European Offshore Wind Deployment Centre
Environmental Statement

Chapter 25: Energy Use and Emissions

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25 ENERGY USE AND EMISSIONS

25.1 Introduction

1 This chapter reports on the energy use and emissions that are expected to be generated during the lifecycle of the European Offshore Wind Deployment Centre (EOWDC) project and puts these into the context of reductions in greenhouse gas emissions that offshore wind power deliver in comparison to conventional gas and coal based power generation. This chapter has been prepared in conjunction with Genesis Oil and Gas Consultants.

2 The First Minister for Scotland wants renewable sources to generate the equivalent of 100 % of Scotland's gross annual electricity consumption by 2020. Similarly, a target has been set for renewables sources to provide the equivalent of 11 per cent of Scotland's heat demand by 2020.

3 The Scottish Government's Climate Change Act, sets a target of reducing emissions by 80 % by 2050, including emissions from international aviation and shipping. It also sets a world-leading interim target for a 42 % cut in emissions by 2020.

4 In their annual energy statement the Department of Energy and Climate Change (DECC) report that it is likely that demand for electricity will double over the coming 40 years, as a result of the need to electrify large parts of the heat and transport sectors (DECC, 2010). Furthermore, for the UK to meet its obligations on reducing emissions of greenhouse gases, the electricity being consumed will need to be almost exclusively from low carbon sources. In the first quarter of 2010 nearly 80 % of the UK's electricity was generated by burning gas and coal. This needs to change and offshore wind will be crucial to delivering the UK's renewable and low carbon targets.

25.1.1 Methodology and Data Information and Sources

5 The following information sources have been used:

- DECC (2010) Annual Energy Statement, Departmental Memorandum. The Department of Energy and Climate Change (DECC), 27th July 2010
- Defra (2002) Guidelines for the measurement and reporting of emissions by Direct Participants in UK Emissions Trading Scheme. UKETS(01)05rev2.
- DBERR (2007) Digest of UK Energy Statistics. Department for Business, Enterprise and Regulatory Reform.
- Dft (2008) Department for Transport, Energy Statistics: http://www.dft.gov.uk/pgr/statistics/datatablespublications/energyenvironment/
- EEMS (2008) Atmospheric Emissions Calculations. Environmental Emissions Monitoring System (EEMS), November 2008
- The Institute of Petroleum (2000) Vessels Energy Use and Emissions. The Institute of Petroleum (2000) "Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures)
- Scottish Government (2010) Renewables Action Plan, Renewable Energy Division
- Scottish Government (2011) Carbon Payback Calculator Guidance

- Parliamentary Office of Science and Technology, October 2006, post note 268, Carbon footprint of electricity generation
- Renewable UK (2011) (formerly BWEA) http://www.bwea.com/

25.2 Impact Assessment

25.2.1 Construction Emissions

6 The EOWDC is likely to be installed offshore in stages, with the foundation section installed first, then the tower, the nacelle and finally the rotor.

7 For estimating emissions, it has been assumed that the foundations and transition pieces would be transported to site by a specially built installation vessel or barge. The barge may be self propelled or towed onto station using a tug vessel. Once *in situ*, the foundation structure would be up-ended by crane and installed onto the seabed. The transition piece would be installed by crane. A dive support vessel, and/or speciality rock placement vessel may be used to provide protection to seabed infrastructure. The export cables and inter-array cables would be installed using a cable lay vessel. Throughout the operations support vessels would be needed to transfer personnel and to act as guard vessels, to maintain the navigational safety distances, during construction.

8 Once the EOWDC is operational small maintenance vessels are expected to be needed on a daily basis to service the wind turbines, with larger vessels needed for any major repairs.

9 In order to determine emissions the activities were broken down into construction and operational phases. The expected duration of construction activities were calculated to provide the number of vessel days expected to install the foundations, wind turbine and cables (Table 25.1). The development scenarios with the highest number of days and vessels were chosen in the calculation of construction emissions to illustrate the worst case scenario.

Table 25.1
Vessel Fuel Use during Construction Activities (11 wind turbines)

Vessel type	Duration (days)	Working Consumption * (tonnes/day)	Total fuel use (tonnes)
Barge	132	18	2,376
Tug	20	50	1,000
Jack-up crane vessel	182	20	3,640
Dive support vessel	20	18	360
Standby vessel	207	0.7	145
Total	561	-	7,521

*Fuel use consumption taken from Institute of Petroleum (2000)

Table 25.2 **Vessel Fuel Use during Operation (1 year of operation)**			
Vessel type	**Duration (days)**	**Working Consumption * (tonnes/day)**	**Total fuel use (tonnes)**
Maintenance vessel* (Based on maximum 12 hour working day)	150	0.7	105
Jack-up crane vessel	20	20	400
Total	170	-	505

*Fuel use consumption taken from Institute of Petroleum (2000)

10 Information on vessel days was combined with emission factors for diesel consumption by engines to estimate emissions from both the construction and operational phases of the EOWDC (Table 25.3). It has been assumed that all the construction hours arise in a single year and that emissions from maintenance activities would be annual from year 2 onwards.

Table 25.3 **Total Emissions from Construction and Maintenance Activities**								
Vessel	**Tonnes Diesel Consumed (tonnes)**	**Emissions (tonnes)**						
		CO_2	**NO_x**	**N_2O**	**SO_2**	**CO**	**CH_4**	**VOC**
Emissions Factors (EEMS, 2008)	-	3.2	0.059	0.0002	0.004	0.0157	0.00018	0.002
Construction (Year 1)	7,521	20,416	447	2	30	118	1	15
Maintenance (annual)	505	1,371	30	0.1	2	8	0.1	1
Maintenance (22 years)	1,1110	30,162	660	2.2	44	176	2.2	22
Total construction and maintenance	18,631	50,578	1107	4.2	74	294	3.2	37

11 Operational emissions would arise principally from the activities associated with maintaining the vessels, and are significantly lower than the construction activities. The vessels used in the decommissioning activities are not yet known, however it is expected that vessels similar to that used for the construction activities would be used in a decommissioning capacity. Hence, the installation emissions can be seen to represent the worst case decommissioning emissions.

25.2.2 Emission Reductions Achieved from Wind Energy

12 A comparison of the lifecycle of different electricity generation systems currently used in the UK was undertaken by the Parliamentary Office of Science and Technology in 2006, this report concludes that while all electricity generation technologies emit CO_2 during their lifecycle, and that no CO_2 is actually generated from the wind turbines themselves during the operational stage, offshore wind power ranks as one of the lowest carbon footprints generating 5.25 g CO_2 equivalents/kWh. The only operational CO_2 emissions as part of the EOWDC are activities associated with maintenance of the wind turbines.

13 Electricity generated from offshore wind turbines is able to replace the output of coal and gas fired power stations as these are the most flexible plants on the grid and can relatively easily increase and decrease production capability to meet demand. Wind energy does not replace electricity from nuclear power stations because these operate at 'base load', that is they would be working for the whole time that they are available. The energy savings in tCO_2 have been presented in relation to a variety of conventional energy sources including coal fired plant, grid mix and fossil fuel mix, the savings of tCO_2 per year and over the course of the 22 years of operation are presented along with the associated emission factors are presented in Table 25.4.

14 The emissions reductions in tonnes has been calculated using the following formulae:

$CO_2 = (A*0.35*8,760*\text{Emission factor})$

Where:

- A = the rated capacity of the wind energy development in MW (the EOWDC would include 11 three bladed wind turbines with a maximum power generation of up to 100 MW)
- 0.35 is a constant, assumed capacity factor for offshore, which takes into account the intermittent nature of the wind, the availability of the wind turbines and array losses
- 8,760 is the number of hours in a year

Table 25.4
Emission Factors for Coal Fired Plant, Grid Mix, and Fossil Fuel Mix Emissions

Source	Emission factor tCO_2 MWh^{-1}	Emission reductions per year tCO_2	Emission reductions 22 years tCO_2
Grid mix	0.43*	131,838	2,900,436
Fossil fuel mix	0.607**	186,106	4,094,336
Coal fired plant	0.86*	263,676	5,800,872

*Defra (2002)
**(DECC, 2007; DBERR, 2007)

15 This would lead to emission reductions that are between 131,838 – 236,676 tCO_2 per year and 2,900,436 – 5,800,872 tCO_2 for the up to 22 years that the EOWDC may be operational.

25.2.3 Energy Balance and Pay Back Time for the EOWDC

16 The comparison of energy used in the manufacture with the energy produced by a power station is known as the energy balance. One of the measures of this is the 'pay back' time that is, the time taken for the EOWDC to generate the equivalent amount of energy as used in its manufacture. At this stage in the process the energy costs associated with the wind turbine manufacture are not known so a full lifecycle carbon analysis or calculation of the pay back time is not possible. In carrying out overall system calculations there may be a requirement for a backup figure to be included in line with Scottish guidance, this figure would be 15 % installed capacity or 5 % of the actual output (Scottish Government, 2011 Carbon Payback Calculator).

17 A comparison of the lifecycle emissions saved by the generation of the electricity at the EOWDC, using the lowest emissions reductions of the grid mix (2,900,436 tCO_2), against the emissions generated during the installation

and maintenance over the lifecycle of the project (50,578 tCO_2). The atmospheric emissions generated by installation and maintenance represent only 1.74 % of the emissions that are saved, which is a small proportion of the total savings.

18 Although the emissions associated with the manufacture are not known at present it is expected that the payback of electricity would be accomplished within 10 months, as Renewable UK state "the average wind farm in the UK will pay back the energy used in its manufacture within three to ten months, and over its lifetime the wind turbine will produce over 30 times more energy than was used in its manufacture" (Renewable UK, 2011).

25.3 Summary

19 The main atmospheric emissions would be generated during the manufacture, construction and maintenance of the EOWDC. Once the wind farm is operational the only emissions would be as a result of the regular maintenance trips. The EOWDC is expected to pay back the energy required within a maximum of 10 months. The generation of renewable energy from wind power is expected to result in a significant saving of greenhouse gas emissions in comparison to generating electricity produced from conventional coal and gas power stations.