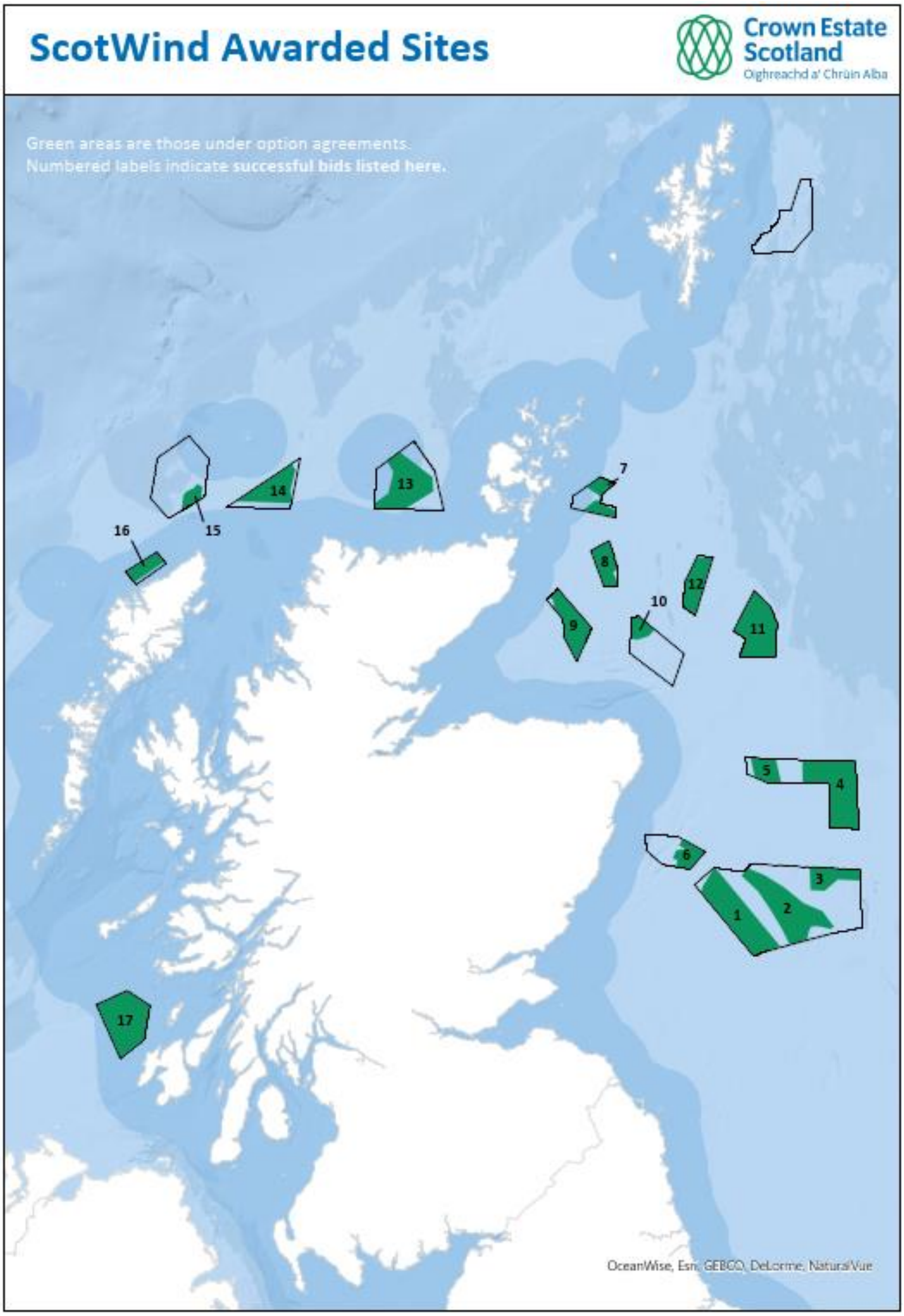

Figure 2.1: ScotWind Option Agreements (Crown Estate Scotland, 2022).

Table 2.1: Scotwind Option Agreements

Map Reference	Lead Applicant	Capacity (MW)	Map Reference	Lead Applicant	Capacity (MW)
1	BP Alternative Energy Investments	2907	10	Falck Renewables	500
2	SSE Renewables	2610	11	ScottishPower Renewables	3000
3	Falck Renewables	1200	12	BayWa	960
4	Shell New Energies	2000	13	Offshore Wind Power	2000
5	Vattenfall	798	14	Northland Power	1500
6	DEME	1008	15	Magnora	495
7	DEME	1008	16	Northland Power	840
8	Falck Renewables	1000	17	ScottishPower Renewables	2000
9	Ocean Winds	1000			

2.2. Floating Wind Technology

Given the technological advancements within offshore wind in recent years (notably, turbine capability, transmission infrastructure; transportation and installation; and operations and maintenance) the trajectory for floating offshore wind to reach cost parity with fixed bottom offshore wind, and therefore other forms of renewable energy generation, will be considerably faster than that followed by fixed bottom offshore wind.

Floating offshore wind represents the best opportunity for deployment of marine technology at scale. No other form of technology is capable of exploiting the advancements made by fixed bottom offshore wind to the same degree and therefore able to reach cost convergence at the same rate. There is no clear technological market lead within other forms of marine generation.

Although the floating offshore wind market is still very much in its nascent phase, the rate of development progress and the scale of this progress indicate a relatively short shift transition between the embryonic and wide scale adoption.

2.2.1. Innovation

In January 2022 the UK Government announced funding for innovation and to support the development of floating offshore wind technology. Over GBP 31 million of UK Government funding matched by over GBP 30 million of industry funding was targeted to research and development of key components needed to install floating turbines (BEIS, 2022).

Among the successful development projects were AWC Technology, awarded a sum to progress development of an articulated wind turbine column designed to reduce construction, installation and maintenance costs. Also, a consortium including Copenhagen Offshore Partners, SSE Renewables, Maersk Supply Service Subsea and Bridon Bekaert Ropes Group for a project to develop and demonstrate new mooring system technologies, cable protection, floating turbine base design and an advanced digital monitoring system.

2.2.2. Maturing technology

The rapidly expanding floating wind market has enabled technology to mature at a high trajectory.

Case Study: TetraSpar Demonstrator

The floating wind TetraSpar Demonstrator (reNEWS.BIZ, 2021), with a Siemens 3.6 MW turbine, has been commissioned and is now in operation. It is anchored in place at a 200-metre water depth off Norway's coast. The TetraSpar consortium comprises RWE, Shell, TEPCO Renewable Power and Stiesdal Offshore Technologies.

Statoil (Equinor) (Ulla, 2015) placed the Hywind demo floating turbine in 2009. The technology coupled a Siemens 2.3 MW WTG to a ballasted slender cylinder foundation that was anchored to the seabed. In 2021, Statoil completed the five-turbine site of Hywind Scotland. Hywind Scotland is the world's first commercial floating wind farm and is situated 29 km off the coast of Peterhead. This coupled 6 MW turbines with similar ballasted slender cylinder foundation that was anchored to the seabed. The Hywind Scotland business case is focused on three key aspects: de-risking the technology, cost reduction and enablement of the supply chain.

As discussed in Section 2.4, Hywind Tampen will be the world's first floating wind farm to power offshore oil and gas installations. It was developed following on from the Scottish demonstrator project. When commissioned in late 2022 it will be the world's largest floating wind farm.

Some notable example development-stage floating wind projects are as follows:

- Spanish floating wind player Greenalia (reNEWS.BIZ, 2021) has secured key permits required for the development of its 50 MW Gofio floating offshore wind project off Gran Canaria.
- An 80:20 joint venture between Shell and CoensHexicon (reNEWS.BIZ, 2021) has secured an electricity business license (EBL) for the first 420 MW phase of the MunmuBaram floating offshore wind project off the coast of Ulsan, South Korea.
- EDF Renewables (reNEWS.BIZ, 2021) achieved a marine licence variation consent for the Blyth demonstrator wind farm, converting consented foundations from fixed to floating and making it the UK's largest consented floating wind farm.
- Green Volt is a pioneering project that will use floating offshore wind to address a major source of UK carbon dioxide emissions from the Buzzard installation.
- Marine consultants Partrac, together with project partners Aktis Hydraulics, has completed a certified metocean study for French offshore wind developer EDF Renewables at the floating wind Blyth Offshore Demonstrator site, with a total capacity of up to 58.4 MW (reNEWS.BIZ, 2021).

2.2.3. Maturing Market & Financing

In 2016, and again in 2020, Simply Blue undertook a ‘Technology and Commercial Review’ of Floating Offshore Wind (FOW) Foundations (Simply Blue, 2021). It was determined that floating wind solutions have matured, and an increasing number of foundations are now financeable.

In 2021, ORE Catapult issued an Invitation to Tender in regards Project Finance (Colledge, 2021). The first large scale (>500 MW) UK FOW projects are expected to use long-term debt to finance a substantial proportion of the project. This is one of the drivers of the anticipated rapid cost reduction in FOW LCOE at the end of the 2020s and early 2030s. The objective of the tender scope is to ensure the finance community understand FOW projects, technologies, risks and opportunities.

2.3. Supply Chain

The Scottish offshore wind supply chain directory (ScottishIndustryDirectories, 2021) was developed on behalf of the Offshore Wind community in Scotland as represented by their industry leadership groups with the support of Scottish Enterprise, Highlands and Islands Enterprise, and Scottish Development International.

In 2020, Scottish Renewables (Scottish Renewables, 2020) published a Scottish offshore wind supply chain directory to detail the capability of the Scottish industrial sector in regards offshore wind. Although produced in 2020 and with a focus on bottom fixed offshore structures, the report nevertheless indicates the capability present and the opportunity for the Scottish industrial sector.

However, Scotland has always faced a challenge in regard to a local supply chain being investable, capable of delivering volumes, of the right quality and, importantly, globally competitive. Through ScotWind and INTOG leasing rounds significant demand has been created. This demand aligns well with the required supply chain investment.

A study commissioned by RWE (ORE Catapult, 2021) identified potential supply chain business opportunities from the current ScotWind seabed leasing round. The study confirmed that both Scottish ports and industry have the existing experience and skills that would enable Scotland to become a world leader in producing low-carbon concrete foundations for floating wind.

The study identified four Scottish ports (Hunterston, Kishorn, Port of Comarty Firth and Ardersier) that could potentially meet the capacities required. Additionally, clusters of ports could develop a strategic supply, such as Cromarty Firth and the Forth & Tay.

Crown Estate Scotland’s “Ports for Offshore Wind” report similarly identified a need for collaborative, strategic focus on expansion of offshore wind construction and operations and maintenance capability in order to support offshore wind build-out rates (Crown Estate Scotland, 2020).

Case Study: Supply Chain Investment: BW Ideol and Ardersier Port

An agreement between Ardersier Port and BW Ideol provides BW Ideol with exclusive access to the port for the manufacture of its concrete floating wind foundations (renews, 2021). The site will comprise of 34ha of floating wind manufacturing hub for concrete foundations. Some enabling works have already commenced.

BW Ideol is one of three partners (together with Elicio and BayWa R.E) in the Floating Energy Allyance, which has submitted applications for offshore wind development rights in the ScotWind leasing round run by Crown Estate Scotland. The Floating Energy Allyance has pledged to manufacture all its floating concrete foundations in Scotland, creating almost 4,000 jobs.

UK and Scottish content will be significantly boosted, as will long-term employment, which will underpin the Just Transition to the renewable industry.

BW Ideol has positioned itself with a dual-track growth strategy, as co-developer of floating wind projects and as floating foundation EPCI (engineering, procurement, construction and installation) provider. BW Ideol has also signed an agreement to acquire a 5% ownership in the 30 MW EolMed floating wind pilot project in the French Mediterranean. EolMed is one of the first floating wind projects in the Mediterranean and is composed of three 10 MW Vestas wind turbines. EolMed final investment decision (FID) has yet to be confirmed, but construction is slated for early 2022.

Case Study: Port of Nigg

During development of this report, SSE announced investment into the Port of Nigg in the Cromarty Firth, alongside other investors within the funding syndicate. This investment was publicised along the lines of both the Just Transition, in providing up to 400 skilled jobs and re-skilling opportunities in the local area, as well as a supply chain bottleneck unlocking provision. The development also benefits from the UK Government Offshore Wind Manufacturing Investment Support programme. The objective is for the facility to be able to produce 135 next generation towers each year. Next generation towers will tend to be classed as 8 m diameter plus towers. Global Energy Group (GEG) and Haizea Wind Group (HWG) are developing the manufacturing plant. This SSE announcement and investment is, in part, driven to provide a Scottish supply chain for SSE Scottish developments, which primarily are bottom-fixed conventional offshore wind platforms. Additionally, Mainstream is also an investor and a strategic partner. While the development is focused on advanced robotic rolling of large monopiles for bottom-fixed projects, the new manufacturing plant could easily support floating wind concepts and, with the provision of significant quayside, provides the opportunity also for floating foundations.

2.4. Enabling Technology Development

Hitachi ABB Power Grids has launched a portfolio of transformer products for floating offshore wind projects (reNEWS.BIZ, 2021). This type of solution could become part of a technical solution whereby several floating wind turbines connect into a floating transformer hub, as well as adjusting voltages to match the oil and gas installation requirements.

Alternatively, a bridge connected facility could be deployed adjacent to the existing oil and gas installation.

2.5. BEIS/OGA Electrification Competition

Launched by the OGA in September 2021, this decarbonisation competition has the aim of driving down offshore emissions through related electrification projects (Penman, 2021). The following winning applications look at various ideas that could speed up essential electrification projects. The work on these projects is due by 31 March 2022, to be followed up with project reports in Q2 2022:

- Orcadian Energy, the North Sea oil firm and partners of Crondall Energy, Enertechnos, Petrofac, North Sea Midstream Partners ("NSMP") and Wärtsilä are developing concepts for electrification innovation.
- Orsted and partners of Neptune Energy and Goal7 are looking at optimal technical design for a stable and reliable power supply [for offshore platforms].
- Katoni Engineering is developing an optimised interface for distributed offshore renewable sources to supply existing installations with secure and low-emissions power.

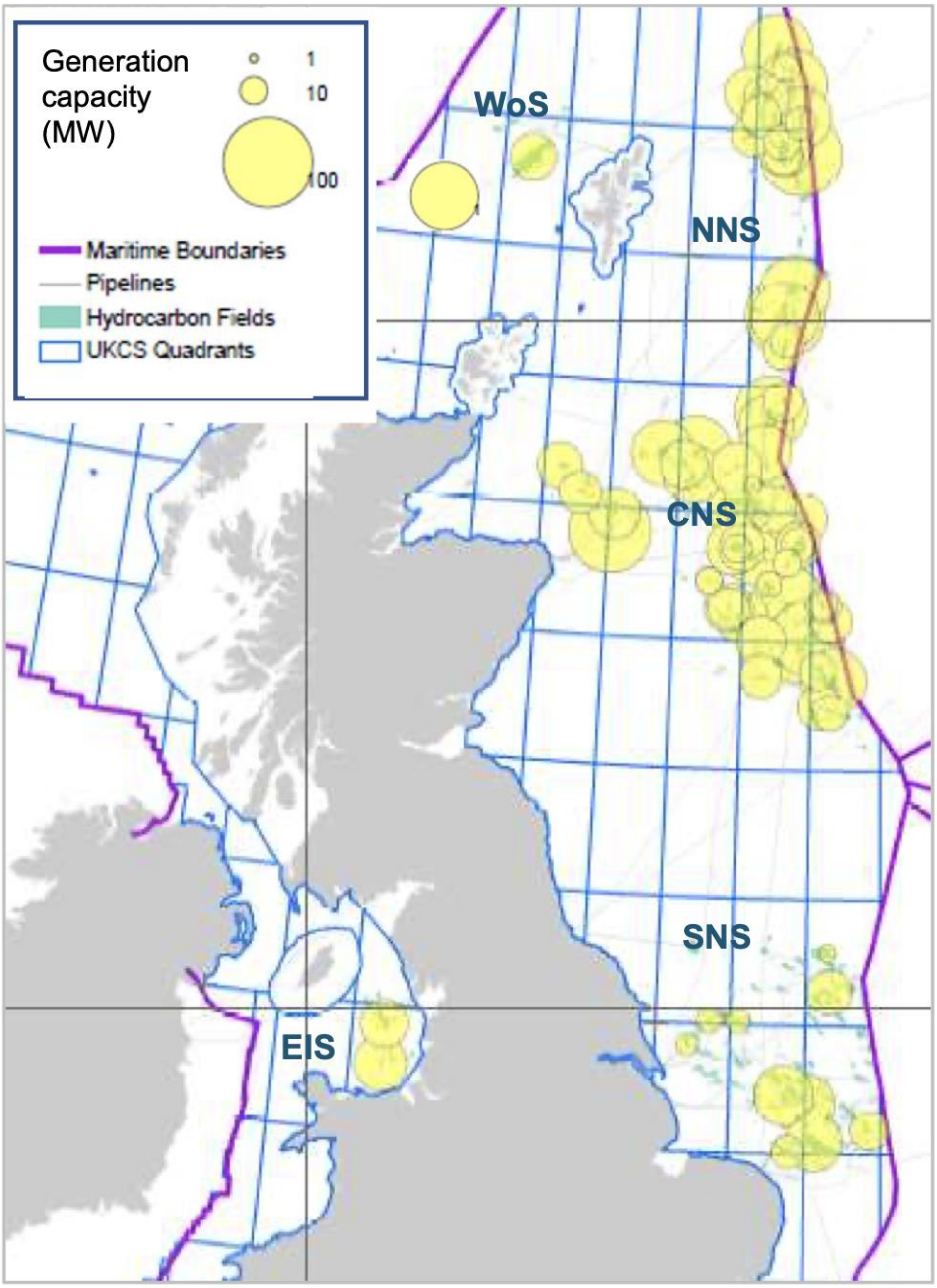

Figure 2.2. Generation Capacity by O&G Installation based on 2018 emission data and typical emission intensities and uptime for the generation equipment deployed (OGA, 2020).

The OGA has identified the Central North Sea (CNS) and West of Shetland (WoS) as key areas for electrification opportunities. This is in part because the power usage in Northern North Sea (NNS), Southern North Sea (SNS) and East Irish Sea (EIS) is expected to decline as fields reach the end of their life. Whereas 57% of UKCS power consumption is in CNS (based on 2018 data) and this is expected to continue into the 2040s due to existing asset longevity (brownfield electrification), and power demand WoS is expected to grow with new projects planned (greenfield electrification)

(OGA, 2020).

3. Opportunity for Offshore Wind

The highly competitive nature of the offshore wind market means that an Option Agreement for a developable, commercially viable area of seabed is, in itself, a valuable asset.

> Scotland's established offshore wind consent pathway, together with the highly competitive nature of offshore wind development globally and the trajectory of technology advancement for floating wind, makes the INTOG round a desirable opportunity.

Scotland has demonstrated, through the consent of Round 3 and Scottish Territorial Water offshore wind projects, that it has a reliable and robust policy framework to facilitate consent of large-scale offshore wind. Further, investment in related and supporting industries such as port and transmission infrastructure has progressed and is being significantly supported through the ScotWind announcement.

Combined with the subject matter expertise developed on the part of regulators, developers and consultancy in Scotland, the opportunity to secure seabed rights through the INTOG leasing round are highly desirable.

3.1. Scale

Crown Estate Scotland's ScotWind leasing round awarded approximately 15 GW of floating wind capacity (Crown Estate Scotland, 2022). The INTOG leasing round has a set target of 4 GW generating capacity, with a cap of 5.7GW. The following graph presents the opportunity in respect of turbine capacity. Of course, this 4 GW is expected to be spread over several INTOG lease areas, with potentially a number of projects within each area.

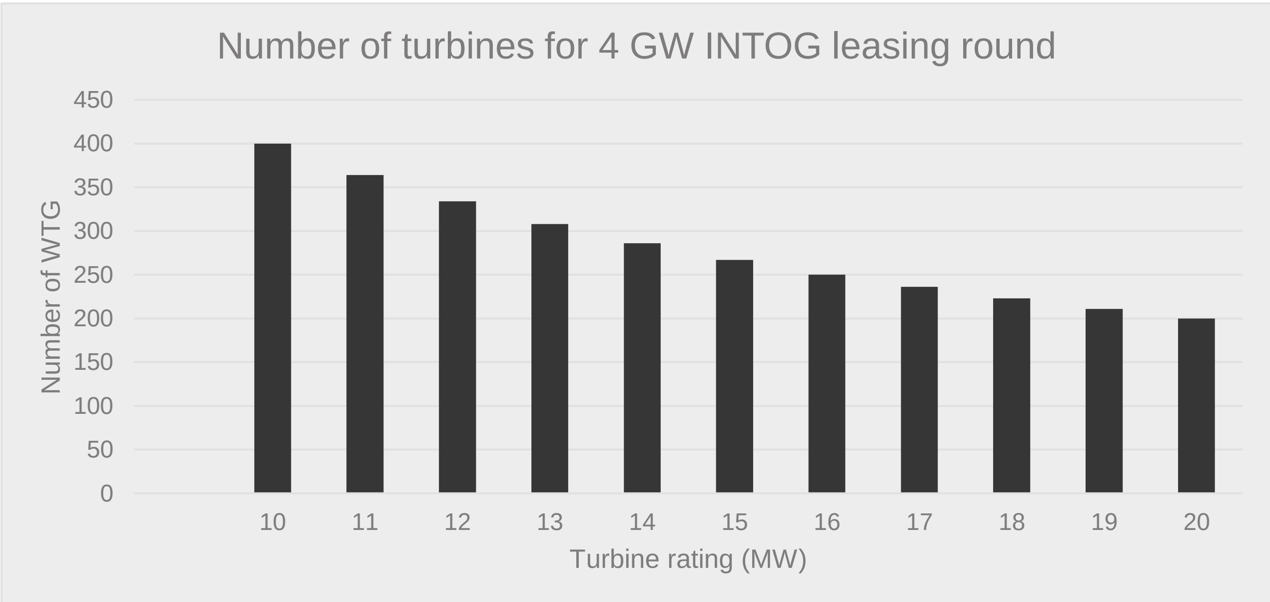

Figure 3.1 – Turbine numbers in respect of a 4 GW leasing round.

In total, Crown Estate Scotland are enabling 19G W of floating wind; this is equivalent to over 1,250 15 MW turbines. In context, the whole of the UK operational offshore capacity is currently 10.46 GW (Crown Estate Scotland, 2022).

3.2. Standardisation

Section 3.1 presents the scale of the opportunity in terms of wind turbine numbers, and Section 4.3 identified credible deployment options and capacities in respect of greenfield and brownfield oil and gas developments. Section **Error! R**

eference source not found. highlights the three winners from the BEIS/OGA electrification competition regarding supporting decarbonisation and in speeding up the process.

The OGA advises that several smaller development opportunities of the order of 70 MW may be available.

To mitigate a potentially challenging Levelised Cost of Energy (LCOE) arising from this, developers may seek to realise synergies across several developments of this scale, such as a coordinated approach to procurement, construction and operations.

Conventional bottom fixed wind farms have bespoke foundations coupled to a wind turbine of a certain class. The class of turbine and the wind environment need to align. For floating wind, it is considered that both the wind turbine and floating sub-structure will need to be designed to a certain class and that the site characteristics will dictate the classification needed. However, as the overall design is now at a class level, some of the bespoke elements of bottom fixed wind turbines have been removed. This should allow for more standardisation in the wind tower and foundation system, accepting that ground conditions for mooring systems and umbilical cables will be site and location specific.

Mooring cable and chains, and inter-array umbilical cable and protection systems are evolving. Likewise, major component exchange methodologies still include site-based (at sea) or off-site (return to port) options. Cost effective solutions and standardisation are necessary in order to reduce the LCOE.

3.3. Commercial Opportunities & Differences

Conventional bottom fixed offshore wind assets are usually supplied by the Original Equipment Manufacturer (OEM) with a five-year Defects Notification Period (DNP) and bundled with some form of warranty, again typically of a five-year duration, although options out to 15 years do exist. Some form of Long-Term Service Agreement (LTSA), usually to year 30, includes access to spare parts and technical support. This commercial relationship has the OEM undertaking the service and maintenance activities during the DNP, with the asset owner typically taking over these duties post warranty. The non-WTG assets, known as balance of plant (BoP), are typically serviced and maintained by the operator/owner (generally a single entity).

INTOG changes this dynamic. Electricity from the WTG is not necessarily the developer or operator’s core business, but it is a critical component part of being able to deliver core oil and gas exploitation at a lower emissions level. This creates several opportunities:

1. A party needs to be the INTOG wind generator operator. That is, a party needs to be in control of the wind generation asset from a commercial, contractual, operational and emergency response perspective. This may not be the installation operator (but could be).
2. Maximising Yield through the warranty is not the Key Performance Indicator (KPI) under INTOG. A reliable working asset is the requirement. Potentially, the warranty aspect could be replaced with a much simpler and much cheaper provision.
3. A party needs to be responsible for asset maintenance and fault rectification. The traditional WTG and BoP split may not be an optimal commercial approach in regard to INTOG[1].
4. The oil and gas operator will already have a significant vessel spread and emergency response provisions. Maximising synergies between existing capability and the requirements of floating wind will result in cost optimisation.

[1] Vessel costs and personnel costs for far offshore assets are likely to be the two main standing cost sources. INTOG projects will comprise developments smaller than conventional commercial scale offshore wind projects. Effective use of associated vessels and personnel will require optimisation.

3.3.1. Asset Operation and Optimisation

The conventional model adopted by the offshore wind industry is for the asset owner to operate the infrastructure, with the OEM taking a supplier role. As operation of floating wind does not necessarily comprise core business activity for O&G operators this presents an opportunity for other parties, such as the wind turbine OEM, to adopt the operator role. This has potential to reduce interfaces and therefore drive down LCOE.

For cost and emission reduction optimisation, the developer needs to maximise use of available wind power. This wind derived energy has an intermittent profile, resulting in outputs from zero MW through to the rated power of the turbine. While the wind profile and wind turbine output can be well forecast, cost and emission reduction optimisation will only occur if the oil and gas production processes use all of the available energy and, where possible, look to energy demand optimisation to reduce loads, where practical, in periods of low wind. This is considered to be more practical on greenfield developments rather than brownfield.

3.3.2. The Maintenance Provider

The maintenance provider services the assets, fixes faults and monitors the asset in regards performance, safety and regulations. The distance from shore provides that remote monitoring and maintenance should be designed into the projects to minimise human intervention. With the cost of offshore activities, the lowest cost method of maintaining the assets is for a single party to be responsible for the entire asset. This allows for holistic maintenance activity and minimum intervention.

The logistics required to service and maintain floating offshore wind is likely to include walk to work vessels. This is primarily due to the distance from shore and the prevailing sea state encountered in these locations. Norwegian energy company Equinor has recently chartered a service operations vessel (SOV), the *Stril Server*, for work on the 88 MW Hywind Tampen floating offshore wind farm off Norway. This will not be an insignificant cost, although opportunities may exist whereby oil and gas operators already have such walk to work vessels on charter. The relative motions between a dynamic positioning vessel and a floating turbine may require walk to work control system changes and optimisation, although there is limited available experience of this.

With the above model, true economies will be returned when multiple O&G owners in a geographic location opt for the same technology and the same operational model. This would allow vessel utilisation and overall maintenance strategy to be optimised.

4. Innovation and Targeted Oil and Gas Decarbonisation (INTOG)

4.1. INTOG Leasing

The INTOG leasing round was launched in February 2022 with the publication by Crown Estate Scotland of the Leasing Information Document and will be based on projects of two forms, as outlined below. Further details of the INTOG Initial Plan Framework and the associated INTOG leasing rounds can be found in the references.

4.1.1. Innovation (IN) Projects

The INTOG leasing round is a process by which developers will be able to apply for seabed rights for small scale (less than 100 MW) innovation projects (discussed in Section 6.2).

4.1.2. Targeted Oil and Gas (TOG) Projects

There will be no minimum or maximum project capacity for TOG projects subject to the minimum requirement criteria to be satisfied by Applicants as detailed in the Leasing Information Document. However, the maximum seabed area per project will be 333km² with a minimum density requirement of 3MW/ km².

4.2. Sectoral Marine Plan

Crown Estate Scotland's 2020–23 Corporate Plan commits to a plan-led approach, where leasing is aligned with Scottish Government's marine spatial plans. The adopted Sectoral Marine Plan (SMP) for Offshore Wind Energy (Marine Scotland, 2020) provided the spatial framework for commercial scale offshore wind farms delivered by the ScotWind leasing round.

Within the adopted SMP, there was provision for consideration of a future leasing round to enable small innovative projects and larger projects aimed at the decarbonisation of the oil and gas sector. In August 2021, the Scottish Government confirmed it would be undertaking a new spatial planning exercise for Innovation and Targeted Oil and Gas projects.

The outcome of the planning process will be a new SMP for offshore wind for INTOG. The Scottish Government does not expect to publish the final plan until Autumn of 2023; potential INTOG projects will therefore be able to apply to Crown Estate Scotland for Exclusivity Agreements at an earlier stage. The draft plan will be based on the projects that are awarded Exclusivity Agreements. Only projects included within the final plan will be awarded Option Agreements.

The Initial Plan Framework identifies 4 GW of power requirements for oil and gas installations through targeted oil and gas projects (Scottish Government, 2022). The Initial Plan Framework also identifies an additional 500 MW of capacity for innovation projects (which must not exceed 100 MW) Projects seeking to support decarbonisation/electrification of the oil and gas sector may be >100 MW and must provide electricity to decarbonise the installation and the production of oil and gas. Conversion of energy to other fuels may be a component but not the primary purpose of the project.

The locations for targeted oil and gas decarbonisation projects and areas of exclusion for INTOG projects are presented in Figure 1.1

4.3. Asset Location

Marine Scotland's planning process will define the location of the INTOG seabed agreements. Due to the disparate nature of oil and gas installations, and therefore INTOG projects, it is likely that potential scenarios for development of offshore wind projects will fall into the following designs.

4.3.1. Single Large Installation

To illustrate the type of practical deployment for floating wind, a nominal 'single large oil producing installation' was considered. This was an installation with a demand of around 60 MW (peak) driven by oil process and export. While the 60 MW peak, which is caused by large machine start-up such as compressors, is temporary, the installation has a constant 24/7 load demand of around 40 MW.

If a 14 MW wind turbine[2] was selected, then around three such turbines would be required, all operating at full load – see Section 6.4 for comments on capacity factors. To cover the start-up peak power, typically five turbines would be required.

This variance between 3–5 wind turbines creates a potential requirement to install capacity that would only be used sporadically and otherwise may be curtailed. An optimal design would ensure supply matched demand, and the two would be reasonably constant. Section 6.7 further discusses alignment of supply and demand.

The wind resource is intermittent, so the wind profile for the turbine site will be key in aligning wind based electrical generation with the oil and gas installation's demand. This wind regime is discussed further in Section 4.3.3.

The final number of deployed turbines would connect into the oil and gas installation by an umbilical electrical cable (array cable). Array cables are further detailed in Section 6.5, and the choice of direct connections and radial connections would be part of each oil and gas installation electrification design. There may be aspects of the solution presented in Section 4.3.2, Adjacent Large Platforms , that would equally apply to some single large platforms.

4.3.2. Adjacent Large Platforms

In contrast to the single oil and gas installation, a small field of platforms was considered. The platforms would typically be in visual sight of one another, and these platforms may have differing functions and roles, rather than a 'single oil producing and pumping installation'.

In this case study, five 'medium' platforms were considered. Each installation, although having a specific function, has a power demand peak of 40 MW, with a resultant field total of 200 MW (peak). Note it is unlikely all installations would require start up concurrently, though the prior discussion on peak power and supply and demand is equally relevant for this case study. However, in this case study, the flexibility of the whole field's electrical demand can be further optimised, including between platforms.

For a peak demand of 200 MW, around 15 Wind Turbine Generator (WTG) would be required. There are many options for the physical layout to connect these 15 WTG to the five platforms, and a cost benefit analysis would be needed for each potential deployment.

4.3.3. Wind Resource

The single large installation, and adjacent large platforms identify several opportunities, as well as a number of design and implementation challenges. In particular, the risk of experience periods of little or no wind generation needs to be considered.

An example of the country experiencing little to no wind arose on 17 December 2021 due to a high-pressure system sat over the UK. The UK grid power provision split by energy source is provided in Figure 4.1. UK demand was 39.25 GW, and wind only accounted for 2% of this supply (0.804 GW), as shown in the GB Electricity National Demand and output per production type (GridWatch, 2021). In contrast, wind generation had peaked at 14.286 GW earlier in the year.

It is therefore evident that for oil and gas platforms to be able to have the option to operate 24/7, alongside floating offshore wind other forms of generation are still required. Section 6 discusses energy storage opportunities with both

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2 Typical size of turbines being planned for deployment currently – expected that for INTOG deployment this size of turbine will be fairly standard, and options may exist for larger turbines.

batteries and hydrogen. However, for these to be of use, additional wind generation would be required. The topic of over planting is discussed in Section 6.7. The two previous case studies also discuss alignment between generation and demand. However, it is expected that a base load minimum value of power consumption exists for each installation, and this would always need to 100% certain.

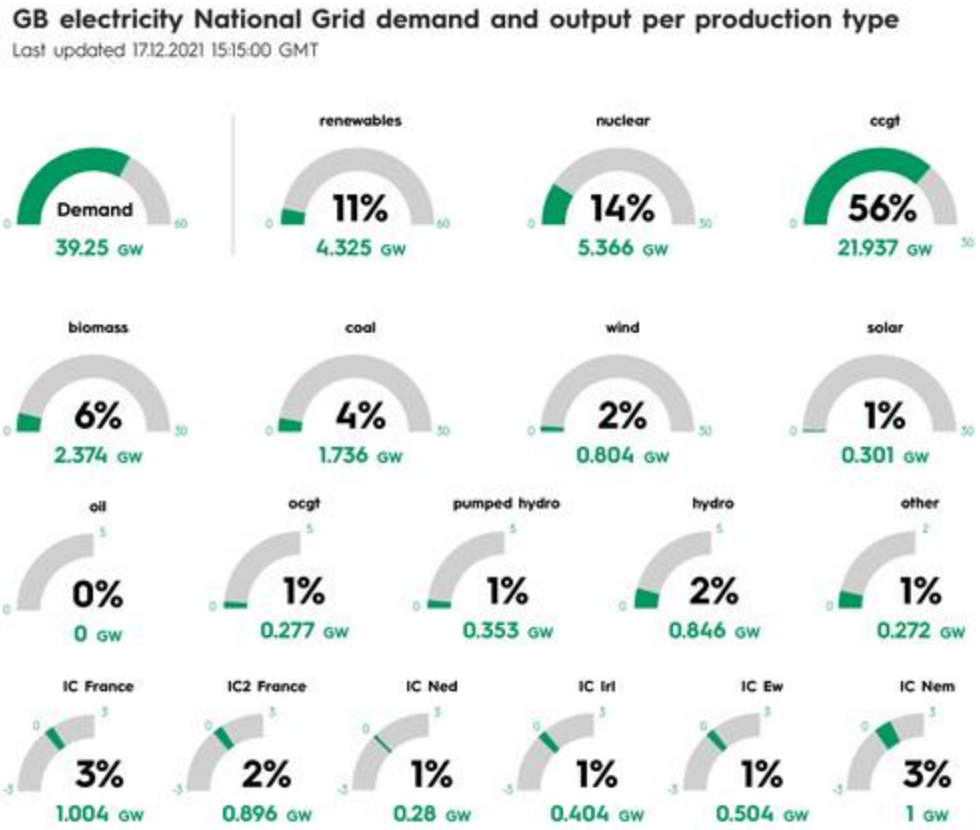


Figure 4.1 Low wind energy yield example (GridWatch, 2021).

Subject to realisation of engineering constraints, floating wind is an ideal partner for providing a source of clean energy to help decarbonise the production of oil and gas. The opportunity is in reducing emissions from oil and gas production, achieved through deployment of floating wind and the optimisation of the use of all such green energy, displacing other forms of hydrocarbon-based power generation.

4.4. Market Participants

Through engagement with the OGA (OGA, 2021) Natural Power was advised that the demand for renewable power from oil and gas operators will likely exceed 1 Giga Watt (GW), requiring up to 4 GW of installed wind power due to capacity factor considerations.

This is a high-level estimate and will be subject to design and installation requirements as noted throughout this report.

A number of opportunities and advantages bespoke to the INTOG leasing round are set out below.

4.4.1. Integration with ScotWind

There may be opportunity for integration of ScotWind offshore wind farm developments with those of INTOG. Several technical options exist. However, regulation, as briefly mentioned in Section 4.4.3, may require clarification or modification.

A number of technical options exist for integration ScotWind and INTOG projects which would present advantages to both. While this list is not comprehensive it exemplifies opportunities that exist between projects.

- **Utilising ScotWind offshore wind farm substations as hub connection points for INTOG**
  - This could be the route for direct installation electrification with no additional deployed assets.
  - To provide a grid connection for INTOG deployed floating turbines, to allow oil and gas assets to maximise local wind generation and import the balance from the grid (thereby, effectively providing grid connection to the installation).
    - This could also provide a direct Power Purchase Agreement (PPA) from the oil and gas installation to the ScotWind project.
- **Utilising the nearest ScotWind offshore wind turbine as a connection point for INTOG**
  - This would reduce the geographical distance of the connecting cable, but it would require a bespoke ScotWind wind farm radial circuit design and a bespoke turbine electrical design.
  - This may be supported by the National Grid ESO Holistic Network Design (National Grid ESO, 2022).

4.4.2. Oil and Gas Electrification Development Drivers

It is considered that there are several development drivers for the oil and gas sector in the electrification of platforms (UKEITI, 2022).

- The environmental, social, governance and ethical need to de-carbonise production to reach and exceed net zero emissions targets. Importantly, this net zero position accepts that oil and gas, to a reduced extent, has a place to play through to and beyond net zero.
- The opportunity to be an integral part of what is becoming and will become the future of the UK's energy solution and to shape and steer from within. Essentially, the path to net zero and beyond, for oil and gas developers, will require a strategic realignment and re-assessment of operating plans and associated budgets.
- Licensing conditions on new platforms and development fields, requiring such greenhouse gas reductions and achieved through installation electrification (other potential sources of de-carbonisation do, of course, exist).
- The recent implementation of the UK Emissions Trading Scheme (ETS) driving year on year CO_2 emission reductions through available allowances or purchase of additional allowances. At a point in time, the cost of electrification becomes financially attractive.
- Capital Asset Tax Allowances for the oil and gas sector, which provide some relief for the capital expenditure. Plant and Machinery Allowances (PMA) are available on capital expenditure on items of plant or machinery used in the ring fence trade. Mostly these are 100% First Year Allowances (FYAs), which allow the full amount of the expenditure to be written off for tax purposes in the accounting period in which the expenditure is incurred. Ring Fence Expenditure Supplement (RFES), which are designed to assist companies that do not yet have sufficient ring fence corporation tax (RFCT) profits against which to set their exploration, appraisal and development costs. The RFES currently increases the value of unused expenditure carried forward from one accounting period to the next by a compound 10% a year for a maximum of 10 years (six years prior to 2014). The company can elect which periods it wants to claim RFES for. They do not have to be consecutive years. The oil taxation manual provides further guidance on RFES. Additionally, legislation in the Finance Act 2015 introduced a new Cluster Area Allowance, which aims to support large development projects in areas of high pressure and high temperature, encouraging exploration and appraisal in the surrounding area (or "cluster"). The allowance is generated by incurring capital expenditure and certain types of operating and leasing expenditure within the cluster area. The value of the allowance is 62.5% of the qualifying expenditure incurred. Any allowance

generated is carried forward year on year until it is activated. Allowance is activated by production income from the cluster area. Once the allowance has been activated, it is set against profits subject to the supplementary charge (SC) so that any such profits are only subject to RFCT at 30%. The OGA determine such Cluster Areas, which include the Central North Sea.

4.4.3. Market Players

The electrification of oil and gas platforms would reduce emissions by replacing the conventional power generation (diesel generators and gas turbines) with floating wind, in the context of this report's focus. However, this alternative power generation is currently not a core business aspect of the oil and gas sector. This is in contrast with the current offshore wind market, where the development, construction and operation of offshore windfarms is a core business activity for the parties involved.

For INTOG this raises an opportunity in the definition of who the offshore wind operator will be. For example:

- **Existing wind developers**.
  For existing, experienced developers, the business case derived through INTOG will be quite different. Several major differences and potential opportunities exist, such as:
  - The potential for no grid connection costs, no OFTO, no Transmission Network Use of System (TNUoS) charges and no network reinforcement requirement or timing constraints linked to grid connection dates.
  - An automatic 100% offtake agreement with the O&G installation operator.
  - A wind generation asset that can potentially be moved (between sites and even customers)[3]. Note this assumes floating devices may be deployed in alternate locations subject to revised planning consent and installation of necessary mooring and electrical export infrastructure.
- **New Operators into the market**
  - For new operators, potential opportunities exist similar to established developers. Novel ownership and responsibility models, such as division of ownership and operational activities for wind assets, may provide opportunity for new market entrants.
- **O&G developers with no renewable energy knowledge but using INTOG as a step-up opportunity**
  - For O&G operators, the opportunity to develop into the renewable market exists and in a relatively low risk manner. The offshore wind sector in Scotland is quite mature, with many expert providers readily able to fill the short-term skills gap and support O&G developers in expanding their offshore wind knowledge.
- **O&G developers (already with renewable project experience)**
  - A number of O&G developers are already in partnership with experienced offshore wind developers. INTOG provides an ideal opportunity for O&G developers to optimise the benefits of floating offshore wind when coupled with oil and gas platforms and processes.

4.4.4. Development Pathway

It is anticipated that the development process for INTOG floating wind assets will follow the same process as existing offshore wind projects. Due to INTOG sites being further from shore, constraints such as ornithological impact may be comparatively reduced. Subject to appropriate agreement with regulators, this could reduce consent risks and challenges.

Alternative offtake solutions, such as connection to Oil and Gas assets, may also reduce consent requirements on projects.

Supply chain commitments are comparable to ScotWind requirements, so they will be considered by INTOG applicants accordingly.

[3] This may be of value in brownfield development sites, where the life expectancy of the wind asset exceeds that of the remaining life of the brownfield asset.

5. The Need for Transition

Both the UK and Scottish Governments have placed transition to net zero at the heart of their policy agendas. In October 2021 the UK Government issued its net zero Strategy: Build Back Greener, which underlined its commitment to end contribution to climate change by 2050 (HM Government , 2021). The Scottish Government has adopted the same target by 2045, with interim targets of 75% reduction by 2030 and 90% by 2040 (UK Government, 2021).

The North Sea and surrounding waters' oil and gas supplies have been at the heart of the UK's energy provision for over fifty years. Although output from these assets is forecast to decline, from current levels and through to 2030, there is a clear need for supplementary determined action to support the transition to net zero. In particular, the UK Government's legally binding commitment to net zero emissions by 2050 applies to regulatory authorities such as the OGA.

5.1. Sector Deals

As part of the UK's Industrial Strategy a series of partnerships have been established between government and industry on sector-specific issues with the intention of creating and enhancing productivity, employment, innovation and skills (BEIS , 2019). These have led to demonstrable success in a number of areas.

The Offshore Wind Sector Deal was published in March 2019 and updated in March 2020 (BEIS, 2020). This agreement sought to build on the UK's strong position in the offshore wind market. As well as detailing some topic-specific challenges and opportunities for the sector, it made a series of targets and commitments, principally:

- provision of visibility of future Contracts for Difference rounds;
- commitment to enhance UK content in projects;
- increase representation of women in the workforce;
- setting ambitious export targets;
- targeted investment in supply chain, including establishing the Offshore Wind Growth Partnership to support productivity and increase competitiveness.

5.1.1. North Sea Transition Deal

The sector deal between the UK Government and the offshore oil and gas industry is known as the North Sea Transition Deal. By creating the North Sea Transition Deal, the UK Government and the UK's oil and gas sector are ambitiously seeking to tackle the challenges of reaching net zero while repositioning the UK's capabilities to serve the global energy industry.

Bodies such as the Committee on Climate Change have made clear that there will still be a requirement for oil and gas in 2045, though that requirement will be much reduced compared to what it is today. Strategies such as Roadmap 2035 from OEUK have begun to set out the role industry believe they can play in a net-zero economy.

BEIS and the North Sea Transition Deal sets out the five major aspects of the deal:

- supply decarbonisation
- carbon capture, usage and storage
- hydrogen
- supply chain transformation
- people and skills.

The INTOG leasing round supports the decarbonisation of supply of the oil and gas industry, in support of Just Transition and net zero targets in the UKCS.

> Earlier this year, the UK's North Sea Transition Deal set a target to reduce emissions from oil and gas production by 50% by 2030. This ambitious target has focused attention on installation electrification.

Just Transition is being realised in Scotland through the Just Transition Commission. The first Just Transition Commission was set up in 2018, and the second in 2021. The Commission is tasked with planning for and enabling Scotland to not only deal with the challenges that the journey to net zero will create, but to grasp the opportunities that such a journey will provide. The future of employment and skills are central to this journey. However, in marked contrast to other countries, the Commission has broadened the scope of its remit to also try to include a degree of levelling up of historic injustices, as well as a broader scale of both domestic and industrial consultees.

5.2. Electrification and Offshore Wind

This report focuses on two key hydrocarbon producing areas: WoS , as the last significant development area in the UKCS, and the CNS , as a significant cluster of existing installations with more than 15 years of production life remaining. These two production areas were defined based on different opportunities:

- WoS: where greenfield operations are planned. That is, new installations with the ability to include electrification as part of the initial installation design. This is considered to be the cost optimal approach, removing the need for offshore conversion.
- CNS: where installations have in excess of 15 years' production life remaining. This criterion was selected as a balance between electrifying existing installations and achieving a level of financial payback, accepting the significant development and deployment time, not only for offshore wind, but in installation modifications. In certain circumstances, the payback may be achievable on installations with a shorter production life.

5.3. Case for the Electrification of Oil and Gas installations

The need case for electrification of oil and gas infrastructure is described above, and driven by the ambition to deliver a net zero economy.

Using data from the Environmental and Emissions Monitoring System (EEMS), which provides the offshore industry with an independent source of totalled environmental data, the OGA report states that 70% of UKCS O&G emissions (~10MtCO_2) are due to power generation, thus concluding "electrification is an essential response by O&G industry to net zero" (Oil & Gas Authority, 2020).

With the provision of power predominantly from onsite generation (diesel generators and gas turbines) using fossil fuels, electrification serves to abate these emissions. Often the fuel for the power generation is imported diesel or gas, again bringing OPEX and logistics related emissions that can be reduced/eliminated through electrification. Even in cases where operators use associated gas from production as fuel gas for power generation, there are potential economic benefits to electrification, not least due to increased revenue from gas sales.

While this report focuses on installation electrification as the decarbonisation solution, there are other carbon sources which will be the subject of different technology and operating solutions in the overall drive to reduce emissions. These other carbon sources are in the region of 30% of the UKCS GHG emissions (Oil & Gas Authority, 2021) and encompass activities such as flaring and venting.

5.4. Case for Electrification through Offshore Wind

In some instances, power from shore may be the most attractive option for oil and gas operators. However, often that is not the case. This is particularly relevant when considering the geographic proximity of oil and gas installations to suitable grid connections. At distances beyond 150 km, High Voltage Alternating Current (HVAC) power transmission is technically challenging and High Voltage Direct Current (HVDC) transmission cost prohibitive. For example, the Shetland HVDC will be 260 km, and the Office of Gas and Electricity Markets (OFGEM) has set an allowance of £642m for the project (reNEWS, 2021).

Advantages of offshore wind over onshore grid connection

It should also be acknowledged that the UK grid continues to rely on fossil fuel generation, so it also has associated emissions. In this sense, offshore wind offers four primary advantages over power from an onshore grid connection

- **The onshore grid is not without emissions**: the average for the year 14 December 2020–14 December 2021 was 42% fossil fuel (Morley, 2021). Thus, the connection to the onshore grid still comes with significant emissions.
- **Proximity to shore does not directly align to proximity to onshore grid** and indeed a technically feasible connection point with available Transmission Entry Capacity (TEC). Creation of such a connection point typically takes significant time and investment.
- **Many of the opportunities are beyond 100 km for a shore grid connection**. This distance introduces technical and economic feasibility issues related to losses and HVDC transmission. By deploying offshore wind developments in the proximity of the demand, these technical and economic challenges are resolved.
- While hydrogen is not part of the targeted offshore wind leasing process, it **could open opportunities to re-use some of the oil and gas infrastructure for hydrogen production**.

There are also potential secondary benefits, including:

- creation of a dedicated microgrid, which is more appropriate to the provision of power to oil and gas installations;
- less complex route to market, derived from direct negotiation with the power purchaser and the absence of grid power supply regulations;
- the opportunity, subject to applicable regulation to inter-connect installations, with other offshore electrical systems, primarily Offshore Transmission Owner (OFTO) assets. By connecting oil and gas installations to the National Grid in this way, this would avoid the need for any kind of storage requirement or alternative electrical production.

The next best alternative for decarbonisation appears to be Carbon Capture and Storage (CCS). This is technically challenging on individual offshore installations and on a longer timeframe than electrification, particularly as the Acorn Project was not prioritised in the UK Government's first round prioritisation of CCS projects, notwithstanding the Scottish Government's offer of support for the project. (Acorn Project, 2021) (Askeland, 2022).

The following Case Study provides an overview of Norway's progress in electrification of the oil and gas sector.

Case Study: The Norwegian Example

Like the UK sector, the Norwegian oil and gas sector has also identified electrification as a key element to decarbonise the sector. Equinor states: "Electrification in the North Sea is one of the main measures to reach our climate ambitions for the next decades" (Equinor, 2022) and is well underway in the process of electrifying projects.

Equinor's Hywind Tampen will be the world's first floating wind farm to power offshore oil and gas installations. It will consist of 11 floating wind turbines delivering a total capacity of 88 MW. This will provide ~35% of the annual electrical power required by five existing installations: Snorre A and B and Gullfaks A, B and C. It is expected this project will reduce CO_2 emissions by 200,000 tons annually. Equinor states the wind farm is set to be a test environment for further developments, including the integration of power systems for both gas and wind (equinor, 2022).

It should be noted that the Norwegian Government provided a grant of 2.3bn Norwegian Krone (NOK) for the Hywind Tampen project (Durakovik, 2020).

Further, the Norwegian Petroleum Directorate (NPD) reports that sixteen fields currently have or have decided to use power from shore. When all these projects are targeted to become operational in 2023, it is expected that power from shore will account for around 45% of overall production of oil and gas on the Norwegian shelf, resulting in avoided emissions estimated at 3.2 million tonnes of CO_2 per year (Norwegian Petroleum Directorate, 2022).

The Norwegian electrification success has primarily been driven by economic policy: emissions trading and CO_2 taxation.

The combined impact of these levers is approximately NOK 700/tonne of CO_2 (~£58/tonne of CO_2) (Norwegian Petroleum Directorate, 2022). It is not beyond the realms of possibility that UK policy makers take a similar approach to driving decarbonisation of the UKCS, which improves the economic viability of offshore wind to electrify installations. The Hywind Tampen project was also subject to NOK 2.3bn (£192m) support from Enova SF, a government enterprise responsible for promotion of environmentally friendly production and consumption of energy.

5.5. UKCS Electrification

There are already electrification projects under consideration in the UKCS. These include a greenfield development proposing a dedicated floating wind power supply to production and wellhead installations and indications that a brownfield decarbonisation project using floating wind is under consideration. Additionally, the Shetland Islands Council's ambitious Orion Project vision sets out an integration of renewable energy and green products such as hydrogen and ammonia with the target of providing more than 3 GW of wind generated electrical power to Shetland, the UK grid, generating green hydrogen and electrification of the offshore oil and gas sector (Shetland Islands Council, 2022).

5.6. Timeframes

> The [oil and gas] sector has already responded to the UK's 2050 net zero targets… the Deal's new early targets correspond to an absolute reduction in production emissions of 10% in 2025, 25% in 2027, and 50% in 2030 on the pathway to net-zero by 2050. (Department for Business, Energy & Industrial Strategy, March 2021).

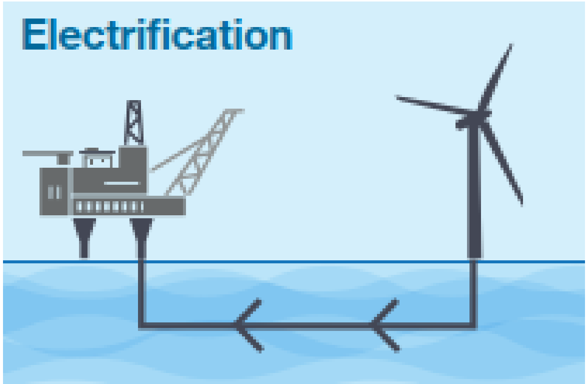
The Scottish Government has set a range of targets and ambitions to cut greenhouse gas emissions and to generate more energy from renewable sources. The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 commits the Scottish Government to reach net zero emissions of all greenhouse gases by 2045. It also sets out interim targets of cutting emissions by 75% by 2030 and 90% by 2040 against the 1990 baseline. The Scottish Government has set a target to generate 50% of Scotland's overall energy consumption from renewable sources by 2030. Furthermore, the North Sea Transition Deal commits to a 50% emission reduction target by 2030.

The North Sea Transition Deal aims to deliver on the commitments of this white paper. It includes the following:

1. The sector committing to early targets for the reduction of greenhouse gas emissions from production against a 2018 baseline and the UK Government identifying potential funding opportunities for early offshore electrification.
2. Achieving a 60 Mt reduction in greenhouse gas emissions, including 15 Mt through the progressive decarbonisation of UKCS production over the period to 2030.
3. Moving away from unabated greenhouse gas emissions resulting combustion of fossil fuels will be achieved through a combination of energy efficiency, electrification, alternative decarbonised energy and the use of carbon capture technology.

6. Technology Solutions

The commitment to electrification of offshore production installations is clear, as noted in Section 2. A key opportunity herein is to use offshore wind as means of production for the electrification of oil and gas installations. This section will explore this opportunity further.



6.1. Floating vs Fixed Wind

Offshore wind development has progressed to date through use of fixed foundation technology, which is more suitable and commercially feasible in shallow water depths. Fixed and floating technology reaches cost parity from around 60 m water depths (Empire Engineering, 2020).

Floating wind is the technology focus of this report (see Section 2.2 of this report). This is driven by the need for a low-carbon source of energy, the location of the demand and the characteristics of these demand locations: far offshore, deeper water than has been used for fixed foundation wind to date, as well as a good wind regime.

6.2. Grid connection

There are a number of considerations regarding the economics and practicality of obtaining a grid connection for potential INTOG projects. The nearest landfall location does not necessarily align with an available grid connection point. It should also be noted that potential grid connection points may not be readily available; capacity constraints and grid strengthening works are often required. Grid connection strengthening works are further constrained by a backlog and pipeline of works, often resulting in a significant timeline for provision.

- Being connected to the grid allows the grid to act as a battery, potentially absorbing excess wind turbine generation and sourcing additional power when demand exceeds turbine supply. It would provide a reliable power supply to the installation while making maximum use of renewable energy generation. This approach would naturally require a detailed, site specific assessment of grid connection cost, complexity and programme implications.
- Off-grid solutions require closer alignment between supply and demand. However, the ability to 'dial-down' output from a wind turbine is a readily available function. Such turbine output reduction does reduce the overall efficiency and the business case. A more likely scenario is that additional/back-up power generation sources are needed to meet the needs of the installation due to the Capacity Factor, as discussed in Section 6.4.

Offshore wind developers bury both grid connection cables and array cables. While this is essentially a risk mitigation activity to prevent cable damage, it is also a legacy way of doing things. Some sites, due the nature of the seabed mobility, would certainly require such cable protection. In contrast, O&G pipelines may or may not be buried and indeed, some bootstrap inter-connector cables or inter-Scottish island connector cables are not buried, primarily due to the cost. In the development of the installation electrification business case this aspect, the risk of burial/non-burial and the opportunities inherent in asset sharing as described in Section 7.2.1 should all be taken into account.

6.2.1. Grid connection technology

The UK transmission grid is primarily based on Alternating Current (AC). Electrical losses are minimised through efficient selection of transmission voltages: longer distances incur lower losses at higher voltages. However, at certain distances, Direct Current (DC) becomes the optimal technology. Both technologies, AC and DC, when transmitting power to and from shore, will do so at voltages optimised to reduce losses. These voltages are in the region of 220 kV rather than the lower voltages required on platforms. This results in grid connections requiring offshore substations to reduce the transmission voltages down to installation levels. Additionally, some oil and gas installations may use 60Hz rather than 50Hz power which may require consideration.

As space and weight on most platforms will be at a premium, another form of substation provision will be needed, such as a bridge connected additional installation. For DC connections, an offshore conversion substation will also be required, converting from DC to installation AC use.

6.3. Layout

Offshore wind projects in the UK have generally adopted two lines of orientation in their layout, in accordance with Maritime Coastguard Agency (MCA) guidelines (currently Marine Guidance Note 654 (Maritime and Coastguard Agency, 2021)). It is likely that INTOG projects may deploy fewer wind turbine generators (WTGs) providing opportunity for optimisation of layouts. There will also be additional seabed and marine operational constraints to be considered. Where used, the co-ordination of catenary mooring lines is going to be a specific sector challenge. The ORE Catapult cover this topic in good detail (Jump, 2021).

6.4. Foundations and Metocean Conditions

There are a number of foundation types being proposed for floating offshore wind turbines by different parties, such as spar, semi-submersible, barge and tension leg platform. It is considered likely that foundation design types will exhibit different behaviours with respect to metocean conditions. For example, a spar design will be less susceptible to wave loading than a semi-submersible design due the difference in foundation surface area. However, there is limited experience in regards the behaviour of foundations, particularly where metocean conditions are significant. For the more exposed sites, such as WoS (where some areas are also in excess of 1000 m deep), there could be a significant challenge in developing floating wind projects.

A detailed narrative of all floating technologies and operations is outside the scope of this report. However, the ORE Catapult produced an excellent summary of the technology, along with case studies. Foundation types, materials, mooring configurations, electrical configurations, maintenance and logistics are discussed in detail in their report (ORE Catapult, 2021).

6.5. Array cables

Array cables connect the wind turbines, usually to the offshore substation. WTGs export AC power at typically 33 kV or 66 kV. Array cables often are installed as radial circuits, with 4–6 WTG being connected in series, before connecting into the offshore substation. However, for O&G, the use of radial circuits may not necessarily be the optimal choice. There will also be additional seabed and marine operational constraints to be considered. Array cables convert into umbilical cables. These are the electrical risers which extend from the seafloor to the floating wind turbine and/or the installation. For major maintenance, such as blade replacements, some combinations of floating foundation type and turbine may require that the installed wind turbine is disconnected from the array cable (and mooring lines) and towed back to a maintenance port. This type of maintenance strategy therefore requires an array and umbilical cable design which facilitates such dis-connection and re-connection. Further, if a number of wind turbines are connected on a radial circuit, the potential removal of an inter-connected turbine, for maintenance purposes, needs consideration.

An option is to directly connect individual wind turbines into the installation. This may be easier for greenfield than for brownfield installations because cable entry points, terminations and voltage step-down transformers can all be designed in conception. Use of an additional installation to act as an offshore substation may also be viable in certain circumstances, such as brownfield conversions and perhaps in a hub concept of a number of local installations.

6.6. Capacity Factor (CF)

Wind turbines have a nominal rated output, such as 10 MW. However, the turbine will only produce this rated output when the wind regime is in a suitable range. Each WTG has a power curve which details the relationship between output power and wind speed.

Over a typical year, due to the varying wind regime, a WTG will generate only a percentage of what it could have produced, had the wind speed been constantly in the zone where the WTG could have generated full power. This percentage is called the capacity factor. Typically, a modern WTG will have a capacity factor in the region of 45%–50% in good offshore locations.

This aspect for oil and gas production is key, as the CF is an average metric over a year. During some hours of the day, the output could be zero. At other times it may be half of rated power or full power. For O&G, this variability, which can be reasonably well forecast, needs to be aligned with production needs and processes. The more that the O&G production processes can align with the wind resource profile, the greater the opportunity to reduce emissions.

However, the net effect of relying on an intermittent source of energy such as the wind is that some form of back-up power will be needed to ensure 24/7 operations.

6.7. Over planting and storage

One potential method of providing such back-up power is to over plant. Over planting is a technique where more generation capacity is installed than demand requires. If power is generated in excess of demand, it can be stored and then released when demand exceeds wind production, this will help to smooth out the demand/generation cycle and potentially further reduce emissions (had fossil fuel sources been used for this back-up period).

This is addressed within Crown Estate Scotland's INTOG Leasing Information Document (Crown Estate Scotland , 2022), which limits Targeted Oil and Gas projects to a capacity of 5 times the annual oil and gas installation power requirement.

6.8. Other Technologies

This report has focused on the role that floating wind could have in the electrification of oil and gas platforms. There are complementary technologies which could have a role to play in optimisation of the integration between floating wind and oil and gas production. At this point in time, these alternative technologies are considered to be challenging in terms of cost, particularly considering the end objective of reducing emissions.

There has been a rise in hybrid projects in recent years, where one or more renewable energy generation and/or energy storage technologies are combined to maximise the use of a grid connection; manage constraints and curtailment; provide a smoother and dispatchable output profile; and access additional revenue streams. To date, this has largely focused on onshore applications, with solar and Li-Ion battery storage proving the most popular type of hybrid asset. The fairly predictable solar generation profile with its mid-day peak is an ideal match for short duration storage technologies like Li-Ion, which typically have a storage duration of 1–4 hours, or up to 6 hours depending on design.

Nevertheless, there are a number of opportunities being explored in relation to the hybridisation of offshore wind projects. This is subject to key considerations such as

- The offshore wind resource profile, which can result in capacity factors well above 40% and frequently results in periods where a wind turbine is exporting at rated power for several consecutive hours.
- Grid connections. To date, there has not been a significant requirement for curtailment for UK offshore wind farms. However, we may experience higher levels of grid constraint and curtailment as the UK moves towards a net zero grid. For projects that would directly connect to an offtake asset, the alignment between generation and demand becomes even more relevant.

- Route to market and exposure to merchant pricing. Historically, UK offshore wind farms have benefitted from a Contract for Difference (CfD) mechanism which provides stable revenue, even during periods of low or negative wholesale pricing. Going forward, projects will be more exposed to capture price risk due to changes to the CfD scheme. Many projects are also looking to sell part of their generation on a more merchant basis and target a more complex revenue stack which includes dynamic Balancing Mechanism participation, Capacity Market and others. Following an announcement by the UK Government in February 2022 CfD auctions will be held on an annual basis (UK Government, 2022)
- Siting. Energy storage technology can either be located offshore alongside the wind turbines or at the onshore substation.

While Li-Ion technology dominates the energy storage market at present, there is growing interest in using excess renewable generation to power electrolysers and generate green hydrogen. The advantage of hydrogen is that it can be stored for longer durations without prohibitive losses, and that it can be used either to convert back to electricity or as a fuel for transport and industrial processes. However, green hydrogen is very much an emerging sector and there are very few commercial applications in the context of renewables co-location at present.

A wide range of other storage technologies exist, such as flywheels, flow batteries, liquid/compressed air solutions and gravity storage concepts. None of these technologies have been able to achieve significant commercial deployment or policy support to date, and as such are considered less relevant in the context of offshore wind co-location.

The business case for combining a floating offshore wind farm connected to an oil and gas asset with some form of energy storage will primarily depend on how much of the asset's electricity demand the floating offshore wind farm can provide. There will only be a need for storage if the generation exceeds the installation's demand to the extent that a large amount of wind generation would have to be curtailed, as the project will not be grid connected.

Li-Ion battery technology is a straightforward way of storing electricity for later use but is constrained in terms of its storage duration (most UK projects range from 0.5–2 hours, with some batteries starting to be designed with a 4–6 hour duration). At present, the more lucrative use for onshore batteries is to participate in ancillary services, balancing and trading, all of which require a grid connection. A battery that only provides curtailment avoidance during periods of high wind and low demand and sits idle for the rest of the time would be unlikely to be commercially attractive.

For example, Downing LLP's utility-scale battery storage project Nursling 2 was energised in September 2021, connecting directly to the National Grid and providing Dynamic Containment, as well as trading and optimisation services in wholesale markets (McManan-Smith, 2021)

While an electrolyser can equally be used to absorb excess wind generation, the process of converting hydrogen back to electricity incurs significantly higher efficiency losses than a Li-Ion battery. For this reason, offshore hydrogen applications typically assume that the hydrogen will either be sold directly or converted to other gases/fuels as the end product (e.g., for fuel cells or industrial applications). Transport to shore could in principle take place via underground pipelines or collection via vessels, with the latter option likely more suited to floating offshore wind installations.

Out of the two technologies, the offshore wind industry appears to be favouring green hydrogen in terms of investment in technology and pilot projects. This is coupled with a recent push from governments across Europe to develop support mechanisms and provide innovation funding. The Scottish Government published a Hydrogen Policy Statement in December 2020, outlining a strategic approach to development of the hydrogen economy in Scotland, with an ambition of 5GW installed hydrogen production capacity by 2030 and 25GW by 2045 (Scottish Government, 2020).

Given the logistics of transporting hydrogen to its end users, the industry has so far focused on applications that involve siting electrolysers onshore or exploring co-location at offshore wind farms that are located relatively close to the shore. This will become more complicated for far-shore, floating wind applications. Significant uncertainty remains as to the cost reduction curve for electrolysers and incentives for green hydrogen offtake. This will ultimately determine whether there is a business case for co-locating electrolyser installations with floating offshore wind turbines in the context of oil and gas decarbonisation.

7. Oil and Gas Challenges and Opportunities

7.1. Challenges

7.1.1. Electrical

The variability of power is considered the biggest technical challenge to the integration of offshore wind and oil and gas infrastructure. Long length AC cables are relatively untested and may prove to be a challenge to maintain consistent supply. Hydrocarbon production requires a steady state power demand, and while it may be possible to vary the demand from some services (heat for example) to match the supply, it is considered unlikely that all demand can be varied to match the supply. However, there are several approaches that can be deployed to address this challenge.

In particular, one solution is the use of combined wind and Gas Turbine Generators (GTGs) in parallel: wind can provide partial power while the base load is generated by more predictable power generation. This is the approach that is being deployed on the Hywind Tampen project, where 88 MW of floating wind will provide 35% of the power to five Equinor installations. It is projected that this operational mode will reduce emissions by 200,000tCO_2e. There are other technical considerations of powering large compressors using a wind turbine, particularly the start-up power demand required to start the VSD driven compressor, which may not be sufficient or available. Therefore, a co-deployed generator may need to be rated and available to assist in such heavy power demand spike situations.

However, there are design techniques which can help to reduce such power demand. These techniques may not have been included in existing installations, as they may not have been required given the conventional fossil fuel power generation systems available.

As noted throughout this report, variability of power is a concern for oil and gas offtake, with storage of surplus power likely necessary. This could be achieved through battery energy storage systems (BESS). While there are examples of BESS being deployed offshore, notable Woodside’s integration of a 1 MWh BESS to replace spinning reserve on Goodwyn A installation (Woodside, 2020), the space taken up by the battery banks may become prohibitive in an offshore project without additional infrastructure such as a bridge-linked platform.

Hydrogen storage within floating foundations can present a solution, though this technology is at an early stage. It should be noted that the round trip efficiency of using electricity to produce hydrogen and then burning the hydrogen to produce electricity introduces inefficiencies to the process.

7.1.2. Water Depth

The oil and gas sector has raised concerns regarding the suitability of floating wind in the harsh West of Shetland environment and water depths reaching 1,100 m. To realise the opportunity for the wind sector in this area, it will be expected that the technology is proven.

The success of the Hywind Tampen project will be significant in this regard, as it is leading on the boundaries for the size of foundation (circa 108 m) and the deployed water depth of between 260 m and 300 m.

For WoS it appears likely that a number of potential proposals for new development will be based on Floating Production System Offtake (FPSO) technology. Historically, there have been challenges importing power to turret moored FPSOs related to voltage drop-out. This challenge is referenced in relation to the case study considered as part of the ORE Catapult’s paper, “Using floating offshore wind to power oil and gas platforms” (Quinn, 2021).

Oil and gas installations are complex, interdependent systems, and electrification of existing installations is not simply a case of replacing an existing generator with a cable. Steve Phimister, VP Upstream and Director Shell UK, best articulated it when he described it as being “as complicated as open-heart surgery” (Lammey, Electrification of older platforms as complicated as ‘open heart surgery’, Shell chief says, 2020). However, the success of electrifying existing installations in the Norwegian sector shows that it is not impossible and there is an appetite from the oil and gas sector to meet these challenges. This is further demonstrated by the three winning projects in the OGA’s Decarbonisation competition for the electrification of offshore oil and gas installations, as described in Section **Error! Reference source not found.**.

7.1.3. Economics

The OGA UKCS’ Energy Integration Project (EIP) offshore electrification economic analysis released in August 2020 considered notional brownfield and greenfield projects to illustrate the key economic levers of UKCS offshore oil and gas electrification options between 2026 and 2035.

The economic analysis highlighted that the offshore electrification economics are critically dependent on electricity prices and carbon pricing and that electricity sourced directly from UK offshore windfarms is likely to be more viable than from the UK onshore grid. The analysis modelled electrification as either from:

- UK shore (at ~£60-65/MWh, based on BEIS manufacturing industry prices and reduced by assuming Energy Intensive Industries (EII) exemptions);
- Cross-border from Norway (~£33-40/MWh); or
- Directly from an offshore windfarm (~£35-40/MWh).

The OGA economic analysis, summarised in Table 7.1, is presented in terms of project Benefit-Cost Ratio (BCR), the ratio between discounted project benefits and initial CAPEX invested (a BCR greater than 1 is NPV positive), and the Levelised cost of CO_2 abatement (LCOA). The option to power from an offshore windfarm comprises 80% from an offshore windfarm and 20% from shore, with the windfarm located halfway between the hub platform and shore.

Table 7.1: OGA UKCS offshore electrification economic analysis summary (Oil & Gas Authority, 2020)

Offshore electrification option	BCR (index)	LCOA (£/tonne)
Brownfield: Power from UK shore	0.39	78
Brownfield: Power cross-border	0.65	42
Brownfield: Power from UK wind farm	0.64	43
Brownfield: CAPEX efficiencies	1.04	23
Greenfield: Power from UK shore	0.92	15
Greenfield: Power from UK wind farm	1.42	6

7.1.4. Brownfield electrification economics

Brownfield electrification (converting existing platforms) from UK shore is unlikely to be economically viable in the timeframe at current electricity prices, with the UK onshore grid electricity cost not offset by the extra gas revenues from the saving of fuel gas (modelled at an average of £36 million per year per platform). This option requires a carbon price higher than £78/tonne and the BEIS reference carbon price projections do not exceed this threshold until the early to mid-2030s. The brownfield electrification economics improve with lower cost electricity supply from Norway or directly from UK offshore windfarms; however, technology driven capital cost efficiencies are still required (a 50% reduction in brownfield medication CAPEX) to achieve economic break-even.

7.1.5. Greenfield electrification economics

Electrification of newbuild platforms (greenfield) is more attractive than existing platforms due to the capital cost savings from platform equipment simplification. Greenfield electrification from UK wind farms shows a Benefit Cost Ratio (BCR) greater than 1, indicating that this option is potentially economically viable.

7.2. Opportunities

The Norwegian sector presents a robust case study of what is possible for the electrification of operating oil and gas installations. The OGA views electrification as essential for the UKCS, and operators are developing projects to overcome the challenges and deliver the electrification of developments. There is a clear appetite for electrification projects, which bring opportunities for offshore wind developments.

However, these opportunities must be targeted at areas when projects are most likely to be technically and economically viable. The OGA UKCS Energy Integration Final Report, Annex 1. Offshore electrification states that an abatement cost of £23-43/tonne CO_2 could be enabled through electrification of brownfield installations using power from offshore windfarms. This is based on an examination of the electrification of seven notional platforms in the Central North Sea. The selection of the CNS is based on installations in this area accounting for 57% of the UKCS power consumption (based on 2018 data), and production is expected to continue into 2040. While taking a cut-off greater than 20 years to Cessation of Production as the limit for electrification of projects, as was done in the Norwegian sector, would rule out ~90% of UKCS installations (Boroujerdi, 2021). Assuming 10 years of remaining production as an economic limit for the electrification of brownfield installations, a rule of thumb that has been adopted by the OGA, and assuming a five-year development for an offshore wind installation, this presents a 15-year window. This 15-year period presents approximately 500 MW of power demand from ~15 platforms in the Central North Sea.

The economic analysis by the OGA identifies a CAPEX of £149m/installation for new electrical equipment (£13m) and the required brownfield modifications (£136m). However, for greenfield developments that are designed for electrification from the outset, these costs are removed and the OGA concludes an abatement cost of £6/tonne CO_2 is achievable. When considering greenfield opportunities, this is most relevant to the West of Shetland, where 300 MW of power demand is expected from new projects (Oil & Gas Authority, 2021).

7.2.1. Collaboration & Sharing

The UK O&G sector is very experienced in collaboration and Joint ventures (JV) between development companies, shared systems and service provision. Rosebank is a good example of a shared license between Equinor (as Operator), Suncor and Siccar Point as equity partners. Gas export from the field is via the West of Shetland Pipeline System and onwards to the Sullom Voe oil processing terminal.

As part of the wider electrification business case of individual fields and installations, this continued collaboration has opportunity, but along the lines of shared assets such as grid connections and shared floating wind farms. Apache demonstrated this concept back in 2003/4 when electrically integrating across the Forties Field.

Considering the opportunities in CNS and WOS more closely highlights the opportunities for the offshore wind sector.

7.2.2. Central North Sea (Central Graben & Outer Moray Firth)

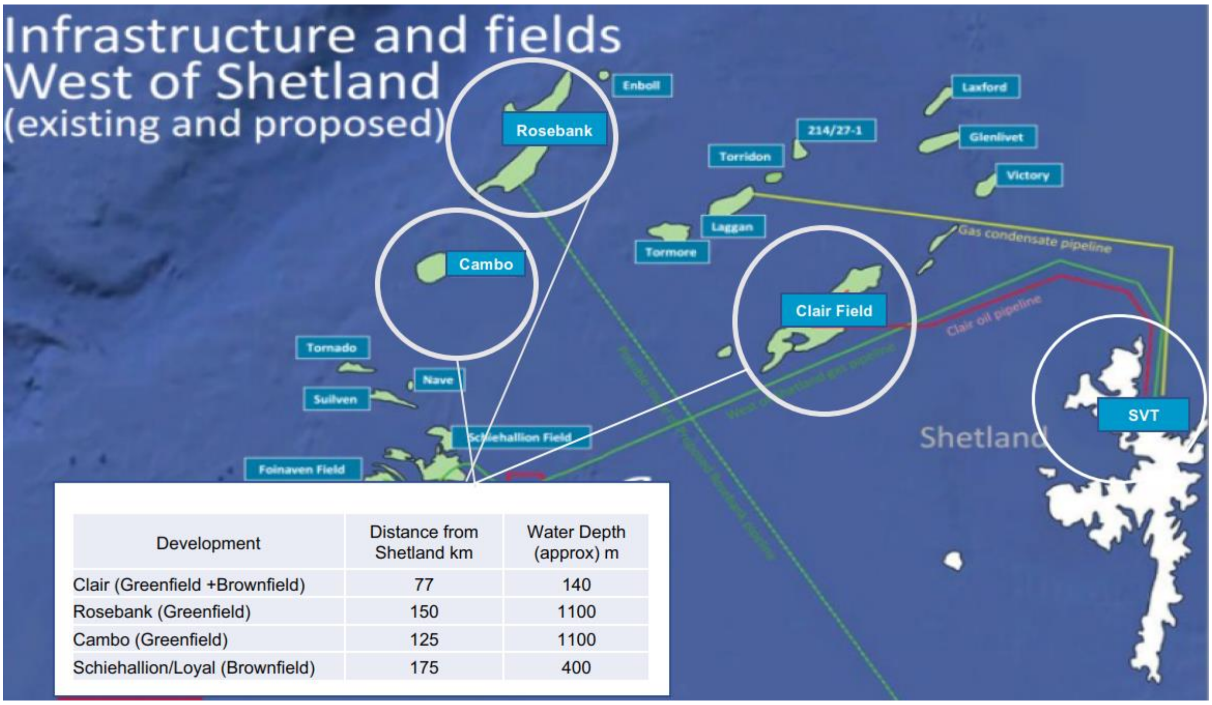
By considering the constraint of 15 years' operating life remaining, then there are 10–15 installations constituting ~500MW demand. These installations can be broadly grouped in two areas:

- Central Graben, which runs northwest to southeast;
- Outer Moray firth, which stretches ~80-200 km west to east from the shore.

There are around seven or eight suitable installations in each of these areas. As with the broader UKCS, these installations vary in size, function, and design. However, the majority use fuel gas in an Open Cycle Gas Turbine (OCGT) to self-generate power. While not without technical challenge, the prize of electrifying these installations is significant, and the well-established infrastructure presents opportunity for hub type developments where wind farms provide power to a cluster of platforms, like the Hywind Tampen concept in Norway.

7.2.3. West of Shetland

The West of Shetland area is technically challenging with water depths approaching 1,100 m and harsh weather conditions. This challenge is why there is relatively little infrastructure, and it is the last development frontier of the UKCS. Minutes from the Shetland Renewables Workshop held on 23 March 2021 state that "West of Shetland operators are entering discussions around the potential for infrastructure sharing in support of Hub Electrification". The minutes also focus on three new developments: (SICCAR POINT ENERGY, 2020) (SICCAR POINT ENERGY, 2021) (Lammey, Mark, 2021).



Development	Distance from Shetland km	Water Depth (approx) m
Clair (Greenfield +Brownfield)	77	140
Rosebank (Greenfield)	150	1100
Cambo (Greenfield)	125	1100
Schiehallion/Loyal (Brownfield)	175	400

Figure 7.1. Geographic locations of selected West of Shetland developments (*Source: OGA*)

8. Summary

The INTOG leasing round is the first of its kind in that it proactively draws together the offshore oil and gas industry and the offshore wind industry. By doing so, it seeks to address strategic aims of the UK and Scottish Governments, namely the decarbonisation of the UKCS, which in 2019 accounted for some 4% of the UK's total GHG emissions. This is underlined by both Governments' net zero strategies as well as the North Sea Transition Deal, and it is fully supported by the Offshore Wind Sector Deal.

Utilisation of floating wind technology at this scale and in the water depths discussed, as well as the integration with both greenfield and brownfield oil and gas technology, present novel challenges to the INTOG leasing round that have not arisen in previous offshore wind developments. However, as this report has detailed, there are some key advantages and opportunities to the INTOG leasing round that are advantageous to the offshore wind market. Considering the areas identified at the outset of the report, these are summarised below.

1. The nature and potential benefits of electrification to the offshore wind industry, as well as the offshore wind supply chain opportunities

The offshore wind market has expanded rapidly in recent years, with countries worldwide seeking to establish both a pipeline of generation projects and a domestic supply chain. Large numbers of organisations from within and outside the energy sector are seeking to diversify into offshore wind development, and the result of this is a highly competitive marketplace.

A product of this competitive market is that seabed rights for commercially viable, consentable offshore wind projects are a highly sought-after asset. This is significantly enhanced in an established market with strong natural resources and where policy, demand and related and supporting industries are aligned to deliver projects. This is the case in Scotland. The commitment and pre-award spend by developers in the ScotWind leasing round is testament to this. The opportunity to secure seabed rights through the INTOG round is, therefore, an appealing one.

Some key opportunities and points of interest exist within the INTOG leasing areas, notably:

1. Potential for an off-grid solution, with a 100% offtake agreement. This would provide for no OFTO, TNUoS costs, network reinforcement or timing constraints
2. Depending on design-life of associated oil and gas infrastructure, INTOG presents an opportunity for secondary deployment of floating wind turbines, subject to appropriate consents and infrastructure.
3. The remote location of INTOG rounds provides a degree of certainty to the consent requirements and timescales, and off-grid solutions may also reduce consent requirements.
4. Opportunity for novel approaches to operations and maintenance strategy and structures.

A corollary of the INTOG round is the opportunity to integrate or extend a ScotWind project into oil and gas installations via an INTOG project, providing a grid-connected solution for oil and gas installations and a source of offtake for the ScotWind project. Whilst this is possible for a ScotWind project without involvement of INTOG infrastructure, the opportunity may be enhanced through the collaborative nature of INTOG.

The ScotWind leasing round carried significant supply chain development commitments, and the INTOG leasing round requires comparable commitment for successful developers. The cumulative scale of INTOG projects increases the pipeline and opportunity for fabrication, manufacturing, construction, operations and maintenance of floating wind components.

Following ScotWind, Scotland became a world leader in floating offshore wind opportunities. By increasing development capacity in Scotland, while maintaining supply chain commitments, INTOG further amplifies this. The nascent stage of this industry gives Scotland an early advantage in this area, which is essential in allowing the country to position itself as global centre for manufacturing and fabrication capability.

2. The role of electrification in delivering a Just Transition

The North Sea Transition Deal identifies decarbonisation of oil and gas supply as its primary outcome, with a series of increasing commitments in reduction of production emissions to full decarbonisation and net zero in 2050. Both the private sector and government committed to establishing a pathway to cost-effective offshore electricity production to facilitate this.

Cost reduction for fixed bottom offshore wind is such that it is now cost competitive with all other forms of electricity generation. Given the technological advancements that have facilitated this, notably turbine capacity, transmission infrastructure, transportation and installation and operations and maintenance, the trajectory for floating offshore wind to reach cost parity will be considerably faster than that followed by fixed bottom offshore wind.

Floating offshore wind represents the best opportunity for deployment of technology in a marine environment at scale, with no clear technological market lead within other forms of marine generation. Therefore, it will play a role in decarbonisation of oil and gas installations.

The Just Transition Commission identifies the need to "pursue an orderly, managed transition to net-zero that creates benefits and opportunities for people across Scotland." As noted below, a key element of the INTOG leasing round is the participation of oil and gas operators, which is central to this goal.

3. Wider effects of electrification on the onshore wind industry, notably in terms of market participation and investment

Development, construction and operation of floating offshore wind projects is not a core business activity for most oil and gas developers. This is in contrast to offshore wind operators who generally are not involved in greenfield or operational oil and gas utility.

This provides an opportunity for collaboration between topic expert organisations. From the perspective of the offshore wind industry these will take the form of:

1. oil and gas owner/operators seeking to decarbonise their infrastructure but without wider ambitions in offshore wind. This would likely provide opportunity for novel ownership and responsibility models.
2. oil and gas organisations with little or no renewable energy experience, using INTOG as an opportunity to establish themselves in the renewables market. This will provide opportunity to existing developers and consultancies in the Scottish offshore wind market for collaboration.
3. oil and gas organisations with a footprint in the offshore wind market. As we have seen through ScotWind, several oil and gas organisations have committed heavily to the offshore wind market. This presents opportunity for partnership approaches in the same way as ScotWind.

As the industry has seen with fixed foundation offshore wind, the floating market will naturally reduce its risk profile with an increased number of projects moving into construction and operation. This will attract finance opportunities in due course. While not an INTOG-specific opportunity, this leasing round will form part of the de-risking process.

4. Wider opportunities surrounding offshore wind electrical offtake, for INTOG and other offshore windfarms.

Distance from shore, distance from other offshore wind projects, available offtake requirements and water depth will play a role in establishing the commercial case for INTOG projects. Alternative, commercially viable means of electricity production and/or means of storage will be an essential component of the integration of offshore wind and oil and gas.

Unique in offshore wind to date, the projects may not require a grid-connected solution or may allow for a grid-connected oil and gas installation via network with INTOG floating wind.

Where distance between projects allows, it may be possible to connect oil and gas installations, INTOG projects and ScotWind projects, providing security of supply to the installation, and a guaranteed offtake to the windfarm projects. Although this approach could be adopted without INTOG involvement, the collaborative, multi-party nature of the leasing round reduces the barriers to doing so.

For ScotWind developers, opportunity exists to increase their number of projects and seek to realise efficiencies between projects, as well as to potentially develop power purchase agreements for both INTOG and ScotWind projects, with the oil and gas asset owners. By linking oil and gas infrastructure to the National Grid through floating wind developments, this would avoid the need for storage or alternative production.

For developers who do not currently have offshore wind projects in Scotland, direct connections to shore may be feasible depending on the project location. Alternatively, off-grid connection to oil and gas assets would provide a complete off-take.

9. Appendices

9.1. Bibliography

Acorn Project. (2021, October 19). *Scottish Cluster Response to BEIS Cluster Sequencing Announcement*. Retrieved from The Acorn Project: https://theacornproject.uk/2021/10/19/scottish-cluster-response-to-beis-cluster-sequencing-announcement/

Askeland, E. (2022, January 14). *Scottish Government puts £80million on table for north east Acorn project*. Retrieved from Press and Journal: https://www.pressandjournal.co.uk/fp/business/3846546/scottish-government-80million-for-north-east-acorn/

BEIS . (2019, June 28). *Introduction to Sector Deals*. Retrieved from GOV.UK: https://www.gov.uk/government/publications/industrial-strategy-sector-deals/introduction-to-sector-deals

BEIS. (2020, March 4). *Offshore wind Sector Deal*. Retrieved from Gov.UK: https://www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal

BEIS. (2022, January 25). *£60 million boost for floating offshore wind*. Retrieved from Department for Business, Energy & Industrial Strategy: https://www.gov.uk/government/news/60-million-boost-for-floating-offshore-wind

Boroujerdi, L. K. (2021, November 09). *Woodmac: Will Platform Electrification Decarbonize the North Sea?* Retrieved from OFFSHORE ENGINEER: https://www.oedigital.com/news/491955-woodmac-will-platform-electrification-decarbonize-the-north-sea?utm_source=AOGDigital-ENews-2021-11-09&utm_medium=email&utm_campaign=OEDigital-ENews

bp. (2019, September 03). *Platforms of the future*. Retrieved from bp.com: https://www.bp.com/en/global/corporate/news-and-insights/reimagining-energy/oil-and-gas-platforms-of-the-future.html

Buljan, A. (2021, June 14). *Eight Scotland-Funded Projects Present Novel Solutions for Floating Wind*. Retrieved from offshoreWIND.biz: https://www.offshorewind.biz/2021/06/14/eight-scotland-funded-projects-present-novel-solutions-for-floating-wind/

Colledge, C. (2021). *Floating Offshore Wind Project – Project Finance (Lot 1) and Project Insurance (Lot 2) .* Glasgow: ORE Catapult.

Crown Estate Scotland . (2022, February). *INTOG Leasing Information Document*. Retrieved from Crown Estate Scotland: https://www.crownestatescotland.com/resources/documents/leasing-information-document-feb-22

Crown Estate Scotland. (2020, September 2). *Ports for Offshore Wind*. Retrieved from Crown Estate Scotland: https://www.crownestatescotland.com/resources/documents/ports-for-offshore-wind-a-review-of-the-net-zero-opportunity-for-ports-in-scotland

Crown Estate Scotland. (2022, January 17). *ScotWind Map of Option Areas*. Retrieved from Crown Estate Scotland: https://www.crownestatescotland.com/resources/documents/scotwind-map-of-option-areas-170122

Crown Estate Scotland. (2022, January 17). *ScotWind offshore wind leasing delivers major boost to Scotland's net zero aspirations*. Retrieved from Crown Estate Scotland: https://www.crownestatescotland.com/news/scotwind-offshore-wind-leasing-delivers-major-boost-to-scotlands-net-zero-aspirations

Department for Business, Energy & Industrial Strategy. (March 2021). *North Sea Transition Deal.*

Durakovik, A. (2020, March 11). *ESA Nods to Hywind Tampen State Aid*. Retrieved from OffshoreWind.biz: https://www.offshorewind.biz/2020/03/11/esa-nods-to-hywind-tampen-state-aid/

Empire Engineering. (2020, June 12). *The frontier between fixed and floating foundations in offshore wind*. Retrieved from Empire Engineering: https://www.empireengineering.co.uk/the-frontier-between-fixed-and-floating-foundations-in-offshore-wind/

ENERGY VOICE. (2021, May 13). *CNOOC teases floating wind plan to 'build a new energy business' in UK*. Retrieved from energyvoice.com: https://www.energyvoice.com/renewables-energy-transition/322225/cnooc-electrification-floating-wind-new-energy-business-uk/

Equinor. (2022). *Electrification*. Retrieved from Equinor: https://www.equinor.com/en/what-we-do/electrification.html

equinor. (2022, January 10). *hywind-tampwn breakthrough*. Retrieved from equinor.com: https://www.equinor.com/en/magazine/hywind-tampen-breakthrough.html

equinor. (2022, January 10). *Partial electrification of Sleipner approved*. Retrieved from equinor.com: https://www.equinor.com/en/news/20210211-partial-sleipner-electrifiction-approved.html

equinor. (2022, January 10). *why is the new Johan Sverdrup field so important?* Retrieved from equinor.com: https://www.equinor.com/en/magazine/why-is-johan-sverdrup-so-important.html

Flotation Energy. (2021). Web site.

Flotation Energy. (2021, December 16). *UK Green Volt*. Retrieved from FlotationEnergy: https://www.flotationenergy.com/projects/green-volt

GridWatch. (2021, December 17). *GB Electricity National Grid Demand and Output per Production Type*. Retrieved from GridWatch: https://gridwatch.co.uk/?oldgw=

HM Government . (2021, October). *Net Zero Strategy: Build Back Greener*. Retrieved from HM Government: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf

HM Government. (2019). *Offshore Wind Sector Deal*. Retrieved from HM Government: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786279/BEIS_Offshore_Wind_sector_deal_print_ready.pdf

HM Government. (2020, November). *The Ten Point Plan for a Green Industrial Revolution*. Retrieved from HM Government: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

Just Transition Commission. (2020). *Interim Report.* Edinburgh: Crown - Scottish Government.

Lammey, M. (2020, November 12). *Electrification of older platforms as complicated as 'open heart surgery', Shell chief says*. Retrieved from ENERGYVOICE: https://www.energyvoice.com/oilandgas/north-sea/278410/electrification-platforms-open-heart-surgery-shell/

Lammey, Mark. (2021, June 15). *Equinor and Altera 'fully engaged' on study into use of Knarr FPSO for Rosebank project*. Retrieved from ENERGY VOICE: https://www.energyvoice.com/oilandgas/north-sea/west-of-shetland/330085/equinor-altera-knarr-rosebank/

Marine Scotland. (2020). *Sectoral Marine Plan for Offshore Wind Energ* . Edinburgh: Scottish Government.

Marine Scotland. (2021). *Initial Plan Framework for Innovation and Targeted Oil and Gas Decarbonisation.*

Maritime and Coastguard Agency. (2021, April 28). *MGN 654 (M+F) Offshore Renewable Energy Installations (OREI) safety response.* Retrieved from gov.uk: https://www.gov.uk/government/publications/mgn-654-mf-offshore-renewable-energy-installations-orei-safety-response

McManan-Smith, T. (2021, February 26). *Downing LLP finalised funding of 50MW battery storage project*. Retrieved from The Energyst: https://theenergyst.com/downing-llp-finalised-funding-of-50mw-battery-storage-project/

Met Office. (2021, December 17). *urface pressure charts*. Retrieved from metoffice: https://www.metoffice.gov.uk/weather/maps-and-charts/surface-pressure

MetOffice. (2021, December 17). *Surface Pressure Charts*. Retrieved from Governemnt Met Office: https://www.metoffice.gov.uk/weather/maps-and-charts/surface-pressure

Morley, K. R. (2021, December 14). *National Grid Status*. Retrieved from National Grid Status: https://grid.iamkate.com/

National Grid ESO. (2022, January 13). *Offshore Coordination Project*. Retrieved from National Grid ESO: https://www.nationalgrideso.com/future-energy/projects/offshore-coordination-project

Norwegian Petroleum Directorate. (2022, January 10). *POWER FROM SHORE TO THE NORWEGIAN SHELF*. Retrieved from Norwegian Petroleum Directorate: https://www.npd.no/en/facts/publications/reports2/report-archive/Power-from-shore-to-the-Norwegian-shelf/1---summary/

Offshore Engineer. (2021, August 31). *Jersey Oil & Gas Delays Greater Buchan Plans to Allow for Electrification Studies Completion*. Retrieved from Offshore Engineer: https://www.oedigital.com/news/490265-jersey-oil-gas-delays-greater-buchan-plans-to-allow-for-electrification-studies-completion

OGA. (2020, August). *UKCS Energy Integration Annex 1*. Retrieved from Oil & Gas Authority: https://www.ogauthority.co.uk/media/6629/ukcs_energy_integration_annex-1-offshore-electrification-final-august-2020.pdf

OGA. (2020, August). *UKCS Energy Integration Annex 2*. Retrieved from Oil & Gas Authority: https://www.ogauthority.co.uk/media/6630/ukcs_energy_integration_annex-2-ccs-final-august-2020.pdf

OGA. (2021, December 16). OGA Questions. (N. P. Consulting, Interviewer)

OGUK. (2020, September). *Pathway to a Net-Zero Basin: Production Emissions Targets*. Retrieved from OGUK: http://oeuk.org.uk/wp-content/uploads/2020/09/OGUK-Production-Emissions-Targets-Report-2020-1.pdf

Oil & Gas Authority. (2020). *UKCS Energy Integration - Final Report.* Aberdeen: Oil & Gas Authority.

Oil & Gas Authority. (2021, March 23). *West of Shetland Renewable Power Workshop – Power to Offshore Oil and Gas Developments.* Retrieved from ogauthority.co.uk: https://www.ogauthority.co.uk/media/7550/shetland-renewables-workshop-23rd-march-2021.pdf

Oil & Gas Authority. (2022, January 06). *Overview*. Retrieved from Oil & Gas Authority: https://www.ogauthority.co.uk/the-move-to-net-zero/overview/

Orcadian Energy. (2021, December 01). *Concept Select Study for the Pilot Field*. Retrieved from Orcadian Energy: https://orcadian.energy/concept-select-study-for-the-pilot-field/

ORE Catapult. (2021). *FLOATING OFFSHORE WIND TECHNOLOGY AND OPERATIONS REVIEW.* Glasgow: ORE.

ORE Catapult. (2021). *MANUFACTURING CONCRETE FLOATING WIND FOUNDATIONS IN SCOTLAND.*

Penman, H. (2021, December 06). *Energy Voice*. Retrieved from Energ yVoice: https://www.energyvoice.com/oilandgas/370197/oga-names-winners-for-1m-platform-electrification-competition

Quinn, T. (2021, January). *Using floating offshore wind to power oil and gas platforms.* Retrieved from ore.catapult.org: https://ore.catapult.org.uk/wp-content/uploads/2021/01/AI-paper-Floating-wind-for-oil-gas-v02.00.pdf

reNEWS. (2021, November 30). *Ofgem sets £642m allowance for Shetland link*. Retrieved from reNEWS: https://renews.biz/74019/ofgem-sets-642m-allowance-for-shetland-link/

renews. (2021, December 02). *Work starts to create Scottish floater hub*. Retrieved from renews.biz: https://renews.biz/74054/work-starts-to-create-scottish-floater-hub/

reNEWS.BIZ. (2021, December 02). *EDF forms Norwegian offshore wind JV*. Retrieved from reNEWS.BIZ: https://renews.biz/74067/edf-forms-norwegian-offshore-wind-jv/

reNEWS.BIZ. (2021, June 04). *itachi ABB unveils power kit for floaters*. Retrieved from reNEWS.BIZ: https://renews.biz/70058/hitachi-abb-unveils-power-kit-for-floaters/

reNEWS.BIZ. (2021, November 22). *Mainstream secures land to support Scottish offshore plans*. Retrieved from ReNEWS: https://renews.biz/73815/mainstream-secures-land-to-support-scottish-offshore-plans/

reNEWS.BIZ. (2021, December 08). *Metocean studies complete for Blyth floater*. Retrieved from reNEWS.BIZ: https://renews.biz/74200/metocean-studies-complete-for-blyth-floater/

reNEWS.BIZ. (2021, December 01). *RWE commissions Norwegian floater*. Retrieved from reNEWS.BIZ: https://renews.biz/74035/rwe-commissions-norwegian-floater/

reNEWS.BIZ. (2021, November 29). *Shell, CoensHexicon advance Korean floater*. Retrieved from reNEWS.BIZ: https://renews.biz/73982/shell-coenshexicon-advance-korean-floater/

reNEWS.BIZ. (2021, December 02). *Spanish floater clears permit hurdle*. Retrieved from reNEWS.BIZ: https://renews.biz/74068/spanish-floater-clears-permit-hurdle/

Scottish Government. (2020, December 21). *Scottish Government Hydrogen Policy Statement*. Retrieved from Scottish Government: https://www.gov.scot/publications/scottish-government-hydrogen-policy-statement/

Scottish Government. (2022, February 02). *Sectoral Marine Plan - Offshore Wind for INTOG: Initial Plan Framework*. Retrieved from Gov.Scot: https://www.gov.scot/publications/initial-plan-framework-sectoral-marine-plan-offshore-wind-innovation-targeted-oil-gas-decarbonisation-intog/

Scottish Renewables. (2020). *SCOTLAND'S OFFSHORE WIND SECTOR SUPPLY CHAIN IMPACT 2020 A SNAPSHOT.* Scottish Renewables.

ScottishIndustryDirectories. (2021, December 08). *Offshore Wind*. Retrieved from ScottishIndustryDirectories: https://osw.directories.scot/

Shetland Islands Council. (2022, January 10). *Future Hydrogen Production in Shetland.* Retrieved from apse.org.uk: https://www.apse.org.uk/apse/assets/File/Douglas%20Irvine.pdf

SICCAR POINT ENERGY. (2020, June). *Cambo Oil Field, UKCS Blocks 204/4a, 204/5a, 204/9a and 204/10a - Environmental Impact Assessment (EIA).* Retrieved from siccarpoint.co.uk: https://www.siccarpointenergy.co.uk/uploads/D-4261-2021-Cambo-ES.PDF

SICCAR POINT ENERGY. (2021, December 02). *Siccar Point Energy underlines importance of Cambo for UK energy security.* Retrieved from sicarpointenergy.co.uk: https://www.siccarpointenergy.co.uk/uploads/20211202_Cambo_Shell.pdf

Simply Blue. (2021, December 07). *Salamander Floating Offshore Wind*. Retrieved from https://salamanderfloatingwind.com/: https://salamanderfloatingwind.com/floating-offshore-wind/

statista. (2019). *greenhouse-gas-emissions-scotland-annually*. Retrieved from statista: https://www.statista.com/statistics/367892/greenhouse-gas-emissions-scotland-annually/

UK Government. (2021). *North Sea Transition Deal*. Retrieved from Gov.UK: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/972520/north-sea-transition-deal_A_FINAL.pdf

UK Government. (2022, February 9). *Government hits accelerator on low-cost renewable power*. Retrieved from Gov.uk: https://www.gov.uk/government/news/government-hits-accelerator-on-low-cost-renewable-power

UKEITI. (2022). *Oil & Gas in the UK*. Retrieved from UK Extractive Industries Transparency Initiative: https://www.ukeiti.org/oil-gas

Woodside. (2020, January 06). *GOOD CLEAN BESS*. Retrieved from woodside.com: https://www.woodside.com.au/media-centre/news-stories/story/good-clean-bess

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