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Consulting Engineers Limited

Northacre Renewable Energy Facility

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Greenhouse gas assessment

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Document approval

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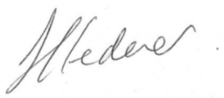
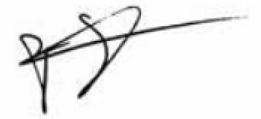
Prepared by:	Hannah Lederer		Environmental Scientist	30/06/2020
Checked by:	James Sturman		Lead Consultant	14/07/2020

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Contents

1 Introduction

Northacre Renewable Energy Limited (NRE) is proposing to build the Northacre Renewable Energy facility (the Facility) on land off Stephenson Road, Westbury, Wiltshire. A detailed description of the activities to be undertaken at the Facility is included within the Supporting Information document.

Northacre Renewable Energy Ltd is applying to the Environment Agency (EA) under the Environmental Permitting Regulations (EPR) for an Environmental Permit (EP) to operate the Facility.

The aim of this report is to assess the impact of greenhouse gas emissions, as previously required by the Environment Agency for similar power generating activities. The assessment considers the direct greenhouse gas emissions from the Northacre Renewable Energy facility (the Facility) and considers these in relation to other forms of power generation in the UK.

In this report, an assessment of the amount of greenhouse gas released through the incineration of waste has been undertaken. The assessment calculates the quantity of emissions of carbon dioxide from the Facility and also other greenhouse gases released (for example nitrous oxide) as a carbon dioxide equivalent.

It is assumed that power generated through energy recovery from the combustion of waste displaces electricity that would have otherwise been sourced from conventional power stations. Therefore, the net change in carbon dioxide emissions as a result of using waste to generate electricity rather than generating it by conventional means (based on the average UK power mix) has been calculated. For the purpose of this report, the power from renewable sources has been assumed to displace the same power as that generated by conventional means.

This report does not consider the release or avoidance of indirect carbon dioxide emissions associated with the operation of the Facility.

2 Assumptions

2.1 Facility

The Facility will use a moving grate as the combustion technology. The Facility will be a single-stream design, with a maximum design capacity of approximately 30.9 tonnes of incoming waste per hour, with a design net calorific value (NCV) of 10.5 MJ/kg. This equates to a design capacity of approximately 243,000 tonnes per annum, assuming approximately 7,860 hours operation per annum.

For the purposes of this assessment the following assumptions have been applied:

1. The Facility has a maximum capacity of 243,000 tonnes per annum.
2. The Facility has an availability of 7,860 hours operation per annum.
3. The boiler will have a thermal capacity of approximately 90 MWth.
4. The Facility will generate approximately 28.60 MWe of electricity at the design capacity. The Facility will have a parasitic load of approximately 2.97 MWe. Therefore, the export capacity of the Facility will be approximately 25.63 MWe.
5. The composition of the incoming waste combusted in the Facility as follows:
   a. the composition of combustible waste contains 26.82% carbon by weight; and
   b. 58.76% of the carbon content of the incoming waste is biodegradable, as defined by the Government in the legislation for the Landfill Allowance Trading Scheme.
6. Ammonia is used as a reagent in the SNCR NOx abatement system. Nitrous oxide (N_2O) is emitted at a concentration of 10 mg/m^3.
7. It is assumed that the Facility will have 4 start-ups and shut-downs per annum. Each period of start-up and shutdown are assumed to take 18 hours in total. Therefore, the auxiliary burners would be in operation for up to 72 hours per annum.
8. During periods when the Facility is not available, the parasitic load is assumed to be approximately 20% of the operational parasitic load. Periods of non-availability are times when the Facility is neither operational nor in the process of start-up or shut-down, i.e. periods where the auxiliary burners are not in operation. Therefore, the Facility will have a non-availability of approximately 828 hours per annum, during which time the parasitic load will be approximately 0.6 MWe.
9. The volumetric flow of flue gases from the Facility is approximately 184,680 Nm^3/hr (dry, ref O_2).
10. The auxiliary burners, which will be fired on low sulphur fuel oil, will operate at 60% of the maximum continuous rating of the thermal capacity of the facility. Therefore, the burner capacity will be approximately 54.52 MWth.
11. The combustion of fuel oil has emissions of 0.25 t CO_2/MWh, as stated in Environment Agency Guidance Note H1 (Annex h – Global Warming Potential).

3 Displaced Power

Power generated from the combustion of waste within the Facility will displace alternative forms of power generation. Table 3-1 shows the energy sources for UK electricity generation, with their associated carbon intensities. It is important to consider which of these power sources would be displaced by the power generated by the Facility.

Table 3-1: UK Electricity Supply Characteristics[1]

Energy Source	Proportion of UK Supply (%)	Carbon Emissions During Operation (gCO_2/kWh)
Coal	5.2	920
Natural Gas	41.4	349
Nuclear	18.7	-
Renewables	32.8	-
Other	1.9	871

Current energy strategy uses nuclear power stations to operate as baseload stations run with relatively constant output over a daily and annual basis, with limited ability to ramp up and down in capacity to accommodate fluctuations in demand. Power supplied from existing nuclear power stations is relatively low in marginal cost and has the benefit of extremely low CO_2 emissions.

Wind and solar plants also have very low marginal operating costs and are supported by subsidies in many cases. This means that they will run when there is sufficient wind or sun and that this operation will be unaffected by the Facility. It is considered that the construction of an ERF will have little or no effect on how nuclear, wind or solar plants operate when taking into account market realities (such as the phase-out of nuclear plants and the generous subsidies often associated with the development of wind and solar plants).

Combined cycle gas turbines (CCGTs) are the primary flexible electricity source. Since wind and solar are intermittent, with the electricity supplied varying from essentially zero (on still nights) to more than 16 GW (on windy or sunny days), CCGTs supply a variable amount of power. However, there are nearly always some CCGTs running to provide power to the grid.

Gas engines, diesel engines and open cycle gas turbines also make a small contribution to the grid. These are mainly used to provide balancing services and to balance intermittent supplies. As they are more carbon intensive than CCGTs, it is more conservative to ignore these for the purposes of this assessment.

The Defra document *'Energy from Waste – A guide to the debate 2014'* provides support for the use of CCGT as a comparator for electricity generated from the combustion of waste. Footnote 29 on Page 21 of the document states that:

> *'A gas fired power station (Combined Cycle Gas Turbine – CCGT) is a reasonable comparator as this is the most likely technology if you wanted to build a new power station today.'*

Therefore, for the purposes of this assessment it is assumed that power from the Facility will displace power which would otherwise be generated in a CCGT, and that the CO_2 emissions from a CCGT power station are equivalent to 349 g/kWh (refer to Table 3-1).

[1] Department of Energy and Climate Change. UK Fuel Mix Disclosure data table (01 April 2018 – 31 March 2019.)

It is acknowledged that the UK government has recently set a target which '*will require the UK to bring all greenhouse gas emissions to net zero by 2050*'. Taking this into consideration, in the future it is anticipated that the power, which the Facility will generate, will displace other forms of power generation, including renewable energy power stations. However, at this stage the mix of future generation capacity additions to the grid that might be displaced by the project is uncertain, and therefore the emissions intensity of future displaced generation cannot be accurately quantified. Therefore, for the purposes of this assessment, it has been assumed that the Facility will displace a gas fired power station as this is considered to be a reasonable comparator.

The following assumptions regarding the energy outputs from the Facility have been made:

- it will generate an average of 28.6 MWe with a net output of approximately 25.63 MWe, giving a gross and net electrical efficiency of 31.73% and 28.44% respectively; and
- there will be no heat export from the Facility (for the purposes of this assessment).

On this basis:

- The Facility will generate approximately 224,800 MWh of power per annum. Of this power approximately 201,500 MWh per annum will be available for export. Therefore, on an annual basis, the power exported from the Facility will displace approximately 70,300 tonnes of carbon dioxide which would otherwise be released from the combustion of natural gas.

4 Emissions from the Facility

The Facility will release emissions of carbon dioxide and their equivalents (other greenhouse gases such as nitrous oxide) from the combustion of incoming waste. Furthermore, during periods when it is not generating power, the Facility will have a parasitic load which will require power to be imported from the grid.

In addition, during start-up, auxiliary burners will be used to raise the temperature within the boiler to ≥850°C before starting to feed waste into the combustion chamber, as required by the Industrial Emissions Directive (IED). These burners will also be used to maintain the temperature within the boiler above 850°C when needed, as required by the IED. During shut-down, the auxiliary burners will be used to ensure complete burn-out of the waste. The combustion of auxiliary fuel will release carbon dioxide.

4.1.1 Emissions from the incineration of incoming waste

The Facility will export 829 kWh of power per tonne of incoming waste.

The carbon dioxide equivalent emissions from the incineration of waste would be 983 kg per tonne of incoming waste, of which 405 kg per tonne of incoming waste will be from non-biogenic sources.

The total carbon dioxide equivalent emissions from fossil fuels (excluding auxiliary fuels) will be approximately 98,500 tonnes per year.

4.1.2 Emissions of nitrous oxide

The Facility will release approximately 14,516 kg of nitrous oxide per annum. Nitrous oxide has a GWP of 310 carbon dioxide equivalents (according to the United Nations Framework for Climate Change Global Warming Potentials). Nitrous oxide is produced when the free radical molecules derived from ammonia react with nitric oxide (NO) produced from the combustion of nitrogen-containing substances in the waste.

Therefore, the total carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 4,500 tonnes per year.

4.1.3 Import of electricity

During periods of start-up and shutdown the Facility will have an electrical demand of approximately 214 MWh electricity; and during periods of non-availability the Facility will have an electrical demand of approximately 492 MWh electricity. On this basis, the Facility will consume approximately 706 MWh of electricity per annum.

As stated in Environment Agency Guidance Note H1, the import of electricity from public supply should be assumed to have emissions of 0.166 t CO_2/MWh. Therefore, the Facility is anticipated to release approximately 120 tonnes per year of carbon dioxide equivalent from the import of electricity.

4.1.4 Emissions from auxiliary firing

The auxiliary burners will consume approximately 3,900 MWh of fuel oil per annum. This corresponds to approximatly 1,000 tonnes per year of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing.

4.2 Summary

In summary, the operation of the Facility will lead to the release of approximately:

- 98,500 tonnes per year of carbon dioxide equivalent would be released from the combustion of the non-biogenic component of the waste;
- 4,500 tonnes per year of carbon dioxide equivalent from nitrous oxide from the combustion of incoming waste;
- 120 tonnes per year of carbon dioxide equivalent from imported electricity for the combustion of incoming waste; and
- 1,000 tonnes per year of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing in the Facility.

Therefore, in total it is predicted that approximately 104,120 tonnes per year of carbon dioxide equivalent would be released from the Facility.

5 Conclusions

The information presented within this assessment is summarised in Table 5-1.

Table 5-1: Greenhouse gas assessment summary

	GWP (tonnes CO_2 equivalent)	
Parameter	**Released**	**Saving/Offset**
CO_2 emissions derived from fossil fuels (a)	98,500	
N_2O from the process (urea) (b)	4,500	
Indirect CO_2 emissions (imported electricity) (c)	120	
Direct CO_2 emissions (auxiliary fuel) (d)	1,000	
Total released (e=a+b+c+d)	**104,120**	
Energy recovered (electricity) (f)		70,300
Energy recovered (heat) (g)		-
Total offset (h=f+g)		**70,300**
Net GWP (j=e-h)	**33,820**	

To conclude, this assessment indicates that the operation of the Facility would result in an increase (33,820 tonnes per annum) in the emissions of carbon dioxide equivalent released from the generation of power from the incineration of incoming waste within the Facility, compared to generating the equivalent power in a conventional CCGT power station.

However, it should be noted that the assessment methodology does not consider the avoidance of emissions from the disposal of the waste in a landfill, or from any other alternative methods of waste treatment.

A detailed assessment of carbon emission has been undertaken to support the planning application. The assessments takes into consideration emissions associated with alternative methods of waste treatment and transport. The full carbon assessment demonstrated that the Facility would result in a carbon saving of 57,844 tCO2e per annum when compared to the alternative scenario of disposing the waste in landfill.

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