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Consulting Engineers Limited

Killoch Energy Recovery Facility

Barr Environmental Ltd

Greenhouse Gas Assessment

ENGINEERING CONSULTING

Document approval

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1 Introduction

Barr Environmental Limited (Barr) is developing the Killoch Energy Recovery Facility (the 'Facility') to incinerate incoming non-hazardous residual waste fuel. The Facility will be located at the site of the existing Barr Environmental Facility in Killoch.

1.1 Background

The aim of this report is to assess the impact of greenhouse gas emissions associated with the operational phase of the Facility. This assessment considers the direct greenhouse gas emissions from Killoch Energy Recovery Facility (the Facility) and considers these in relation to other forms of power generation in the UK.

An assessment of the amount of greenhouse gas released through the incineration of waste, associated with the Facility, has been undertaken. The quantity of emissions of CO_2 from the Facility has been calculated and also the other greenhouse gases released (for example N_2O) presented 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 using 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 Facility.

2 Assumptions

2.1 Facility

The Facility will use a moving grate as the combustion technology. The Facility will be one stream, with a nominal design capacity of approximately 19 tonnes of refuse-derived fuel (RDF) per hour (referred to as incoming waste) with an expected net calorific value (NCV) of 10.5 MJ/kg. The maximum throughput at the design capacity is approximately 166,000 tonnes per annum, assuming 8760 hours operation. However this assessment has assumed the operating hours will be 8000 hours per year. The annual throughput at the design point for 8000 hours of operation will be 150,000 tonnes per annum.

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

1. It will have an availability of 8,000 hours of operation.
2. It will have a nominal design capacity of 150,000 tonnes per annum.
3. It will have a thermal capacity of 54.7 MW_{th}.
4. It will generate up to 17.2 MW_e (design maximum) with a parasitic load of 1.7 MW_e.
5. The composition of the incoming waste combusted is as follows:
    a. The waste contains 27.2% carbon by weight; and
    b. Of which 51.5% of the carbon content of the incoming waste is biogenic carbon;
6. Ammonia is used as a reagent in the SNCR NOx abatement system. Nitrous oxide is emitted at a concentration of 10 mg/m^3.
7. It is estimated the Facility will have 10 start-ups and 10 shut-downs per annum. Each period of start-up and shut-down 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 'unavailable' for 580 hours per annum, where the parasitic load is 0.3 MW.
9. The volumetric flow of flue gases is 109,872 Nm^3/hr.
10. The auxiliary burners, which will be fired on low sulphur fuel oil (herein referred to as 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 32.8 MWth.
11. As stated in Environment Agency Guidance Note H1,
    a. the import of electricity from public supply has been assumed to have emissions of 0.166 tCO_2e/MWh; and
    b. the combustion of fuel oil has emissions of 0.25 t CO_2eq/MWh.

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	6.3	985
Natural Gas	72.0	371
Nuclear	8.2	0
Renewables	8.3	0
Other	5.2	920

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 that this operation will be unaffected by the Facility. Furthermore, it is considered that the construction of the Facility 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 and/or sunny days), 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 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 371 g/kWh (refer to Table 3-1).

[1] Department of Energy and Climate Change. UK Fuel Mix Disclosure data table (1 April 2019 to 31 March 2020)

In 2019, the UK government 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 generation capacity which could be added in the future to the grid that could be displaced by the project is uncertain, and the carbon 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 and is in accordance with Defra guidance.

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

- The Facility will generate up to 17.2 MW of electricity with a net output of 15.5 MW, giving a gross and net electrical efficiency of 31.5% and 28.3% respectively.
- For the purposes of this greenhouse gas assessment, there will be no heat export from the Facility.

On this basis:

- The Facility will generate approximately 137,600 MWh of power per annum. Of this power approximately 124,000 MWh per annum will be available for export. This will displace a total of approximately 46,000 tonnes of carbon dioxide equivalent.

4 Emissions from the EfW Facility

The Facility will release emissions of carbon dioxide and their equivalents (other greenhouse gases such as nitrous oxide) from the combustion of non-hazardous 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 827 kW of power per tonne of waste.

The carbon dioxide equivalent emissions from the incineration of waste would be 998 kg per tonne of waste, of which 484 kg per tonne of waste will be from non-biogenic sources.

The total carbon dioxide equivalent emissions from fossil fuels (excluding the combustion of auxiliary fuel, refer to section 4.1.4) will be approximately 72,600 tonnes per annum.

4.1.2 Emissions of nitrous oxide

The Facility will release approximately 8.8 tonnes of nitrous oxide per annum. Nitrous oxide has a Global Warming Potential (GWP) of 310 carbon dioxide equivalents.

The total carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 2,700 tonnes per annum.

4.1.3 Electricity import

During periods of start-up and shutdown, the Facility will have an electrical demand of approximately 300 MWh electricity; and during periods of non-availability the Facility will have an electrical demand of approximately 200 MWh electricity. On this basis, the Facility will consume approximately 500 MWh of electricity per annum.

This will be equivalent to approximately 80 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 5,900 MWh of fuel oil per annum for start-up and shutdown purposes.

This will be equivalent to approximately 1,500 tonnes per annum of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing.

4.2 Summary

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

- 72,600 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 2,700 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 80 tonnes per annum of carbon dioxide equivalent from imported electricity which is used for the incineration of incoming waste; and
- 1,500 tonnes per annum of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing in the Facility.

Therefore, in total it is predicted that the operation of the Facility will result in the release of approximately 76,880 tonnes per annum of carbon dioxide.

5 Conclusions

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

Table 5-1: Greenhouse Gas Assessment Summary

	GWP (tonnes CO_2 equivalent)	
Process	**Facility**	
Parameter	**Released**	**Saving/Offset**
CO_2 emissions derived from fossil fuels (a)	72,600	
N_2O from the process (ammonia) (b)	2,700	
Indirect CO_2 emissions (imported electricity) (c)	80	
Direct CO_2 emissions (auxiliary fuel) (d)	1,500	
Total released (e=a+b+c+d)	**76,880**	
Energy recovered (electricity) (f)		46,000
Energy recovered (heat) (g)		-
Total offset (h=f+g)		**46,000**
Net GWP (j=e-h)	**30,880**	

To conclude, the operation of the Facility will result in an increase (30,880 tonnes per annum) in the emissions of carbon dioxide 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, 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 Facility. The carbon assessment produced in support of the planning application determined that the Facility would have a net benefit of approximately 13,000 tCO_2e per annum compared to disposal of the waste in a landfill.

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. The export of heat from the Facility would increase any carbon savings associated with the operation of the Facility.

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