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Consulting Engineers Limited

Riverside Resource Recovery Facility EP Variation

Riverside Resource Recovery Limited

Greenhouse Gas Assessment

ENGINEERING CONSULTING

Document approval

	Name	Signature	Position	Date
Prepared by:	Simon Render		Senior Environmental Consultant	25/02/2021
Checked by:	James Sturman		Lead Environmental Consultant	25/02/2021

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1 Introduction

Riverside Resource Recovery Limited (RRRL) operates the Riverside Resource Recovery Facility (the Facility) which incinerates incoming non-hazardous residual waste fuel. The Facility is located on the banks of the River Thames at Belvedere in the London Borough of Bexley. RRRL is applying to vary the Environmental Permit (EP) for the Facility to increase the annual processing capacity of the Facility from 785,000 tpa to 850,000 tpa.

As explained in the Supporting Information submitted in support of this application, RRRL has installed an enhanced combustion control system (CCS), which will enable the Facility to process additional waste and generate additional power.

1.1 Background

The aim of this report is to assess the impact of greenhouse gas emissions associated with the proposed increase in annual processing capacity and considers this in relation to other forms of power generation in the UK. The assessment considers the direct greenhouse gas emissions associated with the proposed capacity and compares this with the greenhouse gas emissions associated with the permitted capacity.

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.

This assessment calculates the quantity of emissions of CO_2 from the Facility (both the consented and proposed designs) and also other greenhouse gases released (for example N_2O) as a CO_2 equivalent.

Power generated through energy recovery from waste in the Facility 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 a conventional power station.

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

2 Assumptions

For the purposes of this assessment, the following assumptions have been applied to both the permitted and proposed designs:

1. The composition of the incoming waste combusted is as follows:
   a. The waste contains 26.27% carbon by weight; and
   b. Of which 59.3% of the carbon content of the incoming waste is biogenic carbon;
2. Ammonia is used as a reagent in the SNCR NOx abatement system. Nitrous oxide is emitted at a concentration of 10 mg/Nm^3.
3. The Facility will have 6 start-ups and 6 shut-downs per annum – this is a conservative assumption. 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 108 hours per annum.
4. As stated in Environment Agency Guidance Note H1, the combustion of fuel oil has emissions of 0.25 t CO_2eq/MWh.

2.1 Consented Design

The consented design uses a moving grate as the combustion technology. The Facility has three streams, with a nominal design capacity of approximately 30.348 tonnes of waste per hour (referred to as incoming waste) each, giving a design capacity for the Facility of approximately 91.0 tonnes of waste per hour with an expected net calorific value (NCV) of 9.6 MJ/kg.

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

1. Operational data from 2018 to 2019 indicates that the Facility processed approximately 750,000 tonnes per annum operated for an average of 8,200 hours in each year. It is noted the EP allows for a processing capacity of up to 785,000 tonnes.
2. It has a thermal capacity of 242.8 MW_{th}.
3. It generates up to 72.3 MW_e (design maximum) with a parasitic load of approximately 7 MW_e.
4. During periods when it is not available (excluding start-up and shutdown), the parasitic load is 20% of the operational parasitic load. Therefore, it is 'unavailable' for 452 hours per annum, where the parasitic load is 1.4 MW.
5. The volumetric flow rate of flue gases is 500,011 Nm^3/hr.
6. The auxiliary burners, are fired on low sulphur fuel oil (herein referred to as fuel oil), operate at 60% of the maximum continuous rating of the thermal capacity of the Facility. Therefore, the burner capacity is approximately 145.7 MW_{th}.

2.2 Proposed Design

Following implementation of the enhanced CCS system, each of the three lines will be capable of processing approximately 34.6 tonnes of waste per hour with an expected net calorific value (NCV) of 9.6 MJ/kg. Therefore, the design capacity of the Facility is approximately 103.8 tonnes of waste per hour.

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

1. It will have a nominal design capacity of approximately 850,000 tonnes per annum, assuming the same availability as 2018 and 2019, i.e. 8,200 hours of operation.

2. It will have a thermal capacity of 276.4 MW_{th}.
3. It will generate up to 83.9 MW_e (nominal design capacity) with a parasitic load of approximately 7 MW_e.
4. 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 452 hours per annum, where the parasitic load is 1.4 MW.
5. The volumetric flow rate of flue gases is 573,253 Nm^3/hr.
6. The auxiliary burners, which will be fired on low sulphur fuel oil (herein referred to as fuel oil), remain unchanged. Therefore, the burner capacity is the same, i.e. it is 145.7 MW_{th}.

3 Displaced Power – Consented and Proposed

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 sunlight and that this 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 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)

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 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 the reasonable comparator.

3.1 Current Operation

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

- The consented design will generate up to 72.3 MW of electricity with a net output of 65.7 MW. This gives a gross and net electrical efficiency of 29.8% and 27.1% 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 592,767 MWh of power per annum. Of this power 538,893 MWh per annum will be available for export. This will displace a total of approximately 199,900 tonnes of carbon dioxide equivalent.

3.2 Proposed Capacity

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

- The Facility will generate up to 83.9 MW of electricity with a net output of 76.6 MW. This gives a gross and net electrical efficiency of 30.3% and 27.7% 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 688,256 MWh of power per annum. Of this power 628,478 MWh per annum will be available for export. This will displace a total of approximately 233,000 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 Current Operation

The Facility exports 717 kW of power per tonne of waste.

The carbon dioxide equivalent emissions from the incineration of waste would be 963 kg per tonne of waste, of which approximately 392 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 4.4) will be approximately 292,300 tonnes per annum.

4.1.2 Proposed capacity

The Facility will export 742 kW of power per tonne of waste.

The carbon dioxide equivalent emissions from the incineration of waste would be 990 kg per tonne of waste, of which approximately 392 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 4.4) will be approximately 333,200 tonnes per annum.

4.2 Emissions of nitrous oxide

4.2.1 Current Operation

The Facility will release approximately 28.5 tonnes of nitrous oxide per annum. Nitrous oxide has a GWP of 298 carbon dioxide equivalents.

The total additional carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 8,500 tonnes per annum.

4.2.2 Proposed capacity

The Facility will release approximately 32.5 tonnes of nitrous oxide per annum. Nitrous oxide has a GWP of 298 carbon dioxide equivalents.

The total additional carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 9,700 tonnes per annum.

4.3 Electricity import

Current Operation During periods of start-up and shutdown the Facility will have an electrical demand of approximately 1,260 MWh electricity; and during periods of non-availability the Facility will have an electrical demand of approximately 532 MWh electricity. On this basis, the Facility will consume approximately 1,792 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 230 tonnes per annum of carbon dioxide equivalent from the import of electricity.

4.3.1 Proposed capacity

The electrical demand of the Facility during periods of unavailability remains unchanged following the increase in processing capacity. Therefore, the increased throughput 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

Current Operation The auxiliary burners will consume approximately 15,700 MWh of fuel oil per annum approximately. This will be equivalent to a total of approximately 3,900 tonnes per annum of carbon dioxide equivalent from the combustion of additional fuel oil for auxiliary firing.

4.4.1 Proposed capacity

The auxiliary burners will consume approximately 15,700 MWh of fuel oil per annum approximately. This will be equivalent to a total of approximately 3,900 tonnes per annum of carbon dioxide equivalent from the combustion of additional fuel oil for auxiliary firing.

4.5 Summary

4.5.1 Current Operation

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

- 292,300 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 8,500 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; and
- 3,900 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 results in the release of approximately 305,000 tonnes per annum of carbon dioxide.

4.5.2 Proposed capacity

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

- 333,200 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 9,700 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; and
- 3,900 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 at the proposed capacity will result in the release of approximately 347,000 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

Parameter	Current operation		Proposed design	
	Released	Displaced	Released	Displaced
CO2 emissions derived from fossil fuels (a)	292,300		333,200	
N2O from the process (ammonia) (b)	8,500		9,700	
Indirect CO2 emissions (imported electricity) (c)	230		230	
Direct CO2 emissions (auxiliary fuel) (d)	3,900		3,900	
Total released (e=a+b+c+d)	**304,930**		**347,030**	
Energy recovered (electricity) (f)		199,700		233,000
Energy recovered (heat) (g)		-		-
Total displaced (h=f+g)		**199,700**		**233,000**
Net GWP (j=e-h)	**105,230**		**114,030**	
Change in GWP	**8,800**			

To conclude, compared to generating the equivalent power in a conventional gas fired power station the current operation will result in an increase of approximately 105,230 tonnes per annum in the emissions of carbon dioxide released from the generation of power and the incineration of waste. In comparison, the proposed capacity will result in an increase of approximately 114,030 tonnes per annum in the emissions of carbon dioxide released from the generation of power and the incineration of waste, compared to generating the equivalent power in a conventional gas fired power station. Therefore, the proposed increase in processing capacity of the Riverside Resource Recovery Facility will result in an overall increase of 8,800 tonnes per annum in the emissions of carbon dioxide.

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. This assessment purely considers the base 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 – refer to section 1.1.

The carbon assessment produced in support of the amendment to the section 36 planning consent for the Facility includes a more detailed analysis of the carbon benefits of the development compared to disposal of waste in a landfill, and takes into account other indirect carbon emissions (from transport etc). The carbon assessment concludes that, for the base case, operating at the proposed capacity is predicted to lead to a net reduction in greenhouse gas emissions of approximately 29,150 tonnes of CO2-equivalent (CO2e) per annum compared to the landfill counterfactual.

ENGINEERING CONSULTING

FICHTNER

Consulting Engineers Limited

Kingsgate (Floor 3), Wellington Road North,
Stockport, Cheshire, SK4 1LW,
United Kingdom

t: +44 (0)161 476 0032
f: +44 (0)161 474 0618

www.fichtner.co.uk