Swadlincote Energy Recovery Facility (SERF)

Greenhouse Gas Assessment

on behalf of R&P Clean Power Limited

Application for Environmental Permit

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1 Introduction

The proposed Swadlincote Energy Recovery Facility 'SERF' (the 'Facility') is located in South Derbyshire at Cadley Hill, approximately 2km west of Swadlincote, Derbyshire. The Facility is centred at National Grid Reference SK 268 190, with the nearest postcode at DE11 9EN. The surrounding area is characterised by a mix of rural and residential land. Immediately adjacent land uses include; Willshee's Materials Recycling Facility (MRF); Stanton Sewage Works and the A444 Burton Road to the north and east respectively; residential properties to the north and south; and arable farmland to the west and south.

The proposed Energy Recovery Facility (ERF) will have a maximum annual throughput of 230,000 tonnes per annum (tpa) of non-hazardous residual (post-recycled) waste and a stack of 60m height above ground. The ERF will have a steam turbine driven power generation capacity of approximately 20.5 MW of electricity. The Facility will have grid connection cables, plant and equipment including a high voltage power distribution system to enable electricity to be supplied to the public supply network.

The role of this report is to consider the direct greenhouse gas emissions emission from the facility in relation to other forms of power generation in the UK. The report calculates the emission of carbon dioxide (CO2) and other primary gases that are known to contribute to the greenhouse effect as a global warming potential of the facility. For this report, this is taken as that displaced by the average UK generation mix for 2019[1].

Note that the report does not consider indirect emissions (or emissions savings) from the embodied energy within the facility or alternative waste disposal techniques that may have been used should the facility not be operated.

[1] NationalGrid ESO estimate the average carbon intensity of the UK electricity supply for 2019 at 215g/kWh

2 The Facility

2.1 Key assumptions

The accepted wastes are defined with European Waste Catalogue (EWC) waste codes from the List of Wastes (LoW), the wastes are listed below, hereafter referred to as the 'fuel':

- 19 12 10 - Combustible Waste (Refuse Derived Fuel)
- 19 12 12 - Other Wastes (Including Mixtures of Materials) from Mechanical Treatment of Wastes other than those mentioned in 19 12 11
- 20 03 01 - Mixed Municipal Waste
- Other wastes listed in Table 1b of Form B3

The Facility will utilise the fuel to generate electricity for export into the national grid. The additional end products include flue gases, bottom ash and residues from flue gas treatment. The ERF will comprise of a single-line mass incineration system linked to a dual burner system. The fuel used in the Facility will have average calorific value of 10.5 MJ/kg. The proposed Facility will have a maximum waste processing capacity of approximately 230,000 tonnes per annum (tpa) and will operate 24 hours per day, 365 days a year (8,760 hours per annum). Up to 760 hours per year are expected to be allocated for planned and unplanned maintenance (most of which occurs during the summer months).

Operating Assumptions for the purpose of this assessment:

Table 1: Operating Assumption for Assessment

Assumption	Value	Unit
Operating hours	8,000	hr/yr
Design throughput	23.2	t/hr
Boiler thermal capacity	67.667	MW_{th}
Carbon content of wastes	~50	%
NO_x emission	120	mg/m^3 (of which 12.5% is Nitrous oxide)

3 Emissions from the facility

The combustion process that occurs through the operation of the Facility will produce several major emissions. Some indirect greenhouse gases produced include nitrogen oxides (NO_x) and carbon monoxide (CO) and sulphur dioxide (SO_2). Guidance suggests that emissions will be produced from the combustion of the carbon within the incoming waste, formation of nitrous oxide (N_2O) during combustion, the use of auxiliary burners during start up and shut down procedure and the indirect emissions from the use of electricity during periods of maintenance.

3.1 Direct emissions from the combustion of waste

The carbon dioxide emission from each tonne of waste combusted will vary with the composition of the waste over time but is estimated within this calculation that the emission of CO_2 from non-biogenic sources will be 415 kg/t of waste combusted. Therefore, the total emission of CO_2 annually from the non-renewable waste combusted in the facility is estimated at 93,849t.

During the combustion of the waste, oxides of nitrogen will also be formed. Of these, nitrous oxide (N_2O) is the most significant, and it is estimated that the total emission will be approximately 16tCO2e/yr. This emission has an equivalent global warming potential compared to CO_2 of 310, and therefore is equivalent of 2,790tCO2e/yr.

3.2 Direct emissions from use of auxiliary burners

The Facility will have auxiliary burners which will be used to increase the temperature to >850°C, at which point the feeding of waste into the combustion chamber can recommence. The auxiliary burners are used for all shut down and start-up operations and are fuelled by burning diesel oil.

It has been assumed that the Facility will have 6 start-ups and 6 shut-downs per annum. Each start-up will last 18 hours and each period of shut down 2 hours. The auxiliary burners will be in operation for these periods and therefore for 120 hours per annum. During these firing periods, the burners will operate at 70% of the maximum continuous rating of the furnace which is 38.748MW. Therefore, the auxiliary burners will consume approximately 3255 MWh of gas oil per annum. With an emission factor for gas-oil of 0.25 t/MWh, this indicates that emissions from these burners will be approximately 814 tCO2e/yr.

3.3 Indirect emissions from the purchase of electricity

The estimated annual operating time will be 8,000 hrs/yr with 760 hrs/yr during which the Facility will either be shut down, started up, or in maintenance. During the periods of time during operation, start up and shut down the Facility operating loads will be 1,832 kW_e and outside of this time electricity consumption will be 10% of this maximum, i.e., 183 kW_e. It is assumed that there will be no electricity generation on-site during all these periods, and therefore the annual purchase of electricity will be 220MWh (during start up and shut down) and 117MWh (during maintenance), a total of 337MWh. At an emission factor of 0.166t CO_2/MWh, this equates to an emission of 56 tCO2e/yr.

4 Displaced Power

Table 2 below provides the proportion of fuels used for electricity generation from the last years available[2],[3].

Table 2: Fuels for electricity generation

Fuel	2020	2021
Coal	2%	2.1%
Natural Gas	35.7%	39.9%
Nuclear	16.1%	14.9%
Renewables	43.1%	39.6%
Other	2.9%	2.9%

In order to consider the carbon emissions that would be offset by the generation provided to the public network by the Facility, it is necessary to consider which of the above facilities would be displaced. Current policy continues to be to support the operation and development of nuclear and renewable technologies, which have a very low emission of CO_2 during operation. Therefore, it is reasonable to assume that the displaced generation would likely be that provided by natural gas and from coal power plants. As it can be expected that all the remaining coal plants in the UK will close before the Facility is operational, it could be assumed that any generation exported will displace electricity generated by the most efficient method of using natural gas – namely combined cycle gas turbines CCGT. The energy intensity of this technology is approximately 357g CO_{2e}/kWh generated. This compares to the overall carbon intensity of the electricity generation which is estimated at 215 g CO_{2e}/kWh.

However, for this report, the generation from the Facility is assumed to displace the average for the UK grid. The Facility will generate approximately 20.5 MW (164,000 MWh/year) of electricity, of which ca. 18.5 MW (148,000MWh/year) will be exported to the public distribution network operated by National Grid Electricity Distribution. Therefore, the operation of the Facility is expected to generate 148,000 MWh / year of electricity that equivalent to 31,080 tCO_{2e} per annum if it was drawn from the grid, using the 2024 average emission factor[4].

[2] DUKES 2021 Chapters 1 to 7 (publishing.service.gov.uk)
[3] DUKES 2022 (publishing.service.gov.uk)
[4] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk)

5 Summary

The Facility will result in total emissions of approximately 108,606,292 $kgCO_2$-eq, which will be partially offset by the electricity exported to the public network that displaced other generation that would otherwise have been required. However, this calculation does not consider additional emissions that would have resulted had other disposal methods been utilised for the waste, such as landfill, nor the opportunities for export of heat to the local area.

Table 3: Summary Impacts

Total GHG emission	**$kgCO_2$ -eq**
Scope 1	104,686,421
Scope 2	369,544
Scope 3	3,550,327
Total emissions	**108,606,292**
Total avoidance emissions	**$kgCO_2$ – eq**
Electricity generation	82,514,186
Recycling	25,813,830
Landfill diversion	55,565,978
Total avoided emissions	**163,893,994**

Scope 1: All direct GHG emissions released from controlled assets e.g., on-site combustion of fuels from processes, generators, company vehicles etc.
Scope 2: Indirect GHG emissions from the generation of purchased electricity, heat, or steam (i.e., purchased from the National Grid, not incl. on-site energy generation which would be scope 1).
Scope 3: Cover all other indirect emissions associated with a project, e.g., the extraction and production of purchased materials and fuels, outsourced activities, etc.

The following table compares the carbon emission equivalent of carbon savings and the carbon intensity factor.

Table 4: Comparison of carbon emissions

Carbon Saving	
Carbon Savings ($kgCO_2$-eq)	-55,287,702
Carbon intensity factor for SERF gCO_2e/kWh	-354