1. Introduction

1.1 This document forms a GWP comparison against the potential flue gas emissions abatement technology options for the Biomass Energy Facility on Woodham Road, Barry.

1.2 This document has been prepared by Sol Environment Ltd in conjunction with Power Consulting Midlands Ltd (Project Owners Engineer), Outotec Ltd (Project technology partner) and Biomass UK No.2 Ltd (The Applicant).

1.3 Abatement technology comparison data has been sourced and referenced from Annex 10.2 of the EC BREF Document (Reference Document on the Best Available Techniques for Waste Incineration).

2. Basis of Design – Barry Biomass Energy

2.1 The Installation has been designed to incorporate urea based SNCR and dry flue gas treatment for the abatement and control of NOx and Acid Gases respectively.

2.2 Table 2.1 provides a summary of the potential abatement options and provides a reference to the technical justification on the suitability of the technology for this application.

Table 2.1: Basis of Design – Flue Gas Treatment

Pollutant	Gas Treatment Technology Options	Incorporated into design	Technical Justification
NOx abatement	SCR (ammonia)	Yes	This plant has been included in the design of the plant and operates WITHOUT the need for additional ammonia / urea. Sufficient ammonia slip is present from the upstream SNCR systems. Considered Suitable
	SNCR (ammonia)	No	Suitable, but ammonia considered to have higher H&S risks
	SNCR (urea)	Yes	Suitable and has been incorporated into the design of the plant in conjunction with additional SCR
Acid gas abatement	Wet (NaOH)	No	Undesirable – energy cost, waste generation and footprint
	Wet (CaO)	No	Undesirable – energy cost, waste generation and footprint: Not cost effective at sub 250MWth scale
	Wet (CaOH)	No	Undesirable – energy cost, waste generation and footprint: Not cost effective at sub 250MWth scale

	Semi/Dry (CaOH)	No	Undesirable – energy cost, waste generation and footprint: Not cost effective at sub 250MWth scale
	Dry ($NaHCO_3$)	No	Suitable – however there is a global shortage of supply
	Dry (CaOH)	Yes	Suitable

3. NOx Abatement Options (Selective Non Catalytic Reduction [SNCR] Vs Selective Catalytic Reduction [SCR]

3.1 Selective Catalytic Reaction SCR utilizes a catalyst to reduce NOx by way of a catalytic reaction. The catalyst in the catalytic converter is sensitive to chemical impurities and carbon monoxide in the flue gas stream which are known to kill the catalysts. SCR can also be blinded by fly ash particles.

3.2 Given the homogeneous nature of the waste wood feedstock, the presence of fly ash and carbon monoxide in the combustion products is not considered to be excessive, therefore SCR is considered suitable and has been included in the plant design. However, in order to protect the catalyst, the SCR has been included after the ash removal cyclones. SCR is not considered suitable as a sole means of NOx removal in this plant and has been selected as a secondary means of

3.3 Selective Non Catalytic Reaction SNCR utilizes a reagent to reduce NOx by way of chemical reaction. The reagent will be Urea that will dosed as required in the combustion process to inhibit the formation of NOx. The process is one of a chemical reaction and will not be impeded by a change in fuel chemistry, influenced by increased un-combusted materials and fly ash particles.

3.4 The reason that SNCR is chosen as the primary method of NOx control is because it will be unaffected by a chemical inconsistency if fuel quality and a change in the combustion parameters of the combustion process and fly ash blinding. Whereas will be SCR sensitive to these changes (hence has been chosen as a secondary means of NOx abatement).

3.5 It is important to note the SNCR is the preferred method of NOx control for waste to energy plants and the dosing process is controlled by the reactive continuous emission monitoring equipment to minimise any over dosing of reagents. Excess ammonia (ammonia slip) will be removed by the SCR catalyst.

SNCR Reagent Options: Urea vs. Ammonia

3.6 Urea is quite safe to handling while Ammonia imposes Health and Safety Risk in a power plant due to its corrosive nature, both to personnel as well as environment.

3.7 Therefore Ammonia is not considered a desirable option for the SNCR operations at Barry.

3.8 The selected reagent is therefore a urea based direct injection SNCR system.

3.9 No ammonia or urea injection is required for the SCR abatement.

4. Acid Gas Treatment Options (Wet Systems Vs Dry Systems)

4.1 Wet ‘scrubber’ systems involve the scrubbing of the flue gas with an aqueous based alkaline reagent to remove / neutralise the acid gas content of the emissions.

4.2 Wet flue gas desulfurisation (FGD) systems achieve high SO_2 and HCl removal. FGD systems typically have a very high operational cost and require addition effluent treatment requirements, water use and disposal costs.

4.3 FDG systems are commonly used in large scale combustion applications >250MWth and have a higher operational costs (parasitic electrical load).

4.4 Dry scrubbing techniques compare favourably with FGD systems or semi-dry scrubbers, and generally achieve the best acid gas removal efficiencies. It also eliminates any water effluent treatment requirements and allows for use with other reagents such as activated carbon for the absorption and removal of heavy metals, dioxins, VOC and other harmful substances.

4.5 Dry Flue Gas Treatment (Dry FGT) has become the predominant solution for modern flue gas facilities. The basic dry FGT consists of a filtration unit combined with an injection of dry sorbent.

4.6 Benefits of the dry FGT over wet scrubbing systems include;

- Low Investment Cost;
- Simplicity of design and operation;
- Proven ability to meet stringent emission limits;
- Small physical footprint;
- Lower parasitic loads;
- Flexible operation with regards to temperature and capacity; and
- Easy stabilisation of dry residues.

Dry FDG Options Hydrated Lime Vs Sodium Bicarbonate

4.7 The technique that has been selected for the acid gas treatment is a dry scrubbing system utilising a lime based reagent.

4.8 High purity calcium hydroxide (lime) based powder will be used, specifically designed to remove gaseous acid pollutants using dry processes and related methods.

4.9 The sorbent has a high surface area and provides a high removal efficiency within in the duct and on the surface of the filter bags.

4.10 Other options such as sodium bicarbonate could also be used in the process in a similar manner, however it is higher in purchase cost and has a limited supply base.

4.11 A BAT Comparison table (Table 6.4) was provided in the original application and has been repeated below.

Table 4.1 (6.4): BAT Comparison

BAT Criteria	Lime	Sodium Bicarbonate
Storage	Can be difficult to handle, especially in the presence of humidity. Will be stored within hoppers.	Easy to handle Safe reagent
Reagent Preparation	A ready to use reagent	Can be a ready to use reagent – a pre-milled, ready to inject reagent is available
Availability	Readily available	Possible UK supply chain issue as limited suppliers
Temperature	Operates in a temperature window o 140 – 160°C.	Is injected at temperatures higher than 140°C up to 400°C+. The consumption is the same regardless of temperature
Efficiency	Medium to high efficiency (assuming high surface area lime is used)	Very high efficiency
Recirculation	A residue recycle loop has been incorporated into the design to increase removal efficiency	Due to high efficiency only goes once through the system – no need for recirculation
Use in Scrubbing systems	Can be used in wet, dry or semi-dry systems	Proven in dry systems
Residue Handling	Lime residues are hazardous and need to be contained. All lime residues will be stored within a sealed silo.	Residues are easy to handle. They contain NaCl, Na_2SO_4 and Na_2CO_3 stable sodium salts
Operating Costs	Lime is readily available and cost effective.	Raw material costs of Sodium Bicarbonate are high and the security of supply is uncertain.

Table 4.1 (6.4): BAT Comparison		
BAT Criteria	Lime	Sodium Bicarbonate
(Reagent cost plus disposal cost)	Residue production per tonne of lime is high, so disposal costs are higher. Overall there are no cost advantages over Sodium Bicarbonate	Residue production is lower per tonne of reagent. Overall there are no cost advantages over Lime

5. GWP Comparison - Flue Gas Treatment Options

5.1 A GWP assessment has been carried out an all options based the quoted specific energy figures provided within BREF guidance Tables 10.28 – 10.32.

Table 5.1: GWP Options Appraisal

	Gas Treatment Technology Options	Predicted GWP (energy + emission contributions)	Best Option	Preferred Option
NOx abatement	SCR (ammonia)	4,058[1]		
	SNCR (ammonia)	1,014[2]	1,014	
	SNCR (urea)	1,014[3]	1,014	1,014
Acid gas abatement	Wet (NaOH)	9,637[3]	4,565	
	Wet (CaO)	9,637[4]		
	Wet (CaOH)	9,637[5]		
	Semi/Dry (CaOH)	7,400[6]		
	Dry ($NaHCO_3$)	4,565[7]		
	Dry (CaOH)	4,565[8]		4,565
		Total GWP teCO_{2}(e)	**5,579**	**5,579**

5.2 Based on the information provided above the most appropriate and lowest impact solution (in terms of GWP) has been selected.

5.3 This selection has also been supported by the project BAT justification and engineering feasibility assessment carried out in support of the project.

[1] Assumes 8kW/tonne (Sector BREF Table 10.31: Specific Costs of SCR as function of waste throughput)
[2] Assumes 2kW/tonne (Sector BREF Table 10.32: Specific Costs of SNCR as function of waste throughput)
[3] Assumes 19kW/tonne (Sector BREF Table 10.30: Specific Costs of NaOH scrubber as function of waste throughput)
[4] Assumes 19kW/tonne (Sector BREF Table 10.28: Specific Costs of gypsum scrubber as function of waste throughput)
[5] Assumes 19kW/tonne (Sector BREF Table 10.29: Specific Costs of a scrubber with precipitation as function of waste throughput)
[6] Based on assumed ratio of costs between dry and semi dry systems
[7] Assumes 9kW/tonne (Sector BREF Table 10.33: Specific Costs of a flow injection absorber as a function of waste throughput)

6. GWP Direct Releases

6.1 The following table has been complied using the H1 data base tool and associated methodology for direct emission of Carbon Equivalent Emissions.

Table 6.1: Direct Carbon Equivalent Emissions

Parameter	GWP (tonnes CO_2 equivalent per annum)		Calculations
	Released	Saving/ offset	
Direct CO_2 emissions (auxiliary fuel)	42		Based on two starts per annum (220MWh gas usage assu)
Direct CO_2 emissions (imported electricity)	0	NA	All electrical loads taken directly from onsite generation
CO_2 emissions from the process	4288.82		Based on 100% biogenic content
N_2O from the process	0		All emissions as NOx not N_2O
Total released	4320.82		
Energy recovered (electricity)		36,975.2	Based on export to grid of 10MWe for 8000 hour per annum (80,000MWe) and assuming Grid generation CO_2 figures of 0.46219kgCO_2/kWh
Energy recovered (heat)		0	
Total offset		36975.2	
Net GWP	-32,644.38		