Cerulean Winds Aspen Project Limited

Aspen Offshore Wind Farm

Offshore Environmental Impact Assessment Report

Volume 3, Appendix 18.1: Greenhouse Gas Technical Report

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Aspen GHG Assessment

Offshore Environmental Impact Assessment Report

Cerulean Winds

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Basis of Report

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Glossary

Term	Definition
Applicant	Cerulean Winds Aspen Project Limited.
Landfall	The area between Mean Low Water Spring (MLWS) and Mean High Water Spring (MHWS) where the Offshore Transmission Cables (OTCs) will connect onshore to offshore.
Offshore Substation Platform (OSP)	Offshore platform consisting of High Voltage Alternating Current (HVAC) substations or High Voltage Direct Current (HVDC) substations.
Offshore Transmission Cables	The subsea electricity cables running from Landfall in the region of Stonehaven to the Offshore Substation Platform(s) (OSP(s)) in Aspen Array Area. The OTCs will act as both a demand and supply cable. The OTCs will provide both traditional supply of power to grid but also ensures robust secure power supply to oil and gas assets when the Aspen Array Area is not generating sufficient renewable power to support their demand.
Pay-back period	How long into the lifetime of the Proposed Development before the carbon emissions associated with its construction are counter-acted by the lower carbon emissions of the electricity it generates.
Project	Aspen Offshore Wind farm – comprises the wind farm and all associated offshore and onshore components (for this offshore EIAR, only the offshore infrastructure excluding the cables to Oil and Gas assets are considered, referred to as the “Proposed Development”).
Proposed Development	The offshore components of the Project (Aspen Offshore Wind Farm) which include all offshore infrastructure associated with Aspen Array Area and the Offshore Transmission Cables (OTCs).
Wind Turbine Generator (WTG)	The wind turbine that generates electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.

Acronyms and Abbreviations

Term	Definition
AR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
AR6	Intergovernmental Panel on Climate Change Sixth Assessment Report
CCGT	Combined Cycle Gas Turbine
CO_2e	Carbon dioxide equivalents
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
GHG	Greenhouse Gas
gCO_2e/kWh	Grams of CO_2 equivalents per kilowatt hour
GW	Gigawatt
IAC	Intra-Array Cable
Mt	Million tonnes
MW	Megawatt

MWh	Megawatt hour
GWh/yr	Gigawatt hour per year
GWP	Global Warming Potential
GWP100	Global Warming Potential over a 100-year timeframe
HVAC	High Voltage Alternating Current
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organisation
ktkm	Thousand Tonne-kilometres
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
OCGT	Open Cycle Gas Turbine
O&G	Oil and Gas
O&M	Operation and maintenance
OSP	Offshore Substation Platform
OTC	Offshore Transmission Cable
OWF	Offshore Wind Farm
t	Tonne
WTG	Wind Turbine Generator

1.0 Introduction

Cerulean Winds Aspen Project Limited (hereafter referred to as the ‘Applicant’ is proposing to develop the Aspen Offshore Wind Farm (hereafter ‘the Project’). The Project is made up of both offshore and onshore components. The subject of this Offshore Environmental Impact Assessment Report (Offshore EIAR) is the offshore infrastructure of the Project seaward of Mean High Water Springs (MHWS) which is hereafter referred to as ‘the Proposed Development’.

The Aspen Array Area covers an area of approximately 333 km^2 and is located approximately 84 km east of Peterhead on the east coast of Scotland. The offshore infrastructure of the Proposed Development includes Wind Turbine Generators (WTGs) and associated Floating Foundations, Offshore Substation Platform(s) (OSP(s)) and associated foundations, the Inter-array Cables (IACs), Inter-link Cables, Offshore Transmission Cables (OTCs) and Landfall.

The cables which are intended to connect the WTGs to Oil and Gas assets have been assigned out of scope. Their details are not known at this stage of the project, and they are fully expected to be relatively insignificant in terms of their Greenhouse Gas (GHG) contribution to the overall Project.

Since the industrial revolution, humans have accelerated the release of previously stored carbon (in the form of carbon dioxide) and other gases into the atmosphere, where they act to trap heat and cause global warming. Climate change is the term for this long-term rise in average temperatures, which is also associated with changes to global weather patterns.

This document presents the results of the Offshore Environmental Impact Assessment (EIA) process to determine the potential impacts of the Proposed Development on climate change. Specifically, this document considers the potential impacts from the construction, Operation and Maintenance (O&M), and decommissioning of the WTGs and associated Floating Foundations, mooring systems, semi-submersible anchors, OSPs, IACs and OTCs.

The climate change impacts of a product, process, service or installation can be determined using a technique known as Life Cycle Assessment (LCA). The International Standards Organisation (ISO), in its series ISO 14040-44, defines LCA to be the “compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle”, and outlines the four-step method adopted for this analysis. The sections that follow cover each of these steps in turn, explaining:

- Setting the system boundary to define the scope of work;
- Collecting the necessary data for the modelling;
- Bringing together the flow data and characterisation factors; and
- Interpreting and reporting the results.

Additionally, this GHG assessment has considered the IEMA guide on assessing greenhouse gas emissions and evaluating their significance[1].

This guide outlines six steps which a GHG assessment should incorporate.

1. Set the scope and boundaries of the GHG assessment. This is addressed in section 2.0.

[1] 2022_iema_greenhouse_gas_guidance_eia.pdf

2. Develop the baseline. This is the climate change impact that would occur if the Proposed Development was not completed, which is addressed in section 4.4, where the emissions from the counterfactual electricity are discussed.
3. Decide upon the emissions calculation methodologies, which is discussed below and shown in Table 1-1.
4. Data collection. This is addressed in section 3.0.
5. Calculate/determine the GHG emissions inventory. This is addressed in section 4.2.
6. Consider mitigation opportunities. This is not applicable, as the Proposed Development will result in a reduced climate change impact compared to the baseline.

The relative contributions that different so-called GHGs make towards climate change are denoted by the Global Warming Potential (GWP) of each gas, relative to the chosen reference gas, carbon dioxide. Because the gases dissipate at different rates in the atmosphere, the GWP of gases varies according to the timeframe of the analysis. Whilst datasets exist for GWP over 20-year and 500-year timeframes, the usual basis for international analysis and reporting is 100-years (GWP100).

Within this timeframe, the United Nations Intergovernmental Panel on Climate Change (IPCC) has published a series of Assessment Reports to provide the latest scientific opinion on the GWP factors that should be used. The most recently issued GWP results are from the Sixth Assessment Report (AR6), however, the latest UK government carbon reporting factors for 2024 are currently based on Fifth Assessment Report (AR5; UN IPCC, 2013), and so the GWP factors used in this report are based on that report and are presented below. Table 1-1 lists all the gases that contribute to the total reported, and no significant emissions are thought to be excluded from the calculations.

Table 1-1 GWP100 factors (from AR5) used in this analysis

Greenhouse gas	GWP100 factor (in kg CO_2e per kg)
Carbon dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265
Sulphur Hexafluoride (SF_6)	23,500

2.0 Setting the goal and scope for analysis

The first step was to agree the goal and scope for the analysis, defining what would be within the scope of study and what would not. The topics and the decisions agreed are summarised in Table 2-1.

Table 2-1 Scope of Analysis

Topic	Decision
Study goal:	To determine the GHG emissions from the lifetime operations of the Proposed Development, and to compare them with emissions that would otherwise arise from generating the same electricity.
Scenarios:	Eighteen scenario combinations were calculated (see Section 3.1), considering deployment of three Mooring Configurations, three Anchor Types, and two Anchor Piling energy values.
Time:	Based in the near present and so using current estimations of material production impacts.
Geography:	Located in Scotland, but also cognisant of materials sourced from around the world.
Functional unit:	Initial calculations to determine the total emissions across the lifetime of the installation, then factor in the total electricity produced to scale emissions to a carbon intensity of generation, in grams of CO_2e per kilowatt-hour (gCO_2e/kWh).
Impact criteria:	Only global warming potential (climate change) over a 100-year timeframe was considered in this study.
Data sources:	Detailed in Section 3.0 - a combination of primary data from the applicant and literature data.
Life-cycle stages:	All life cycle stages, from cradle to grave.

3.0 Data collection

Data collection is the most challenging aspect of an LCA study. Looking to model the entire burdens of an offshore wind farm before, during and after an assumed 35 years of operation involves collecting data from the across six stages of the life cycle:

- Raw Materials;
- Manufacturing;
- Installation;
- Operation;
- Freight; and
- End of Life.

The rest of this section provides more detail on the data collected for each of the six stages. The primary source of data for the Proposed Development was information regarding the planned design and construction of the wind farm that has also been used to inform the EIA process to date for the Proposed Development.

3.1 Raw materials

'Raw Materials' refers to the environmental impacts embedded in the materials of construction of the windfarm (but not their fabrication or installation, which are covered in later stages). Details of the materials that are expected to be needed for, for example, the WTGs, were sourced by a combination of information provided by the applicant, and conservative estimates based on previous SLR experience. This information was supported with data provided in a bespoke template, on the amounts of materials expected to be used in the construction. The main components and weights are listed in Table 3-1. For the purposes of undertaking a robust, conservative analysis, it was assumed that none of these materials would contain recycled content, instead being from newly extracted materials.

Only one main scenario was considered for the Proposed Development. However, several sub scenarios were considered, with only the one with the highest GWP100 impact for each set of sub scenarios being chosen and included in the final calculations. As each sub-scenario had to be considered in combination with every other sub-scenario (eg the taut mooring configuration was considered in combination with the six possible combinations of anchor types and anchor piling energy scenarios), this resulted in a total of 18 scenario combinations being considered (three mooring configurations multiplied by three anchor types multiplied by two anchor piling scenarios). These sub scenarios are explained below.

Three different mooring configurations were considered. These consisted of:

- Taut;
- Semi-taut; and
- Catenary.

The semi-taut mooring configuration was found to have the largest expected GWP100 impact of the three. Therefore, this sub scenario was the one that was included in the calculations.

Three different anchor types were considered. These consisted of:

- Driven pile (1 per mooring);
- Driven pile (2 per mooring); and
- Suction anchor.

The driven pile (2 per mooring) anchor type was found to have the largest expected GWP100 impact of the three. Therefore, this sub scenario was the one that was included in the calculations.

Two Anchor Piling energy scenarios were considered. These were:

- 2,000kJ piling energy required per anchor (432 anchors); and
- 2,400kJ piling energy required per anchor (216 anchors).

Due to the higher number of anchors, the 2,000kJ piling energy required per anchor (432 anchors) sub scenario had the larger expected GWP100 impact, so this sub scenario was the one that was included in the calculations.

These are the scenarios that were used to compile the list of materials presented in Table 3-1.

Table 3-1 Main materials in the Aspen components, and their amounts (indicative values)

Description	Detail	Amount	Units
WTG Tower	Steel	115,000	t
	Aluminium	1,800	t
	Cast Iron	18,000	t
WTG Blades	Carbon fibre	15,800	t
	Wood	28,800	m^3
WTG Nacelle	Copper	14,400	t
	Other	57,600	t
	Oil & Grease	2	t
	Neodymium	1,440	t
	Polymer	720	t
	Steel	15,000	t
Fluids & Gasses	Oil & Grease	1,500	t
	Nitrogen	12,200	t
	Coolant	3,650	t
	Batteries	295	t
Floating Foundations	Steel	331,000	t
Mooring configuration 2: Semi-taut	Synthetic rope/mooring line	30,700	t
	Steel	396,000	t
	Carbon fibre	11,900	t
Type 1b Anchor: Driven Pile (2 per mooring)	Steel	108,000	t
Offshore Substation Platform Foundation	Steel	8,630	t
	Cement	370	t
Intra-array cables	Copper	8,810	t
	Steel	5,690	t
	Aluminium	4,520	t
	Plastic	3,820	t

Description	Detail	Amount	Units
Offshore transmission cables	Copper	31,100	t
	Lead	11,100	t
	Steel	20,900	t
	Plastic	17,600	t
Offshore Substation Topside	Steel	1,300	t
OSP Fluids & Gases	Oil & Grease	376	t
	Diesel	82	t
	SF6	10	t
	Batteries	290	t
	Water	7	t
	Refrigerant	0.12	t
	Urea	3	t
OSP Topside	Equipment	1,260	t
	Steel	7,150	t
	Insulation	759	t
	Copper	29	t

3.2 Manufacturing

Some of the values in the above section simply cover the production of, for example, a tonne of steel. Further emissions are embedded during the manufacturing of the wind farm components from those materials. From SLR's experience, it is not practical to gather actual manufacturing data for all components, and many would make a negligible contribution to the final impacts, but it was deemed appropriate to estimate the manufacturing burdens for some of the materials, as detailed in Table 3-2. The quoted weights were deduced from all the data described above.

Table 3-2 Materials weights separately assigned manufacturing burdens

Description	Detail	Amount	Units
Metal working	Aluminium	6,320	t
	Copper	112,000	t
	Lead	11,000	t
	Steel	1,010,000	t

3.3 Installation

Installation covers the extensive effort associated with constructing the Proposed Development. The typical expected consumption and use data for the different aspects of installation are presented in Table 3-3 below.

Table 3-3 Installation stages separately assigned burdens

Description	Detail	Amount	Units
Construction transport	Helicopter movements	406	hr
	Vessel movements	508,000	ktkm
Construction	Diesel	20,300	t
Intra array cables	Scour protection	50,000	t
Offshore transmission cables	Scour protection	92,000	t

3.4 Operation and maintenance

During operation of the Proposed Development, many trips will again be needed to keep the installation in good working order. The anticipated transportation movements across the operational phase of the Proposed Development are summarised in Table 3-4.

Table 3-4 Vessel activities during operation and maintenance (Across Lifetime)

Description	Detail	Amount	units
O&M Transport	Helicopter movements	10,700	hr
	Vessel movements	3,860,000	ktkm
	Drone movements	2,730	ktkm

It is anticipated that maintenance work will include regular replacement of various materials. The predicted material requirement for a portion of the materials was agreed based on figures from previous SLR experience. The anticipated materials required are summarised in Table 3-5. However, because no detailed maintenance data was available, and so to cover any remaining maintenance needs, an additional 2% of all the raw materials and manufacturing processes used to construct the Proposed Development are assumed to be required for maintenance/replacement across its lifetime.

Table 3-5 Anticipated materials required for maintenance/replacement (Across Lifetime)

Description	Detail	Amount	units
WTG Fluids & Gases	Oil & Grease	1,730	t
	Nitrogen	8,340	t
	Diesel	70	t
	SF6	18	t
	Coolant	2,760	t
	Batteries	140	t
Substation Fluids & Gases	Diesel	1,380	t
	SF6	413	t

It is also anticipated that to enable its efficient operation, the Proposed Development will consume a relatively low level of grid electricity. There is some uncertainty about the level involved, however the estimate used in these calculations, based on data from other offshore wind farms in the British Isles, is that grid electricity equivalent to less than 0.2% of the generated electricity will be required.

3.5 Freight

In addition to the vessel movements already described, the calculations consider the freight that will bring the construction and maintenance materials to the local area, and (at end of life) remove the materials for recycling or disposal. As mentioned in Table 2-1, at this stage these distances are based on indicative distances and locations.

The estimated total additional amounts of freight movements required, in thousands of tonne-kilometres (ktkm) by road and by sea, are presented in Table 3-6.

Table 3-6 Additional anticipated freight requirements

	Road ktkm	Ship ktkm
Raw Materials	299,000	24,200,000
End of Life	227,000	0

3.6 Decommissioning (end of life)

It is difficult to be certain what will happen to the Proposed Development's materials at end of life, simply because this will not occur for another 35 years, by which time, the state of available technology may be very different. However, the choice of the "cut-off" approach for accounting for recycled content and recycling means this is less critical.

In that accounting framework, the Proposed Development could be given credit for any recycled materials used in its lifetime, as these (typically) contain less embedded carbon than the unprocessed (virgin) materials they replace. As described in the raw materials section above, however, it has been assumed that all materials are unprocessed (virgin), in effect as a conservative estimate of the true impacts. At the end of their life, the materials must be managed until they are either disposed of or ready to be recycled.

For wind turbine infrastructure, this means that the transport elements at end of life must be included, but once the materials reach the point where they are ready to be recycled, they exit the analysis boundary of this report and are not considered further. Moreover, for the materials that are landfilled, associated emissions should be included, however it is anticipated there should be little if any emissions from the inert materials whilst in landfill. This is due to low/no decomposition of organic material, so the burden is reduced to two elements.

Firstly, the freight impacts mentioned above in Table 3-6, which covers the transportation from the installation port (Ardersier, UK) to disposal/recycling. Secondly, the transportation from the windfarm to the installation port, which is demonstrated by Table 3-7. This assumes an equal amount of helicopter and vessel movements to the installation phase to be required.

Table 3-7 End of Life decommissioning transport burdens

Description	Detail	Amount	Units
Decomissioning transport	Helicopter movements	406	hr
	Vessel movements	508,000	ktkm

4.0 Life Cycle Impact Assessment (LCIA)

By bringing together all the above information, and applying appropriate characterisation factors, an initial estimation was calculated for the GHG emissions of the Proposed Development.

4.1 Characterisation factors

Three sources were used to estimate the unit impacts of the different flows required across the lifetime model of the wind farm, as follows:

- The UK Government's "conversion factors for company reporting of greenhouse gas emissions" was used for some energy unit conversions and waste management processes. These are themselves based on the AR5 from the IPCC;
- An article published in ScienceDirect detailing a study on the emissions of drones was used to calculate a characterisation factor for drone use; and
- All the remaining characterisation factors were taken from the ecoinvent database (Ecoinvent, 2016). To ensure consistency with the UK Government's data, the method used was the same IPCC2013 data from the AR5 report.

This selection of sources for the characterisation factors means that all impacts are reported as emissions of greenhouse gases that contribute to climate change, considered over a 100-year period, relative to the impact of carbon dioxide i.e.in units of weight of Carbon Dioxide equivalents (CO_2e).

4.2 Climate change results

Applying the chosen characterisation factors to the inventory of flows generated during the data collection, and summing by life cycle stage, led to the compilation of the initial results presented in Table 4-1.

Table 4-1 Climate change impact (in t CO_2e) contributions from each life cycle stage

Life Cycle Stage	Climate change impact (t CO_2e)
Raw Materials	3,900,000
Manufacture	2,470,000
Transport	325,000
Installation	23,100
Use	233,000
End of Life	5,210
Total	**6,960,000**

The results show that the Proposed Development's materials (and their manufacture) make the largest contribution (92%) to the overall impacts. In contrast, despite the large quantum of fuel consumption from vessel movements throughout the lifetime, the impacts from transport are relatively insignificant, accounting for 5% of the respective overall impacts.

4.3 Carbon intensity calculation

Looking at Table 4-1, the total expected GWP100 impact of the Proposed Development over its lifetime is 6.96 million tonnes (Mt) CO_2e. This should be assessed in the context of the electricity it will generate. There are uncertainties about how much electricity will be generated (these are explored later in Section 4.6), however it is estimated that its annual production levels might be of the order of 4,671 Gigawatt hours per year (GWh/yr).

This is estimated based on the number and size of the wind turbines, and using a load factor of 52.9%, which is the mid-point of the range (52.9% ± 6.9%) offered in a study for UK Government (DNV, 2019). Running at this rate for 35 years, the Proposed Development will generate 163,000 GWh of electricity over its lifetime. Dividing the aforementioned 6.96 Mt CO_2e of carbon emissions across this electricity generated yields the average carbon intensity of the electricity over the Proposed Development's lifetime:

$$Carbon\ Intensity = \frac{Lifetime\ carbon\ emissions}{Lifetime\ electricity\ generated} = \frac{6.96\ \text{Mt}}{163{,}000\ \text{GWh}} = 42.6g\ CO2e/kWh$$

4.4 Pay-back period

It is common practice to determine a wind farm's carbon "pay-back" period – that is, how long into the lifetime of the wind farm before the carbon emissions associated with its construction are counter-acted by the lower carbon emissions of the electricity it generates. To perform this calculation, it is necessary to determine how the electricity would otherwise be generated.

The primary purpose of the Proposed Development is to decarbonise the electricity mix of several Oil and Gas (O&G) platforms, which would otherwise generate their electricity using gas, namely Open Cycle Gas Turbine (OCGT) with a carbon intensity of 500g/kWh[2]. The Proposed Development is expected to send 200MW to O&G platforms, which accounts for

[2] According to the IPIECA website Open-cycle gas turbines (2022) | Ipieca

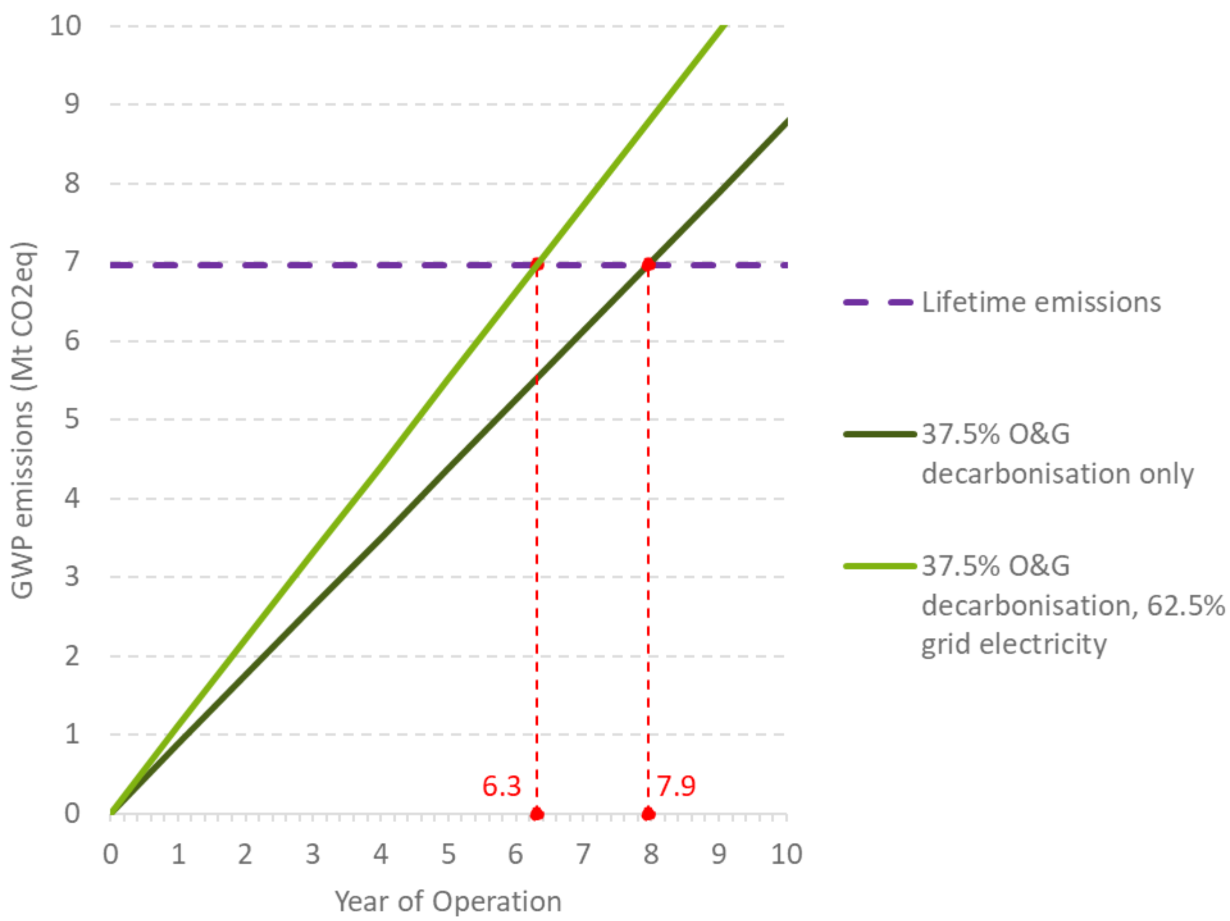
approximately 37.5% of the expected total electricity generation of the Proposed Development (when accounting for load factor assumptions).

Therefore, the primary pay-back scenario considered is 37.5% of the electricity generated by the Proposed Development offsetting OCGT (with a carbon intensity of 500g/kWh), with the remaining 62.5% of electricity generated not being considered.

Although the primary purpose of the Proposed Development is decarbonisation of O&G platforms, it is reasonable to assume that the remaining electricity generated will be supplied to the UK National Grid. When calculating the pay-back, it is necessary to estimate how the electricity would otherwise be generated. A pessimistic assumption uses the overall carbon intensity of the National Grid, which is estimated to be an average of 78g/kWh (see Box 4-1). Therefore, a secondary pay-back scenario considered is 37.5% of the electricity generated by the Proposed Development offsetting OCGT, with the remaining 62.5% of electricity offsetting the UK National grid. This results in an average carbon intensity of 236g/kWh.

Multiplying these intensities by the 4,671 GWh of electricity generated each year reveals that the counterfactual-sourced electricity would be responsible for 876,000t CO_2e (Primary Scenario) or 1.1Mt CO_2e (Secondary Scenario) per year. The cumulative effect of this over the first 10 years of operation is compared in Figure 4.1 with the total lifetime emissions for the Proposed Development. As the annotations show, under the assumptions outlined above, the Proposed Development would be expected to achieve carbon pay-back in between 6.3-7.9 years (and then deliver annual savings for each of the subsequent years of operation).

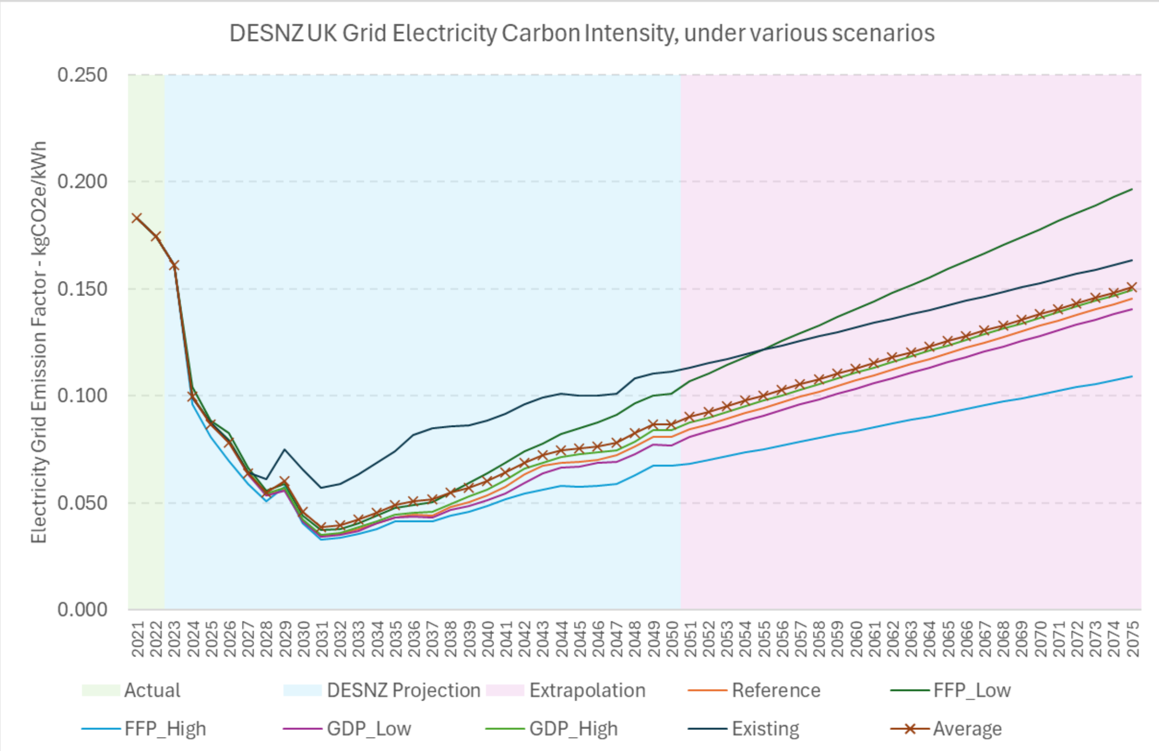
Figure 4.1 GWP "Pay-Back" Analysis for Primary and Secondary scenarios



Box 4-1: Future Carbon Intensity of UK Grid Electricity

Projections from the Department for Energy Security and Net Zero (DESNZ, 2024) estimate how much electricity will be generated by different technologies in the future under their different scenarios. DESNZ also estimates the total carbon emissions from power supply, enabling us to derive projections of the future carbon intensity of UK grid. Beyond 2050, SLR has extrapolated carbon intensities based on figures between 2040 and 2050.

As can be seen, all projections of future and planned capacity anticipate progressively rising carbon intensity from around 2031. The average scenario is shown with crosses marking its points. Over the 35-year period from 2029 to 2063 that the Proposed Development is expected to operate, the average annual carbon intensity is 78gCO_2e/kWh.



Another way of looking at this is to determine the cumulative impacts of 35 years of the alternative electricity sources. These turn out to be 30.7Mt CO_2e (Primary Scenario) or 38.6Mt CO_2e (Secondary Scenario), between 4 and 6 times the lifetime carbon emissions of the Proposed Development, depending on the alternative electricity source.

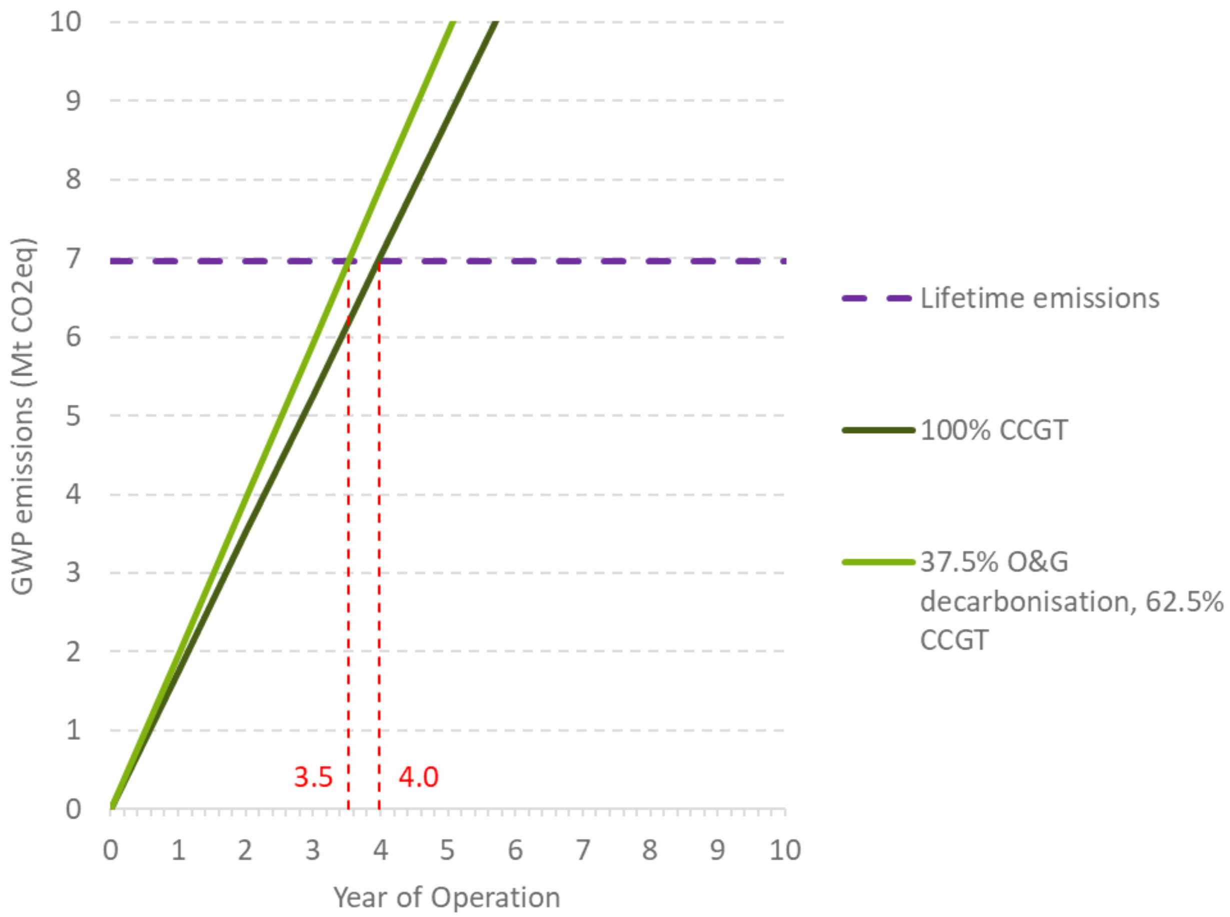
Although the National Grid carbon intensity projection is used in the calculations above, it is accepted that when the wind farm comes online, its additional electricity will not replace other renewable generating technologies. Rather, it will displace whatever generation technology would have been “the last to be turned on”. Not the grid mix therefore, but the so-called “marginal mix”. In the UK, for the foreseeable future, the marginal mix technology is expected to be gas, namely Combined Cycle Gas Turbine (CCGT), which has a carbon intensity of about 375g/kWh (DUKES, 2023). Therefore, the Primary and Secondary scenarios could be considered slightly pessimistic, as they either do not give any pay-back benefit to the 62.5% of electricity not going to O&G platforms, or only give the relatively small benefit of offsetting the UK electricity grid, whereas offsetting CCGT would give a much higher benefit.

For this reason, a third scenario was considered, where 37.5% of the electricity generated by the Proposed Development is offsetting OCGT (as normal), and the remaining 62.5% of electricity is offsetting CCGT (considered to be a more likely outcome than the UK National Grid). This results in an average carbon intensity of 422g/kWh.

It is typical for offshore windfarms to send all their electricity to the grid. That the Proposed Development is sending 37.5% of its electricity to O&G platforms is a rare case. Therefore, a fourth scenario was considered, where all the electricity generated by the Proposed Development is offsetting CCGT (with a carbon intensity of 375g/kWh). This scenario is considered for reference, as it is typically the primary scenario considered.

As with the previous two scenarios, multiplying these intensities by the 4,671 GWh of electricity generated each year reveals that the counterfactual-sourced electricity would be responsible for 1.97Mt CO_2e (Third Scenario) or 1.75Mt CO_2e (Fourth Scenario) per year. The cumulative effect of this over the first 10 years of operation is compared in Figure 4.2 with the total lifetime emissions for the Proposed Development. As the annotations show, under the assumptions outlined above, the Proposed Development would be expected to achieve carbon pay-back in between 3.5-4 years (and then deliver annual savings for each of the subsequent years of operation).

Figure 4.2 GWP “Pay-Back” Analysis for Third and Fourth scenarios



The cumulative impacts of 35 years of these alternative electricity sources turn out to be 69Mt CO_2e (Third Scenario) or 61.4Mt CO_2e (Fourth Scenario), between 9 and 10 times the lifetime carbon emissions of the Proposed Development, depending on the alternative electricity source.

Overall, the Proposed Development is deemed to have a significant net benefit regarding lifetime emissions reduction, with a net benefit of 23.7Mt CO_2e for the primary scenario (O&G decarbonisation only), 31.7Mt CO_2e for the secondary scenario (O&G decarbonisation and UK National grid mix), 62Mt CO2e for the third scenario (O&G decarbonisation and CCGT) and 54.4Mt CO2e for the fourth scenario (CCGT only).

4.5 Sensitivity testing

In an LCA, when we have completed the initial analysis, a critical step is to explore how some of the most important underlying assumptions and uncertainties affect the results. If we can show that our conclusions do not change in the light of plausible (or even excessive) changes, we can have more confidence in the validity of our conclusions.

As previously discussed, the pay-back time is uncertain to an extent because it relies on variables that can fluctuate, such as its load factor. As demonstrated in Figure 4.1 and Figure 4.2, where the pay-back period varies, it is good practice to explore how the results might depend on important uncertainties or assumptions in the underlying data.

The results are conclusive that the Proposed Development is 4-10 times more beneficial, in the context of climate change, than the likely counterfactual electricity alternatives. However, it is still instructive to explore how much the values might change, based on changes in the underlying data. In the following sections a check is performed on the load factor and construction burden.

4.6 Annual electricity production

It was stated above in Section 4.3 that there is some uncertainty about the amount of electricity that the Proposed Development might annually produce, with the initial value used being 4,671 GWh/yr. Underpinning these values is an inherent assumption about the possible load factor of the Offshore Windfarm (OWF), which makes it a valuable topic for a sensitivity test.

To explore this, alternative scenarios were proposed, in which the electricity generated might differ from the initial assumption (of 52.9%). Alternative values of 40.6% (from RenewableUK, based on the last five years of generation) and 61.5% (from UK Government estimates for new-build wind farms from 2025-2028) were selected.

Reducing the assumed Load Factor from 52.9% to 40.6% increases the pay-back time to 4.5-7.9 years[3], so has little effect on the results. To explore a much more extreme possibility, the annual electricity production was halved, to 2,336 GWh/yr. Even under these circumstances, the Proposed Development still achieved carbon pay-back after 7.1-12.6 years of operation.

Conversely, a higher Load Factor for the Proposed Development of 61.5% for was also evaluated. Under these circumstances, the Proposed Development would achieve carbon pay-back in 3.1-7.9 years.

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[3] It should be noted that the pay-back time of the primary scenario does not change under this sensitivity, as this scenario considers 200MW of electricity being sent to O&G decarbonisation only. Therefore, increasing the electricity production does not result in more electricity being sent anywhere, and reducing the electricity production even by half does not reduce the total production below 200MW.

The Proposed Development's GHG results are seen to be relatively robust to uncertainties around the exact amount of electricity that will be generated, in each case achieving carbon pay-back in under 13 years of operation.

4.7 Construction burdens

As there are some uncertainties about the exact details surrounding the materials to be used for the Proposed Development, it was decided to explore how the results would change if the material burdens were double the originally estimated values (as were their manufacturing, transport and installation values). In this scenario, the Proposed Development would take 7.1-15.9 years to pay-back its carbon burden. Overall, these results demonstrate the strong carbon benefit of the Proposed Development.

5.0 Summary

This study has performed a GHG Assessment of the Proposed Development. The scope considered impacts across the whole life cycle, from the production of the raw materials used to construct the facility, all the way through to the recycling or disposal of those same materials after decommissioning at the end of its lifetime.

The GHG emissions across an assumed 35-year lifetime operation are estimated to be 6.96Mt CO_2e.The Proposed Development is expected to produce 4,671 GWh of electricity each year, meaning the carbon intensity of the electricity generated will be about 42.6g CO_2e/kWh.

Four scenarios have been developed to explore how quickly the project may "pay-back" the carbon emissions embedded in its construction and materials. In the most pessimistic scenario, the project is only credited with providing 37.5% of its electricity to nearby Oil and Gas (O&G) platforms, and takes 7.9 years to pay-back its emissions. Subsequent scenarios add in sending the balance of its electricity to the grid, offsetting either grid or CCGT, or entirely offsetting CCGT. All of these have lower pay-back times, the lowest being 3.5 years.

Other sensitivities explore different load factors and even doubling all the burdens of construction, but all return pay-back times significantly shorter than the anticipated lifetime of the Proposed Development.

6.0 References

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