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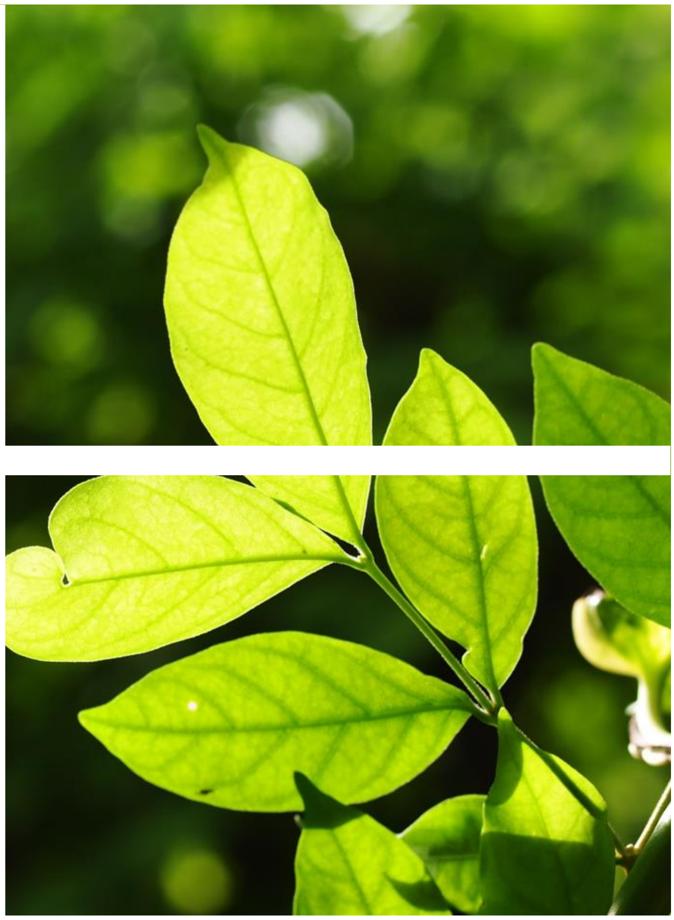

Thameside Energy Recovery Facility EP Variation

Thameside Energy Recovery Limited

Greenhouse Gas Assessment

ENGINEERING CONSULTING

Document approval

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1 Introduction

Thameside Energy Recovery Facility Limited (TERFL) is constructing the Thameside Energy Recovery Facility (the Facility) which will incinerate incoming non-hazardous residual waste fuel. The Facility is in the western part of the Port of Tilbury on the north side of the Thames Estuary in the Borough of Thurrock in Essex. TERFL is applying to vary the Environmental Permit (EP) for the Facility to increase the annual processing capacity of the Facility from 170,000 tpa to 350,000 tpa following the evolution of the design of the Facility.

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 27.34% carbon by weight; and
    b. of which 68% 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 10 start-ups and 10 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 180 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 Permitted capacity

The consented design uses a moving grate as the combustion technology. The Facility has one stream, with a nominal design capacity of approximately 14.9 tonnes of waste per hour (referred to as incoming waste) with an expected net calorific value (NCV) of 13.8 MJ/kg.

For the purposes of this assessment the following assumptions have been applied to the consented capacity of the Facility:

1. The Facility is permitted to process up to 170,000 tonnes per annum of waste.
2. It will have a thermal capacity of 57 MW_{th}.
3. It will generate up to 20 MW_e (design maximum) with a parasitic load of approximately 2 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 580 hours per annum, where the parasitic load is 0.4 MW.
5. The volumetric flow rate of flue gases is 149,900 Nm^3/hr.
6. The auxiliary burners, which will be fired on low sulphur fuel oil (herein referred to as fuel oil), will consume approximately 880 tonnes of fuel oil per annum.

2.2 Proposed capacity

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

1. It will have a nominal design capacity of approximately 350,000 tonnes per annum, assuming 8,000 hours of operation.
2. It will have a thermal capacity of 126.4 MW_{th}.
3. It will generate up to 44 MW_e (nominal design capacity) with a parasitic load of approximately 4 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 580 hours per annum, where the parasitic load is 0.9 MW.
5. The volumetric flow rate of flue gases is 253,656 Nm^3/hr.

6. The auxiliary burners, which will be fired on low sulphur fuel oil, will consume 420 tonnes of fuel oil per annum.

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	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 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 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, 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 Permitted capacity

In accordance with the permitted design, the following assumptions associated with the power and heat export from the Facility have been made.

- The consented design will generate up to 20 MW of electricity with a net output of 18 MW. This gives a gross and net electrical efficiency of 35.1% and 31.6% 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 160,000 MWh of power per annum. Of this power 144,000 MWh per annum will be available for export. This will displace a total of approximately 54,700 tonnes of carbon dioxide equivalent.

3.2 Proposed capacity

In accordance with the proposed changes to the design, the following assumptions associated with the power and heat export from the Facility have been made:
The Facility will generate up to 44 MW of electricity with a net output of 40.0 MW. This gives a gross and net electrical efficiency of 34.8% and 31.6% 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 352,000 MWh of power per annum. Of this power 320,000 MWh per annum will be available for export. This will displace a total of approximately 121,600 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 1149 kW of power per tonne of waste.

The carbon dioxide equivalent emissions from the incineration of waste would be 928 kg per tonne of waste, of which approximately 334 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 4.4.1) will be approximately 56,800 tonnes per annum.

4.1.2 Proposed capacity

The Facility will export 913 kW of power per tonne of waste.

The carbon dioxide equivalent emissions from the incineration of waste would be 1,002 kg per tonne of waste, of which approximately 321 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 4.4.2) will be approximately 112,300 tonnes per annum.

4.2 Emissions of nitrous oxide

4.2.1 Permitted capacity

The Facility will release approximately 17.7 tonnes of nitrous oxide per annum. Nitrous oxide has a GWP of 310 carbon dioxide equivalents.

The total additional carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 3,700 tonnes per annum.

4.2.2 Proposed capacity

The Facility will release approximately 20.3 tonnes of nitrous oxide per annum. Nitrous oxide has a GWP of 310 carbon dioxide equivalents.

The total additional carbon dioxide equivalent emissions from emissions of nitrous oxide will be approximately 6,300 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 396 MWh electricity; and during periods of non-availability the Facility will have an electrical demand of approximately 255 MWh electricity. On this basis, the Facility will consume approximately 651 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 tCO_2e/MWh. Therefore, the permitted capacity will result in the release of approximately 110 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 720 MWh electricity; and during periods of non-availability the Facility will have an electrical demand of approximately 465 MWh electricity. On this basis, the Facility will consume approximately 1,185 MWh of electricity per annum. Therefore, the permitted proposed capacity will result in the release of approximately 200 tonnes per annum of carbon dioxide equivalent from the import of electricity.

4.4 Emissions from auxiliary firing

4.4.1 Permitted capacity

The auxiliary burners will consume approximately 11,200 MWh of fuel oil per annum approximately. This will be equivalent to a total of approximately 2,800 tonnes per annum of carbon dioxide equivalent from the combustion of additional fuel oil for auxiliary firing.

4.4.2 Proposed capacity

The auxiliary burners will consume approximately 5,275 MWh of fuel oil per annum approximately. This will be equivalent to a total of approximately 1,300 tonnes per annum of carbon dioxide equivalent from the combustion of additional 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:

- 56,800 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;
- 110 tonnes per annum of carbon dioxide equivalent from imported electricity; and
- 2,800 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 permitted capacity will result in the release of approximately 63,410 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:

- 112,300 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 6,300 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 200 tonnes per annum of carbon dioxide equivalent from imported electricity; and
- 1,300 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 proposed capacity will result in the release of approximately 120,100 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)	56,800		112,300	
N2O from the process (ammonia) (b)	3,700		6,300	
Indirect CO2 emissions (imported electricity) (c)	110		200	
Direct CO2 emissions (auxiliary fuel) (d)	2,800		1,300	
Total released (e=a+b+c+d)	**63,410**		**120,100**	
Energy recovered (electricity) (f)		54,700		121,600
Energy recovered (heat) (g)		-		-
Total displaced (h=f+g)		**54,700**		**121,600**
Net GWP (j=e-h)	**8,710**		**-1,500**	
Change in GWP	**-10,210**			

To conclude, the proposed increase in waste throughput will lead to an increase in CO_2 emissions from the Facility of 56,690 tonnes per annum. However, the corresponding increase in electrical output from the proposed Facility will displace an additional 66,900 tonnes per annum compared to the output from the permitted Facility, when compared to generating the equivalent power in a conventional gas fired power station.

Therefore, the proposed increase in processing capacity of the Tilbury Energy Recovery Facility, allowing for the displacement of power generation from the conventional sources, will result in an net decrease of 10,210 tonnes per annum of carbon dioxide emisisons.

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.

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