Neart na Gaoithe Offshore Wind Farm
Carbon Life Cycle Assessment Report
Emu Ltd

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Integrated Services
Total Field Development

Carbon Life Cycle Assessment Report

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ACRONYMS AND UNITS

CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food, and Rural Affairs
DUKES	Digest of UK Energy Statistics
GB	Gravity Base
GHG	Green House Gas
HGV	Heavy Goods Vehicle
IPCC	Inter-governmental Panel on Climate Change
LCA	Life Cycle Assessment
TAR	Third Assessment Report
WTG	Wind Turbine Generator
XLPE	Cross-linked polyethylene

GW	Gigawatt
GWh	Gigawatt hour
h	Hour
km	Kilometer
m	metre
MW	Megawatt
t	Tonne

EXECUTIVE SUMMARY

The Neart na Gaoithe offshore wind farm (“Neart na Gaoithe”) is 15.5 km east of Fife Ness and covers an area of 105 km2. The proposed site is located 11.5 km south-east from Bell Rock and 16 km east of the Isle of May. 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 450MW of renewable energy.

This carbon Life Cycle Analysis (LCA) report has been commissioned by Emu to determine the carbon life cycle emissions which will result from Neart na Gaoithe. This carbon LCA measures Neart Na Gaoithes effect on the environment in regard to Green House Gases (GHG) throughout its life-time. The assessment includes a carbon dioxide equivalent (CO_2e) emission inventory, using an Xodus developed carbon LCA tool. The inventory provided a quantification of total CO_2e emissions attributed to the development, within the scope, which was then used to calculate the nett CO_2e emissions, and carbon payback period.

Neart na Gaoithe is still at an early design stage, and necessarily, is defined by a Rochdale envelope, which gives flexibility for the final design decisions post consenting. The level of uncertainty of the final project design, required that this assessment aim to provide a reasonable reflection of the approximate range, rather than a definitive total, for the total CO_2e emissions and carbon payback period of the development. This report makes no attempt to assess the level of impact (positive or negative) from the results of the carbon LCA.

The assessment boundary included the entire wind farm from wind turbine generators (WTGs) to the onshore cable route, however it did not include the upgrades associated with the substation at the grid connection point, as these were considered necessary regardless of additional generation from Neart Na Gaoithe.

Emissions emitted in the production of the materials used in the various components are included, but not emissions associated with the delivery of these materials to the manufacturing plants, and additional emissions from assembly, this is due to the complexity and level of detail that would be required in determining the potential methods of manufacture and delivery for individual suppliers of components. It is considered that in the context of the development these emissions would represent a very small percentage of the total emissions compared with the emissions from the original manufacture and final delivery to site

To help refine the potential design scenarios, emissions from each component were calculated and considered through each phase (construction, operation, and decommissioning), and the potential combinations combined to identify the highest and lowest emission scenario. The scenarios used to identify the CO_2e emission range and payback periods are identified in Table S.1. Only emissions which occur once the project has been consented have been included.

Emission Scenario	WTG	WTG foundation	Export cable	Array cable	Collector station	Onshore cables	Transition and jointing pits	Operation strategy
High	126 - 3.6 MW, with nacelle and rotor sourced in China, tower and blades sourced in Europe	126 Gravity Base foundations for WTG, sourced from Europe	2 cables 33km length, sourced from China	3 core aluminium 240km, sourced from Europe	2 collector stations, sourced from Europe, using jacket foundations also sourced from Europe	2 cable routes 12km length, imported from Europe	2 Transition pits, jointing pits every 300m along the cable routes	Mother vessel with catamarans
Low	64 - 7.0 MW, sourced in the UK	64 Jacket foundations sourced in the UK	2 cables 33km length, sourced in Europe	3 core copper 120km, sourced in Europe	1 collector station, sourced in Europe, using jacket foundation sourced in the UK	2 cable routes 12 km length, sourced in the UK	2 Transition pits, jointing pits every 500m along the cable routes	Shore based using catamarans

Table S.1 Neart na Gaoithe development scenarios

The construction phase considers the manufacture of required materials for the wind farm components, the transport from the fabrication site to the installation site, and the emissions associated with the installation itself.

The operation phase of the wind farm will not produce any emissions beyond exhaust emissions from vessels required in the maintenance of the various offshore components. It is assumed that there will be no emissions from onshore operations.

The decommissioning phase considers the decommissioning and removal of all new built electrical infrastructure, excluding the array and export cables which are most likely to be left in-situ. Decommissioning of onshore infrastructure has not been included as it is likely that export cables if not required in the future would not be removed and any additional infrastructure would remain in place.

The final calculated high emission scenario, and low emission scenario, total life cycle CO_2e emissions from Neart na Gaoithe are presented in Table S.2. These emissions assume a 25 year life of the WTGs.

Emission scenario	CO_2e Emissions (t)			
	Construction	Operational (25 years)	Decommissioning	Life Cycle
High	1,046,481	125,893	439,801	1,612,175
Low	445,348	22,367	114,754	582,469

Table S.2 Total CO_2e emissions from Neart na Gaoithe

The carbon payback period of a project is analogous to the financial payback period, and represents the period of time before a product or project has saved more CO_2e emissions than has been produced by its construction and operation. The potential CO_2e savings of the development were determined by calculating the equivalent CO_2e emissions that would be generated from other forms of electricity generation, under the assumption that Neart na Gaoithe will displace the requirement for generation from these other sources.

The calculated high emission scenario, and low emission scenario, nett CO_2e emissions from Neart Na Goithe considering the displacement of other energy sources are presented in Table S.3. Where nett CO_2e emissions are negative it represents the displaced equivalent emissions for that generation source, i.e. the “saved” emissions.

Emission scenario	Nett CO_2e emissions				
	Coal	Oil	Gas	Fossil combined	All
High	-35,802,283	-25,266,736	-14,772,344	-22,674,004	-17,241,613
Low	-30,582,816	-21,806,047	-13,063,561	-19,646,138	-15,120,616

Table S.3 Nett CO_2e emissions from other generation sources

Assuming a 25 year life of the WTGs, the development will displace CO_2e emissions from other energy sources by between 13.0 and 30.6 million tonnes in the low emissions scenario, and between 14.7 and 35.9 million tonnes in the high emissions scenario. The payback range for Neart na Gaoithe has been calculated to be within 2 to 3 years from the start of installation.

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 south-east from Bell Rock and 16 km east of the Isle of May. 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.

This carbon Life Cycle Analysis (LCA) report has been commissioned to determine the carbon life cycle emissions which will result from the Neart na Gaoithe offshore wind farm development. A carbon LCA is a method of measuring a product or process’s effect on the environment in regard to Green House Gases (GHG) throughout its life-time. For the remainder of this report the total GHG emissions will be referred to as carbon dioxide equivalents (CO_2e). CO_2e describes for a given GHG, the amount of carbon dioxide (CO_2) that would have the same global warming potential, when measured over 100 years.

The general approach for carbon LCA requires defining the scope and intention of the assessment before undertaking a CO_2e emission inventory. The inventory produces a quantification of total CO_2e emissions within the scope. This can then be used to calculate additional project factors such as the nett CO_2e emissions, and carbon payback period.

2 CLIMATE CHANGE

The interest in carrying out a carbon LCA is due to the potential effects GHGs are considered to have on climate change and global warming, The Intergovernmental Panel on Climate Change (IPCC) in its most recent (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' "* [1]

This is due in part to the burning of fossil fuels.

The Scottish government has put in place a number of ambitious goals relating to the reduction of GHGs in particular to "decarbonise" energy generation. Offshore wind farms are expected to be a large contributor to this decarbonisation. However renewable generation projects will only be successful in this, if the CO_2e emitted in their construction and operation is less than that which would be emitted by the other generation sources they displace.

3 SCOPE AND OBJECTIVE

The Neart na Gaoithe development is currently defined by a "Rochdale envelope". The intention of the Rochdale envelope approach is to allow for some flexibility in the final design and procurement options of a project where elements of the project cannot be finalised prior to consultation and applying for consent. With this in mind, the carbon LCA has been carried out by assessing a variety of possible design scenarios, and reporting on the highest and lowest potential GHG emissions.

Given the level of uncertainty within the final project design, the objective of the assessment is to provide a reasonable reflection of the approximate range, rather than a definitive total, for the total CO_2e emissions and carbon payback period of the development. This report makes no attempt to assess the level of impact (positive or negative) from the results of the carbon LCA. The assessment was undertaken using the Xodus developed carbon LCA tool, which is able to be updated in the future as more details on the components become available, should Mainstream wish to.

The assessment boundaries are outlined in Figure 3.1, and includes the entire offshore wind farm and onshore cable, however it does not include the upgrades associated with the substation at the grid connection point, as these were considered necessary regardless of additional generation due to Neart na Gaoithe. The detail of the assessment approach is presented in section 5. The assessment considers the emissions emitted in the production of the materials used in the various components, but does not consider the delivery of these materials to the manufacturing plants, and additional emissions from assembly, this is due to the complexity and level of detail that would be required in determining the potential methods of manufacture and delivery for individual suppliers of components. It is considered that in the context of the development these emissions would represent a very small percentage of the total emissions compared with the emissions from the original manufacture and final delivery to site.

The assessment only includes emissions which occur once the project has been consented, it does not include pre-consent emissions associated with Neart na Gaoithe such as environmental monitoring and Geophysical/Geotechnical investigations, as these emissions have already been released and are not influenced by future design decisions.

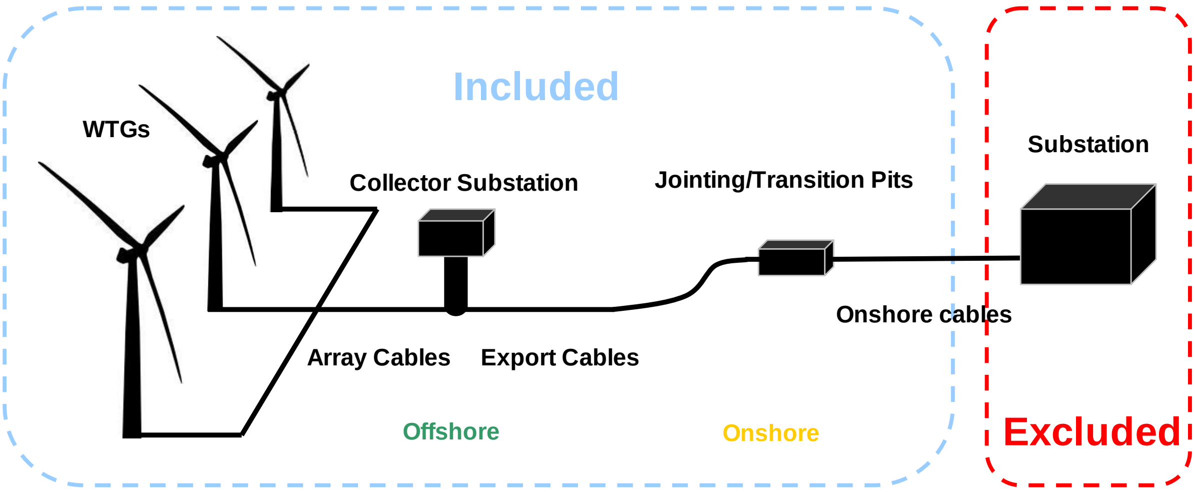

Figure 3.1 Assessment boundaries

4 DEVELOPMENT SCENARIOS

Within the Rochdale envelope there are a number of options for each component of the development. For example when considering the potential transport options for each component for installation there are 12 Wind Turbine Generator (WTG) options, 16 foundation options, 2 export cable options, 4 array cable options, 2 collector substation options and 2 onshore cable options, leading to over 6,144 potential emission combinations.

To help refine the potential scenarios, emissions from each component were assessed through each phase, and the potential combinations combined to identify the highest and lowest emission scenario. The scenarios which were selected to identify the CO_2e emission range and payback periods are identified in Table 4.1.

Emission Scenario	WTG	WTG foundation	Export cable	Array cable	Collector station	Onshore cables	Transition and jointing pits	Operation strategy
High	126 - 3.6 MW, with nacelle and rotor sourced in China, tower and blades sourced in Europe	126 Gravity Base foundations for WTG, sourced from Europe	2 cables 33km length, sourced from China	3 core aluminium 240km, sourced from Europe	2 collector stations, sourced from Europe, using jacket foundations also sourced from Europe	2 cable routes 12km length, imported from Europe	2 Transition pits, jointing pits every 300m along the cable routes	Mother vessel with catamarans
Low	64 - 7.0 MW, sourced in the UK	64 Jacket foundations sourced in the UK	2 cables 33km length, sourced in Europe	3 core copper 120km, sourced in Europe	1 collector station, sourced in Europe, using jacket foundation sourced in the UK	2 cable routes 12 km length, sourced in the UK	2 Transition pits, jointing pits every 500m along the cable routes	Shore based using catamarans

Table 4.1 Neart na Gaoithe development scenarios

5 EMISSIONS INVENTORY

5.1 Introduction

The emission inventory for the various stages of the project is divided into 3 phases:

- Construction CO_2e - which includes the manufacture of the main components and their installation at Neart na Gaoithe
- Operational CO_2e - which includes the emissions from activities associated with operation and maintenance
- Decommissioning CO_2e - which includes the emissions associated with the removal of components at the projects end of life

Each of these phases is then divided three further times into a category, a component, and finally an activity or material. For example CO_2e emissions associated with the steel used in the manufacture of the WTG would be captured as shown in Figure 5.1.

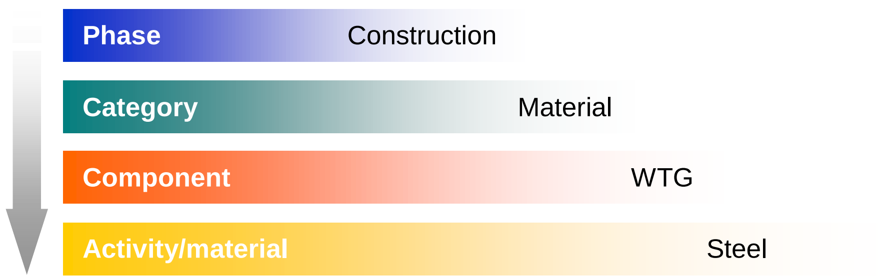

Figure 5.1 Process for identifying component materials

Each activity or material has an assigned unit of measurement, and an associated CO_2e emission factor, a table of all the emission factors used within the assessment is presented in appendix A. and the full emissions inventory for the high and low emission scenarios are presented in appendix B

5.2 Phase Definitions

5.2.1 Construction CO_2e

The construction section of the methodology entails the manufacture of required materials for the wind farm components, the transport from the fabrication site to the installation site, and the emissions associated with the installation itself.

As mentioned in section 3, the assessment has not captured emissions for any required transport of the materials used in the construction of the components, or additional emissions associated with assembly of the components. For example: the emissions associated with the wind turbine has taken into account the mass of copper used and emissions associated with manufacturing the copper, but it has not included the delivery of the copper to the wind turbine manufacturer, and the additional emissions associated with combining the copper with the other individual components within the wind turbine.

The emissions associated with these two activities not captured in this assessment are difficult to establish without knowledge of the potential manufacturers supply chains and processes, made more difficult when suppliers have not yet been established. However, it is considered that these emissions would represent a very small part of the total construction emissions as defined for this assessment, and would therefore not alter the fundamental outcome or value of this assessment.

For the offshore components, the manufacture, delivery to site, and installation CO_2e emissions has been considered for: cables (export and array), collector substations, WTGs, and their associated foundations.

For the onshore components, the manufacture, delivery to site, and installation CO_2e emissions have been considered for the onshore export cables, and jointing and transition pits. Emissions associated with the extension to the substation at the grid connection have been excluded, as the upgrades are required to be undertaken regardless of any additional generation.

5.2.2 Operational CO_2e

It has been assumed that the operation of the wind farm will not produce any emissions beyond exhaust emissions from vessels required in the maintenance of the various offshore components. It is assumed that there will be no emissions from onshore operations.

5.2.3 Decommissioning CO_2e

The decommissioning section considers the decommissioning and removal of all new built electrical infrastructure, excluding the array and export cables which are most likely to be left in-situ. Decommissioning of onshore infrastructure has not been included as it is likely that export cables if not required in the future would be left buried and any additional infrastructure would remain in place.

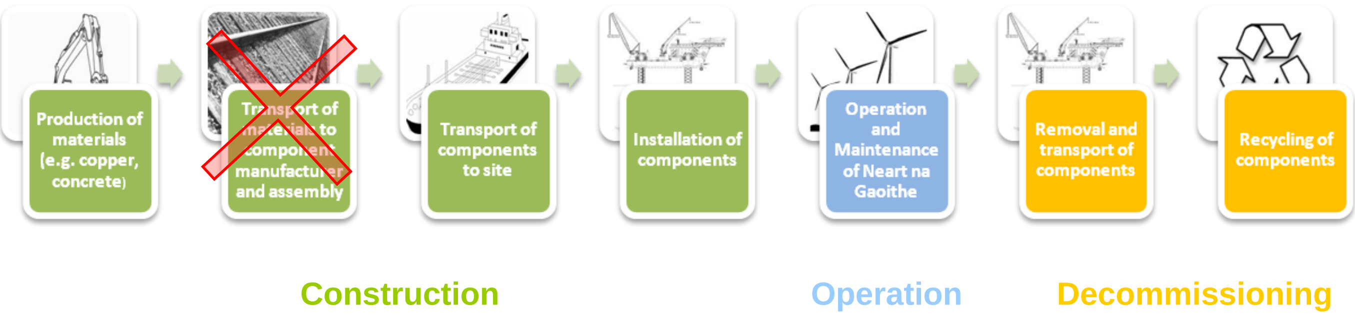

Figure 5.2 Summary of included phases and categories

5.3 Component descriptions

The details provided below set out the activities and materials accounted for in each component, within each phase.

5.3.1 Construction Materials

5.3.1.1 Wind Turbine Generators

The WTG has been considered as a single unit which is made up of the tower, nacelle, and blades. There are four potential options for the project WTGs considered in the assessment: a Siemens 3.6 MW, Siemens 6 MW, GE 4.135 MW, and a Vestas 7 MW, details of the masses of the materials required in each of these turbines were not available for this assessment. The total mass for the major materials which make up the WTG (steel, copper, aluminium, and fibreglass) have been estimated based on details provided in a life cycle analysis study of the Vestas V90 3.0 MW WTG[2], further details of the calculations used are presented in appendix C.

Because the total MW capacity of Neart na Gaoithe will be approximately 450 MW regardless of the WTG option chosen; each WTG option will result in a different number of total WTGs being used.

5.3.1.2 WTG foundations

Foundations are required to hold the WTGs to the seabed within the array. Foundations may also require scour protection to prevent the removal of local sediment within the vicinity of the foundation. Two options for foundations are being considered, gravity base (GB) or jacket. The number of each foundation type is dependent on the WTG option selected. The materials required for the GB foundation are concrete, steel, scour protection, gravel and ballast. Materials required for the jacket foundation are steel and scour protection. For this assessment scour protection has been assumed to be gravel/rock in both cases.

In reality the size (and hence weight) of the foundations will change with WTG size and water depths. In this assessment this variation has been accounted for by selecting the maximum potential weight for a 6 MW WTG.

5.3.1.3 Offshore cables

Two export cables of 33 km are required to transfer electricity from the offshore collector substation(s) to the onshore landing point. The cables have been assumed to be 3 core, cross-linked polyethylene (XPLE) submarine cables, with their major materials being copper or aluminium, and polyethylene. The total mass of these components was calculated from cross-sectional areas presented in ABB *XPLE Submarine Cable Systems – Attachment to XPLE Land Cable Systems User's Guide*[3].

Array cabling is required to transfer the electricity generated at each WTG to the offshore collector station(s). Two array cabling options are being considered: one requiring 120 km of cable and one requiring 240 km of cable. The materials for the array cabling are the same as those for the export cable.

The offshore cables may require rock dumping for protection, however the amount required will be very small compared to turbine scour protection assumptions, and so is considered to be accounted for within the foundation scour protection.

5.3.1.4 Collector substation and foundation

The collector substation acts as a collector point the electricity from individual WTGs and steps up the voltage for export to shore. The Neart na Gaoithe development may require up to two collector substations, made primarily of copper, aluminium, and steel. The collector substation foundation(s) will be a jacket foundation(s) made of steel.

For this assessment data on the material balance for the collector substation was not available, so the entire weight has been assumed to be steel.

5.3.1.5 Onshore transition and jointing pits

Transition and jointing pits are required to connect new lengths of cable together at the landing point and along the onshore cable route. The materials required for the pits are concrete and steel. There will be two transition pits at the landfall point, and jointing pits are assumed to be required every 300 to 500 m.

5.3.1.6 Onshore cables

Onshore buried cables will transport electricity from the offshore export cable at the landing point to the grid connection point. The cables have been assumed to be single core XPLE type cables with the major materials being copper and aluminium. The total mass of these materials was provided by Mainstream Renewable Power.

5.3.2 Construction Transport

5.3.2.1 Wind Turbine Generators

A combination of three potential manufacturing scenarios have been considered to establish transport emissions for WTGs. The manufacturing locations considered in these scenarios are broadly categorised as China, Europe, and UK. Emissions are based on a 10,000 tonne capacity deck barge, using two tugs, and travelling at 10 knots. The three scenarios are defined as:

1. Complete WTG from Europe
2. Tower and blades from Europe, nacelle and rotor from china
3. Complete WTG from UK

5.3.2.2 WTG foundations

Both the GB and jacket foundation have two potential manufacturing locations: Europe or the UK. Foundations are assumed to be transported by a 1000 or 2000 tonne deck barge, using two tugs, and travelling at 10 knots.

5.3.2.3 Offshore cables

Offshore export and array cables will be transported from either China or Europe, and are also assumed to be transported on a 10,000 tonne deck barge using two tugs, and travelling at 10 knots.

5.3.2.4 Collector substation and foundation

The collector substation(s) are assumed to be manufactured in Europe and transported direct to site by 5,000 tonne deck barge using two tugs, and travelling at 10 knots. The foundation(s) will be manufactured in either Europe or the UK and also transported by a 5,000 tonne deck barge using two tugs, and travelling at 10 knots.

5.3.2.5 Onshore cables

There are two potential locations for onshore cables being considered: Europe or the UK. Cables are assumed to be transported by 5,000 tonne deck barge using two tugs, and travelling at 10 knots, and by heavy goods vehicle (HGV) the length of the cable route.

5.3.3 Construction Installation

Emissions from the offshore installation activities have been taken from Neart na Gaoithe Atmospheric Emissions Environmental Impact Assessment Report[4] using vessel use data provided by Mainstream Renewable Power[5]. Summaries of the vessels required for each installation activity are presented below.

5.3.3.1 Offshore Infrastructure

Construction and installation emissions for the offshore infrastructure were provided in four scenarios: a high and low scenario for each of the two potential foundation types.

The highest emission case of the provided scenarios was the high emission gravity base foundation scenario which included vessels for foundation placement, gravelling, scour protection, dredging, WTG and substation topside installation, and vessels for inter array and export cable installation, as well as smaller vessels to support these activities.

The lowest emission case of the provided scenarios was the low emission jacket foundation scenario which included vessels for jacket placement, piling, WTG and substation topside installation, and vessels for inter array and export cable installation, as well as smaller vessels to support these activities.

5.3.3.2 Onshore cable

The onshore cable installation will require the use of an excavator to dig the cable trench(es) and jointing pits. An onshore cable route length of 12 km has been assumed, with a trench width of 1 m and depth of 1.5 m.

5.3.4 Operation

Emissions from the offshore operation and maintenance activities have been taken from Neart na Gaoithe Atmospheric Emissions Environmental Impact Assessment Report[4]. There are two potential strategies; a shore based strategy using catamarans, and a “mother vessel” strategy using the Sea Energy Marine home vessel and catamarans. Both strategies include a jack-up vessel for major unplanned maintenance. It is assumed that the range of turbines will have very limited effect on fuel use and that the life-time of the site will be 40 years.

It is further assumed that there will be no emissions from onshore operations.

5.3.5 Decommissioning Removal

Emissions from the offshore decommissioning activities have been taken from Neart na Gaoithe Atmospheric Emissions Environmental Impact Assessment Report[4]. A detailed decommissioning strategy has not been established; consequently emissions from the offshore decommissioning have been assumed to be equivalent to those required for installation/construction, with the exception of the offshore cables which have been assumed not to be removed.

As with the offshore cables it is assumed that any cables no longer required would be left buried, as such, no emissions are included for onshore decommissioning.

5.3.6 Decommissioning Transport

It is assumed that all the removed components will be returned to the UK for recycling/scraping. Items are assumed to be transported by a 10,000 Tone deck barge using two tugs, and travelling at 10 knots.

5.3.7 Decommissioning Recovery

The assessment has assumed that the metals used in the infrastructure will be recycled and as such, are included as avoided production i.e. saving the emissions associated with extracting and preparing new material. The emissions avoidance has been conservative in that it assumes the material is recycled into the least carbon intensive material and the full mass of the material is not recycled (this also accounts for additional emissions associated with the recycling process). No recycling of offshore or onshore cables is included as it is assumed they will remain in-situ (section 5.3.5).

The percentage recycling values used for the selected materials are presented in Table 5.1, and have been taken from life cycle analysis study of the Vestas V90 3.0 MW WTG[2].

Material	Assumed percentage recycled
Aluminium	90
Copper	90
Steel	90

Table 5.1 Assumed material recycling percentages

6 CARBON PAYBACK

The carbon payback period is analogous to the financial payback period, and represents the period of time before a product or project has saved more CO_2e emissions than has been produced by its construction and operation.

In order to establish the carbon payback period the potential CO_2e savings of the development need to be established. This has been ascertained by calculating the equivalent CO_2e emissions that would be generated from other forms of electricity generation, under the assumption that Neart na Gaoithe will displace the requirement for generation from these other sources.

To calculate the total annual generation from Neart na Gaoithe, Mainstream wind analysts' have provided capacity factors calculated for Neart na Gaoithe for various WTG types[6]. The capacity factor is the ratio of the actual energy produced in a given period, to the hypothetical maximum possible. For example in the 3.6 MW WTG case at Neart na Gaoithe the hypothetical maximum annual energy production is:

Wind farm total generation capacity	**= 450 MW**
Hypothetical maximum annual energy production	**= 450 MW x 8760 h / 1000 (convert MW to GW)**
	= 3942 GWh

Dividing this by the expected energy production gives the capacity factor:

Predicted annual generation (from Mainstream)	**= 1714.77 GWh**
Capacity Factor	**= 3942 GWh / 1714.77 GWh**
	= 43.5 %

The total installed capacity for each year of operation has been multiplied by a capacity factor of 43.5% for the 3.6 MW WTG case and by 36.4% for the 7.0 MW WTG case (based on 6 MW WTG analysis).

To calculate the equivalent CO_2e emissions produced by other generation sources, the predicted annual energy production figure is multiplied by an emission factor for each of the other fuels used in electricity generation in the UK. For example to calculate the equivalent annual emissions from coal:

Predicted annual generation of Neart na Gaoithe	**= 1714.77 GWh**
Emission factor for coal	**= 909 tCO_2e/GWh**
Equivalent annual CO_2e emissions	**= 1714.77 GWh x 909 tCO_2e/GWh**
	= 1,558,726 tCO_2e

Emission factors for the other generation sources considered are presented in Table 6.1. Emission factors have been taken from 2011 Digest of UK Energy Statistics (DUKES)[7]. It should be noted that:

- The factors do not reflect any potential changes in energy mix, efficiency improvements, and new technology (such as carbon capture and storage) which may occur throughout the life of Neart na Gaoithe.
- The factors represent direct emissions, and do not include indirect emissions, which may be associated with the other fuel sources such as fuel refining or transport costs.

Generation Source	Emission factor (t CO_2e per GWh)
All[1] (includes nuclear and renewable)	458
Coal	909
Fossil Combined	590
Gas	398
Oil	653

Table 6.1 Other generation sources emission factors

1 "All" is the full energy mix which includes renewable and nuclear sources.

7 RESULTS

7.1 Total development CO_2e emissions

The final calculated high emission scenario, and low emission scenario, total life cycle CO_2e emissions from Neart na Gaoithe are presented in Table 7.1 and graphically in Figure 7.1 and Figure 7.2. These emissions assume a 25 year life of the WTGs.

The low emission scenario is calculated to produce approximately 36% of the emissions of the high emission scenario. The reduction can be attributed mostly to the reduction of construction phase emissions, which are reduced due to the smaller number of turbines (and hence foundations and installation emissions), which are required.

Emission scenario	CO_2e Emissions (t)			
	Construction	Operational (25 years)	Decommissioning	Life Cycle
High	1,046,481	125,893	439,801	1,612,175
Low	445,348	22,367	114,754	582,469

Table 7.1 Total CO_2e emissions from Neart na Gaoithe

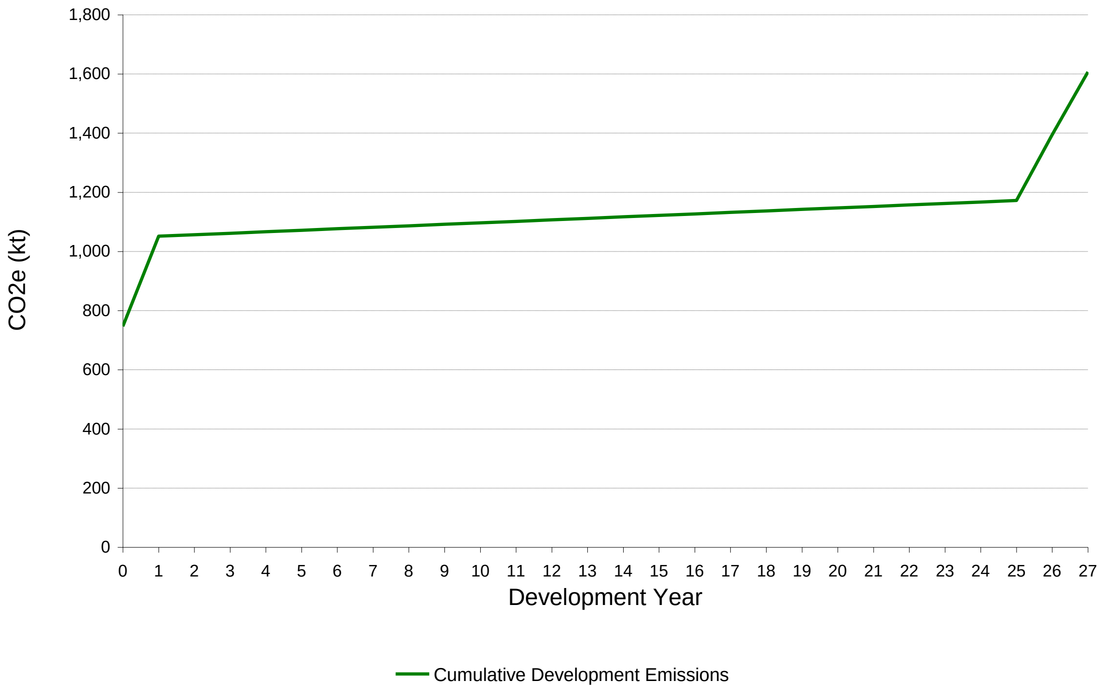

Figure 7.1 High emission scenario cumulative CO_2e emissions

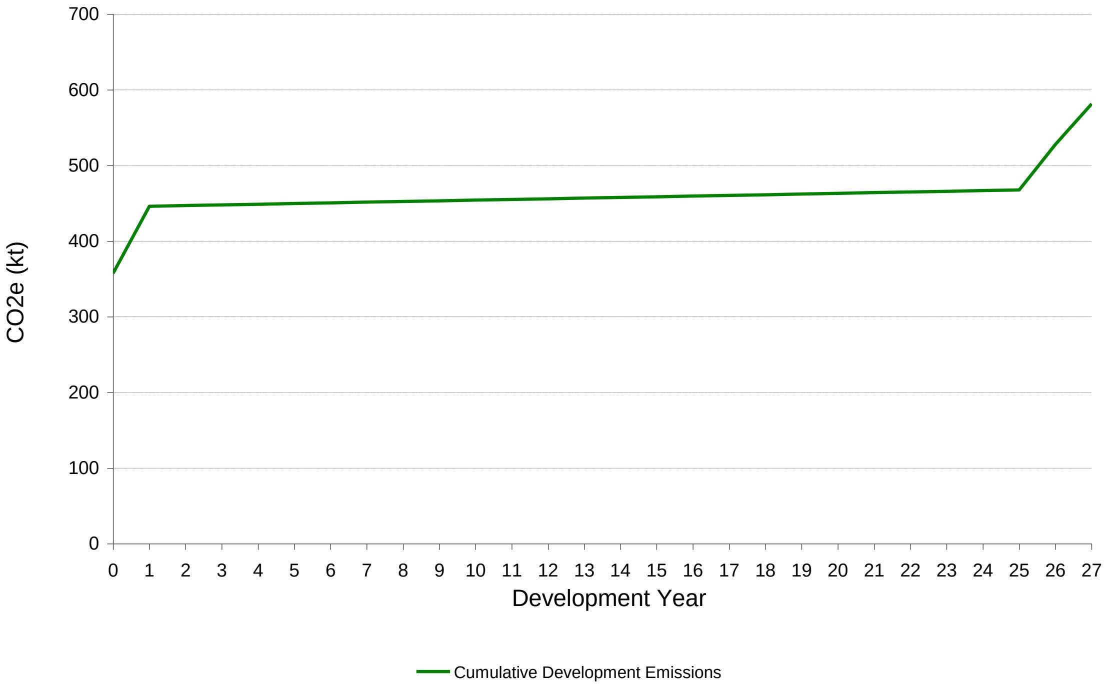

Figure 7.2 Low emission scenario cumulative CO_2e emissions

7.2 Carbon payback

The calculated high emission scenario, and low emission scenario, nett CO_2e emissions from Neart Na Goithe considering the displacement of other energy sources are presented in Table 7.2 and graphically in Figure 7.3 and Figure 7.4 respectively. Where nett CO_2e emissions are negative it represents the displaced equivalent emissions for that generation source, i.e. the “saved” emissions.

Emission scenario	Nett CO_2e emissions				
	Coal	Oil	Gas	Fossil combined	All
High	-35,802,283	-25,266,736	-14,772,344	-22,674,004	-17,241,613
Low	-30,582,816	-21,806,047	-13,063,561	-19,646,138	-15,120,616

Table 7.2 Nett CO_2e emissions from other generation sources

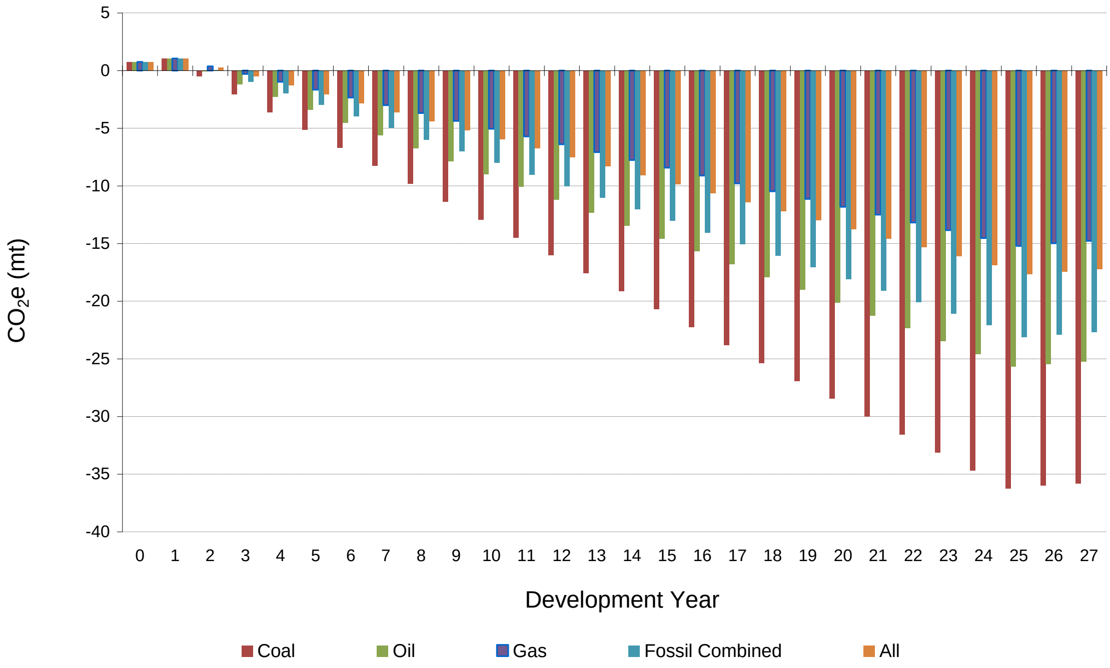

Figure 7.3 High emission scenario nett CO_2e emissions

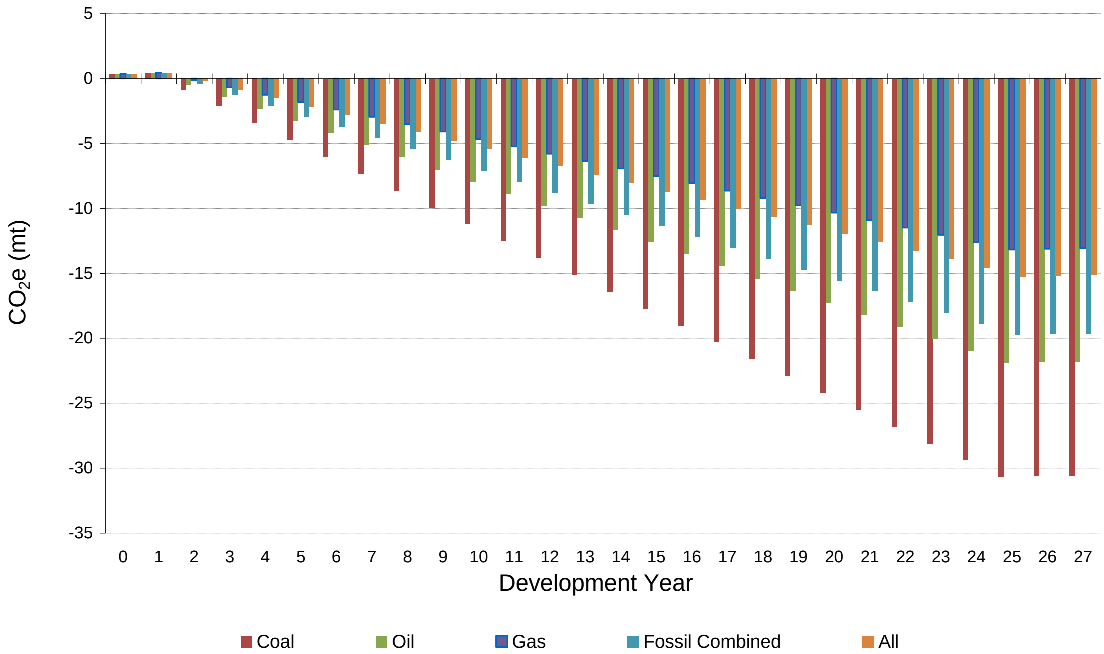

Figure 7.4 Low emission scenario nett CO_2e emissions

Assuming a 25 year life of the WTGs the development will displace CO_2e emissions from other energy sources by between 10.9 and 25.5 million tonnes in the low emissions case, and between 12.4 and 29.9 million tonnes in the high emissions case.

Although it might be expected that the high emissions scenario results in a lower nett displacement of CO_2e, the increased annual generation calculated for the high emissions scenario over time displaces more emissions, resulting in a greater nett displacement.

The payback range for Neart na Gaoithe is presented in Table 7.3 and has been calculated to be within 2 to 3 years from the start of installation.

Emission scenario	**Payback period from installation (within)**				
	Coal	**Oil**	**Gas**	**Fossil combined**	**All**
High	2 years	2 years	3 years	3 years	3 years
Low	2 years	2 years	2 years	2 years	2 years

Table 7.3 Carbon payback period as compared to other generation fuels

8 REFERENCES

Endnotes referenced within this report are presented in section 9, however additional material was considered in the development of this report and the associated carbon LCA tool, these are referenced here.

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9 ENDNOTES

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APPENDIX A CO_2e EMISSION FACTORS

Activity	Conversion factor (tCO_2e/Unit)	Units of conversion
Aluminium: Extruded	9.08	Tonnes
Aluminium: General	9.16	Tonnes
Catamaran - shore	651	Annual Use
Catarmaran - Mother vessel	29.7	Annual Use
Commissioning Vessel - Small	32.49	Days
Concrete (XS2 - Saline submerged)	0.13	Tonnes
Concrete: XC1 (Freshwater - permanently dry or wet)	0.11	Tonnes
Copper: EU Tube & Sheet	2.71	Tonnes
Dredging Vessel - Small	48.73	Days
Dredging Vessel - Large	97.47	Days
Export Cable Vessel - Small	25.99	Days
Export Cable Vessel - Large	48.73	Days
Flotel	96.00	Days
Foundation Placement Vessel - Large	81.22	Days
Foundation Placement Vessel - Small	48.73	Days
Glass Reinforced Plastic - GRP - Fibreglass	8.10	Tonnes
Graveling Vessel - Small	32.49	Days
Graveling Vessel - Large	48.73	Days
HGV - All UK Average	1.07	km
High Density Polyethylene (HDPE) Resin	1.93	Tonnes
Inter Array Vessel - Small	25.99	Days
Inter Array Vessel - Large	48.73	Days
Jacket Placement Vessel - Large	81.22	Days
Marine aggregate	0.01	Tonnes
Piling Vessel - Small	48.73	Days
Piling Vessel - Large	81.22	Days
Rail (diesel/Electric)	0.00003	Tonnes freight / km
Rubber	2.85	Tonnes
Scour Protection Vessel - Small	32.49	Days
Scour Protection Vessel - Large	48.73	Days
Sea Energy Marine	12.99	Days
Soil Excavation - general / rammed soil	0.04	m^3
Steel: General - UK (EU) Average Recycled Content	1.46	Tonnes
Substation Topside Inst. Vessel - Small	48.73	Days
Substation Topside Inst. Vessel - Large	81.22	Days
Tug	16.24	Days
Turbine Installation Vessel - Large	81.22	Days
Workboat	12.99	Days

APPENDIX B EMISSION INVENTORIES

Appendix B.1 High emission scenario emission inventory

Phase	Category	Included	Area / Item	# of Items	Activity / Material	Unit 1	Unit 2	Units of conversion	Emission Factor (tCO_2/unit)	tonnes of CO_2
Construction	**Materials**		3.6 WTG Siemens	126	Steel: General - UK (EU) Average Recycled Content	388		Tonnes	1.46	71376.48
				126	Aluminium: General	5		Tonnes	9.16	5770.8
				126	Copper: EU Tube & Sheet	8		Tonnes	2.71	2731.68
				126	Glass Reinforced Plastic - GRP - Fibreglass	72		Tonnes	8.1	73483.2
		x	Total							153362.16
			WTG Foundation GB	126	Steel: General - UK (EU) Average Recycled Content	832		Tonnes	1.46	153054.72
				126	Concrete (XS2 - Saline submerged)	7488		Tonnes	0.127	119822.976
				126	Marine aggregate			Tonnes	0.00809	
				126	Marine aggregate			Tonnes	0.00809	
		x	Total							272877.696
			Offshore Export Cables	2	Aluminium: Extruded	89.1		Tonnes	9.08	1618.056
				2	High Density Polyethylene (HDPE) Resin	85		Tonnes	1.93	328.1
		x	Total							1946.156
			Offshore Array Cables 240 km	2	Aluminium: Extruded	259.2		Tonnes	9.08	4707.072
				2	High Density Polyethylene (HDPE) Resin	69		Tonnes	1.93	266.34
		x	Total							4973.412
			Offshore Substation double unit	2	Steel: General - UK (EU) Average Recycled Content	1800		Tonnes	1.46	5256
				2	Aluminium: General			Tonnes	9.16	
				2	Copper: EU Tube & Sheet			Tonnes	2.71	
		x	Total							5256
			Substation Foundation Jacket	2	Steel: General - UK (EU) Average Recycled Content	1574		Tonnes	1.46	4596.08
		x	Total							4596.08
			Onshore Cables	1	Copper: EU Tube & Sheet	160		Tonnes	2.71	433.6
				1	Aluminium: Extruded	120		Tonnes	9.08	1089.6
		x	Total							1523.2
			Onshore Jointing Pits	39	Steel: General - UK (EU) Average Recycled Content	2.5		Tonnes	1.46	142.35
				39	Concrete: XC1 (Freshwater - permanently dry or wet)	430		Tonnes	0.105353373	1766.77607
			Onshore Transition Pit	1	Steel: General - UK (EU) Average Recycled Content	130		Tonnes	1.46	189.8
				1	Concrete: XC1 (Freshwater - permanently dry or wet)	0.27		Tonnes	0.105353373	0.028445411
		x	Total							2098.954516
	Total									**446633.6585**
	Transport - High		WTG GB foundation - EU	2	Tug	1200.95		Days	16.24425	39017.06408
		x	Total							39017.06408
			3.6 WTG China Nacel and Rotor, EU tower and blades	2	Tug	1412.89		Days	16.24425	45902.67677
		x	Total							45902.67677
			Export Cable China	2	Tug	449.6		Days	16.24425	14606.8296
		x	Total							14606.8296
			Substation (2)	2	Tug	15.75		Days	16.24425	511.693875
		x	Total							511.693875
			Substation foundations (2) EU	2	Tug	22.5		Days	16.24425	730.99125
		x	Total							730.99125
			Array Cable	2	Tug	22.6		Days	16.24425	734.2401
		x	Total							734.2401
	Total									**101503.4957**
	Installation - High		WTG Gravity Base foundation scenario	1	Foundation Placement Vessel - Large	532		Days	81.22125	43209.705
				1	Dredging Vessel - Large	529		Days	97.4655	51559.2495
				1	Graveling Vessel - Large	532		Days	48.73275	25925.823
				1	Scour Protection Vessel - Large	1064		Days	48.73275	51851.646
				1	Substation Topside Inst. Vessel - Large	36		Days	81.22125	2923.965
				1	Turbine Installation Vessel - Large	675		Days	81.22125	54824.34375
				1	Export Cable Vessel - Large	77		Days	48.73275	3752.42175
				1	Inter Array Vessel - Large	74		Days	48.73275	3606.2235
				1	Foundation Placement Vessel - Small	1064		Days	48.73275	51851.646
				1	Dredging Vessel - Small	1058		Days	48.73275	51559.2495
				1	Graveling Vessel - Small	1064		Days	32.4885	34567.764
				1	Scour Protection Vessel - Small	2128		Days	32.4885	69135.528
				1	Substation Topside Inst. Vessel - Small	72		Days	48.73275	3508.758
				1	Commissioning Vessel - Small	1282		Days	32.4885	41650.257
				1	Export Cable Vessel - Small	154		Days	25.9908	4002.5832
				1	Inter Array Vessel - Small	148		Days	25.9908	3846.6384
		x	Total							497775.8016
			Onshore Cables - trenches	2	Soil Excavation - general / rammed soil	1800		m3	0.0408	146.88
			Onshore Cables - cable transport	2	HGV - All UK Average	12		km	1.07127	25.71048
		x	Total							172.59048
			Onshore Jointing Pits	39	Soil Excavation - general / rammed soil	60		m3	0.0408	95.472
			Onshore Transition pits	2	Soil Excavation - general / rammed soil	92		m3	0.0408	7.5072
		x	Total							102.9792
	Total									**498051.3713**
Operation	**Maintenance Vessels**		Mother vessel	1	Catamaran - Mother vessel	1		Days	48.73275	48.73275
				1	Sea Energy Marine	365		Days	12.9954	4743.321
				1	Jack-up Installation Vessel	3		Days	81.22125	243.66375
		x	Total							5035.7175
	Total									**5035.7175**
Decommissioning	**Recovery - High**		WTG Gravity Base foundation scenario	1	Foundation Placement Vessel - Large	532		Days	81.22125	43209.705
				1	Dredging Vessel - Large	529		Days	97.4655	51559.2495
				1	Graveling Vessel - Large	532		Days	48.73275	25925.823
				1	Scour Protection Vessel - Large	1064		Days	48.73275	51851.646
				1	Substation Topside Inst. Vessel - Large	36		Days	81.22125	2923.965
				1	Turbine Installation Vessel - Large	675		Days	81.22125	54824.34375
				1	Foundation Placement Vessel - Small	1064		Days	48.73275	51851.646
				1	Dredging Vessel - Small	1058		Days	48.73275	51559.2495
				1	Graveling Vessel - Small	1064		Days	32.4885	34567.764
				1	Scour Protection Vessel - Small	2128		Days	32.4885	69135.528
				1	Substation Topside Inst. Vessel - Small	72		Days	48.73275	3508.758
		x	Total							440917.6778
			Onshore Cables	0	Soil Excavation - general / rammed soil	1800		m3	0.0408	0
			Total							0
			Onshore Jointing Pits	0	Soil Excavation - general / rammed soil	60		m3	0.0408	0
			Onshore Transition pits	0	Soil Excavation - general / rammed soil	92		m3	0.0408	0
			Total							0
	Total									**440917.6778**
	Material recycling		3.6 WTG Siemens	126	Steel: General - UK (EU) Average Recycled Content	282	-0.9	Tonnes	1.46	-46689.048
				126	Aluminium: Extruded	4	-0.9	Tonnes	9.08	-4118.688
				126	Copper: EU Tube & Sheet	6	-0.9	Tonnes	2.71	-1843.884
				126	Glass Reinforced Plastic - GRP - Fibreglass	52	0	Tonnes	8.1	0
		x	Total							-52651.62
			WTG Foundation GB	75	Steel: General - UK (EU) Average Recycled Content	832	0	Tonnes	1.46	0
				75	Concrete (XS2 - Saline submerged)	7488	0	Tonnes	0.127	0
				75	Marine aggregate			Tonnes	0.00809	
				75	Marine aggregate			Tonnes	0.00809	
			Total							0
			Offshore Export Cables	66	Copper: EU Tube & Sheet		0	Tonnes	2.71	
				66	High Density Polyethylene (HDPE) Resin		0	Tonnes	1.93	
			Total							-726329.682
			Offshore Array Cables 240 km	240	Copper: EU Tube & Sheet		0	Tonnes	2.71	
				240	High Density Polyethylene (HDPE) Resin		0	Tonnes	1.93	
			Total							-2905318.728
			Offshore Substation double unit	2	Steel: General - UK (EU) Average Recycled Content	1800	-0.9	Tonnes	1.46	-4730.4
				2	Aluminium: Extruded			Tonnes	9.08	
				2	Copper: EU Tube & Sheet			Tonnes	2.71	
		x	Total							-4730.4
			Substation Foundation Jacket	2	Steel: General - UK (EU) Average Recycled Content	1574	-0.9	Tonnes	1.46	-4136.472
		x	Total							-4136.472
			Onshore Cables	1	Copper: EU Tube & Sheet	160	0	Tonnes	2.71	0
				1	Aluminium: Extruded	120	0	Tonnes	9.08	0
			Total							0
			Onshore Jointing Pits	29	Steel: General - UK (EU) Average Recycled Content	2.5	0	Tonnes	1.46	0
				29	Concrete: XC1 (Freshwater - permanently dry or wet)	430	0	Tonnes	0.105353373	0
			Onshore Transition Pits	30	Steel: General - UK (EU) Average Recycled Content	0.27	0	Tonnes	1.46	0
				31	Concrete: XC1 (Freshwater - permanently dry or wet)	130	0	Tonnes	0.105353373	0
			Total							0
	Total									**-8866.872**
	Transport - High		WTG GB foundation	2	Tug	76.1		Days	16.24425	2472.37485
		x	Total							2472.37485
			3.6 WTG	2	Tug	6.7		Days	16.24425	217.67295
		x	Total							217.67295
			Substation	1	Tug	0.8		Days	16.24425	12.9954
		x	Total							12.9954
			Substation foundation	1	Tug	0.7		Days	16.24425	11.370975
		x	Total							11.370975
	Total									**2714.414175**

Appendix B.2 Low emission scenario emission inventory

Phase	Category	Included	Area / Item	# of Items	Activity / Material	Unit 1	Unit 2	Units of conversion	Emission Factor (tCO_2/unit)	tonnes of CO_2
Construction	**Materials**		7 WTG Vestas	64	Steel: General - UK (EU) Average Recycled Content	655		Tonnes	1.46	61203.2
				64	Aluminium: General	9		Tonnes	9.16	5276.16
				64	Copper: EU Tube & Sheet	14		Tonnes	2.71	2428.16
				64	Glass Reinforced Plastic - GRP - Fibreglass	121		Tonnes	8.1	62726.4
		x	**Total**							**131633.92**
			WTG Foundation Jacket	64	Steel: General - UK (EU) Average Recycled Content	1343		Tonnes	1.46	125489.92
				64	Marine aggregate	327.5		Tonnes	0.00809	169.5664
		x	**Total**							**125659.4864**
			Offshore Export Cables	2	Copper: EU Tube & Sheet	295		Tonnes	2.71	1598.9
				2	High Density Polyethylene (HDPE) Resin	85		Tonnes	1.93	328.1
		x	**Total**							**1927**
			Offshore Array Cables 120 km	1	Copper: EU Tube & Sheet	858		Tonnes	2.71	2325.18
				1	High Density Polyethylene (HDPE) Resin	69		Tonnes	1.93	133.17
		x	**Total**							**2458.35**
			Offshore Substation single unit	1	Steel: General - UK (EU) Average Recycled Content	2100		Tonnes	1.46	3066
				1	Aluminium: General			Tonnes	9.16	
				1	Copper: EU Tube & Sheet			Tonnes	2.71	
		x	**Total**							**3066**
			Substation Foundation Jacket	1	Steel: General - UK (EU) Average Recycled Content	1574		Tonnes	1.46	2298.04
		x	**Total**							**2298.04**
			Onshore Cables	1	Copper: EU Tube & Sheet	160		Tonnes	2.71	433.6
				1	Aluminium: Extruded	120		Tonnes	9.08	1089.6
		x	**Total**							**1523.2**
			Onshore Jointing Pits	23	Steel: General - UK (EU) Average Recycled Content	2.5		Tonnes	1.46	83.95
				23	Concrete: XC1 (Freshwater - permanently dry or wet)	430		Tonnes	0.105353373	1041.944862
			Onshore Transition Pit	1	Steel: General - UK (EU) Average Recycled Content	130		Tonnes	1.46	189.8
				1	Concrete: XC1 (Freshwater - permanently dry or wet)	0.27		Tonnes	0.105353373	0.028445411
		x	**Total**							**1315.723307**
	Total									**269881.7197**
	Transport - Low		WTG Jacket foundation - UK	2	Tug	9		Days	16.24425	292.3965
		x	**Total**							**292.3965**
			7 WTG All UK	2	Tug	54		Days	16.24425	1754.379
		x	**Total**							**1754.379**
			Export Cable EU	2	Tug	22.5		Days	16.24425	730.99125
		x	**Total**							**730.99125**
			Substation (1)	2	Tug	15.75		Days	16.24425	511.693875
		x	**Total**							**511.693875**
			Substation foundation (1) UK	2	Tug	1.12		Days	16.24425	36.38712
		x	**Total**							**36.38712**
			Array Cable EU	2	Tug	9		Days	16.24425	292.3965
		x	**Total**							**292.3965**
	Total									**5555.208615**
	Installation - Low		WTG Jacket foundation scenario	1	Piling Vessel - Large	424		Days	81.22125	34437.81
				1	Jacket Placement Vessel - Large	152		Days	81.22125	12345.63
				1	Substation Topside Inst. Vessel - Large	36		Days	81.22125	2923.965
				1	Turbine Installation Vessel - Large	225		Days	81.22125	18274.78125
				1	Export Cable Vessel - Large	77		Days	48.73275	3752.42175
				1	Inter Array Vessel - Large	74		Days	48.73275	3606.2235
				1	Piling Vessel - Small	848		Days	48.73275	41325.372
				1	Substation Topside Inst. Vessel - Small	72		Days	48.73275	3508.758
				1	Commissioning Vessel - Small	1282		Days	32.4885	41650.257
				1	Export Cable Vessel - Small	154		Days	25.9908	4002.5832
				1	Inter Array Vessel - Small	148		Days	25.9908	3846.6384
		x	**Total**							**169674.4401**
			Onshore Cables - trenches	2	Soil Excavation - general / rammed soil	1800		m3	0.0408	146.88
			Onshore Cables - cable transport	2	HGV - All UK Average	12		km	1.07127	25.71048
		x	**Total**							**172.59048**
			Onshore Jointing Pits	23	Soil Excavation - general / rammed soil	60		m3	0.0408	56.304
			Onshore Transition pits	2	Soil Excavation - general / rammed soil	92		m3	0.0408	7.5072
		x	**Total**							**63.8112**
	Total									**169910.8418**
Operation	**Maintenance Vessels**		Shore based	1	Catamaran - shore	1		Annual Use	651	651
				1	Jack-up Installation Vessel	3		Days	81.22125	243.66375
		x	**Total**							**894.66375**
			Mother vessel	1	Catermeran - Mother vessel	1		Annual Use	29.7	29.7
				1	Sea Energy Marine	365		Days	12.9954	4743.321
				1	Jack-up Installation Vessel	3		Days	81.22125	243.66375
			Total							**5016.68475**
	Total									**894.66375**
Decommissioning	**Recovery - Low**		WTG Jacket foundation scenario	1	Piling Vessel - Large	424		Days	81.22125	34437.81
				1	Jacket Placement Vessel - Large	152		Days	81.22125	12345.63
				1	Substation Topside Inst. Vessel - Large	36		Days	81.22125	2923.965
				1	Turbine Installation Vessel - Large	225		Days	81.22125	18274.78125
				1	Export Cable Vessel - Large	77		Days	48.73275	3752.42175
				1	Inter Array Vessel - Large	74		Days	48.73275	3606.2235
				1	Piling Vessel - Small	848		Days	48.73275	41325.372
				1	Substation Topside Inst. Vessel - Small	72		Days	48.73275	3508.758
		x	**Total**							**120174.9615**
			Onshore Cables	0	Soil Excavation - general / rammed soil	1800		m3	0.0408	0
			Total							**0**
			Onshore Jointing Pits	0	Soil Excavation - general / rammed soil	60		m3	0.0408	0
			Onshore Transition pits	0	Soil Excavation - general / rammed soil	92		m3	0.0408	0
			Total							**0**
	Total									**120174.9615**
	Material recycling		7 WTG Vestas	64	Steel: General - UK (EU) Average Recycled Content	655	-0.9	Tonnes	1.46	-55082.88
				64	Aluminium: Extruded	9	-0.9	Tonnes	9.08	-4707.072
				64	Copper: EU Tube & Sheet	14	-0.9	Tonnes	2.71	-2185.344
				64	Glass Reinforced Plastic - GRP - Fibreglass	121	0	Tonnes	8.1	0
		x	**Total**							**-61975.296**
			WTG Foundation Jacket	64	Steel: General - UK (EU) Average Recycled Content	1343	-0.9	Tonnes	1.46	-112940.928
				64	Marine aggregate	327.5	0	Tonnes	0.00809	0
		x	**Total**							**-112940.928**
			Offshore Export Cables	66	Copper: EU Tube & Sheet		0	Tonnes	2.71	
				66	High Density Polyethylene (HDPE) Resin		0	Tonnes	1.93	
			Total							**-687495.87**
			Offshore Array Cables 120 km	120	Copper: EU Tube & Sheet		0	Tonnes	2.71	
				120	High Density Polyethylene (HDPE) Resin		0	Tonnes	1.93	
			Total							**-1374991.74**
			Offshore Substation single unit	1	Steel: General - UK (EU) Average Recycled Content	2100	-0.9	Tonnes	1.46	-2759.4
				1	Aluminium: Extruded			Tonnes	9.08	
				1	Copper: EU Tube & Sheet			Tonnes	2.71	
		x	**Total**							**-2759.4**
			Substation Foundation Jacket	2	Steel: General - UK (EU) Average Recycled Content	1574	-0.9	Tonnes	1.46	-4136.472
		x	**Total**							**-4136.472**
			Onshore Cables	1	Copper: EU Tube & Sheet	160	0	Tonnes	2.71	0
				1	Aluminium: Extruded	120	0	Tonnes	9.08	0
			Total							**0**
			Onshore Jointing Pits	29	Steel: General - UK (EU) Average Recycled Content	2.5	0	Tonnes	1.46	0
				29	Concrete: XC1 (Freshwater - permanently dry or wet)	430	0	Tonnes	0.105353373	0
			Onshore Transition Pits	30	Steel: General - UK (EU) Average Recycled Content	0.27	0	Tonnes	1.46	0
				31	Concrete: XC1 (Freshwater - permanently dry or wet)	130	0	Tonnes	0.105353373	0
			Total							**0**
	Total									**-6895.872**
	Transport - Low		WTG Jacket foundation	2	Tug	11.3		Days	16.24425	367.12005
		x	**Total**							**367.12005**
			7 WTG	2	Tug	5.8		Days	16.24425	188.4333
		x	**Total**							**188.4333**
			Substation	1	Tug	0.8		Days	16.24425	12.9954
		x	**Total**							**12.9954**
			Substation foundation	1	Tug	0.7		Days	16.24425	11.370975
		x	**Total**							**11.370975**
	Total									**579.919725**

APPENDIX C WTG MATERIAL BALANCES

Material balances for the WTGs were not available from manufacturers for this assessment, in order to establish the mass of the main materials used, the balances were calculated using data available in the *Vestas Life cycle assessment of onshore and offshore sited wind power plants based on Vestas V90-3.0 MW turbines* report and other available Vestas information.

Using the available data, the mass of the main materials in the offshore WTG were converted to a percentage of the tower, rotor, blades, and nacelle's overall mass. These percentages were then used to estimate the mass of the main materials of the various WTG options being considered for Neart na Gaoithe, based on their total mass. Where the total mass of the turbine was also not known, it was estimated by using a linear scaling between the Vestas 3.0 MW WTG and the Vestas 7.0 MW WTG.

Assumed Vestas 3.0 MW WTG material balance (including tower):

Steel	**216.3 t**
Aluminium	**3 t**
Copper	**4.7 t**
Glass Fibre	**40 t**

Percentage of overall mass:

Steel	**82%**
Aluminium	**1%**
Copper	**2%**
Glass Fibre	**15%**

Example calculation for Siemens 3.6 MW:

Total WTG mass (including tower)	**473 t**

Material balance:

Steel	**473 t x 82% = 388 t**
Aluminium	**473 t x 1% = 5 t**
Copper	**473 t x 2% = 8 t**
Glass Fibre	**473 t x 15% = 72 t**