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Consulting Engineers Limited

Redcar Energy Centre

Redcar Holdings Limited

Greenhouse Gas Assessment

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Document approval

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Contents

1 Introduction

Redcar Holdings Limited (Redcar Ltd) is developing the Redcar Energy Centre (REC) which will comprise the following waste treatment processes:

- a fuel preparation facility;
- Energy Recovery Facility (ERF) to incinerate incoming non-hazardous residual waste; and
- an IBA treatment/processing facility (IBA facility).

REC will be located on approximately 10 hectares of land at the Redcar Bulk Terminal, approximately 4.5 km west of Redcar town centre and 8.5km northeast of Middlesbrough city centre.

1.1 Background

The aim of this report is to assess the impact of greenhouse gas emissions as a result of the operation of REC.

The majority of greenhouse gas emissions will result from the incineration of incoming waste at the ERF. Greenhouse gas emissions resulting from the operation of the fuel preparation facility and the IBA facility are expected to make up only a small proportion of the total greenhouse gas emissions from REC, and the recovery of materials from these waste treatment processes will result in reductions in greenhouse gas emissions off-site, through the displacement of virgin materials.

A quantitative assessment of greenhouse gas emissions from the operation of the ERF has been undertaken as required by the Environment Agency (EA) for power generating activities. Greenhouse gas emissions from the ERF have also been considered in relation to other forms of power generation in the UK.

The EA guidance titled, '*Assess the impact of air emissions on global warming*' requires an application for a bespoke environmental permit to identify:

- direct greenhouse gas emissions; and
- indirect greenhouse gas emissions (from heat or power imported to the site).

The application should then calculate the total carbon impact associated with the activity.

The assessment calculates the quantity of emissions of CO_2 from the ERF and also other greenhouse gases released (for example N_2O) as a CO_2 equivalent

Power generated through energy recovery from waste displaces electricity that would have otherwise been sourced from conventional power stations. Therefore, the net change in carbon dioxide emissions has been calculated as a result of combusting incoming residual waste to generate electricity rather than generating it by conventional means (based on the average UK power mix). For the purpose of this assessment, 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 ERF.

2 Assumptions – ERF

The ERF will use a moving grate as the combustion technology. The ERF will consist of a two-stream design, with a nominal design capacity of approximately 28.1 tonnes of incoming residual waste per hour per stream, giving a design capacity for the ERF of approximately 56.2 tonnes of residual waste per hour with an expected net calorific value (NCV) of 10. 5 MJ/kg.

For the purposes of this assessment the following assumptions have been applied to the design and operation of the ERF:

1. It will have a nominal design capacity of 450,000 tonnes per annum.
2. It will have an annual availability of 8,000 hours of operation.
3. It will have a thermal capacity of 164.1 MW_{th}.
4. It will generate up to 49.9 MWe (design maximum) with a parasitic load of approximately 5 MWe.
5. The composition of the incoming waste combusted is as follows:
    a. The waste contains 27.28% carbon by weight; and
    b. Of which 53.21% of the carbon content of the incoming waste is biogenic carbon;
6. Ammonia is used as a reagent in the selective non-catalytic (SNCR) system for the abatement of nitrogen oxides (NOx). Nitrous oxide (N_2O) is assumed to be emitted at a concentration of 10 mg/Nm^3.
7. It will have 10 start-ups and 10 shutdowns per annum – this is a conservative assumption. Each period of start-up and shutdown will take approximately 18 hours in total. Therefore, the auxiliary burners will be in operation for approximately 180 hours per annum.
8. During periods when it is not available (excluding start-up and shutdown), the parasitic load will be approximately 20% of the operational parasitic load. Therefore, it will be 'not available' for 580 hours per annum, where the parasitic load is approximately 1.0 MW.
9. The volumetric flow of flue gases is 398,880 Nm^3/hr for both streams.
10. The auxiliary burners, which will be fired on low sulphur fuel oil (herein referred to as fuel oil), will operate at 65% of the maximum continuous rating of the thermal capacity of the ERF. Therefore, the total burner capacity will be approximately 106.64 MW_{th} for both streams.
11. As stated in Environment Agency Guidance Note H1, the combustion of fuel oil has emissions of 0.25 t CO_2eq/MWh.

3 Displaced Power – ERF

Power generated from the combustion of incoming waste within the ERF 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 ERF.

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

Energy Source	Proportion of UK Supply (%)	Carbon emissions during operation (gCO_2/kWh)
Coal	2.7	997
Natural Gas	38.2	380
Nuclear	16.1	0
Renewables	40.3	0
Other	2.7	797

The current UK 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, in many cases, are supported by subsidies. This means that they will run when there is sufficient wind or sun, and their operation will be unaffected by the ERF. It is considered that the construction of the ERF will have little or no effect on how nuclear, wind or solar plants operate when considering 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 19 GW and 9.6 GW respectively for wind and solar (peak generation recorded to date at the time of writing), CCGTs supply a variable amount of power. However, records show that there are only very limited periods when CCGTs are not operational and providing 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 generated by the ERF 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 380 g/kWh (refer to Table 3-1).

[1] Department of Energy and Climate Change. UK Fuel Mix Disclosure data table (1 April 2020 to 31 March 2021)

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 generated by the ERF, will displace other forms of power generation, including renewable energy power stations. However, at this stage, the mix of generation capacity which could be added in the future to the grid that could be displaced by the project is uncertain. Therefore, the carbon intensity of future displaced generation cannot be accurately quantified. For the purposes of this assessment, it has been assumed that the ERF 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 ERF have been made.

- The ERF will generate up to 49.9 MW of electricity with a net output of 44.9 MW, giving a gross and net electrical efficiency of 30.42% and 27.37% respectively.
- For the purposes of this greenhouse gas assessment, there will be no heat export from the ERF.

On this basis:

- The ERF will generate approximately 399,200 MWh of power per annum. Of this power approximately 359,280 MWh per annum will be available for export. This will displace a total of approximately 136,500 tonnes of carbon dioxide equivalent.

4 Emissions from the ERF

The combustion of incoming residual waste within the ERF will result in release emissions of carbon dioxide and their equivalents (other greenhouse gases such as nitrous oxide). Furthermore, during periods when it is not generating power, the ERF 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 ERF will export 798 kW of power per tonne of incoming waste.

The carbon dioxide equivalent emissions from the incineration of incoming waste would be 1,000 kg per tonne of waste, of which approximately 468 kg per tonne of waste will be from non-biogenic sources.

The total carbon dioxide equivalent emissions from fossil fuels (excluding the combustion of fuel oil, refer to section 4.1.4) will be approximately 210,600 tonnes per annum.

4.1.2 Emissions of nitrous oxide

The ERF will release approximately 18.9 tonnes of nitrous oxide per annum. Nitrous oxide has a GWP of 310 carbon dioxide equivalents.

The total carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 5,860 tonnes per annum.

4.1.3 Electricity import

During periods of start-up and shutdown the ERF will have an electrical demand of approximately 898 MWh electricity; and during periods of non-availability the ERF will have an electrical demand of approximately 579 MWh electricity. On this basis, the ERF will consume approximately 1,477 MWh of electricity per annum. It should be noted that this is a conservative assumption, as in reality, each line will have annual maintenance outages broadly in sequence. Therefore, the electricity required during periods of maintenance is likely be supplied by the 'other' line.

As stated in Environment Agency Guidance Note H1, the import of electricity from public supply should be assumed to have emissions of 0.166 tCO_2e/MWh. Therefore, the operation of the ERF is anticipated to result in the release of approximately 250 tonnes per annum of carbon dioxide equivalent from the import of electricity.

4.1.4 Emissions from auxiliary firing

The auxiliary burners will consume approximately 19,200 MWh of fuel oil per annum. This will be equivalent to a total of approximately 4,800 tonnes per annum of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing.

4.2 Summary – ERF

The operation of the ERF will lead to the release of approximately:

- 210,600 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 5,860 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 250 tonnes per annum of carbon dioxide equivalent from imported electricity which is used for the incineration of incoming waste; and
- 4,800 tonnes per annum of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing in the ERF.

Therefore, in total it is predicted that the operation of the ERF will result in the release of approximately 221,510 tonnes per annum of carbon dioxide.

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)	
Process	**ERF**	
Parameter	**Released**	**Saving/Offset**
CO_2 emissions derived from fossil fuels (a)	210,600	
N_2O from the process (ammonia) (b)	5,860	
Indirect CO_2 emissions (imported electricity) (c)	250	
Direct CO_2 emissions (auxiliary fuel) (d)	4,800	
Total released (e=a+b+c+d)	**221,510**	
Energy recovered (electricity) (f)		136,500
Energy recovered (heat) (g)		-
Total offset (h=f+g)		**136,500**
Net GWP (j=e-h)	**85,010**	

To conclude, the operation of the ERF will result in an increase (85,009 tonnes per annum) in the emissions of carbon dioxide released from the generation of power from the incineration of incoming waste within the ERF, compared to generating the equivalent power in a conventional CCGT power station. The operation of the fuel preparation facility and IBA facility are expected to result in savings of greenhouse gas emissions off-site from the displacement of virgin materials.

However, it should be noted that this 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. In addition, this assessment does not consider the carbon savings available from the potential to export heat from the ERF. This assessment only considers the direct and indirect carbon emissions as a result of the operation of the ERF, including carbon offset as a result of recovered energy as electricity, as required by the EA in support of an application for a bespoke EP – refer to section 1.1.

As set out in the Heat Plan (Appendix G of the application), there are a number of opportunities for the export of heat to potential heat-users within the local area. If it is assumed that this heat would otherwise be generated from the combustion of fossil fuels, exporting heat to these potential heat-users will further off-set carbon emissions from the ERF.

The Facility is well located due to its proximity to the Northern Endurance Partnership Project, and there is area of land within the installation boundary which has been identified as suitable for a carbon capture, use and storage (CCUS) system. The feasibility and technical specification of the CCUS system is subject to detailed design. However, if a CCUS system is implemented at the Facility, it would capture approximately 90% of the emissions of carbon dioxide from the combustion of the incoming residual waste which would result in significant carbon savings.

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