APPLICATION FOR AN ENVIRONMENTAL PERMIT UNDER THE ENVIRONMENTAL PERMITTING (ENGLAND AND WALES) REGULATIONS 2016 (AS AMENDED)

COST BENEFIT ANALYSIS – NOx ABATEMENT TECHNIQUES

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ACRONYMS/TERMS USED IN THE TEXT

AQO	**Air Quality Objective**
Bref	**Best Available Techniques Reference**
CO_2	**Carbon Dioxide**
EA	**Environment Agency**
ECL	**Environmental Compliance Limited**
EP	**Environmental Permit**
ERF	**Energy Recovery Facility**
FCC	**FCC Waste Services (UK) Limited**
GLC	**Ground Level Concentration**
GWP	**Global Warming Potential**
HZI	**Hitachi Zosen Inova**
NO	**Nitrogen Oxide**
NO_2	**Nitrogen Dioxide**
NO_x	**Nitrogen Oxides**
NO_x	**Oxides of Nitrogen**
PC	**Process Contribution**
PEC	**Predicted Environmental Contribution**
POCP	**Photochemical Ozone Creation Potential**
SCR	**Selective Catalytic Reduction**
SNCR	**Selective Non-Catalytic Reduction**
The Installation	**Tees Valley Energy Recovery Facility**

1. INTRODUCTION

1.1. Overview of Assessment

1.1.1. Environmental Compliance Limited ("ECL") has been commissioned by FCC Waste Services (UK) Limited ("FCC") to undertake a cost benefit analysis ("CBA") for nitrogen oxides ("NOx") abatement techniques as part of an Environmental Permit ("EP") application for the proposed Tees Valley Energy Recovery Facility ("ERF") located at Grangetown Prairie, Grangetown, Redcar, TS6 6TY, hereafter referred to as "the Installation".

1.1.2. Two options have been considered for NO_x abatement, namely Selective Catalytic Reduction ("SCR"), which involves the injection of ammonia solution into the flue gases immediately upstream the combustion chamber into a reaction vessel containing layers of catalyst; and Selective Non-Catalytic Reduction ("SNCR"), which involves the injection of ammonia into the combustion chamber.

1.1.3. The data used in the assessment has been obtained from publicly available data, information from the technology supplier Hitachi Zosen Inova ("HZI"), information from FCC and/or information from other similar operational facilities.

2. COST BENEFIT ANALYSIS

2.1. Emissions to Air

2.1.1. The emission rates for oxides of nitrogen (NO_x) are provided in Table 1 below, together with the tonnages abated. A long-term concentration of 70mg/Nm^3 has been used for abated emissions for SCR as it is considered that this is an appropriate level that can be maintained based on data from the Waste Incineration Best Available Techniques Reference Document ("Bref").[1] Whilst 120mg/Nm^3 is typically used as an emission limit value for SNCR, FCC have voluntarily committed to a lower level of 100mg/Nm^3.

2.1.2. Emissions rates have been calculated based on the volumetric flow rate of 42.19Nm^3/s[2] and 8,000 hours of operation.

Table 1: NOx Removed Annually

Parameter	Units	SNCR	SCR
Unabated emission concentration	mg/Nm^3	350	350
Unabated emission rate	t/yr	420	420
Abated emission concentration	mg/Nm^3	100	70
Abated emission rate	t/yr	122	85
NOx Removed	t/yr	304	340

2.1.3. The impact of emissions of NO_x has been considered in detail in ECL Report ECL.007.04.01/ADM February 2022, Issue 1a. Table 2 provides a summary of predicted ground level concentrations for both options.

Table 2: Impact of Emissions of NOx to Air

	Parameter	Units	SNCR	SCR
	Abated Emissions Concentration	mg/Nm^3	100	70
Long Term Impacts	Process Contribution @ Max Ground Level Concentration ("GLC")	µg/m^3	0.603	0.422
	Background	µg/m^3	24.8	24.8
	Predicted Environmental Concentration	µg/m^3	25.403	25.2221
	Air Quality Objective	µg/m^3	40	40
	Process Contribution as a percentage of the Air Quality Objective	%	1.51	1.06
	Predicted Environmental Concentraiton as a percentage of the Air Quality Objective	%	64	63
Short Term Impacts	Process Contribution @ Max GLC	µg/m^3	5.21	3.65
	Background	µg/m^3	49.6	49.6
	Predicted Environmental Concentration	µg/m^3	54.81	53.247
	Air Quality Objective	µg/m^3	200	200

[1] https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-01/JRC118637_WI_Bref_2019_published_0.pdf

[2] ECL Report ECL.007.04.01/ADM February 2022, Issue 1a.

Table 3: Impact of Emissions of NOx to Air (Cont.)

Parameter		Units	SNCR	SCR
Short Term Impacts (Cont.)	Process Contribution as a percentage of the Air Quality Objective	%	2.61	1.82
	Predicted Environmental Concentraiton as a percentage of the Air Quality Objective	%	27	27

2.1.4. The long-term process contributions ("PCs") for both abatement systems cannot be screened out as insignificant in accordance with the Environment Agency ("EA's") online guidance[3], consequently the predicted environmental concentration ("PEC") was calculated. As the PEC is less than 70% of the Air Quality Objective ("AQO"), the long-term emissions can be considered not significant.

2.1.5. The short-term PCs for both abatement systems can be screed out as insignificant in accordance with the EA's online guidance[3], as they are less than 10% of the AQO.

2.2. Nutrient Nitrogen Deposition

2.2.1. A summary of the predicted nutrient nitrogen deposition rates at the identified European Sites and Sites of Special Scientific Interest is provided in Table 27 of ECL Report ECL.007.04.01/ADM, February 2022. This concludes that whilst some PCs are greater than 1% of the critical load, PECs do not exceed either the lower or upper critical load, and impacts can be considered not significant. Consequently, as the assessment was undertaken on an emission concentration of 100mg/Nm^3, it can also be concluded that an emission concentration of 70mg/Nm^3 would also not have any significant impact on the ecological sites considered.

2.3. Impact on the Water Environment

2.3.1. There are no emissions to water from either system.

2.4. Photochemical Ozone Creation Potential

2.4.1. NO_x is released as a combination of nitrogen oxide ("NO") and nitrogen dioxide ("NO_2"). It is reasonable to assume that 10% of NO_x is released as NO_2 with the remainder as NO.

2.4.2. In accordance with the EA's H1 Assessment tool (or the withdrawn H1 Emissions to Air Guidance document)[4], NO has a photochemical ozone creation potential ("POCP") of -42.7, and NO_2 has a POCP of 2.8. Consequently, based on the total NO_x abated (see Table 1), the POCP for SNCR is -4671, and -3269 for SCR, thus indicating that SCR is the less favourable option[5].

[3] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

[4] https://assets.publishing.service.gov.uk/media/5a7f3081e5274a2e8ab4aab2/withdrawn_H1_Annex_F.pdf

[5] NO converts to NO_2 by reacting with O_3 (ozone), consequently removing O_3.

2.5. Global Warming Potential

2.5.1. Emissions of greenhouse gases will be the same for both options as emissions of carbon dioxide (“CO_2”) and NO will be the same for both. The energy consumption varies for both options, which would therefore change the amount of power available for export. This means that the reduction in greenhouse gas emissions due to the displacement of power generated by other power stations would be different in each case.

2.5.2. In order to calculate the Global Warming Potential (“GWP”), the quantity of CO_2, which has a GWP of 1, emitted per MWh of electricity consumed has to be calculated.

2.5.3. To calculate the quantity of CO_2 emitted for the actual - i.e. delivered - energy consumption, an emission factor of 166kg[6]. of CO_2 per MWh is used. However, the actual energy consumption has to be converted to the equivalent primary energy equivalent; a conversion factor of 2.4 is used for this. Accordingly, a factor of 2.4 x 166kg of CO_2 per MWh of primary energy is used, which equates to 398.4kg/MWh.

2.5.4. Table 3 below details the GWP associated with each of the two acid gas abatement options considered.

Table 4:GWP for NOx Abatement Options

Parameter	Units	SNCR	SCR
Net Power Consumption[(a)]	MWh/annum	3,923	13,462
GWP	Tonnes of CO_2	1,563	5,363

Note to Table
(a) Estimated figures based on data from a similar HZI Installation.

2.5.5. It can be seen from the data in Table 3 that the GWP for SNCR option is significantly lower than the GWP for SCR.

2.6. Reagents

The estimated annual consumption of raw materials for the two NOx abatement options is indicated in Table 4 below.

Table 5: Reagent Consumption

Parameter	Units	SNCR	SCR
Ammonia	Tonnes per annum	1,008	924

2.7. Waste Streams

2.7.1. There are no additional waste streams associated with either of the NO_x abatement options.

[6] https://www.gov.uk/guidance/assess-the-impact-of-air-emissions-on-global-warming

2.8. Relative Costs

2.8.1. The estimated costs associated with each of the abatement options are presented in Table 5. The costs used are approximate and rounded to the nearest £10,000.

2.8.2. In order for direct comparisons to be made, the costs are presented as annualised costs, with the capital investment and financing costs spread over a twenty-five year lifetime, with a rate of return of 9%, using the approach detailed in Horizontal Guidance Note H1[4].

Table 6: Relative Cost Data for NOx Abatement Options

Parameter	SNCR	SCR
Capital Cost	£880,000	£7,470,000
Annual Average Operating Costs	£350,000	£910,000
Maintenance	£18,000	£150,000
Reagent Cost[7]	£147,000	£134,000
Parasitic load cost/net power consumption[8]	£181,000	£620,000
Present Value of Cost of Option	£4,260,000	£16,330,000
Equivalent Annual Cost	£434,000	£1,663,000
Project Lifetime Cost	**£10,835,000**	**£41,560,000**

[7] Based on ammonia cost of £145/tonne

[8] Based on electricity cost of £46/MWh

3. SUMMARY OF ASSESSMENT

3.1. Overview

3.1.1. Table 6 compares the two NO_x abatement options for the parameters considered in this report.

Table 7: Comparison of NO_x Abatement Options

Parameter	Units	SNCR	SCR
Quantity of NOx Abated	t/a	304	340
Quantity of NOx Abated over 25 years	t	7,596	8,508
POCP	-	-4,671	-3,269
GWP	tCO_2/a	1,563	5,363
Ammonia consumption	t	1,008	924
Total Annualised Cost	£/a	£434,000	£1,663,000
Total Lifetime Cost	£/25yrs	£10,835,000	£41,560,000
Cost Per Tonne of NOx abated	£/t	£1,426.41	£4,885.09
PC (long term)	$\mu g/m^3$	0.603	0.4221
PEC (long term)	$\mu g/m^3$	25.40	25.22

3.1.2. It is evident from the data in Table 6 that the performance of the two NO_x abatement systems varies. Both options abate similar quantities of NO_x, however, SCR has a greater impact on climate change i.e. a higher GWP, and higher annualised costs.

3.1.3. Using SCR increases the annualised cost by approximately 283%. It also increases the amount of CO_2 released by approximately 3,800t/a. However, the use of SCR does provide minor environmental benefits in relation to both the reduced quantity of NO_x released to the environment (36t/a), and the reduced consumption of ammonia at 84t/a.

3.1.4. Notwithstanding these benefits, it is considered that the much lower cost per tonne of NO_x abated for SNCR means that SNCR represents BAT for the abatement of NO_x.

3.1.5. Taking these factors into consideration, it is considered that SNCR represents BAT for the proposed Tess Valley ERF.