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Consulting Engineers Limited

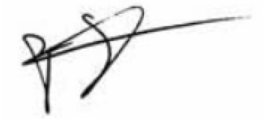
Lostock Sustainable Energy Plant

Lostock Sustainable Energy Plant Ltd

Greenhouse Gas Assessment

ENGINEERING CONSULTING

Document approval

	Name	Signature	Position	Date
Prepared by:	Katie Hampton		Environmental Consultant	29/06/2021
Checked by:	James Sturman		Lead Consultant	28/07/2021

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Contents

1 Introduction

Lostock Sustainable Energy Plant Ltd (LSEP Ltd) is proposing to vary the Environmental Permit (EP) for the Lostock Sustainable Energy Plant (the 'Facility'). A number of changes are being proposed, which are described as follows:

1. Increase the capacity of the Facility from 600,000 tonnes per annum (based on a throughput of 72.2 tonnes per hour and an availability of around 8,000 hours) to 728,000 tonnes per annum (assuming a throughput of 91 tonnes per hour and an availability of 8,000 hours);
2. Amend the Site Layout to align with the design of the Facility allowing for its design evolution since the original EP was granted;
3. Amend the Operating Techniques to align with the design of the Facility allowing for its design evolution since the original EP was granted; and
4. Introduce two additional EWC codes to the EP.

1.1 Background

The aim of this report is to assess the impact of greenhouse gas emissions from the Facility, as required by the Environment Agency (EA) for similar power generating activities. This assessment considers the direct greenhouse gas emissions from the Facility and considers these in relation to other forms of power generation in the UK.

The EA guidance '*Assess the impact of air emissions on global warming*' requires the following to be identified and calculated, for 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 through the incineration of waste, associated with the Facility, has been undertaken. The assessment calculates the quantity of emissions of CO_2 from the Facility 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 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 Design assumptions

The Facility will use a moving grate as the combustion technology and will be of a twin-stream design. Furthermore, it has been assumed that emissions of N_2O will be approximately 4 kg/TJ (net) of waste[1].

The Facility will have an annual throughput of 728,000 tpa, based on a design capacity of approximately 91 tonnes of waste per hour (45.5 tonnes per line) and an availability of 8,000 hours, with an expected NCV of 9.5 MJ/kg. This is at the Maximum Continuous Rating (MCR) point on the new firing diagram.

A carbon assessment has been undertaken to support the recent s36 variation application in relation to the planning for the Facility. A review of published waste composition data has indicated that an NCV of 9.5 MJ/kg (i.e. the MCR point on the firing diagram) is not wholly reflective of the overall waste to be received at the Facility. Therefore, the carbon assessment has been undertaken based on the 'design' case (DSG point on the firing diagram), as this is considered to be more reflective of typical operation at the Facility.

As such, it is also proposed to undertake this GHG assessment based on the DSG point on the firing diagram, to allow for a suitable comparison. Notwithstanding this, the justification for the proposed increase in capacity in the EP variation application remains based on the MCR point, as a theoretical maximum capacity.

The firing diagram is provided for reference within Appendix A of the Supporting Information.

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

Table 1: Design assumptions

Parameter	Units	'Proposed' design – DSG design point
Hourly throughput (total)	t/hour	86.4
Hourly throughput (per line)	t/hour	43.2
Availability	hours/year	8,426
Annual throughput	tonnes/year	728,000
Design NCV	MJ/kg	10
Thermal capacity (total)	MWth	240
Thermal capacity (per boiler)	MWth	120
Gross electrical generation	MWe	76.9
Parasitic load	MWe	7
Net electrical generation	MWe	69.9
Heat generation	MWth	0
Carbon content of waste	%	26.12

1 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 2, Table 2.2 default emissions factors for stationary combustion in the energy industries, Municipal Wastes (non-biomass fraction)

Parameter	Units	'Proposed' design – DSG design point
Biogenic carbon content	%	58.38%
Nitrous oxide concentration	mg/Nm^3	10
Number of start-ups and shutdowns each year[1]	-	10
Duration of start-up/shutdown	hours/year	18
Total operation of auxiliary boilers	hours/year	180
Parasitic load during non-available period (excluding start-up and shutdown)	% of operational parasitic load	20%
Parasitic load during non-available period (excluding start-up and shutdown)	MW	1.4
Periods of unavailability each year	hours/annum	580
Auxiliary burner capacity	% of MCR of thermal capacity of Facility	65%
Auxiliary burner capacity	MWth	156.1
Emissions from combustion of fuel oil[2]	t CO_2e/MWh	0.25

[1]: Conservative assumption applied for purposes of assessment.

[2] Source: Environment Agency Guidance Note H1 Annex H – Global Warming Potential

3 Displaced power

Power generated from the combustion of waste within the Facility will displace alternative forms of power generation. Table 2 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[2]

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. 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 2).

2 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. Therefore, 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.

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

Table 3: Energy outputs assumptions

Parameter	Units	'Proposed' design
Gross electrical generation	MWe	76.9
Parasitic load	MWe	7
Net electrical generation	MWe	69.9
Heat generation	MWth	-
Gross electrical generation	MWh	647,959
Net electrical generation	MWh	588,977
Heat generation	MWh	-
Gross electrical efficiency	%	32.04%
Net electrical efficiency	%	29.13%
Total system efficiency	%	49.03%

On this basis:

- The Facility would generate approximately 647,959 MWh of power per annum. Of this power approximately 588,977 MWh per annum would be available for export. This would displace a total of approximately 218,500 tonnes of carbon dioxide equivalent. It has been assumed that the Facility would not export heat.

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.

4.1.1 Emissions from the incineration of incoming waste

The Facility will export around 809 kW of power per tonne of waste. For the Facility, the carbon dioxide equivalent emissions from the incineration of waste would be 958 kg per tonne of waste, of which approximately 399 kg per tonne of waste will be from non-biogenic sources. For the Facility, the total carbon dioxide equivalent emissions from fossil fuels (excluding the combustion of fuel oil, refer to section 4.1.4) will be approximately 290,200 tonnes per annum.

4.1.2 Emissions of nitrous oxide

The Facility will release approximately 29.1 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 for the Facility will be approximately 9,027 tonnes per annum.

4.1.3 Electricity import

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 216 MWh electricity. On this basis, the Facility will consume approximately 1,476 MWh of electricity per annum.

It should be noted that these are conservative assumptions, 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 240 tonnes per annum of carbon dioxide equivalent from the import of electricity.

4.1.4 Emissions from auxiliary firing

For the Facility, the auxiliary burners will consume approximately 28,100 MWh of fuel oil per annum. This will be equivalent to a total of approximately 7,000 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:

- 290,200 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 9,027 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 240 tonnes per annum of carbon dioxide equivalent from imported electricity which is used for the incineration of incoming waste; and
- 7,000 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 306,467 tonnes per annum of carbon dioxide.

5 Conclusions

The information presented within this assessment is summarised in Table 4 below.

Table 4: Greenhouse Gas Assessment Summary

Parameter	GWP (tonnes CO2 equivalent)	
	Released	Saving/Offset
CO2 emissions derived from fossil fuels (a)	290,200	
N2O from the process (ammonia) (b)	9,027	
Indirect CO2 emissions (imported electricity) (c)	240	
Direct CO2 emissions (auxiliary fuel) (d)	7,000	
Total released (e=a+b+c+d)	306,467	
Energy recovered (electricity) (f)		218,500
Energy recovered (heat) (g)		-
Total offset (h=f+g)		218,500
Net GWP (j=e-h)	87,967	

To conclude, the operation of the Facility will lead to a small amount of carbon dioxide emissions being released.

It has been assumed that the Facility will not export heat from the outset. However, as set out in the CHP assessment (refer to Appendix C of the Supporting Information), there are still a number of opportunities for the export of heat to potential heat-users within the local area. Exporting heat to these potential heat-users would further increase the carbon benefits of the Facility.

This greenhouse gas assessment does not consider the avoided emissions from alternative methods of waste disposal (e.g. landfill). Should these avoided emissions be incorporated, the carbon benefits of the scheme would increase. A detailed carbon assessment has been undertaken to support the planning application, which concluded that the operation of the Facility will result in overall carbon benefits compared to the alternative of disposing waste in a landfill.

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