29 April 2016
Ref – 37482/C000/020

George Smith
Operation Technical Support North
SEPA
Inverdee House
Baxter Street
Torry, Aberdeen
AB11 9QA

Dear Mr Smith

Planning Application reference 160276 - East Tullos Energy From Waste

This letter details our response to SEPA's queries relating to the above planning application and in particular the Environmental Statement (ES) and the accompanying Heat and power Plan (HPP) submitted March 2016 to Aberdeen City Council.

Our clarifications are presented below in response to SEPA clarification subjects as per an e-mail dated 14 April 2016.

1. ES Process Description

a) Site footprint and available space

SEPA: Limited space available on site for any significant modification/addition to the site layout.

The design has focused on maximising the footprint of the building to provide internal vertical and horizontal flexibility to accommodate technology or BAT related modifications. This is to minimise the potential for external clutter on the site. The design process involved a review of different potential technology providers in order to ensure maximum flexibility within the proposed layout. It is recognised that this is a restricted site, however internal space configuration should allow for anticipated modifications whether technology or Best Available Techniques (BAT) driven.

SEPA: Pre-sorting/Quarantine

We can confirm that any items removed from the waste stream would be held within the tipping hall back-loading area for removal from the site. There is no proposal for external storage.

b) Supplementary Fuel

SEPA: A fuel oil tank is identified in the site layout plot plan. Confirmation of its use particularly with any potential implications for emissions modelling or with respect to the heat and power plan and overall plant efficiency.

Fuel oil is only used for plant start-up and shut-down, and maintenance of combustion conditions. Quantity of fuel oil has not been finalised at this stage, but initial calculations suggest approximately 1500 te/year with a storage capacity on site for approximately 60te. The final details would be confirmed as part of the PPC Permit application.

Continued…

c) Alternative Technologies

SEPA: Section 2.3.4 to 2.3.6 describes that the applicant carried out a review of various technologies capable of processing residual municipal waste. Detail of these assessment will be required to be submitted as part of a PPC application and a demonstration made that the option selected (mass burn – moving grate) represents BAT.

It is noted that consideration of alternative technologies will be required as part of the PPC Permit application and a demonstration of selected technology representing BAT.

d) Site Drainage – fire water

SEPA: Section 7.4.4 – Drainage on site to Detention Basin and underground storage tanks. Capacity based on 1 in 200yr flood event +20%. What consideration has been given to collection of fire water runoff with respect to design (liner/partial liner, routing surface/foul sewer/ valve shut off etc.) and capacity.

In terms of pollution from runoff, it is likely that the foam would be removed by the filter drains as proposed. Other spillage could be managed through the installation of additional oil interceptors within the site drainage system. It is anticipated that the final capacity requirements for the proposed fire water tank would be determined as part of conditional requirements including a detailed drainage scheme. This would then inform any additional water run off requirements in the event of usage. There would be capacity to increase the underground storage tanks if required.

2. Environmental Impact

a) Dust

SEPA: Chp 11, S 11.2.72 – Dust scoped out as waste deliveries covered and processing carried out indoors. What about delivery of chemicals – any powders and generation of wastes – Bottom ash, fly ash etc. needs to be covered.

All deliveries and exports from the site will be made by covered or enclosed vehicles. Unloading of waste and chemicals for the flue gas treatment plant, and loading of incinerator bottom ash and fly ash, will only take place within the main enclosed building and not in external areas as per proposed site layout (application drawing 1319_PL10).

b) Odour

SEPA: Ch11 discusses odour potential and use of carbon bed on roof of building. Takes air when no combustion air required (maintenance downtime/interlock stopping feed etc.). Looks at potential emission from this point as an Abnormal scenario. Would argue that this would represent a not routine scenario – expected to happen. Abnormal may be better represented by breakthrough of the carbon bed i.e. unabated odour release.

As referenced in in footnote A of Table 2.3 of the ES, Volume 3, Appendix 11.A, the assessment has assumed partial breakthrough of the carbon bed by using a higher outlet odour concentration (by a factor of 2.5) than that which would likely to be achievable with a fresh bed of carbon. It is highly improbable that the carbon will become completely exhausted due to procedures in the Odour Management Plan requiring regular monitoring for breakthrough when the plant is shut down. Such monitoring procedures may include, for example, sniff testing or PID monitors at multiple points across the bed to detect progression of carbon saturation. The specific monitoring procedures will be documented in the PPC Permit application.

SEPA: App 11A&B – Table 2.3 – Release point is given as building height. Normally where less than 3m above roof ridge treat as having effective release height of 0. Considerably affected by building effects. How treated here?

Continued…

This procedure would only be used for the purposes of an H1 screening assessment, not once a decision has been made to proceed to detailed modelling. The buildings module within the dispersion model fully takes in to account effects such as building induced downwash and will calculate the fraction of the plume entrained within the building recirculation zone based on the building dimensions, height of release and its buoyancy/momentum.

3. Air Dispersion Modelling

a) AQS/EAL Selection

SEPA: Chp 11, Table 11.2 – Addition - HF also has an annual EAL listed of 16 ug/m3 (monthly average).

In the report produced by the Expert Panel on Air Quality Standards (EPAQS) from which the monthly average EAL was derived[1], it is stated:

> *"It is unlikely that the ambient monthly mean would approach this value if the 1-hour guideline value for irritancy is not exceeded as an air pollutant emitted from a chimney stack."*

This relationship has been used to estimate the likelihood of exceedence of the monthly mean EAL, as opposed to predicting a monthly mean process contribution due to the complex nature of predictions over this timescale (most models will only produce output up to weekly averaging periods as standard). The hourly mean predicted environmental concentration (PEC) is just 4% of the EAL. On this basis, as per the EPAQS report, it is highly unlikely that the monthly mean EAL will be exceeded.

SEPA: Chp 11, Table 11.2 – Confirmation – Mn annual EAL listed in table as 1 ug/m3 however in literature as 0.15 ug/m3,

Although Regulators in England and Wales have reduced the Environmental Assessment Level (EAL) to 0.15 $\mu g\ m^{-3}$ in the H1 guidance, the EAL in SEPA's own version of this equivalent guidance is still listed as 1 $\mu g\ m^{-3}$. Even if the lower value adopted in England and Wales had been used, the PEC would only account for 0.3% of the EAL.

SEPA: Chp 11, Table 11.2 – Confirmation – PAH annual also listed as 1 nanogram per cubic meter of BaP total content within the PM10 fraction – how does this compare with the 0.25 ng/m3 employed.

The assessment has used the objective for PAHs (as B[a]P) in the 2007 Air Quality Strategy for England, Scotland, Wales and Northern Ireland. This is lower (by a factor of 4) than the equivalent EU Limit Value and Air Quality Standard and requires an assessment of total B[a]P, as opposed to that just in the PM_{10} fraction, and therefore enables a more conservative assessment.

b) Emission Rate Selection

SEPA: Where possible emission rates are derived from compliance with IED ELVs. Except for NOx emissions, where a design basis daily average emission concentration of 140 mg/m3 has been assumed. Need to discuss why done and how achievable this figure is.

Due to the sensitivity of the area, in particular the presence of several Air Quality Management Areas (AQMAs), a decision was made at an early stage of the design process to include enhanced NOx abatement as embedded mitigation through the use of advanced selective non-catalytic reduction (SNCR). Suppliers of advanced SNCR systems now advise

---

[1] EPAQS, 2008. 'Addendum to Guidelines for Halogen and Hydrogen Halides in Ambient Air for Protecting Human Health Against Acute Irritancy Effects'

concentrations in the region 120 - 150 mg Nm^{-3} can be achieved by using multiple urea injection points across several vertical planes of the combustion chamber. As opposed to conventional SNCR, which generally only injects in a limited number of points on a single plane, this approach ensures all potential temperature zones within the combustion chamber are captured and, thus, optimises the NO_x reduction reactions. This figure will be proposed to SEPA as part of the PPC Permit application as a 'beyond BAT' emission limit value to be entered in to the Permit.

SEPA: Where ELVs are not specified (e.g. PAH), 'emissions data have been derived from manufacturer data or from typical levels monitored at other UK EfW facilities'. Need to confirm which was used in each case, if represents an average and how comparable the sites are i.e. technology type, waste composition etc.

This approach was only adopted for polycyclic aromatic hydrocarbons (PAHs) and was based on monitored emissions data available on the public register obtained from mass burn UK municipal solid waste incinerators using moving grate technology. This is the same design basis as the proposed East Tullos EfW plant and would produce a similar estimate of emissions.

c) Background values

SEPA: Confirm appropriateness of background value selections for example Section 11.3.13 – which selected and how compares to urban setting as considered in 11.3.12 – HCL and for Metals S11.3.15 closest urban set chosen (Belfast) is this the most representative of this site?

The monitored NH_3 values in 11.3.13 are only provided for reference as the UK Air Pollution Information System (APIS) mapped background values for each individual receptor have been used in the impact assessment. There are only a limited number of monitoring locations for certain pollutants in the UK (e.g. metals and dioxins). Rather than simply taking data from the nearest monitoring location, which in the majority of cases was a rural monitoring location and would not provide representative data for the Aberdeen urban area, in some cases data from a monitoring station located much further away (but where the land use and subsequent emissions would be more representative of the dispersion site area) was used in preference to data from the rural stations to ensure a robust, conservative assessment. However, for certain metal species, data was only available from the rural monitoring network.

d) Release Rate Calculation

SEPA: Provide working for how calculated Release rates and in particular the normalised flow with corrections for temperature, water vapour and oxygen content.

Please see enclosed emissions calculations which informs the assessment in the ES Chapter 11.

e) Conversion of NO to NO_2

SEPA: Need to seek justification on use of worst case scenario 35 and 70% respectively.

Justification for conversion of NO to NO_2 is discussed at length in section 2.8 of the Appendix 11.A of the ES, Volume 3.

f) Treatments

SEPA: Costal Effects – 11.3.27 and App 11A&B The coastal effects module within the model used to predict dispersion in this assessment does not consider specific weather phenomena such as a sea haar. Report mitigates by saying that by using meteorological data from a monitoring station likely to be subject to the same coastal effects as those occurring at the development site, these phenomenon are already captured within the modelled

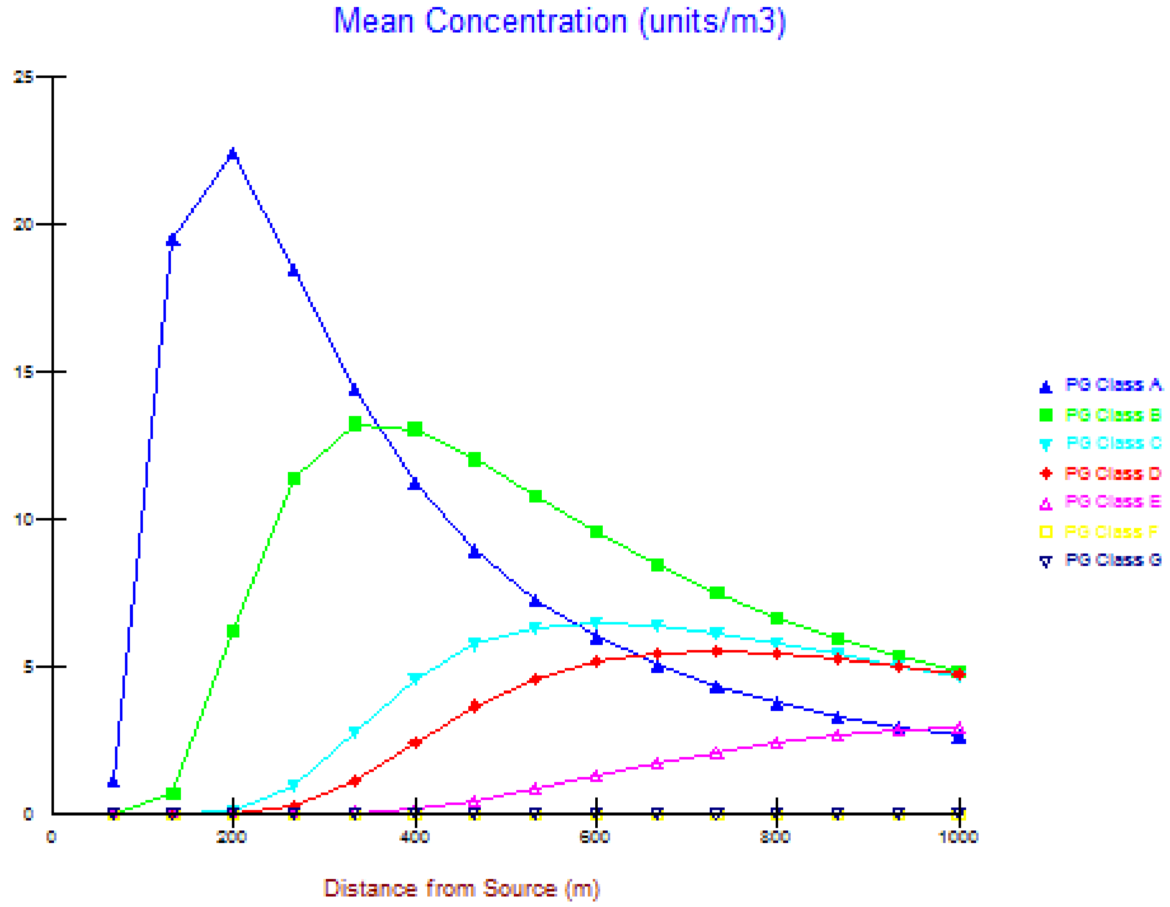
Continued…

meteorological data. However the Dyce station is 11km inland and not subject to same events/frequency of events.

SEPA: Costal Effects – need further justification for the statement that In essence, dispersion of stack emissions from the Proposed Development during a haar would be more favourable than during typical, average weather conditions.

Haars may stretch tens of kilometres in land in certain cases; however it is accepted that the frequency of occurrence may increase as a function of distance to the coast. However, for the reasons discussed in the following section, haars are not considered to have a significant effect on dispersion in this particular instance.

It is fundamental dispersion theory that the maximum impact from an elevated source occurs during unstable, convective conditions when portions of the plume can be drawn towards ground level due to strong vertical turbulent motion. This contrasts to ground level release where the maximum impact does occur during stable conditions, such as those that may be present during a haar, due to the lower levels of turbulent mixing and with the plume becoming 'trapped' at low level. The graph overleaf, which plots ground level concentration from an elevated release as a function of downwind distance for a range of different stability classes, demonstrates this relationship. It can be clearly seen that unstable conditions (PG Class A-C) produce significantly higher maximum ground level concentrations than the neutral or stable stability classes (PG Class D-G) which are a pre-requisite for development of, or conditions during, a haar.



SEPA: Costal effects – sensitivity is basically comparing coastal against terrain and buildings. Showing that terrain and buildings are dominant. Why not compare coastal with no buildings and terrain against and no costal with no buildings and terrain to ascertain potential effect of costal module alone?

Continued…

The sensitivity analysis in the technical appendix clearly demonstrates that buildings and terrain have to be included in the model set up as they will have an important effect on dispersion. The question that then needs to be answered is, what additional effect would the coastal module have on model predictions with this particular set up. There would be little merit in comparing results without buildings and terrain because both are present in reality and both have been shown to have a significant effect on dispersion.

g) Stack Height

SEPA: App 11A&B – Section 5.1 identifies that the optimum stack height, from the perspective of applying Best Available Technique (BAT), occurs at the point where the incremental decrease in ground level concentration becomes disproportionate to the incremental increase in stack height (and associated increase in investment cost). Visually, this point can be depicted as the 'knee-point' on a graphical curve of ground level concentration against stack height. Then states that Figure 5.1 indicates that the 'knee-point' occurs in the region between 90-100 m. However a stack height of 80m selected. BAT demonstration for this height has not been provided.

It is important to emphasise that Figure 5.1 provided at planning application stage should only be used to provide a likely indication of the BAT stack height. Importantly, it does not consider cost, which is a fundamental component of BAT determination, because such estimates are not available at this stage of the design process. However, given impacts are already assessed as negligible or insignificant at 80m, it is unlikely that justification for a taller stack can be made once a full cost-benefit analysis is undertaken. Such an assessment, however, will be provided with the PPC Permit application.

h) Abnormal Scenarios

SEPA: Not clear as to why these scenarios have been selected and not others. All centred on failure of FGT and increase in emissions what about change in dispersion loss of fan etc.

There are many different theoretical abnormal scenarios which could occur during operation of the plant. Given the large number of potential scenarios, the assessment only considers those which will have the greatest impact on air quality. Increases in emission rates will likely have a greater impact than loss of an induced draft fan for example, since there will still be an element of momentum-driven plume rise due to natural draft and emissions will still be emitted at temperature. Whereas there is a positive linear relationship between emission rate and ground level impact, e.g. an increase in the emission rate by a factor of 5 would increase the ground level impact by a factor of 5, discharge velocity has an inverse non-linear relationship with ground level concentration and, due to the linkages with discharge temperature as part of overall plume rise, a reduction in discharge velocity by a factor of 5 would increase ground level concentrations by a factor less than 5.

It should also be emphasised that the abnormal scenarios considered in this assessment are consistent with those agreed with SEPA for the air quality assessment of the Irvine waste biomass plant in 2014.

SEPA: Some scenarios discounted due to shutdown sequence enacted. How long will this take – what is the emission profile in this case.

In some scenarios, rapid shut down of the plant could be performed in less than 1 hour but this will be confirmed as part of the PPC Permit application. As discussed in the air quality assessment, during these particular scenarios, there is the potential that higher CO and TOC emissions could occur. However, Industrial Emissions Directive (IED) still requires ELVs for these substance to be met during all scenarios so additional mitigation measures e.g. increase primary air rates, increase carbon dosing rates etc, can be incorporated in to the design to ensure CO and TOC emissions during these scenarios would be no higher than normal operation. The specific design measures will be confirmed as part of the PPC Permit application.

SEPA: Was the scenario for NOx run with baseline of 140mg/m3.

The abnormal scenario for NOx was run with the baseline half-hourly average ELV of 400 mg Nm^{-3} with a factor of 2 uplift to take account of failure of the urea dosing pump, i.e. an abnormal emission concentration of 800 mg Nm^{-3} was modelled.

SEPA: Dust – does not appear to consider dust emissions for periods of abnormal emissions. Section 11.5.29 – states 'As Article 46(6) of Directive 2010/75/EU states ELVs must not be exceeded for more than 4 hours uninterrupted, only those pollutants with an AQO averaging period less than this duration are considered as part of the abnormal emissions assessment.'. This should be extended to consideration of those pollutants with an averaging value of 24hrs. It seems reasonable to consider that a 4hr elevated emission could contribute to a 24hr average breach.

Based on simple extrapolation of the results, it is highly unlikely that a four hour period would be sufficient to fundamentally change the conclusion of the assessment for those pollutants with daily mean assessment metrics. If an abnormal scenario occurs, causing an exceedence lasting the full 4-hour period permitted by IED, it is highly likely that the plant will enter a full shutdown whilst the issue is investigated and rectified. As such, whilst there would be a four hour period of elevated emission, there would then be a 20 hour period of no emission. In this scenario, overall daily emissions would actually be 17% lower than during normal operation. In the highly unlikely scenario whereby the plant operates up to the 4 hour period of exceedence, identifies and rectifies the issue in the last few minutes and continues to operate for the remainder of the day, total daily TPM emissions would increase by two-thirds. However, this would still only cause the daily mean PM_{10} PEC to increase from 60.4% of the Air Quality Objective (AQO) to 60.9% of the AQO.

i) Results

SEPA: General discussion where close to have exceedance of AQS/EAL and high background concentrations.

This discussion is included in the main body of the ES Chapter 11 text and in the summary significance Table 11.8.

4. Heat and Power Plan

a) Clarification on Values

SEPA: Section 2.7.13 & Section 2.2 (HPP) - the Proposed Development would be capable of generating approximately 13.5 MWe of electricity in total, of which 2.1 MWe would be needed for plant requirements. The remaining 11.1 MWe could be fed to the local electricity network via an onsite substation. 13.5 – 2.1 = 11.4MWe (clarification sought).

The correct total electricity figure should be 13.2MWe, combining 2.1MWe for plant requirements and 11.1 MWe for export.

SEPA: Table 1 and 3.1 – assume max gross electrical power out should be 13.5MWe and using figures given in tables heat release from combustion calculated at 47.5 MW not 49.05MW. Note if use CV 9.3 (end of Sect 3) then calculation fine.

Table 1 and section 3.1 of the Heat and Power Plan, the CV value should read 9.3 MJ/kg rather than 9 MJ/kg.

The Heat released from combustion = 150,000 tonnes * 9.3 MJ/kg * 1/3.6 = 387,500 MWh divided by 7,900 hours = 49.05 MWth

Continued…

SEPA: Table 3.2 (HPP) – Taking total mass and calorific value get a figure of 8.14MJ/kg as oppose to the 9.3 MJ/kg employed in the calculation and design range of 9 - 12 MJ/kg.

The design perimeter used in the assessment is based on 9.3 MJ/kg as set out on page 17 of the Heat Plan. It is recognised that this varies from Table 3.2 which suggest an average CV of 8.142MJ/kg based on waste composition studies.

It is anticipated that the CV into the plant is likely to be in a range of 8.5 - 10.5 MJ/kg, the actual figure will depend greatly on the week-by-week waste composition. A figure of 9.3 MJ/kg is realistic mid-point, and the one that the main firing diagram would be based around, so all calculations regarding the EFW power/energy balance should be based on this. The design window of the EFW is able to accept waste with a CV range of 8 – 12 MJ/kg.

Whether a CV of 8.21 or 9.3 calculations in line with Annex 4 of the SEPA Thermal Treatment Guidelines (2014) shows that the minimum energy efficiency requirement of 20% can be achieved.

The electrical efficiency is largely independent of the waste CV (less energy in from the waste, less electrical energy out, but in the same proportion to the changed CV). Looking at the SEAP Thermal Treatment of Waste Guidelines Annex 4, the expected Overall Indicative Efficiency will be in the range of 24% - 27% (with no heat export).

SEPA: Need to provide actual calculation on how reached efficiency figure of 27% and 28% (net and gross respectively).

Calculations on efficiency figures:

- Energy within steam = 2,921 kJ/kg;
- Waste Input energy = 176.58 GJ;
- Steam volume to turbine = 176.58 GJ * 1000 * (0.85/2921 kJ/kg) = 51.4 tonnes/hr – assumes 85% boiler efficiency;
- Total steam energy available = (Energy within steam * steam volume to turbine)/1000/3.6 = (2921*51.4)/1000/3.6 = 41.7 MW;
- Net Electrical output = 11.1 MWe;
- So Net Efficiency figure = 11.1 MWe/41.7 MW = 27%;
- Gross Electricity output at generator terminals = 13.5 MWe;
- Gross waste input energy available = 49.05 MWth; and
- So gross efficiency figure = 13.5/49.05 = 28%.

Additional calculations based on SEPA's thermal Treatment Guidelines (2014) are enclosed.

SEPA: How has any supplementary fuel use been considered?

No explicit consideration of supplementary fuel use at this stage due to the initial feasibility stage of a potential district heating scheme.

b) Annex 2

SEPA: Need to discuss how the submitted heat and power plan meets the requirements of Annex 2 of the SEPA Thermal Treatment guidelines and demonstrates achievement of targets highlighted in Annex 1.

The Heat Plan has been prepared in accordance with Annex 2 of SEPA's thermal Treatment guidelines and has also sought to demonstrate the requirements set out in Annex 1 in regards to performance and implementation.

Continued…

A phased approach to implementing the heat plan has been proposed and it is anticipated that initial heat supply could be commenced within a year of initial operations (2021/2022) followed by further development of a heat network within five years of operations. It is anticipated at PPC Permit application stage, further details regarding the heat plan implementation will be available.

With heat export, the proposed EfW should achieve the 35% minimum requirement following implementation of Phase 1 and 2 of the heat plan.

d) Combined Heat and Power

SEPA: Section 3 (HPP) – statement made that It has been assumed that back-up boilers will be required when the Proposed Development is not available and to take into consideration periods of peak demand. If located on the same site that will fall within the same Permit application if located elsewhere still likely to be close by and hence consideration of emissions – peak loads in particular where operating at the same time. Can discuss.

At this stage, the feasibility study of the district heating scheme does not identify the location for a potential back-up boiler. If required, this may be located on-site within the CHP building or up to 5km away the site. If applicable, this will be considered in further detail within the PPC Application permit.

5. Summary

We trust the above address SEPA's clarification requests.

Should you require any further information, please do not hesitate to get in touch.

Yours sincerely

Heidi Thorsdalen

HEIDI THORSDALEN
Associate Director
Direct Line – 0141 222 1284
E-mail – heidi.thorsdalen@amecfw.com

CC: Nicholas Lawrence, Aberdeen City Council

Enc:

EFW emission calculations; SEPA TTG Calculations 8.1 $MJkg^{-1}$; and
SEPA TTG Calculations 9.3 $MJkg^{-1}$

Reference Conditions:		
Volumetric flow at NTP	105000	Nm3/h
Volumetric flow at reference conditions	28.4	Nm3/s
	273	k
	101.3	kPa
	11	% O2
	0	% moisture

Actual Conditions:					
Operating Hours:	8000	hours			
O2 Content:	8.9	%			
Moisture Content:	14.1	%			
Flue gas exit temperature:	**130**	C			
Flue gas exit temperature:	403	K			
Actual volumetric flow	40.1	Am3/s	27.1757679	33.0775761	28.41364
Velocity	**15**	m/s			
Area of Stack	2.674441	m2			
Diameter of Stack	**1.85**	m			

Long-Term:						1 line plant	
Particulate Matter	10	mg/Nm3	284.14	mg/s	**0.28**	g/s
VOCs (as TOC)	10	mg/Nm3	284.14	mg/s	**0.28**	g/s
Hydrogen chloride	10	mg/Nm3	284.14	mg/s	**0.28**	g/s
Hydrogen fluoride	1	mg/Nm3	28.41	mg/s	**0.03**	g/s
Carbon Monixide	50	mg/Nm3	1,420.68	mg/s	**1.42**	g/s
SO2	50	mg/Nm3	1,420.68	mg/s	**1.42**	g/s
Nox (NO and NO2 expressed as NO2) - Existing plant > 6t/h or new plant	140	mg/Nm3	3,977.91	mg/s	**3.98**	g/s
Nitrous oxide	ˆ	mg/Nm3				
Ammonia	10	mg/Nm3	284.14	mg/s	**0.28**	g/s
Cadmium and Thallium	0.05	mg/Nm3	1.42	mg/s	**0.0014**	g/s
Mercury	0.05	mg/Nm3	1.42	mg/s	**0.0014**	g/s
Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V and their compounds	0.5	mg/Nm3	14.21	mg/s	**0.014**	g/s
Dioxins and furans - I-TEQ	0.1	ng/Nm3	2.84	ng/s	**2.8E-09**	g/s
Dioxins and furans - WHO-TEQ	n/a	ng/Nm3				
Dioxin Like PCBs	n/a	ng/Nm3				
PAHs	0.012	µg/Nm3	0.34	µg/s	**3.4E-07**	g/s

Short-Term:					1 Line Plant	
Particulate Matter	30	mg/Nm3	852.41	mg/s	**0.85**	g/s
VOCs (as TOC)	20	mg/Nm3	568.27	mg/s	**0.57**	g/s
Hydrogen chloride	60	mg/Nm3	1,704.82	mg/s	**1.70**	g/s
Hydrogen fluoride	4	mg/Nm3	113.65	mg/s	**0.11**	g/s
Carbon Monixide	100	mg/Nm3	2,841.36	mg/s	**2.84**	g/s
SO2	200	mg/Nm3	5,682.73	mg/s	**5.68**	g/s
Nox (NO and NO2 expressed as NO2) - Existing plant > 6t/h or new plant	400	mg/Nm3	11,365.46	mg/s	**11.4**	g/s
Nitrous oxide	ˆ	mg/Nm3				
Ammonia	15	mg/Nm3	426.20	mg/s	**0.43**	g/s
Cadmium and Thallium	n/a	mg/Nm3	1.42	mg/s	**0.0014**	g/s
Mercury	n/a	mg/Nm3	1.42	mg/s	**0.0014**	g/s
Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V and their compounds	n/a	mg/Nm3	14.21	mg/s	**0.014**	g/s
Dioxins and furans - I-TEQ	n/a	ng/Nm3	2.84	ng/s	**2.8E-09**	g/s
Dioxins and furans - WHO-TEQ	n/a	ng/Nm3				
Dioxin Like PCBs	n/a	ng/Nm3				
PAHs	n/a	ng/Nm3				

Input Variables

Energy within steam	2,921	kJ/kg
Waste input energy	176.81	GJ
Boiler efficiency	85%	
Steam volume to turbine	51.45	tonnes/hr
Total steam available	41.75	MW
Net electrical output	9.80	MWe
Gross electrical output at generator terminals	11.90	MWe
Operating hours	7,900	hrs/yr
Net heat output	20.00	MWth
Parasitic Load	2.10	MWe

Electricity Only Mode

Energy Inputs

Residual waste	150,000	tonnes	
Gross Calorific Value	8.10	$MJkg^{-1}$	
Energy Input (Waste)	337,500	MWh	
Support Fuel	50	tonnes	Assumed quantity of fuel oil
Gross Calorific Value	43	MJm^{-3}	
Energy Input (Support Fuel)	597	MWh	
Total Electrical Power (Parasitic Load)	16,590	MWh	
Return Heat from users	0	MWh	
Total Energy Input (gross CV)	**354,687**	MWh	

Energy Outputs

Power Efficiency	Electrical power provided to users / total energy input	
Electrical Output	94,010	MWh
Total Energy Input	354,687	MWh
Power Efficiency	**26.5%**	**%**

Heat Efficiency	Heat energy provided to external users/total eneergy input	
Heat Energy Provided	0	MWh
Total Energy Input	354,687	MWh
Heat efficiency	**0.0%**	**%**

Overall Indicative Efficiency	Total Energy Exported / Total Energy Input	
Total Energy Exported	94,010	MWh
Total Energy Input	354,687	MWh
Overall Efficiency	**26.5%**	%

CHPQA Index NA Electricity only mode

Input Variables

Energy within steam	2,921	kJ/kg
Waste input energy	176.81	GJ
Boiler efficiency	85%	
Steam volume to turbine	51.45	tonnes/hr
Total steam available	41.75	MW
Net electrical output	11.10	MWe
Gross electrical output at generator terminals	13.20	MWe
Operating hours	7,900	hrs/yr
Net heat output	20.00	MWth

Electricity Only Mode

Energy Inputs

Residual waste	150,000	tonnes	
Gross Calorific Value	9.3	$MJkg^{-1}$	
Energy Input (Waste)	387,500	MWh	
Support Fuel	50	tonnes	Assumed quantity of fuel oil
Gross Calorific Value	43	MJm^{-3}	
Energy Input (Support Fuel)	597	MWh	
Total Electrical Power (Parasitic Load)	16,590	MWh	
Return Heat from users	0	MWh	
Total Energy Input (gross CV)	**404,687**	MWh	

Energy Outputs

Power Efficiency	Electrical power provided to users / total energy input	
Electrical Output	104,280	MWh
Total Energy Input	404,687	MWh
Power Efficiency	**25.8%**	**%**
Heat Efficiency	Heat energy provided to external users/total eneergy input	
Heat Energy Provided	0	MWh
Total Energy Input	404,687	MWh
Heat efficiency	**0.0%**	**%**
Overall Indicative Efficiency	Total Energy Exported / Total Energy Input	
Total Energy Exported	104,280	MWh
Total Energy Input	404,687	MWh
Overall Efficiency	**25.8%**	%
CHPQA Index	NA	Electricity only mode