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Consulting Engineers Limited

Beddington EP Variation

Viridor South London Limited

Greenhouse Gas Assessment

ENGINEERING — CONSULTING

Document approval

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1 Introduction

Viridor South London Limited (Viridor) operates the Beddington Energy Recovery Facility (the ERF) which incinerates incoming non-hazardous residual waste (referred to as incoming waste). The ERF is located at Beddington Lane, Croydon.

1.1 Background

The aim of this report is to assess the impact of greenhouse gas emissions, as required by the Environment Agency (EA) for power generating activities. This assessment considers the direct greenhouse gas emissions from the ERF and considers these in relation to other forms of power generation in the UK. The emissions from the ERF operating at 110% thermal capacity (the 'proposed design') are compared to the emissions calculated within the greenhouse gas assessment submitted with the original EP application which assumes operation at 100% thermal capacity (the 'existing design'). Both scenarios assume operation based on the same NCV of waste. The two scenarios are described further within section 2.1 below. Furthermore, a copy of the original greenhouse gas assessment is presented within Appendix A for reference.

The EA guidance '*Assess the impact of air emissions on global warming*' requires the following to be identified and calculated, for bespoke environmental permit applications where the activity produces air emissions:

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

In this report, an assessment of the amount of greenhouse gas released from the incineration of the incoming waste at the ERF has been undertaken for both the existing design and the proposed design. 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 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

2.1 Design comparison

It is proposed to assess the ERF based on the design point, at an NCV of 9.8 MJ/kg, for the existing case (at 100% thermal capacity) and the proposed case (at 110% thermal capacity). The two points to be assessed have been highlighted in red on the firing diagram below (Figure 1). The firing diagram is shown for one incineration line.

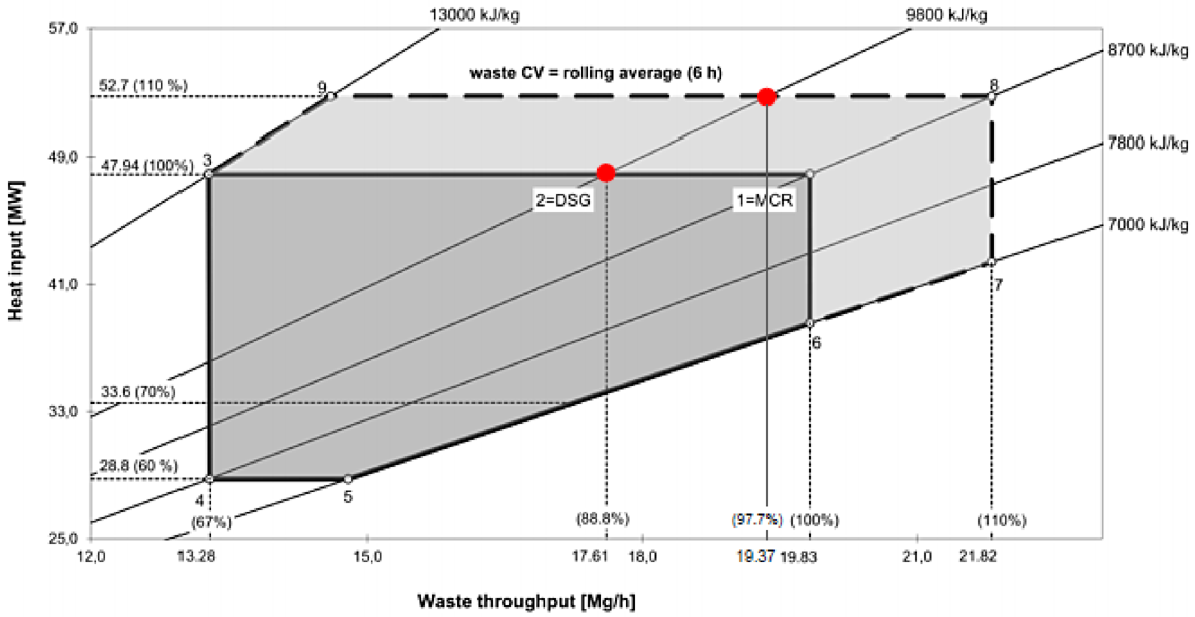

Figure 1: Firing diagram

2.2 Assumptions

The ERF uses a twin-line moving grate as the combustion technology. The assumptions to be used within the assessment are set out below:

Table 1: Assumptions

Parameter	Unit	Existing design case	Proposed design case
Thermal capacity	%	100%	110%
Thermal capacity (per line)	MWth	47.94	52.7
Thermal capacity (total)	MWth	95.88	105.4
Hourly throughput (per line)	tph	17.61	19.37
Hourly throughout (total)	tph	35.22	38.74
Operating hours	hours	7,800	7,800[(a)]
Nominal annual throughput	tpa	275,000	302,172[(b)]

Parameter	Unit	Existing design case	Proposed design case
Electrical generation (gross)	MW	26.1	29.5
Electrical generation (net)	MW	22.2	26.5
Parasitic load(c)	MW	3.9	3
Parasitic load during periods of start-up and shutdown(d)	MW	0.78	0.6
Start-up and shutdown periods each year	hours per annum	340	340
Periods of non-availability each year	hours per annum	620	620
Auxiliary burner capacity(e)	MW	57.5	63.2

(a) Availability assumed to be the same as existing case for the purposes of the GHG assessment, to allow periods of start-up and shutdown to be included for within the assessment and allow for an appropriate comparison between the two cases.

(b) Nominal value for the purposes of the GHG assessment.

(c) The parasitic load assumed in the original GHG assessment (existing design case) was based on pre-build data, whereas the parasitic load assumed for the proposed design case is based on operational data – hence the discrepancy. It should be noted that these are average values and parasitic load can vary dependent on weather.

(d) Assumed to be 20% of parasitic load.

(e) Assumed to operate at 60% of the maximum continuous rating of the thermal capacity of the Facility

Assumptions common to both cases are set out below:

1. The composition of the incoming waste combusted is as follows:
    a. The waste contains 23.4% carbon by weight; and
    b. Of which 64% of the carbon content of the incoming waste is biogenic carbon;
2. The waste will have an NCV of 9.8 MJ/kg;
3. Ammonia is used as a reagent in the SNCR NOx abatement system. Nitrous oxide is emitted at a concentration of 6 mg/Nm^3;
4. As stated in Environment Agency Guidance Note H1, the combustion of heavy fuel oil has emissions of 0.26 t CO_2eq/MWh.

3 Displaced Power

Power generated from the combustion of incoming 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 2: 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 Facility. 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 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 CO2 emissions from a CCGT power station are equivalent to 380 g/kWh (refer to Table 2). It is important to note that the

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

grid mix has changed since the original GHG assessment was developed; therefore, the calculations for displaced electricity are different in this assessment.

It is acknowledged that the UK government has 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 is uncertain (so 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.

For the purposes of this assessment, it is assumed that there will be no heat export from the Facility.

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

- For the existing design case, the Facility will generate up to 26.1 MW of electricity with a net output of 22.2 MW, giving a gross and net electrical efficiency of 27.2% and 23.1% respectively.
- For the proposed design case, the Facility will generate up to 29.5 MW of electricity with a net output of 26.5 MW, giving a gross and net electrical efficiency of 28.0% and 25.1% respectively.

On this basis:

- The existing design case for the Facility will generate approximately 203,580 MWh of power per annum. Of this power approximately 173,160 MWh per annum will be available for export. This will displace a total of approximately 65,800 tonnes of carbon dioxide equivalent.
- The proposed design case for the Facility will generate approximately 230,100 MWh of power per annum. Of this power approximately 206,700 MWh per annum will be available for export. This will displace a total of approximately 78,500 tonnes of carbon dioxide equivalent.

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 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 Emissions from the incineration of incoming waste

4.1.1 Permitted capacity

The Facility will export 630 kW of power per tonne of incoming waste.

The carbon dioxide equivalent emissions from the incineration of incoming waste would be 858 kg per tonne of waste, of which approximately 309 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) will be approximately 84,900 tonnes per annum.

4.1.2 Proposed capacity

The Facility will export 684 kW of power per tonne of incoming waste.

The carbon dioxide equivalent emissions from the incineration of incoming waste would be 858 kg per tonne of waste, of which approximately 309 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) will be approximately 93,300 tonnes per annum.

4.2 Emissions of nitrous oxide

4.2.1 Permitted capacity

The Facility will release approximately 10.8 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 3,300 tonnes per annum.

4.2.2 Proposed capacity

The Facility will release approximately 11.8 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 3,700 tonnes per annum.

4.3 Electricity import

4.3.1 Permitted capacity

During periods of start-up and shutdown, the Facility will have an electrical demand of approximately 1,326 MWh electricity; and during periods of non-availability an electrical demand of approximately 484 MWh electricity. On this basis, the Facility will consume approximately 1,810 MWh of electricity per annum. It should be noted that this is a conservative assumption, as in reality, each stream of the plant will have annual maintenance outages broadly in sequence and therefore imported electricity would be replaced with reduced electrical export from the waste incineration process.

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 Facility is anticipated to result in the release of approximately 300 tonnes per annum of carbon dioxide equivalent from the import of electricity.

4.3.2 Proposed capacity

During periods of start-up and shutdown, the Facility will have an electrical demand of approximately 1,020 MWh electricity; and during periods of non-availability an electrical demand of approximately 372 MWh electricity. On this basis, the Facility will consume approximately 1,392 MWh of electricity per annum. It should be noted that this is a conservative assumption, as in reality, each stream of the plant will have maintenance outages broadly in sequence and therefore imported electricity would be replaced with reduced electrical export from the waste incineration process.

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 Facility is anticipated to result in the release of approximately 230 tonnes per annum of carbon dioxide equivalent from the import of electricity.

4.4 Emissions from auxiliary firing

4.4.1 Permitted capacity

For the purposes of this assessment, it is conservatively assumed that the auxiliary burners will consume approximately 19,600 MWh (or 1,800 tonnes) of fuel oil per annum. This will be equivalent to a total of approximately 5,100 tonnes per annum of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing. These numbers have been calculated to the nearest hundred compared to the original GHG assessment.

4.4.2 Proposed capacity

For the purposes of this assessment, it is conservatively assumed that the auxiliary burners will consume approximately 21,500 MWh (or 2,000 tonnes) of fuel oil per annum. This will be equivalent to a total of approximately 5,600 tonnes per annum of carbon dioxide equivalent from the combustion of fuel oil for auxiliary firing.

4.5 Summary

4.5.1 Permitted capacity

The operation of the Facility at the permitted design will lead to the release of approximately:

- 84,900 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 3,300 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 300 tonnes per annum of carbon dioxide equivalent from imported electricity which is used for the incineration of incoming waste; and
- 5,100 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 under the existing design case will result in the release of approximately 93,600 tonnes per annum of carbon dioxide.

4.5.2 Proposed capacity

The operation of the Facility at the proposed design will lead to the release of approximately:

- 93,300 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 3,700 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 230 tonnes per annum of carbon dioxide equivalent from imported electricity which is used for the incineration of incoming waste; and
- 5,600 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 under the proposed design case will result in the release of approximately 102,830 tonnes per annum of carbon dioxide.

5 Conclusions

The information presented within this assessment is summarised in Table 3.

Table 3: Greenhouse gas assessment summary

	GWP (tonnes CO_2 equivalent)			
Process	**Current operation**		**Proposed operation**	
Parameter	**Released**	**Saving/Offset**	**Released**	**Saving/Offset**
CO_2 emissions derived from fossil fuels (a)	84,900		93,300	
N_2O from the process (ammonia) (b)	3,300		3,700	
Indirect CO_2 emissions (imported electricity) (c)	300		230	
Direct CO_2 emissions (auxiliary fuel) (d)	5,100		5,600	
Total released (e=a+b+c+d)	**93,600**		**102,830**	
Energy recovered (electricity) (f)		65,800		78,500
Energy recovered (heat) (g)		-		-
Total offset (h=f+g)		**65,800**		**78,500**
Net GWP (j=e-h)	**27,800**		**24,330**	

To conclude, the proposed increase in waste throughput will result in an increase of 9,230 tonnes per annum in the emissions of carbon dioxide released from the generation of power from the incineration of incoming waste within the Facility. However, the corresponding increase in electrical output from the proposed operation of the Facility will displace an additional 12,700 tonnes per annum compared to the output from the permitted Facility, when compared to generating the equivalent power in a conventional CCGT power station.

Therefore, the operation of the Facility under the proposed design case represents a decrease in the greenhouse gas emissions of around 3,500 tonnes per annum compared to the operation of the Facility under the existing design case.

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 Facility. This assessment only considers the direct and indirect carbon emissions as a result of the operation of the Facility, 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.

Appendices

A Original GHG assessment

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