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Consulting Engineers Limited

Newhurst ERF

Covanta Energy Limited

Greenhouse Gas Assessment

ENGINEERING + CONSULTING

Document approval

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1 Introduction

Covanta Energy Limited (Covanta) will operate the Newhurst Energy Recovery Facility (the Facility) to incinerate incoming non-hazardous residual waste (referred to as incoming waste). The Facility is located at Newhurst Quarry, Shepshed, Leicestershire. Within this application, Covanta is applying to vary the Environmental Permit (EP) to allow for an increase in the waste processing capacity of the Facility from 350,000 tonnes per annum to 455,000 tonnes per annum of waste. The increase in waste processing capacity will be achieved by increasing the thermal capacity at which the Facility operates from 100% MCR to 102% MCR, a decrease in the average NCV of waste processed at the Facility, and an increase in the availability of the Facility.

1.1 Background

The aim of this report is to calculate the change in greenhouse gas emissions as a result of the proposed increase in the waste processing capacity of the Facility. This report has been developed in accordance with the requirements of Environment Agency (EA) guidance for power generating activities. It includes an estimate of direct greenhouse gas emissions from the Facility and a comparison of these emissions against other forms of power generation in the UK. The emissions from the Facility operating at 102% MCR are compared to the emissions calculated for the Facility operating at 100% MCR. Both scenarios are described in more detail within section 2.1.

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 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 the difference between the CO_2-equivalent (CO_2e) emissions released from the incineration of waste at the Facility, and the CO_2e emissions released from generating the same quantity of electricity from conventional means (based on the average UK power mix). For this assessment, the power from renewable sources is 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 such as transport that are associated with the Facility.

2 Assumptions

2.1 Design comparison

It is proposed to assess the Facility based on the 'design' NCV of 10.5 MJ/kg, for both the 100% MCR and the 102% MCR points. The two points to be assessed on the 10.5 MJ/kg NCV line can be seen on the firing diagram below.

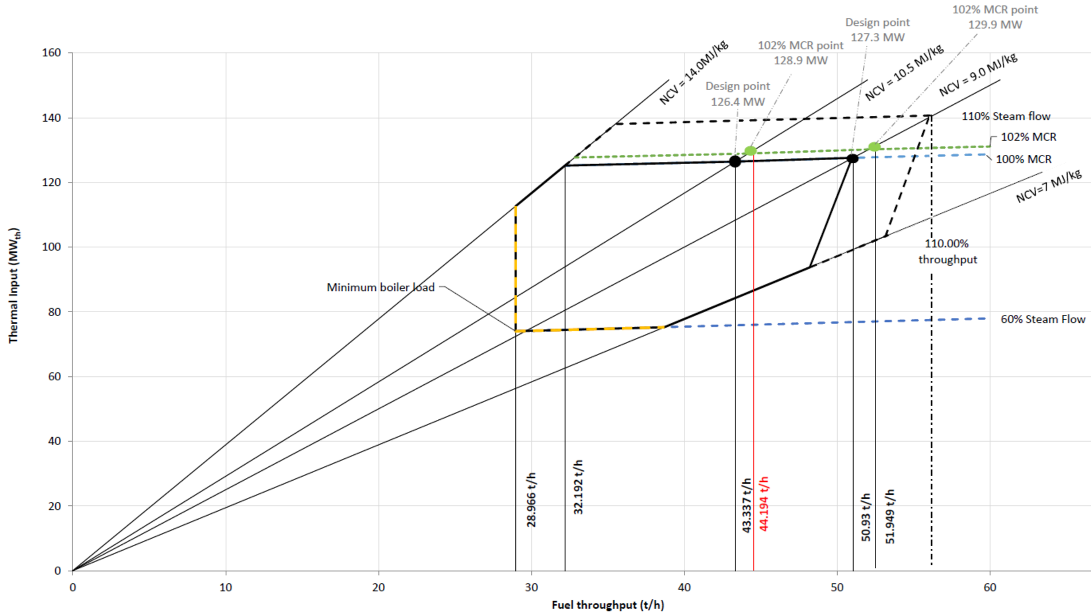

Figure 1: Firing diagram

2.2 Assumptions

The Facility uses a moving grate as the combustion technology. The assumptions used within this report are provided in Table 1:

Table 1: Assumptions

Parameter	Unit	100% MCR	102% MCR
Thermal capacity	%	100%	102%
Thermal capacity (per line)	MWth	126.4	128.9
Hourly throughput (per line)	tph	43.337	44.194
Operating hours	hours	8,076 [a]	8,076 [a]
Annual capacity	tpa	350,000	356,911[b]
Electrical generation (gross)	MW	43[c]	44[d]
Electrical generation (net)	MW	38[c]	40[d]
Parasitic load	MW	5	4
Average parasitic load during periods of start-up and shutdown[e]	MW	0.8	0.8

Parameter	Unit	100% MCR	102% MCR
Start-up and shutdown periods each year(f)	hours per annum	180	180
Periods of non-availability each year	hours per annum	504	504
Auxiliary burner capacity(g)	MW	70	70

(a) *For the 100% MCR case, 8,076 hours availability corresponds to currently permitted 350,000 tonnes per annum capacity. For the 102% MCR case, availability is assumed to be the same as the 100% MCR case to provide a like-for-like comparison.*
(b) *Nominal value calculated for the purpose of this assessment.*
(c) *Consistent with previous EP variation application.*
(d) *Expected net power of approximately 40 MW reflects final design and lower parasitic load of the Facility compared to previous EP application.*
(e) *For both cases, this is assumed to be 20% of operational parasitic load for the 102% case (this has been chosen as it best reflects the final design and lower parasitic load of the Facility).*
(f) *Conservatively assumes 10 start-ups/shutdowns a year, taking 18 hours each.*
(g) *Auxiliary burner capacity has been sized as approximately 55% of the 100% MCR thermal load. The installed maximum burner capacity is therefore the same for both cases.*

Assumptions common to both cases are set out below:

1. The composition of the incoming waste combusted is as follows (consistent with the original GHG assessment)
    a. The waste contains 27.6% carbon by weight[1]; and
    b. 56.0% of the carbon content of the incoming waste is biogenic carbon[2];
2. The waste will have an NCV of 10.5 MJ/kg;
3. Nitrous oxide is emitted from the process at a rate of 4 kg/TJ waste[3];
4. As stated in Environment Agency Guidance Note H1, the combustion of fuel oil has emissions of 0.25 t CO_2eq/MWh.

1 Consistent with design waste specification for the plant.

2 Derived from a project-specific waste composition calculation, assuming 75% MSW and 25% C&I waste, using published data (WRAP, 2020, "*National Municipal Waste Composition, England 2017*", Table 3 and WRAP Cymru, 2020, "*Commercial and Industrial Waste in Wales*", Appendix 3) with some analysis to remove plastic bags and WEEE.

3 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)

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 and 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[4]

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. These are 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 operation of the Facility. Therefore, it is considered that operation of the Facility will have little or no effect on how nuclear, wind or solar plants operate.

Combined cycle gas turbines (CCGTs) are the primary flexible sources of electricity generation. Since wind and solar generators are intermittent, with the electricity supplied varying from essentially zero (on still nights) to more than 19 GW and 9.6 GW respectively for wind and solar (peak generation recorded to date at the time of writing), 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 when electricity demand exceeds the generated supply from other generators. 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 2).

[4] Department of Energy and Climate Change. UK Fuel Mix Disclosure data table (1 April 2020 to 31 March 2021). At the time of writing, this was the most up-to-date table available.

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, it is anticipated that, in the future, the power generated by the Facility will displace power from other forms of generation, including renewable energy power stations. However, since the make-up of future generation capacity is uncertain, the carbon intensity of future displaced generation is difficult to quantify accurately. Therefore, it has been assumed that the Facility will displace a CCGT power station, as this is considered to be a reasonable comparator.

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

- For the 100% MCR case, the Facility will generate up to approximately 43 MW of electricity with a net output of 38 MW, giving a gross and net electrical efficiency of 34.02% and 30.06% respectively.
- For the 102% MCR case, the Facility will generate up to approximately 44 MW of electricity with a net output of 40 MW, giving a gross and net electrical efficiency of 34.16% and 31.06% respectively.
- There will be no heat export from the Facility.

On this basis:

- The 100% MCR case for the Facility will generate approximately 347,268 MWh of power per annum. Of this power, approximately 306,888 MWh per annum will be available for export. This will displace a total of approximately 116,600 tonnes of carbon dioxide equivalent.
- The 102% MCR case for the Facility will generate approximately 355,344 MWh of power per annum. Of this power approximately 323,040 MWh per annum will be available for export. This will displace a total of approximately 122,800 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). If required, the burners will also be used to maintain the temperature within the boiler above 850°C whenever waste is being incinerated. This includes shut-down periods until the grate is clear of waste. The combustion of auxiliary fuel in the burners will release carbon dioxide.

4.1 Emissions from the incineration of incoming waste

4.1.1 100% MCR

The Facility will export 877 kWh of electricity per tonne of incoming waste (or 306,950 MWh for 350,000 tpa of waste).

The carbon dioxide equivalent emissions from the incineration of incoming waste would be 1,012 kg per tonne of waste (or 354,200 tCO_2e for 350,000 tpa of waste). Of this, approximately 567 kg per tonne of waste will be from biogenic sources and 445 kg per tonne of waste will be from non-biogenic sources (198,450 tCO_2e and 155,750 tCO_2e respectively for 350,000 tpa of waste).

Therefore, the total carbon dioxide equivalent emissions from the fossil carbon content of the waste will be approximately 155,800 tonnes per annum.

4.1.2 102% MCR

The Facility will export 905 kW of power per tonne of incoming waste (or 323,004 MWh for 356,911 tpa of waste).

The carbon dioxide equivalent emissions from the incineration of incoming waste would be 1,012 kg per tonne of waste (or 361,194 tCO_2e for 356,911 tpa pf waste). Of this, approximately 567 kg per tonne of waste will be from biogenic sources and 445 kg per tonne of waste will be from non-biogenic sources (202,369 tCO_2e and 158,825 tCO_2e respectively for 356,911 tpa of waste).

Therefore, the total carbon dioxide equivalent emissions from the fossil carbon content of the waste will be approximately 158,900 tonnes per annum.

4.2 Emissions of nitrous oxide

4.2.1 100% MCR

The Facility will release approximately 14.7 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 4,560 tonnes per annum.

4.2.2 102% MCR

The Facility will release approximately 15.0 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 4,650 tonnes per annum.

4.3 Electricity import

Although, as explained in Table 1(d), the parasitic load for the 102% MCR case is lower than that for the 100% MCR case, for the purposes of estimating the electricity import during periods of start-up/shutdown/non-operation, it is assumed that the imported power will be the same for both cases.

This allows for a more conservative assessment of the change in impacts between the two cases, as if the greater parasitic load is assumed for the 100% MCR case, this will result in increased CO_2e impacts from electricity import.

4.3.1 100% MCR and 102% MCR

During periods of start-up and shutdown, the Facility will have an electrical demand of approximately 720 MWh electricity per annum; and during periods of non-availability an electrical demand of approximately 403 MWh electricity per annum. On this basis, the Facility will consume approximately 1,123 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 operation of the Facility is anticipated to result in the release of approximately 190 tonnes per annum of carbon dioxide equivalent from the import of electricity (calculated as 0.166 tCO_2e/MWh x 1,404 MWh).

4.3.2 102% MCR

4.4 Emissions from auxiliary firing

As stated in Table 1, the auxiliary burner capacity has been sized as approximately 55% of the 100% MCR load. The installed maximum burner capacity is therefore the same for both cases. Therefore, the emissions from auxiliary firing are assumed to be the same for both cases.

4.4.1 100% MCR and 102% MCR

For the purposes of this assessment, it is assumed that the auxiliary burners will consume approximately 6,800 MWh of fuel oil per annum. This assumption is based on the performance guarantees for maximum fuel use during start-up and shutdown, and a conservative assumption that annual fuel (including auxiliary firing during normal operation) will be the equivalent of 10 start-ups/shutdowns each year.

The combustion of 6,800 MWh of fuel oil in the auxiliary burners will be equivalent to a total of approximately 1,700 tonnes per annum of carbon dioxide equivalent.

4.5 Summary

4.5.1 100% MCR

The operation of the Facility at the 100% MCR case will lead to the release of approximately:

- 155,800 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 4,560 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 190 tonnes per annum of carbon dioxide equivalent from imported electricity to the Facility; and
- 1,700 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 100% MCR case will result in the release of approximately 162,250 tonnes per annum of carbon dioxide.

4.5.2 102% MCR

The operation of the Facility at the 102% MCR case will lead to the release of approximately:

- 158,900 tonnes per annum of carbon dioxide equivalent from the incineration of the non-biogenic component of the incoming waste;
- 4,650 tonnes per annum of carbon dioxide equivalent from nitrous oxide from the incineration of incoming waste;
- 190 tonnes per annum of carbon dioxide equivalent from imported electricity to the Facility; and
- 1,700 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 102% MCR case will result in the release of approximately 165,440 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

	Global Warming potential (GWP) in tonnes CO_2 equivalent			
Process	**100% MCR case**		**102% MCR case**	
Parameter	**Released**	**Saving/Offset**	**Released**	**Saving/Offset**
CO_2 emissions derived from fossil fuels (a)	155,800		158,900	
N_2O from the process (ammonia) (b)	4,560		4,650	
Indirect CO_2 emissions (imported electricity) (c)	190		190	
Direct CO_2 emissions (auxiliary fuel) (d)	1,700		1,700	
Total released (e=a+b+c+d)	**162,250**		**165,440**	
Energy recovered (electricity) (f)		116,600		122,800
Energy recovered (heat) (g)		-		-
Total offset (h=f+g)		**116,600**		**122,800**
Net GWP (j=e-h)	**45,650**		**42,640**	

To conclude, the proposed increase in the waste processing capacity will result in increased emissions of 3,190 tonnes CO_2e per annum (calculated as 165,440 – 162,250) from the incineration of waste within the Facility and associated use of auxiliary fuel and imported electricity. However, the corresponding increase in electrical output at 102% MCR would displace an additional 6,200 tonnes CO_2e per annum, assuming the displaced power would have been generated in a conventional CCGT power station.

Taking this into consideration, the operation of the Facility under the 102% MCR case represents a decrease in the net greenhouse gas emissions of around 3,010 tonnes per annum compared to the operation of the Facility under the 100% MCR case.

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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