Low Carbon

Atmospheric Emissions for NNG Offshore Wind Farm

Neart na Gaoithe Offshore Wind Farm - Environmental Impact Assessment

Emu Ltd

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EXECUTIVE SUMMARY

This report presents an assessment of the potential impacts of atmospheric emissions from Neart na Gaoithe offshore wind farm including nitrogen oxides (NO_X), sulphur dioxide (SO_2), and carbon dioxide (CO_2) emissions from vessels being used in its construction and operation. The potential impacts from the presence of Neart na Gaoithe on local meteorological conditions has also been considered.

NO_X and SO_2 can have human health effects relating to lung function, damaging effects to vegetation, and can contribute to acidification and/or eutrophication of sensitive habitats leading to loss of biodiversity, often at locations far removed from the original emissions. Carbon dioxide is a Green House Gas and contributes to global warming and thus, climate change effects.

The regulatory concerns relating directly to atmospheric emissions are The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which implement MARPOL Annex VI in the UK and establish controls on marine engines and marine fuel in order to limit emissions, in particular NO_X and SO_2.

Emissions of CO_2, NO_X, and SO_2 were compiled using vessel type and use data provided by Mainstream and which represent a realistic worst case. There are expected to be no other atmospheric emissions associated with the project beyond vessel emissions. Emission factors for the calculation of the emission inventories have been taken from the National Atmospheric Emissions Inventory, Emissions Factor Database (2011). The emission factors used were for Integrated Pollution Prevention and Control (IPPC) definition international shipping, consuming fuel oil. Vessel fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum guidelines (2000) and estimates provided by Mainstream. A summary of the annual project atmospheric emissions are presented in Table S1.

Year	Total Fuel Use (t)	Total Emissions (kt)		
		CO_2	NO_X	SO_2
1	141761	456.9	11.0	7.6
2	15032	48.4	1.2	0.8
3 - 25	1694	5.5	0.1	0.1
26	65810	212.1	5.1	3.5
27	72635	234.1	5.6	3.9

Table S1 Annual estimated atmospheric emissions from Neart Na Gaoithe

This represents a large increase over current emissions within the development area, however due to the dispersive nature of the environment, the mobile source of emissions, and the lack of receptors in the vicinity of Neart Na Gaoithe, local elevated concentrations of emissions will be short lived and are unlikely to be detectable except at a short distance away from any of the activities.

At the regional and global level Neart na Gaoithe emissions would represent only a small fraction of the total shipping emissions within the UK, particularly during the operation and maintenance phase of the development. Table S2 presents Neart Na Gaoithe annual emissions as a percentage of the total 2007 UK shipping emissions at the 12 NM and 200 NM limits.

Project Year	% of 2007 UK Shipping Emissions - 12 NM Limit			% of 2007 UK Shipping Emissions - 200 NM Limit		
	CO_2	NO_X	SO_2	CO_2	NO_X	SO_2
1	9.63%	10.99%	17.73%	1.13%	1.19%	1.93%
2	1.02%	1.17%	1.88%	0.12%	0.13%	0.20%
3 - 25	0.12%	0.13%	0.21%	0.01%	0.01%	0.02%
26	4.47%	5.10%	8.23%	0.53%	0.55%	0.89%
27	4.93%	5.63%	9.09%	0.58%	0.61%	0.99%

Table S2 Neart Na Gaoithe annual emissions as a percentage of total UK shipping emissions

As part of the renewable generation mix, Neart na Gaoithe will help to reduce emissions of CO_2, NO_X, and SO_2 during the operation phase equivalent to the annual emissions of CO_2, NO_X, and SO_2 from traditional thermal generation sources for the generation it replaces. A comparison of Neart na Gaoithe annual emissions with the equivalent annual emissions associated with traditional thermal generation sources are presented in Table S3.

Generation Source	Total annual emissions (t) for 1434.2 GWh		
	CO_2	NO_X	SO_2
Neart na Gaoithe	5460.4	131.7	91.4
Coal	1303687.8	2614.5	2046.6
Natural Gas	570811.6	1.0	N/A

Table S3 Annual atmospheric emissions for equivalent GWh

The atmospheric emissions from Neart Na Gaoithe will contribute to mass emissions of CO_2, NO_X, and SO_2 at a regional and global scale however the overall low percentages of these emissions mean it is unlikely to have a noticeable effect. Once operational Neart na Gaoithe is likely to have a nett positive effect on regional and global air quality, in particular a reduction in CO_2 emissions where it replaces traditional thermal generation sources.

With regard to micro-climate effects it is considered unlikely that the operation of Neart Na Gaoithe will lead to the creation of sea fog, due to historically low percentage of time that fog occurs in the local area (fog defined as visibility < 1 km), however it may increase the density of fog directly behind the wind turbines when fog already persists.

1 INTRODUCTION

The Neart na Gaoithe offshore wind farm ("Neart na Gaoithe") is 15.5 km east of Fife Ness and covers an area of 105 km^2. The proposed site is located 11.5 km southeast from Bell Rock and 16 km east of the Isle of May.(Figure 1). Mainstream Renewable Power Ltd ("Mainstream") was awarded the site in February 2009 by the Crown Estate as part of a competitive bidding process. The project has the potential to generate 450 MW of renewable energy.

A Scoping Report for the project was issued to Scottish Ministers in November 2009, who have consulted stakeholders on the report, including: Local Planning Authorities, Scottish Natural Heritage, Scottish Environment Protection Agency, and RSPB. The Scottish Ministers have collated responses from the various stakeholders into a single Scoping Opinion, which provides guidance on what stakeholders would like to see assessed in the Environmental Impact Assessment (EIA).

In order to provide a comprehensive EIA and following comments made in the Scoping Opinion, it was decided that atmospheric impacts from Neart na Gaoithe would be assessed. This report presents a general assessment of the potential impacts of atmospheric emissions from Neart na Gaoithe, including nitrogen oxides (NO_X), sulphur dioxide (SO_2), and carbon dioxide (CO_2) emissions from vessels being used in its construction and operation. The report also considers potential impacts from the presence of Neart na Gaoithe, on local meteorological conditions. An assessment following the Neart Na Gaoithe Environmental Statement (ES) assessment matrix guidance is provided in the ES chapter report.

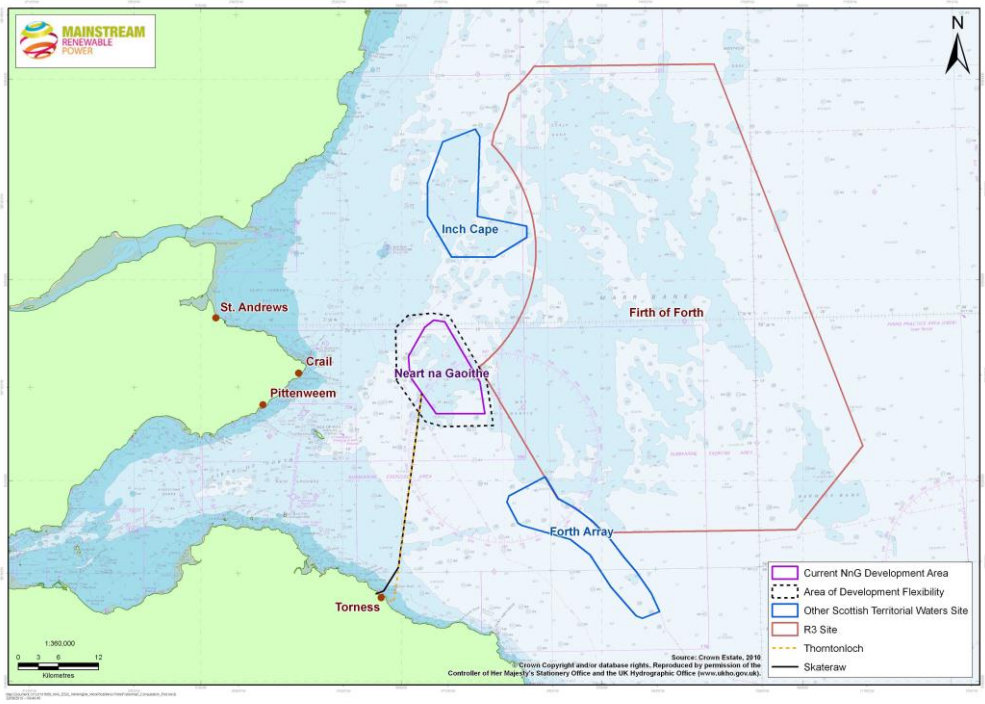

Figure 1: Location of Neart na Gaoithe

2 REGULATORY REGIME

Neart na Gaoithe will not produce atmospheric emissions from the operation of the permanent infrastructure required for the project. All atmospheric emissions from the project will result from the vessels used in the construction and operation, as such, the only regulations applicable to atmospheric emissions will be the merchant shipping (prevention of air pollution from ships) Regulations 2008.

The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 implement MARPOL Annex VI in the UK and establish controls on marine engines and marine fuel in order to limit emissions, in particular NO_X and SO_2. The Neart Na Goaithe development will require various installation and support vessels during its lifetime and all vessels will need to have the appropriate UK Air Pollution Certificate (UKAPP) or International Air Pollution Certificate (IAPP) in place as required.

3 AIR QUALITY IMPACTS

3.1 Air Quality

Atmospheric pollution can have impacts on natural ecosystems and human well-being, and these effects occur at a local, regional, and global scale.

Past regulatory attention has focused on local and regional issues such as the generation of acid rain from NO_X and SO_2 released from combustion, and the human health effects of ground level NO_2, and SO_2 (released from combustion), and ozone (generated via sunlight action on NO_X and VOCs). The potential effects of these pollutants are given in The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Defra 2010) and are summarised in Table 3.1.

Pollutant	Potential Effects
NO_X	At high levels NO_2 causes inflammation of the airways. Long term exposure may affect lung function and respiratory symptoms. High levels of NO_X can have an adverse effect on vegetation. Deposition of pollutants derived from NO_X emissions contribute to acidification and/or eutrophication of sensitive habitats leading to loss of biodiversity, often at locations far removed from the original emissions. NO_X also contributes to the formation of secondary particles and ground level ozone, both of which are associated with ill-health effects.
SO_2	SO_2 causes constriction of the airways of the lung. This effect is particularly likely to occur in people suffering from asthma and chronic lung disease. SO_2 is a precursor to secondary Particulate Matter (PM) and therefore contributes to the ill-health effects caused by PM_{10} (particulate matter less than 10 microns in diameter) and $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter). Potential damage to ecosystems at high levels, including degradation of chlorophyll, reduced photosynthesis, raised respiration rates and changes in protein metabolism. Deposition of pollution derived from SO_2 emissions contribute to acidification of soils and waters and subsequent loss of biodiversity, often at locations far removed from the original emissions.

Table 3.1 Potential Effects of NO_X and SO_2

More recently, attention has increasingly focused on global warming and climate change. The Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report states: “Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG [Green House Gas] concentrations. This is an advance since the TAR’s [third assessment report] conclusion that ‘most of the observed warming over the last 50 years is likely to have been due to the increase in GHG concentrations’ ” (2007), due in part to the burning of fossil fuels.

3.2 Micro-climate

The scoping opinion received by Mainstream requested that micro-climate effects of Neart na Gaoithe be considered. While no specific effects were mentioned previously raised concerns at other wind farms have been regarding “sea fog” creation. The concern regarding this appears to have originated from an article in the Daily Mail (Andrew Levy, 2010) which reported micro climate effects of sea fog at the Scroby Sands offshore wind farm. The theory is that the spinning blades of the wind turbines aide in mixing the warm sea air with the cooler air above the turbines at the same time as reducing air-flow directly behind the turbines.

4 EMISSIONS QUANTIFICATION

Mass emissions from the three main stages of the offshore wind farm development (installation, operation & maintenance, and decommissioning) have been determined.

The emissions inventory was compiled using vessel type and vessel strategy data provided by Mainstream and which represents a realistic worst case. There are expected to be no other atmospheric emissions associated with the project beyond vessel emissions. Emission factors for the calculation of the emission inventories have been taken from the National Atmospheric Emissions Inventory, Emissions Factor Database (2011). The emission factors used were for IPPC definition international shipping, consuming fuel oil. Vessel fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum guidelines (2000) and estimates provided by Mainstream. Details of all emissions calculations are provided in Appendix A.

4.1 Installation

Year 1 and year 2 installation emissions are presented in Table 4.1 and Table 4.2 respectively, and are based on a high emissions scenario for gravity base foundations which represents the realistic worst case. Details of the jacket foundation scenario emissions are also available in Appendix A. The vessels have been separated into large vessels and small or supporting vessels which may accompany the larger vessels. Installation will occur over approximately 18 months with 90.9 % of fuel use occurring in the first 12 months. An export cable length of33 km has been assumed to be required as well as array cabling totaling 100 km.

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Large Vessels					
Foundation Placement Vessel 2	25	6825	22.0	0.5	0.4
Dredging Vessel 1	30	7770	25.0	0.6	0.4
Dredging Vessel 2	30	8100	26.1	0.6	0.4
Graveling Vessel 1	15	3885	12.5	0.3	0.2
Foundation Placement Vessel 1	25	6475	20.9	0.5	0.3
Scour Protection Vessel 1	15	3990	12.9	0.3	0.2
Graveling Vessel 2	15	4095	13.2	0.3	0.2
Scour Protection Vessel 2	15	3990	12.9	0.3	0.2
Substation Topside Inst. Vessel 1	25	900	2.9	0.1	0.0
Turbine Installation Vessel 1	25	10050	32.4	0.8	0.5
Export Cable Vessel 1	15	1155	3.7	0.1	0.1
Inter Array Vessel 1	15	1110	3.6	0.1	0.1
Scour Protection Vessel 3	15	3780	12.2	0.3	0.2
Scour Protection Vessel 4	15	4200	13.5	0.3	0.2

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Small/Support Vessels					
Foundation Placement Vessel 2	15	8190	26.4	0.6	0.4
Dredging Vessel 1	15	7770	25.0	0.6	0.4
Dredging Vessel 2	15	8100	26.1	0.6	0.4
Graveling Vessel 1	10	5180	16.7	0.4	0.3
Foundation Placement Vessel 1	15	7770	25.0	0.6	0.4
Scour Protection Vessel 1	10	5320	17.1	0.4	0.3
Graveling Vessel 2	15	8190	26.4	0.6	0.4
Scour Protection Vessel 2	10	5320	17.1	0.4	0.3
Substation Topside Inst. Vessel 1	15	1080	3.5	0.1	0.1
Commissioning Vessel 1	10	2620	8.4	0.2	0.1
Commissioning Vessel 2	10	2840	9.2	0.2	0.2
Export Cable Vessel 1	8	1232	4.0	0.1	0.1
Inter Array Vessel 1	8	1184	3.8	0.1	0.1
Scour Protection Vessel 3	10	5040	16.2	0.4	0.3
Scour Protection Vessel 4	10	5600	18.0	0.4	0.3
Totals	-	**141761**	**456.9**	**11.0**	**7.6**

Table 4.1 **Year 1 estimated vessel emissions from project installation activities**

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Large Vessels					
Turbine Installation Vessel 1	25	6825	22.0	0.5	0.4
Small/Support Vessels					
Commissioning Vessel 1	10.0	3540	11.4	0.3	0.2
Commissioning Vessel 2	10.0	3820	12.3	0.3	0.2
Totals	**-**	**14185**	**45.7**	**1.1**	**0.8**

Table 4.2 **Year 2 estimated vessel emissions from project installation activities**

4.2 Operation & Maintenance

Operation & maintenance emissions result from the vessels used to maintain and inspect the turbines and other offshore infrastructure components. The estimated vessel emissions for the wind farm operation were calculated for two potential operational strategies, a shore based option and a "mother vessel" option. The emissions of the worst case strategy (mother vessel) are presented in Table 4.3. Further details of the calculations used are presented in Appendix A as well as details of the shore based strategy.

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Sea Energy Marine	4	1460	4705.6	113.5	78.7
Catamaran	NA	9	29.7	0.7	0.5
Jack-up	25	225	725.2	17.5	12.1
Total	**-**	**1694**	**5460.4**	**131.7**	**91.4**

Table 4.3 Estimated vessel emissions from operation and maintenance activities

4.3 Decommissioning

Year 27 and year 28 decommissioning emissions are presented in Table 4.4 and Table 4.5 respectively, a detailed decommissioning strategy has not been established at this early stage as it is likely that technology will change over the lifetime of the wind farm. Therefore, emissions from decommissioning have been assumed to be equivalent to those required for installation/construction, with the exception of cable vessel emissions as cables are expected to remain buried. Emissions from the jacket foundation scenario are also available in Appendix A.

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Large Vessels					
Foundation Placement Vessel 2	25.0	3413	11.0	0.3	0.2
Dredging Vessel 1	30.0	3885	12.5	0.3	0.2
Dredging Vessel 2	30.0	4050	13.1	0.3	0.2
Graveling Vessel 1	15.0	1943	6.3	0.2	0.1
Foundation Placement Vessel 1	25.0	3238	10.4	0.3	0.2
Scour Protection Vessel 1	15.0	1995	6.4	0.2	0.1
Graveling Vessel 2	15	2048	6.6	0.2	0.1
Scour Protection Vessel 2	15	1995	6.4	0.2	0.1
Substation Topside Inst. Vessel 1	25	450	1.5	0.0	0.0
Turbine Installation Vessel 1	25	5025	16.2	0.4	0.3
Scour Protection Vessel 3	15	1890	6.1	0.1	0.1
Scour Protection Vessel 4	15	2100	6.8	0.2	0.1

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Small/Support Vessels					
Foundation Placement Vessel 2	15	4095	13.2	0.3	0.2
Dredging Vessel 1	15	3885	12.5	0.3	0.2
Dredging Vessel 2	15	4050	13.1	0.3	0.2
Graveling Vessel 1	10	2590	8.3	0.2	0.1
Foundation Placement Vessel 1	15	3885	12.5	0.3	0.2
Scour Protection Vessel 1	10	2660	8.6	0.2	0.1
Graveling Vessel 2	15	4095	13.2	0.3	0.2
Scour Protection Vessel 2	10	2660	8.6	0.2	0.1
Substation Topside Inst. Vessel 1	15	540	1.7	0.0	0.0
Scour Protection Vessel 3	10	2520	8.1	0.2	0.1
Scour Protection Vessel 4	10	2800	9.0	0.2	0.2
Total		**65810**	**212.1**	**5.1**	**3.5**

Table 4.4 Year 27 estimated vessel emissions from project decommissioning activities

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Large Vessels					
Foundation Placement Vessel 2	25	3413	11.0	0.3	0.2
Dredging Vessel 1	30	3885	12.5	0.3	0.2
Dredging Vessel 2	30	4050	13.1	0.3	0.2
Graveling Vessel 1	15	1943	6.3	0.2	0.1
Foundation Placement Vessel 1	25	3238	10.4	0.3	0.2
Scour Protection Vessel 1	15	1995	6.4	0.2	0.1
Graveling Vessel 2	15	2048	6.6	0.2	0.1
Scour Protection Vessel 2	15	1995	6.4	0.2	0.1
Substation Topside Inst. Vessel 1	25	450	1.5	0.0	0.0
Turbine Installation Vessel 1	25	11850	38.2	0.9	0.6
Scour Protection Vessel 3	15	1890	6.1	0.1	0.1
Scour Protection Vessel 4	15	2100	6.8	0.2	0.1
Small/Support Vessels					
Foundation Placement Vessel 2	15	4095	13.2	0.3	0.2

Emission Source	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (kt)		
			CO_2	NO_X	SO_2
Dredging Vessel 1	15	3885	12.5	0.3	0.2
Dredging Vessel 2	15	4050	13.1	0.3	0.2
Graveling Vessel 1	10	2590	8.3	0.2	0.1
Foundation Placement Vessel 1	15	3885	12.5	0.3	0.2
Scour Protection Vessel 1	10	2660	8.6	0.2	0.1
Graveling Vessel 2	15	4095	13.2	0.3	0.2
Scour Protection Vessel 2	10	2660	8.6	0.2	0.1
Substation Topside Inst. Vessel 1	15	540	1.7	0.0	0.0
Scour Protection Vessel 3	10	2520	8.1	0.2	0.1
Scour Protection Vessel 4	10	2800	9.0	0.2	0.2
Total		**72635**	**234.1**	**5.6**	**3.9**

Table 4.5 Year 28 estimated vessel emissions from project decommissioning activities

4.4 Annual Emissions

A summary of the annual emissions for the life of the project are presented in Table 4.6. The estimate assumes that the installation occurs over 18 months with operations beginning as soon as installation is complete (i.e. 6 months of operational emissions are included in year 2).

Year	Total Fuel Use (t)	Total Emissions (kt)		
		CO_2	NO_X	SO_2
1	141761	456.9	11.0	7.6
2	15032	48.4	1.2	0.8
3 - 26	1694	5.5	0.1	0.1
27	65810	212.1	5.1	3.5
28	72635	234.1	5.6	3.9

Table 4.6 Estimated annual vessel emissions across the life of the project

The largest total annual emissions from the development of Neart na Gaoithe result from the first year installation stage of the development. Ongoing operation and maintenance emissions which represent the majority of the development lifetime are significantly lower than both years of the estimated installation emissions. Potential effects from these emissions and a comparison with the baseline, UK 12 NM shipping, and UK 200 NM shipping emissions are presented in Section 6.

5 NEART NA GAOITHE POTENTIAL IMPACTS

5.1 Local

5.1.1 Air Quality

Current mass emissions for the Neart na Gaoithe project area for CO_2, NO_X, and SO_2 were 340 t, 7.33 t, and 2.60 t respectively (Xodus, 2011) and is low as a result of the minimal marine traffic passing through the project area. The Neart na Gaoithe development will increase the mass emissions within the project area significantly during the project lifetime, particularly during installation and decommissioning. However, due to the dispersive nature of the environment, the mobile source of emissions, and the lack of receptors in the vicinity of Neart Na Gaoithe, local elevated concentrations of emissions will be short lived and are unlikely to be detectable except at a short distance away from any of the activities. The Offshore Energy Strategic Environmental Assessment 2 (DECC, 2011) concludes that with regard to air quality; "The likely geographic spread and timing of projected activities which may follow leasing/licensing, and the limited scale of other such sources offshore indicate that significant effects on local and regional air quality will not occur.".

5.1.2 Micro-climate

Low visibility (< 1 km) due to sea fog has been recorded 1.1% of the time in the Firth of Forth between 1981 and 2010 (Xodus, 2011), the historically low percentage of fog creation in the local area, and the fact turbines require dynamic wind conditions to operate (where fog would usually require calm conditions), means it is highly unlikely that the operation of Neart na Gaoithe would lead to any additional sea fog creation. However other instances of increased density of fog behind wind turbines has been captured at Horns Rev wind farm (Supergen Wind Energy Technologies Consortium, 2009), and it is possible that when fog is prevalent in the area surrounding Neart Na Gaoithe, the wind turbines could serve to increase the density of the fog.

5.2 Regional and Global

5.2.1 Air Quality

As noted in Section 3 NO_X and SO_2 are a concern at a regional level due to their contribution to acid rain production, and CO_2 contributes to global green house gas concentrations, which is very likely to have led to increased average global temperatures and contribute to climate change (IPCC, 2007). Total CO_2, NO_X, and SO_2 emissions in 2007 from shipping in the UK in the 12 NM limit are 4,745 kt, 100.2 kt and 43. kt respectively and within the 200 NM limits are 40401 kt CO_2, 929 kt NO_X, and 397 kt SO_2 (Entec, 2010). Table 5.1 presents the emissions from the Neart na Gaoithe development as a percentage of the total UK shipping emissions within the 12 NM and the 200 NM limits.

Project Year	% of 2007 UK Shipping Emissions - 12 NM Limit			% of 2007 UK Shipping Emissions - 200 NM Limit		
	CO_2	NO_X	SO_2	CO_2	NO_X	SO_2
1	9.63%	10.99%	17.73%	1.13%	1.19%	1.93%
2	1.02%	1.17%	1.88%	0.12%	0.13%	0.20%
3 - 26	0.12%	0.13%	0.21%	0.01%	0.01%	0.02%
27	4.47%	5.10%	8.23%	0.53%	0.55%	0.89%
28	4.93%	5.63%	9.09%	0.58%	0.61%	0.99%

Table 5.1 Annual Neart na Gaoithe atmospheric emissions compared with 2007 UK shipping

Clearly, emissions of CO_2, NO_X, and SO_2 from the Neart na Gaoithe development will add to mass emissions at the regional and global level. However, Neart na Gaoithe emissions would represent only a small fraction of the total shipping emissions within the UK, particularly during the operation & maintenance phase of the development. The Offshore Energy Strategic Environmental Assessment 2 (DECC, 2011) concludes that with regard to air quality; "Operational effects of offshore renewables are expected to be negligible, and effects at the strategic level are not considered to be significant". In addition to this, local meteorological data shows a predominant westerly wind which will help in dispersing pollutants released within the site away from the Scottish coast and mainland (Xodus, 2011).

5.2.2 Emissions Avoidance

Renewable generation is intended to help "decarbonise" Scotland's electricity generation portfolio, by reducing the requirement for traditional thermal generation. As part of the renewable generation mix, Neart na Gaoithe will help to reduce emissions of CO_2, NO_X, and SO_2 during the operation phase equivalent to the annual emissions of CO_2, NO_X, and SO_2 from traditional thermal generation sources for the generation it replaces.

A comparison of Neart na Gaoithe annual emissions with the equivalent annual emissions associated with traditional thermal generation sources are presented in Table 5.2. The estimate is based on the most likely worst case prediction for Neart na Gaoithe electricity generation (i.e. the lowest predicted gigawatt hours (GWh) per year), and emission factors from the Defra National Atmospheric Emissions Inventory (NAEI) Emissions Database (Defra, 2009).

It should be noted that the coal and gas emissions relate only to emissions from fuel burnt, and do not take into account other sources of emissions associated with thermal power generation such as collection, processing, and transport of fuel, and emissions associated with maintenance.

Generation Source	**Total annual emissions (t) for 1434.2 GWh**		
	CO_2	**NO_X**	**SO_2**
Neart na Gaoithe	5460.4	131.7	91.4
Coal	1303687.8	2614.5	2046.6
Natural Gas	570811.6	1.0	N/A

Table 5.2 Annual atmospheric emissions for equivalent GWh

Once operational Neart na Gaoithe is likely to have a nett positive effect on regional and global emissions of NO_X, and SO_2 when replacing traditional coal fired generation, and provide a very significant reduction in CO_2 emissions over traditional sources of thermal power generation.

6 MITIGATION

Project emissions are expected to have a negligible impact on the environment, and so very little mitigation is required. As all atmospheric emissions associated with the development are from vessel emissions, potential impacts will be reduced by taking total vessel emissions into account when designing the final installation, operation & maintenance, and decommissioning strategies to minimise as far as practicable the number of vessel movements and installation time required. Additionally all vessels employed during the project development will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008 and where sensible, contracts with the vessels will include a requirement for energy management, to minimise energy usage.

7 SUMMARY

Offshore wind farm developments have the potential to impact on air quality through the release of CO_2, NO_X, and SO_2 from exhaust emissions from development related activities that require ships and power generation. In addition, and they have also been reported to produce micro-climatic effects through the mixing of warm sea air with the cooler air above by the turbine blades.

An emissions inventory has been undertaken for Neart na Gaoithe which has quantified the potential mass emissions from the vessels used in the development, according to the various development phases (installation, operation & maintenance, and decommissioning). Vessel emissions will be the only source of atmospheric emissions associated with Neart na Gaoithe.

The maximum estimated annual emissions occur during the first year of construction with CO_2, NO_X, and SO_2 totalling 456.9 kt, 11.0 kt, and 7.6 kt respectively, this is a large increase over current emissions within the project area (which is expected as the area is currently not used significantly by marine traffic) which were identified as 340 t CO_2, 7.33 t NO_X, and 2.60 t SO_2 (Xodus, 2011). Ongoing annual operations and maintenance emissions were estimated to be 5460 t CO_2, 132 t NO_X, and 91 t SO_2.

Due to the dispersive nature of the environment, the mobile source of emissions, and the lack of receptors in the vicinity of Neart Na Gaoithe, local elevated concentrations of emissions will be short lived and are unlikely to be detectable except at a short distance away from any of the activities.

At a regional and global level, the operation and maintenance emissions, based on 2007 UK ship emissions, would be the equivalent of 0.12% of CO_2 emissions within the UK 12 NM limit and 0.01% within the 200 NM limit the equivalent percentages for NO_X are 0.13% (12 NM) and 0.01% (200 NM), and for SO_2 0.21% (12 NM) and 0.02% (200 NM).

The atmospheric emissions from Neart Na Gaoithe will contribute to mass emissions of CO_2, NO_X, and SO_2 at a regional and global scale however the overall low percentages of these emissions mean it is unlikely to have a noticeable effect. Once operational Neart na Gaoithe is likely to have a nett positive effect on regional and global air quality, in particular a reduction in CO_2 emissions where it replaces traditional thermal generation sources.

With regard to micro-climate effects it is considered unlikely that the operation of Neart Na Gaoithe will lead to the creation of additional sea fog, due to historically low percentage of fog creation in the local area, however it may lead to an increased density of fog directly behind the wind turbines when fog already exists.

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APPENDIX A VESSEL ATMOSPHERIC EMISSION CALCULATIONS

Neart na Gaoithe Installation Emissions

Gravity Base Foundation - High emission case

Year 1 (12 Months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Foundation Placement Vessel 2	273	25	6825	21997.0	530.4	368.0
Dredging Vessel 1	259	30	7770	25042.7	603.8	419.0
Dredging Vessel 2	270	30	8100	26106.3	629.5	436.8
Graveling Vessel 1	259	15	3885	12521.4	301.9	209.5
Foundation Placement Vessel 1	259	25	6475	20868.9	503.2	349.1
Scour Protection Vessel 1	266	15	3990	12859.8	310.1	215.1
Graveling Vessel 2	273	15	4095	13198.2	318.2	220.8
Scour Protection Vessel 2	266	15	3990	12859.8	310.1	215.1
Substation Topside Inst. Vessel 1	36	25	900	2900.7	69.9	48.5
Turbine Installation Vessel 1	402	25	10050	32391.2	781.0	541.9
Export Cable Vessel 1	77	15	1155	3722.6	89.8	62.3
Inter Array Vessel 1	74	15	1110	3577.5	86.3	59.9
Scour Protection Vessel 3	252	15	3780	12182.9	293.7	203.8
Scour Protection Vessel 4	280	15	4200	13536.6	326.4	226.5
Foundation Placement Vessel 2	546	15	8190	26396.4	636.4	441.6
Dredging Vessel 1	518	15	7770	25042.7	603.8	419.0
Dredging Vessel 2	540	15	8100	26106.3	629.5	436.8
Graveling Vessel 1	518	10	5180	16695.1	402.5	279.3
Foundation Placement Vessel 1	518	15	7770	25042.7	603.8	419.0
Scour Protection Vessel 1	532	10	5320	17146.4	413.4	286.9
Graveling Vessel 2	546	15	8190	26396.4	636.4	441.6
Scour Protection Vessel 2	532	10	5320	17146.4	413.4	286.9
Substation Topside Inst. Vessel 1	72	15	1080	3480.8	83.9	58.2
Commissioning Vessel 1	262	10	2620	8444.3	203.6	141.3
Commissioning Vessel 2	284	10	2840	9153.3	220.7	153.1
Export Cable Vessel 1	154	8	1232	3970.7	95.7	66.4
Inter Array Vessel 1	148	8	1184	3816.0	92.0	63.8
Scour Protection Vessel 3	504	10	5040	16243.9	391.7	271.8
Scour Protection Vessel 4	560	10	5600	18048.8	435.2	302.0
Total				456895.7	11016.2	7643.8

Year 2 (approx. 6 months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Turbine Installation Vessel 1	273	25	6825	21997.0	530.4	368.0
Commissioning Vessel 1	354	10	3540	11409.4	275.1	190.9
Commissioning Vessel 2	382	10	3820	12311.9	296.9	206.0
Total				45718.3	1102.3	764.9

Emission Factors	CO2	NOX	SO2
	3.223	0.07771	0.05392

Emission Factors are taken from the National Atmospheric Emissions Inventory (NAEI) Emission Factor Database. Emission Factors used were for IPPC Definition International Shipping, using Fuel Oil. CO2 has been converted from an emission factor for CO2 as C.

Fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum 2000 and Mainstream Renewable Power estimates.

Neart na Gaoithe Installation Emissions

Jacket Foundation - High emission case

Year 1 (12 Months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Piling Vessel 1	142	25	3550	11441.7	275.9	191.4
Piling Vessel 2	142	25	3550	11441.7	275.9	191.4
Piling Vessel 3	142	25	3550	11441.7	275.9	191.4
Piling Vessel 4	142	25	3550	11441.7	275.9	191.4
Jacket Placement Vessel 1	230	25	5750	18532.3	446.8	310.0
Substation Topside Inst. Vessel 1	37	25	925	2981.3	71.9	49.9
Turbine Installation Vessel 1	678	15	10170	32777.9	790.3	548.4
Export Cable Vessel 1	77	15	1155	3722.6	89.8	62.3
Inter Array Vessel 1	75	15	1125	3625.9	87.4	60.7
Piling Vessel 1	284	15	4260	13730.0	331.0	229.7
Piling Vessel 2	284	15	4260	13730.0	331.0	229.7
Piling Vessel 3	284	15	4260	13730.0	331.0	229.7
Piling Vessel 4	284	15	4260	13730.0	331.0	229.7
Substation Topside Inst. Vessel 1	74	15	1110	3577.5	86.3	59.9
Commissioning Vessel 1	510	10	5100	16437.3	396.3	275.0
Commissioning Vessel 2	532	10	5320	17146.4	413.4	286.9
Export Cable Vessel 1	154	8	1232	3970.7	95.7	66.4
Inter Array Vessel 1	150	8	1200	3867.6	93.3	64.7
Total				207325.9	4998.9	3468.5

Year 2 (approx. 6 months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Commissioning Vessel 1	294	10	2940	9475.6	228.5	158.5
Commissioning Vessel 2	358	10	3580	11538.3	278.2	193.0
Total				21014.0	506.7	351.6

Emission Factors	CO2	NOX	SO2
	3.223	0.07771	0.05392

Emission Factors are taken from the National Atmospheric Emissions Inventory (NAEI) Emission Factor Database. Emission Factors used were for IPPC Definition International Shipping, using Fuel Oil. CO2 has been converted from an emission factor for CO2 as C.
Fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum 2000 and Mainstream Renewable Power estimates.

Neart na Gaoithe Operation and Maintenance Emissions

Shore-based Strategy

Emision Source	Number of Vessels	Duration per task (days)	Number of Tasks	Fuel Consumption (te/day)	Total Fuel Use (te)	Total Emissions (te)		
						CO2	NOX	SO2
Catamaran[1]	3	NA	NA	NA	202	651.0	15.7	10.9
Jack-up	1	3	3	25	225	725.2	17.5	12.1
Total					427	1376.2	33.2	23.0

Mother Vessel Based Strategy

Emision Source	Number of Vessels	Duration per task (days)	Number of Tasks	Fuel Consumption (te/day)	Total Fuel Use (te)	Total Emissions (te)		
						CO2	NOX	SO2
Sea Energy Marine	1	1	365	4	1460	4705.6	113.5	78.7
Catamaran[1]	1	NA	NA	NA	9.2	29.7	0.7	0.5
Jack-up	1	3	3	25	225	725.2	17.5	12.1
Total					1694.2	5460.4	131.7	91.4

[1]Catermeran fuel use based on total estimated annual mileage and a consumption of 0.21 tonnes of fuel per 26 Nm

Emission Factors	CO2	NOX	SO2
	3.223	0.07771	0.05392

Emission Factors are taken from the National Atmospheric Emissions Inventory (NAEI) Emission Factor Database. Emission Factors used were for IPPC Definition International Shipping, using Fuel Oil. CO2 has been converted from an emission factor for CO2 as
Fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum 2000 and Mainstream Renewable Power estimates.

Neart na Gaoithe Decommissioning Emissions

Gravity Base Foundation - High emission case

Year 27 (approx. 6 Months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Foundation Placement Vessel 2	136.5	25	3412.5	10998.5	265.2	184.0
Dredging Vessel 1	129.5	30	3885	12521.4	301.9	209.5
Dredging Vessel 2	135	30	4050	13053.2	314.7	218.4
Graveling Vessel 1	129.5	15	1942.5	6260.7	151.0	104.7
Foundation Placement Vessel 1	129.5	25	3237.5	10434.5	251.6	174.6
Scour Protection Vessel 1	133	15	1995	6429.9	155.0	107.6
Graveling Vessel 2	136.5	15	2047.5	6599.1	159.1	110.4
Scour Protection Vessel 2	133	15	1995	6429.9	155.0	107.6
Substation Topside Inst. Vessel 1	18	25	450	1450.4	35.0	24.3
Turbine Installation Vessel 1	201	25	5025	16195.6	390.5	270.9
Scour Protection Vessel 3	126	15	1890	6091.5	146.9	101.9
Scour Protection Vessel 4	140	15	2100	6768.3	163.2	113.2
Foundation Placement Vessel 2	273	15	4095	13198.2	318.2	220.8
Dredging Vessel 1	259	15	3885	12521.4	301.9	209.5
Dredging Vessel 2	270	15	4050	13053.2	314.7	218.4
Graveling Vessel 1	259	10	2590	8347.6	201.3	139.7
Foundation Placement Vessel 1	259	15	3885	12521.4	301.9	209.5
Scour Protection Vessel 1	266	10	2660	8573.2	206.7	143.4
Graveling Vessel 2	273	15	4095	13198.2	318.2	220.8
Scour Protection Vessel 2	266	10	2660	8573.2	206.7	143.4
Substation Topside Inst. Vessel 1	36	15	540	1740.4	42.0	29.1
Scour Protection Vessel 3	252	10	2520	8122.0	195.8	135.9
Scour Protection Vessel 4	280	10	2800	9024.4	217.6	151.0
Total				212105.6	5114.1	3548.5

Year 28 (12 months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Foundation Placement Vessel 2	136.5	25	3412.5	10998.5	265.2	184.0
Dredging Vessel 1	129.5	30	3885	12521.4	301.9	209.5
Dredging Vessel 2	135	30	4050	13053.2	314.7	218.4
Graveling Vessel 1	129.5	15	1942.5	6260.7	151.0	104.7
Foundation Placement Vessel 1	129.5	25	3237.5	10434.5	251.6	174.6
Scour Protection Vessel 1	133	15	1995	6429.9	155.0	107.6
Graveling Vessel 2	136.5	15	2047.5	6599.1	159.1	110.4
Scour Protection Vessel 2	133	15	1995	6429.9	155.0	107.6
Substation Topside Inst. Vessel 1	18	25	450	1450.4	35.0	24.3
Turbine Installation Vessel 1	474	25	11850	38192.6	920.9	639.0
Scour Protection Vessel 3	126	15	1890	6091.5	146.9	101.9
Scour Protection Vessel 4	140	15	2100	6768.3	163.2	113.2
Foundation Placement Vessel 2	273	15	4095	13198.2	318.2	220.8
Dredging Vessel 1	259	15	3885	12521.4	301.9	209.5
Dredging Vessel 2	270	15	4050	13053.2	314.7	218.4
Graveling Vessel 1	259	10	2590	8347.6	201.3	139.7
Foundation Placement Vessel 1	259	15	3885	12521.4	301.9	209.5
Scour Protection Vessel 1	266	10	2660	8573.2	206.7	143.4
Graveling Vessel 2	273	15	4095	13198.2	318.2	220.8
Scour Protection Vessel 2	266	10	2660	8573.2	206.7	143.4
Substation Topside Inst. Vessel 1	36	15	540	1740.4	42.0	29.1
Scour Protection Vessel 3	252	10	2520	8122.0	195.8	135.9
Scour Protection Vessel 4	280	10	2800	9024.4	217.6	151.0
Total				234102.6	5644.5	3916.5

Emission Factors	CO2	NOX	SO2
	3.223	0.07771	0.05392

Emission Factors are taken from the National Atmospheric Emissions Inventory (NAEI) Emission Factor Database. Emission Factors used were for IPPC Definition International Shipping, using Fuel Oil. CO2 has been converted from an emission factor for CO2 as C.

Fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum 2000 and Mainstream Renewable Power estimates.

Neart na Gaoithe Decommissioning Emissions

Jacket Foundation - High emission case

Year 27 (approx. 6 Months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Piling Vessel 1	71	25	1775	5720.8	137.9	95.7
Piling Vessel 2	71	25	1775	5720.8	137.9	95.7
Piling Vessel 3	71	25	1775	5720.8	137.9	95.7
Piling Vessel 4	71	25	1775	5720.8	137.9	95.7
Jacket Placement Vessel 1	115	25	2875	9266.1	223.4	155.0
Substation Topside Inst. Vessel 1	18.5	25	462.5	1490.6	35.9	24.9
Turbine Installation Vessel 1	339	15	5085	16389.0	395.2	274.2
Piling Vessel 1	142	15	2130	6865.0	165.5	114.8
Piling Vessel 2	142	15	2130	6865.0	165.5	114.8
Piling Vessel 3	142	15	2130	6865.0	165.5	114.8
Piling Vessel 4	142	15	2130	6865.0	165.5	114.8
Substation Topside Inst. Vessel 1	37	15	555	1788.8	43.1	29.9
Total				79277.7	1911.5	1326.3

Year 28 (approx. 6 Months)

Emision Source	Total Working Days	Fuel Consumption (t/day)	Total Fuel Use (t)	Total Emissions (t)		
				CO2	NOX	SO2
Piling Vessel 1	71	25	1775	5720.8	137.9	95.7
Piling Vessel 2	71	25	1775	5720.8	137.9	95.7
Piling Vessel 3	71	25	1775	5720.8	137.9	95.7
Piling Vessel 4	71	25	1775	5720.8	137.9	95.7
Jacket Placement Vessel 1	115	25	2875	9266.1	223.4	155.0
Substation Topside Inst. Vessel 1	18.5	25	462.5	1490.6	35.9	24.9
Turbine Installation Vessel 1	339	15	5085	16389.0	395.2	274.2
Piling Vessel 1	142	15	2130	6865.0	165.5	114.8
Piling Vessel 2	142	15	2130	6865.0	165.5	114.8
Piling Vessel 3	142	15	2130	6865.0	165.5	114.8
Piling Vessel 4	142	15	2130	6865.0	165.5	114.8
Substation Topside Inst. Vessel 1	37	15	555	1788.8	43.1	29.9
Total				79277.7	1911.5	1326.3

Emission Factors	CO2	NOX	SO2
	3.223	0.07771	0.05392

Emission Factors are taken from the National Atmospheric Emissions Inventory (NAEI) Emission Factor Database. Emission Factors used were for IPPC Definition International Shipping, using Fuel Oil. CO2 has been converted from an emission factor for CO2 as C.

Fuel consumption values are based on average consumption values for vessels in the Institute of Petroleum 2000 and Mainstream Renewable Power estimates.