NORTH LINCOLNSHIRE GREEN ENERGY PARK

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The North Lincolnshire Green Energy Park Development Consent Order

R1 Assessment

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Contents

1 Introduction

1.1.1.1 The North Lincolnshire Green Energy Park (NLGEP) ('the Project'), located at Flixborough, North Lincolnshire, is a Nationally Significant Infrastructure Project (NSIP) with an Energy Recovery Facility (ERF) capable of converting up to 760,000 tonnes of non-recyclable waste into 95 MW of electricity at its heart and a carbon capture, utilisation and storage (CCUS) facility which will treat the excess gasses released from the ERF to remove and store carbon dioxide (CO2) prior to emission into the atmosphere.

1.1.1.2 The NSIP incorporates a switch yard, to ensure that the power created can be exported to the National Grid or to local businesses, and a water treatment facility, to take water from the mains supply or recycled process water to remove impurities and make it suitable for use in the boilers, the CCUS facility, concrete block manufacture, hydrogen production and the maintenance of the water levels in the wetland area.

1.1.1.3 The Project will include the following Associated Development to support the operation of the NSIP:

1. a bottom ash and flue gas residue handling and treatment facility (RHTF);
2. a concrete block manufacturing facility (CBMF);
3. a plastic recycling facility (PRF);
4. a hydrogen production and storage facility;
5. an electric vehicle (EV) and hydrogen (H2) re-fuelling station;
6. battery storage;
7. a hydrogen and natural gas above ground installation (AGI);
8. a new access road and parking;
9. a gate house and visitor centre with elevated walkway;
10. new railway works including, sidings at Dragonby, re-instatement and safety improvements to the 6km private railway spur, and the construction of a new railhead with sidings south of Flixborough Wharf;
11. a north and south district heating and private wire network (DHPWN);
12. Biodiversity Net Gain (BNG) and ecological mitigation, including green infrastructure and 65 acre wetland area;
13. new public rights of way and cycle ways;
14. Sustainable Drainage Systems (SuDs) and flood defence; and
15. an electrical grid connection, lighting and utilities.

1.1.1.4 The Project will also include development in connection with the above works such as security gates, fencing, boundary treatment, hard and soft landscaping, surface and foul water treatment and drainage systems and CCTV.

1.1.1.5 The Project also includes temporary facilities required during the course of construction, including site establishment and preparation works, temporary construction laydown areas, contractor facilities, materials and plant storage, generators, concrete batching facilities, vehicle and cycle parking facilities, offices, staff welfare facilities, security fencing and gates, external lighting, roadways and haul routes, wheel wash facilities, and signage.

1.1.1.6 The overarching aim of the Project is to support the UK's transition to a low carbon economy as outlined in the Sixth Carbon Budget (December 2020), the national Ten Point Plan for a Green Industrial Revolution (November 2020) and the North Lincolnshire prospectus for a Green Future. It will do this by enabling circular resource strategies and low-carbon infrastructure to be deployed as an integral part of the design (for example by re-processing ash, wastewater and carbon dioxide to manufacture concrete blocks and capturing and utilising waste-heat to supply local homes and businesses with heat via a district heating network).

1.1.1.7 Within this technical note it is intended to demonstrate that the design of the North Lincolnshire Green Energy Park (NLGEP, the Project) will ensure that the Project will achieve R1 status and can be classified as a recovery operation as defined in the Waste Framework Directive (WFD).

1.1.1.8 As it is not certain whether selective catalytic reduction (SCR) will be included in the facility, the R1 status has been considered for the facility with and without SCR.

2 Background

2.1.1.1 In accordance with the WFD, incineration facilities for municipal solid waste (MSW) can be regarded as "Recovery" operations if the energy efficiency of the plant is greater than 0.65 (for plants permitted after January 2009). This is referred to as achieving "R1 status". In the UK, R1 status can only be formally granted by the relevant Competent Authority (for the Proposed Facility this will be the Environment Agency) when the facility has been in operation for more than 12 months, but preliminary status can be granted on the basis of a detailed design (known as "design stage" R1 status). Plants which do not meet the energy efficiency criterion are classed as "Disposal" operations and therefore are considered as being equivalent to landfill in terms of the waste hierarchy.

2.1.1.2 The European Commission has published guidance titled 'Guidelines on the Interpretation of the R1 Energy Efficiency Formulae for Incineration Facilities Dedicated to the Processing of Municipal Solid Waste According to Annex II of Directive 2008/98/EC on Waste'. Within the European Commission guidance, the formula to calculate the efficiency of a facility is explained as follows:

$$\text{Energy Efficiency} = \frac{\left(E_p - \left(E_f + E_i\right)\right)}{\left(0.97 \times \left(E_w + E_f\right)\right)}$$

2.1.1.3 where:

- E_p means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (units of GJ/yr)
- E_f means annual energy input to the system from fuels contributing to the production of steam (units of GJ/yr)
- E_w means annual energy contained in the treated waste calculated using the lower calorific value of the waste (units of GJ/yr)
- E_i means annual energy imported excluding Ew and Ef (units of GJ/yr)
- 0.97 is a factor accounting for energy losses due to bottom ash and radiation.

3 R1 Assessment

3.1.1.1 The formula within the European Commission guidance has been used to assess the energy efficiency of the Project. The calculation is based on predicted design figures and predicted levels of fuel consumption and electricity usage, and assumptions on the design of the Project.

3.2 Assessment assumptions without SCR

3.2.1.1 To assess the Project the following assumptions have been made regarding the design of the proposed facility.

1. It consists of three streams with an annual availability of 91.3 %, equating to 8,000 hours per annum.
2. The waste throughput per stream will be 27.1 tonnes per hour.
3. The waste processed will have an average NCV of 14 MJ/kg.
4. The Project will generate an average of 93.5 MW_e, with a parasitic load of 10.8 MW_e.
5. During start-up and shutdown of the Facility, it will consume an average of 10.8 MW_e.
6. Electricity used during non-availability (i.e. excluding start-up and shutdown) would be 20 % of the parasitic load.
7. The auxiliary burners will have a capacity of 65 % of the boiler thermal input.
8. The average auxiliary burner consumption during start-up would be 40%[1] of the burner duty.
9. Number of start-ups and shutdowns per year per line would be 4 and each start up and shut down would take a period of 16 hours and 6 hours respectively. 50% of the fuel used in the start-up would be used for steam production and therefore generate electricity.

3.2.1.2 Taking the above into consideration, the R1 efficiency of the Project has been calculated as **0.747**. A table setting out the calculation is presented in Appendix A.

3.3 Assessment assumptions with SCR

3.3.1.1 To assess the facility the following assumptions have been made regarding the design of the Project.

1. It consists of three streams with an annual availability of 91.3 %, equating to 8,000 hours per annum.
2. The waste throughput per stream will be 27.1 tonnes per hour.
3. The waste processed will have an average NCV of 14 MJ/kg.
4. The Project will generate an average of 91.1 MW_e, with a parasitic load of 10.8 MW_e.
5. It has been assumed that the Project will consume 7.9 MW_{th} internally, for use in SCR.
6. During start-up and shutdown of the Project, it will consume an average of 10.8 MW_e.
7. Electricity used during non-availability (i.e. excluding start-up and shutdown) would be 20 % of the parasitic load.
8. The auxiliary burners will have a capacity of 65 % of the boiler thermal input.

[1] The average auxiliary burner duty during a full cold start is assumed to be 40%. The burners always have to start on low fire and ramp up slowly. All EfW boilers have a warm up curve. The rate of temperature increase in the boiler must be strictly and carefully controlled to avoid damaging the boiler. This is why it takes 16 hours for full cold start up.

9. The average auxiliary burner consumption during start-up would be 40%[2] of the burner duty.
10. Number of start-ups and shutdowns per year per line would be 4 and each start up and shut down would take a period of 16 hours and 6 hours respectively. 50% of the fuel used in the start-up would be used for steam production and therefore generate electricity.

3.3.1.2 Taking the above into consideration, the R1 efficiency of the Project has been calculated as **0.755**. A table setting out the calculation is presented in Appendix A.

4 Conclusions

4.1.1.1 The design of the Project has been assessed in accordance with the European Commission guidance for R1 facilities. As demonstrated within this Technical Note, the R1 efficiency of the ERF has been calculated as 0.747 without including SCR, and 0.755 including SCR. Taking this into consideration the design of the ERF would be able to achieve the R1 status and it would be classified as a recovery operation under the terms of the Waste Framework Directive.

Yours sincerely

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[2] The average auxiliary burner duty during a full cold start is assumed to be 40%. The burners always have to start on low fire and ramp up slowly. All EfW boilers have a warm up curve. The rate of temperature increase in the boiler must be strictly and carefully controlled to avoid damaging the boiler. This is why it takes 16 hours for full cold start up.

Appendices

A Waste Framework Directive energy efficiency calculation

Table 1: R1 Data - without SCR

R1 formula		Unit
Number of streams	3	-
Average through-life availability	91.32%	%
Equivalent full load operating hours per year	8,000	h/y
Feed stock calculations		
Waste throughput per boiler	27.100	tph
Waste NCV	14.00	MJ/kg
Waste throughput	650,370	t/y
Waste Energy input	316.17	MW
Waste Energy input	2,529,217	MWh/y
Waste Energy input	9,105,181	GJ/y
Electric exported		
Gross electricity production	93.54	MW
Gross electrical efficiency	29.59%	
Total electricity produced	748,286	MWh/y
Total electricity produced	2,693,828	GJ/y
Parasitic load	10,830	kW
Parasitic load	86,636	MWh/y
Parasitic load	311,890	GJ/y
Net electrical output	82.7	MW
Net electrical efficiency	26.14%	
Heat exported		
Heat exported	-	MWh/h
Heat efficiency	-	
Heat exported	-	MWh/y
Heat exported	-	GJ/y
	-	
Heat used internally (a)		

R1 formula		Unit
Heat used internally	-	MWh/y
Heat used internally	-	GJ/y
Total heat produced		
Total heat produced	-	MWh/y
Total heat produced	-	GJ/y
Fuel used		
Auxiliary Burner capacity	65%	
Auxiliary Burner capacity per stream	68.50	MW
Average auxiliary burner duty during start up	40%	
Number of start ups per year per stream	4	
Start up and shut down time	22	hrs
Annual time for start ups	264	hrs/y
Total Fuel consumed	7,234	MWh/y
Energy in fuel consumed by start-up burners	26,042	GJ/y
Electricity imported		
Electricity consumption during start-up per steam	3,610	kW
Electricity imported during start-up	953	MWh/y
Electricity imported during start-up	3,431	GJ/y
Electricity consumption during non-availability	2,166	kW
Electricity imported during non-availability	1,647	MWh/y
Electricity imported during non-availability	5,929	GJ/y
Electricity imported during start-up and non-availability	2,600	MWh/y
Electricity imported during start-up non-availability	9,360	GJ/y
WFD Calculation		
Ew	9,105,181	GJ/y
Ep (electricity) ([1])	6,653,755	GJ/y
Ep (heat)	-	GJ/y
Ep total (electricity + heat)	6,653,755	GJ/y
Ef ([2])	13,021.01	GJ/y

R1 formula		Unit
Ei (electricity)	24,336	GJ/y
Ei (heat)(2)	13,021	GJ/y
Ei total (electricity + heat)	37,357	GJ/y
WFD ratio		
WFD ratio	0.7466	-
Pass or fail?	Pass	-
Climate Change Factor		
Heating Degree Days	3,350	
Old Plant or New Plant	New	
Climate Change Factor	1.000	
Adjusted WFD ratio	0.75	
Pass or fail?	Pass	

1. The input data is based on a single design point. The electricity generated has been reduced by 5% to allow for inefficiencies due to partial load operation, boiler fouling and high air temperature during the summer.
2. It is assumed that only 50% of fossil fuel used by the start-up burners generates steam and therefore 50% of fuel energy is included as Ei (heat) and 50% is included as Ef

Table 2: R1 Data - with SCR

R1 formula		Unit
Number of streams	3	-
Average through-life availability	91.32%	%
Equivalent full load operating hours per year	8,000	h/y
Feed stock calculations		
Waste throughput per boiler	27.100	tph
Waste NCV	14.00	MJ/kg
Waste throughput	650,370	t/y
Waste Energy input	316.17	MW
Waste Energy input	2,529,217	MWh/y
Waste Energy input	9,105,181	GJ/y
Electric exported		

R1 formula		Unit
Gross electricity production	91.10	MW
Gross electrical efficiency	28.81%	
Total electricity produced	728,766	MWh/y
Total electricity produced	2,623,559	GJ/y
Parasitic load	10,830	kW
Parasitic load	86,636	MWh/y
Parasitic load	311,890	GJ/y
Net electrical output	80.3	MW
Net electrical efficiency	25.39%	
Heat exported		
Heat exported		MWh/h
Heat efficiency		
Heat exported		MWh/y
Heat exported		GJ/y
Heat used internally (a)		
Heat used internally	63,215	MWh/y
Heat used internally	227,574	GJ/y
Total heat produced		
Total heat produced	63,215	MWh/y
Total heat produced	227,574	GJ/y
Fuel used		
Auxiliary Burner capacity	65%	
Auxiliary Burner capacity per stream	68.50	MW
Average auxiliary burner duty during start up	40%	
Number of start ups per year per stream	4	
Start up and shut down time	22	hrs
Annual time for start ups	264	hrs/y
Total Fuel consumed	7,234	MWh/y
Energy in fuel consumed by start-up burners	26,042	GJ/y
Electricity imported		

R1 formula		Unit
Electricity consumption during start-up per steam	3,610	kW
Electricity imported during start-up	953	MWh/y
Electricity imported during start-up	3,431	GJ/y
Electricity consumption during non-availability	2,166	kW
Electricity imported during non-availability	1,647	MWh/y
Electricity imported during non-availability	5,929	GJ/y
Electricity imported during start-up and non-availability	2,600	MWh/y
Electricity imported during start-up non-availability	9,360	GJ/y
WFD Calculation		
Ew	9,105,181	GJ/y
Ep (electricity) ([1])	6,480,191	GJ/y
Ep (heat)	250,331	GJ/y
Ep total (electricity + heat)	6,730,523	GJ/y
Ef ([2])	13,021.01	GJ/y
Ei (electricity)	24,336	GJ/y
Ei (heat)([2])	13,021	GJ/y
Ei total (electricity + heat)	37,357	GJ/y
WFD ratio		
WFD ratio	0.7553	-
Pass or fail?	pass	-
Climate Change Factor		
Heating Degree Days	3,350	
Old Plant or New Plant	New	
Climate Change Factor	1.000	
Adjusted WFD ratio	0.76	
Pass or fail?	pass	

1. The input data is based on a single design point. The electricity generated has been reduced by 5% to allow for inefficiencies due to partial load operation, boiler fouling and high air temperature during the summer.

R1 formula		Unit
2. It is assumed that only 50% of fossil fuel used by the start-up burners generates steam and therefore 50% of fuel energy is included as Ei (heat) and 50% is included as Ef		