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3 July 2020

Quentin Cooke
EPA Victoria
181 William Street
Melbourne
VIC 3000

Dear Quentin,

RE: Section 22(1) Notice to Supply Further Information - Response

1 Introduction

SMEC Australia Pty Ltd (SMEC) provides this letter to the Environment Protection Authority Victoria (EPA) in response to the Section 22(1) Notice to Supply Further Information (EPA Reference 595276), as issued on 18 June 2020.

The Section 22(1) Notice was provided in relation to the Great Southern Waste Technologies (GSWT) Works Approval Application (SMEC reference 30041688) for a proposed waste to energy facility, located at 70 Ordish Road, Dandenong South. The RFI required response to the following:

1) Please provide calculations for determining Best Available Technique Associated Energy Efficiency Levels for the proposal as defined under the European Commission, Commission Implementing Decision (EU) 2019/2010 of 12 November 2019, establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for waste incineration;
2) Please provide a revision of the R1 calculation for the proposal as defined under the European Union Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives, 2008) to:
   a) take into account the Climate Correction Factor, based on the Heating Degree Days;
   b) include discussion and justification for all assumptions including assumptions of facility operational time;
3) Please provide a set of the calculations requested under item (1) and (2) assuming a net caloric value as determined by the waste audit supplied as Appendix P of the Application (7.2 MJ/kg), and of the minimum net calorific value as identified in the Fuel Specification supplied as Appendix Q of the Application (8 MJ/kg);
4) Please show derivation of the calculated values requested under items (1)-(3) above. Please detail and/or document relevant assumptions for figures used.

In addition to the Section 22(1) Notice, EPA requested further information, as per a telephone discussion and email dated 17 June 2020. The further information requested by EPA included:

1) Summary of measures available to GSWT in the event that the calorific value of waste is below the design point (i.e. < 12MJ/kg), to ensure the facility can continue to accept waste (Refer to Section 4)
2) Clarifications relating to the waste audit (Refer to Section 5)

This letter provides a response to information requested in the Section 22(1) Notice and additional communications.

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2 Energy Efficiency Level (EU BATC 2019)

European Commission Best Available Techniques (BAT) Conclusions for Waste Incineration (2019), under the *Industrial Emissions Directive 2010/75/EU* (*IED*), provides the methodology for calculating the energy efficiency levels associated with best available techniques.

The gross electrical efficiency and gross energy efficiency has been calculated for the proposed facility utilising the formula presented in Figure 2-1.

Gross electrical efficiency	$\eta_e = \frac{W_e}{Q_{th}} \times (Q_b/(Q_b - Q_i))$
Gross energy efficiency	$\eta_h = \frac{W_e + Q_{he} + Q_{de} + Q_i}{Q_{th}}$

Where:

- — W_e: electrical power generated, in MW;
- — Q_{he}: thermal power supplied to the heat exchangers on the primary side, in MW;
- — Q_{de}: directly exported thermal power (as steam or hot water) less the thermal power of the return flow, in MW;
- — Q_b: thermal power produced by the boiler, in MW;
- — Q_i: thermal power (as steam or hot water) that is used internally (e.g. for flue-gas reheating), in MW;
- — Q_{th}: thermal input to the thermal treatment units (e.g. furnaces), including the waste and auxiliary fuels that are used continuously (excluding for example for start-up), in MW_{th} expressed as the lower heating value.

Figure 2-1: Energy Efficiency Calculation (Source: European Commission Best Available Techniques (BAT) Conclusions for Waste Incineration (2019))

The best available techniques associated energy efficiency levels for municipal solid waste facilities are:

- Gross Electrical Efficiency = 25 to 35%
- Gross Energy Efficiency = 72 to 91%

The energy efficiency levels for the proposed facility were calculated based on four scenarios:

- Scenario 1 – Net Calorific Value = 7.2 MJ/kg (as per Waste Audit, HRL 2020)
- Scenario 2 – Net Calorific Value = 8.0 MJ/kg (minimum NCV in firing diagram/fuel specification)
- Scenario 3 – Net Calorific Value = 12 MJ/kg (nominal operating point)
- Scenario 4 – Net Calorific Value = 11.4 MJ/kg (as per Hafslund reference facility)

The calculations have been prepared assuming steam pressures of 41 bar and 420 degrees Celsius. Boiler design and steam pressure will be confirmed through the detailed design stage of the project.

A summary of the energy efficiency results is presented in *Table 2-1.*

Table 2-1: Energy Efficiency Results (EU BATC 2019)

VALUE	CALORIFIC VALUE OF FEEDSTOCK (MJ/kg)			
	7.2 (Scenario 1)	**8.0 (Scenario 2)**	**12 (Scenario 3)**	**11.4 (Scenario 4)**
Gross Electrical Efficiency (%)	26.20	27.01	28.58	N/A
Gross Energy Efficiency (%)	84.61	86.68	92.32	84.32

Assumptions and calculations are presented in **Appendix A**.

A discussion regarding measures to manage calorific value of waste is presented in Section 4.

3 R1 Calculation

The *EPA Guideline 1559: Energy from Waste* (EPA, 2017b) requires an existing or proposed facility to comply with the European Union's *Industrial Emissions Directive 2010/75/EU* (*IED*) and Victorian regulatory requirements.

For thermal processes, the proponent must demonstrate that the proposal targets genuine energy recovery, as specified in EPA Publication 1559. For waste to energy facilities, the thermal efficiency of the facility it to be demonstrated using the R1 Efficiency Indicator as defined in the European Union's Waste Framework Directive 2008/98/EC (WID) and presented in EPA Publication 1559. For a plant to be considered a genuine energy recovery facility, R1 should be equal to or greater than 0.65.

The R1 Efficiency Indicator has been calculated using the following formula, in accordance with EPA Publication 1559.

$$R1 = \frac{E_p - (E_f + E_i)}{0.97 \times (E_w + E_f)}$$

E_p: Annual energy produced as heat or electricity. Calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (GJ/year)
E_f: Annual energy input to the system from fuels contributing to the production of steam (GJ/year)
E_w: Annual energy contained in the treated waste calculated using the net calorific value of the waste (GJ/year)
E_i: Annual energy imported excluding Ew and Ef (GJ/year)
0.97: Factor account for energy losses due to bottom ash and radiation

The R1 value was calculated based on four different scenarios:

- Scenario 1 – Net Calorific Value = 12 MJ/kg (nominal operating point)
- Scenario 2A – Net Calorific Value = 7.2 MJ/kg (as per Waste Audit, HRL 2020)
- Scenario 2B – Net Calorific Value = 7.2 MJ/kg (as per Waste Audit and 80% of the nominal annual throughput, noting 80% municipal solid waste (MSW) and 20% commercial and industrial waste (C&I))
- Scenario 3 – Net Calorific Value = 8.0 MJ/kg (minimum NCV in firing diagram/fuel specification)

The calculations have been prepared assuming steam pressures of 41 bar and 420 degrees Celsius. Boiler design and steam pressure will be confirmed through the detailed design stage of the project.

EU Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives, 2008) in its Annex III, notes that efficiency calculation should take into account the Climate Correction Factor (CCF), based on the Heating Degree Days (HDD). The HDD, based on weather data obtained from the Melbourne Airport weather station, over a 20 year period was 1,680. Based on this, a CCF of 1.12 was applied to the energy efficiency (R1) value. Refer to **Appendix C** for summary of HHDs calculated.

A summary of the R1 value results is presented in Table 3-1.

Table 3-1: R1 Values

VALUE	CALORIFIC VALUE OF FEEDSTOCK (E_i) (MJ/kg)			
	12 (Scenario 1)	**7.2[1] (Scenario 2A)**	**7.2[2] (Scenario 2B)**	**8.0 (Scenario 3)**
R1 Value	0.80	0.73	0.70	0.75
R1 Value with CCF[3]	0.90	0.82	0.78	0.84

Notes:
[1] Based on 100,000 tonnes per year (MSW and C&I)
[2] Based on 80,000 tonnes per year (MSW only component)
[3] CCF of 1.12 applied as HDD < 2,150

Assumptions and calculations are presented in **Appendix B.**

The R1 values calculated for the various scenarios were all greater than 0.78, indicating the facility exceeds the requirements to be considered a genuine energy recovery facility.

4 Calorific Value

The following measures are available to GSWT to adjust the calorific value of waste to achieve the required value for the feedstock.

Prior to construction and to inform the detailed design process, GSWT intend to satisfy themselves that the calorific value of the waste will be suitable for the proposed facility (i.e. around 12 MJ/kg). This will be informed through proposed future waste audits which will incorporate the full seasonal variation, with a waste composition report detailing the final specification of the waste feedstock to be provided to EPA prior to any cold commissioning of the facility. The waste audit will be undertaken in two parts 1/.MSW from a representative catchment 2/. Commercial and Industrial from an agreed supply partner or similar.

It is GSWT's intent to achieve the Net Calorific Value (NCV) design point for the feedstock, at approximately 12 MJ/kg, as this is the optimal performance range. This will be achieved by blending high NCV C&I waste with the MSW to achieve the target NCV. It is anticipated this blending will be at a ratio of approximately 80% MSW to 20% C&I.

It is also noted that the initial waste audit was conducted during winter, where moisture contents are typically considerably higher and prior to any proposed Food and Organics Diversion (FOGO), which result in a lower NCV. As such, it is expected that the NCV of MSW is likely to be significantly higher, where audits are conducted during remaining warmer/drier seasons. NCV will also increase following implementation of kerbside FOGO collections.

GSWT do not anticipate low calorific value feedstock being an issue, due to the ability to source and blend higher NCV material from the C&I collection sector and the likely increases in NCV of MSW following removal of the FOGO component and additional seasonal waste audits.

5 Waste Audit

The following information has been provided in response to correspondence from EPA(in *italics*) on 17 June 2020

In regards to the waste audit (Appendix P) the following questions have been raised and are required to be addressed. I note our discussions earlier today on future auditing to inform detailed design and prior to commencing works, which may be relevant to your response to the questions/comments below.

- *In Section 3.3.1, page 20 of Appendix P (Cutting, 2018), HRL states that "the categories were analysed using the standardized methods listed above in Section 2, Figure 1." However, this figure is absent from the Appendix. Can GSWT/HRL please provide a brief description of the methodology in the derivation of net calorific value and the relevant standards associated with this.*

Figure 1 added to report (refer to **Appendix D** for current Waste Audit Report)

The calorific value (CV) method shown in the table (Figure 1) to be added into the report is an international standard method that is used for all CV analysis of MSW/RDF and Biomass, developed by international organisations specifically for the analysis of these types of materials. The sample, after preparation, is weighed into a crucible and placed inside a bomb canister, pressured with oxygen and placed into the water jacketed compartment of the Calorimeter. The sample is ignited inside the bomb canister and the temperature change of the water jacket surrounding the bomb canister is measured. This change in temperature is used to calculate the CV of the sample. This value is then used in further calculations to determine the Gross Wet, Gross dry and Net Wet calorific Values.

- *It is recommended consideration of a weighted standard deviation and calculation ofa 95% confidence interval. For samples analysed as part of sampling audit 1, 95% of wastes would have a net calorific value ranging between: 3.11 and 13.38.*

This first audit is part one of a four part audit process and is seen as just one data point in determining the 95% confidence intervals for the MSW. Thus, it is not possible to calculate the 95% confidence interval with just one data point. The approach taken for the application of the audit methodology, which is based on the Sustainability Victoria Kerbside waste audit guidelines, recommends that to achieve 95% confidence within of the waste and its composition, 250 bins will need to be collected and audited for putrescibles. We have used this information to therefore set the number of bins for the audit to be of a minimum of 250 bins per audit such that we can achieve the 95% confidence level. As the composition and variability of the MSW is unknown, we have had to take this approach, which is the industry standard approach/methodology. Once we have conducted the remaining three audits we will be able to determine these confidence levels.

- *Weighted average data is missing for heavy metals that allows for comparison against the Fuel Specification limits. In addition, individual waste components from individual audit samples sometimes exceeded Fuel Specification limits.*

It is understood that the comparison made by the EPA is on an individual component basis, and as such it would be possible to have some trace elements exceed the levels on an individual category basis. However, when all components are combined on a weighted average basis (refer tables 11 to 16 and Table 17 of the Waste Audit, HRL 2020) and compared to Table 2 of the Energos fuel specification, the levels of trace elements for the whole of MSW samples, for each individual day are within these limits, except for Day 6 and only for Manganese which was 330mg/kg db compared to a limit of 300mg/kg db.

When comparing the overall average result of the 6 days of audits for this first audit, all trace element results are within the limits set out in the Energos Fuel specification, Table 2.

6 Closing

We trust this response suitably addresses the Section 22(1) Notice and further request for information. Please do not hesitate to contact me if you have any further questions.

Yours sincerely,

SMEC Australia Pty Ltd
Julian Howard
Manager - Waste

Appendices:

Appendix A – Energy Efficiency Calculation (EU BATC 2019)

Appendix B – R1 Calculation

Appendix C – Heating Degree Days

Appendix D – Waste Audit (HRL, 2020) – Commercial in Confidence

Appendix A Energy Efficiency Calculation (EU BATC 2019)

Efficiency for Energos 2-Line Facility

Rev_010720_v07

Nominal operating point:

		Values	Unit
Fuel throughput	Enter Value	12.8	ton/h
Net calorific value; NCV	Enter Value	7.2	MJ/kg

Data from Energos design model / New plant:

Parameter	Design model parameter .....:	Corresponding BAT parameter ....:	Value	Unit	Comment
Gross thermal power	P_th_gross ("innfyrt effekt")	**Q_th**	25.60	MW	Thermal power; gross. Calculated from operation point data.
Net thermal power	P_th_net	**Q_b**	19.66	MW	Thermal power; net; i.e. thermal power produced by / delivered from the boiler. From design model
Thermal efficiency; Energos design mod. output	η_th_designmodel		76.80	%	Thermal efficieny. From the design model
Electrical power generated	P_el	**W_e**	5.50	MW	Electricity / el. power production. From design model
Thermal power used internally (as steam or hot water)	P_internal_usage	**Q_i**	3.54	MW	Feed Water to ECO, incl. turbine bleed, condensate and heat recovery 16.0%
Thermal power supplied to the heat exchangers on the primary side	P_boiler_primary_side	**Q_he**	12.62	MW	ACC cooling to ambient 64.2%
Directly exported thermal power (as steam or hot water) less the power of the return flow	P_th_export	**Q_de**	0.00	MW	Thermal power not exported from the plant.
BAT- efficiencies calculated using the data above:					
Gross electrical efficiency	η_e	Corresponding BAT parameter ....:	26.20	%	
Gross energy efficiency	η_h	Q_th	84.61	%	

Nominal operating point:

		Values	Unit
Fuel throughput	Enter Value	12.8	ton/h
Net calorific value; NCV	Enter Value	8	MJ/kg

Data from Energos design model / New plant:

Parameter	Design model parameter .....:	Corresponding BAT parameter ....:	Value	Unit	Comment
Gross thermal power	P_th_gross ("innfyrt effekt")	**Q_th**	28.44	MW	Thermal power; gross. Calculated from operation point data.
Net thermal power	P_th_net	**Q_b**	22.33	MW	Thermal power; net; i.e. thermal power produced by / delivered from the boiler. From design model
Thermal efficiency; Energos design mod. output	η_th_designmodel		78.50	%	Thermal efficieny. From the design model
Electrical power generated	P_el	**W_e**	6.30	MW	Electricity / el. power production. From design model
Thermal power used internally (as steam or hot water)	P_internal_usage	**Q_i**	4.02	MW	Feed Water to ECO, incl. turbine bleed, condensate and heat recovery 16.0%
Thermal power supplied to the heat exchangers on the primary side	P_boiler_primary_side	**Q_he**	14.34	MW	ACC cooling to ambient 64.2%
Directly exported thermal power (as steam or hot water) less the power of the return flow	P_th_export	**Q_de**	0.00	MW	Thermal power not exported from the plant.
BAT- efficiencies calculated using the data above:					
Gross electrical efficiency	η_e	Q_th	27.01	%	
Gross energy efficiency	η_h	Q_b	86.68	%	

Nominal operating point:

		Values	Unit
Fuel throughput	Enter Value	12.8	ton/h
Net calorific value; NCV	Enter Value	12	MJ/kg

Data from Energos design model / New plant:

Parameter	Design model parameter .....:	Corresponding BAT parameter ....:	Value	Unit	Comment
Gross thermal power	P_th_gross ("innfyrt effekt")	**Q_th**	42.67	MW	Thermal power; gross. Calculated from operation point data.
Net thermal power	P_th_net	**Q_b**	35.75	MW	Thermal power; net; i.e. thermal power produced by / delivered from the boiler. From design model
Thermal efficiency; Energos design mod. output	η_th_designmodel		83.80	%	Thermal efficieny. From the design model
Electrical power generated	P_el	**W_e**	10.00	MW	Electricity / el. power production. From design model
Thermal power used internally (as steam or hot water)	P_internal_usage	**Q_i**	6.44	MW	Feed Water to ECO, incl. turbine bleed, condensate and heat recovery 16.0%
Thermal power supplied to the heat exchangers on the primary side	P_boiler_primary_side	**Q_he**	22.95	MW	ACC cooling to ambient 64.2%
Directly exported thermal power (as steam or hot water) less the power of the return flow	P_th_export	**Q_de**	0.00	MW	Thermal power not exported from the plant.
BAT- efficiencies calculated using the data above:					
Gross electrical efficiency	η_e	n_e = (W_e/Q_th) * (Q_b/(Q_b - Q_i))	28.58	%	
Gross energy efficiency	η_h	n_h = (W_e + Q_he + Q_de + Q_i)/Q_th	92.32	%	

Nominal operating point:

		Values	Unit	
Fuel throughput	Enter Value	10.0	ton/h	
Net calorific value; NCV	Enter Value	11.4	MJ/kg	(Calculated from average values of steam producton / thermal power data from Hafslund during 2010, 2011, 2012, 2013 and 2014)

Data for reference plant / Hafslund:

Parameter	Energos parameter .....:	Corresponding BAT parameter ....:	Value	Unit	Comment
Gross thermal power	P_th_gross ("innfyrt effekt")	**Q_th**	31.67	MW	Thermal power; gross. NCV = 11.4 MJ/kg. Calculated from operatyion point data.
Net thermal power	P_th_net	**Q_b**	26.60	MW	Thermal power; net. Based on measured values.
Thermal efficiency; Energos design mod. output	η_th_Energos		84.00	%	Thermal efficieny used for Hafslund
Electrical power generated	P_el	**W_e**	0.00	MW	From design model
Thermal power used internally (as steam or hot water)	P_internal_usage	**Q_i**	0.07	MW	Enter most likely value (i.e. account for steam blowing (oxidizer), feed water tank heating and blow down. Assumed average values: Steam blowing 0.1 MW, feed water tank heating: 0.5 MW, boiler blow down: 0.07 MW (from Sankey diagram / Design model).
Thermal power supplied to the heat exchangers on the primary side	P_boiler_primary_side	**Q_he**	0.00	MW	No thermal energy export except for direct export of steam energy.
Directly exported thermal power (as steam or hot water) less the power of the return flow	P_th_export	**Q_de**	26.60	MW	Export of steam to Borregaard; based on "innfyrt effekt" and "efficiency".
BAT- efficiencies calculated using the data above:					
Gross electrical efficiency	η_e	0	n.a.	%	Not valid for Hafslund; i.e. Hafslund does not produce electrical energy.
Gross energy efficiency	η_h	0	84.22	%	NOTE: Investigate the meaning of term Q_he

Energy efficiency levels associated with the best available techniques (BAT-AELLs):

Energy efficiency levels ....:			Range	Unit	*... for a:*
New plant			Range	Unit	
Gross electrical efficiency	$\eta_e = (W_e/Q_{th}) * (Q_b/(Q_b - Q_i))$	n_e = (W_e/Q_th) * (Q_b/(Q_b - Q_i))	25-35	%	Incineration plant that produces electricity using a condensing turbine
Gross energy efficiency	$\eta_h = (W_e + Q_{he} + Q_{de} + Q_i)/Q_{th}$	n_h = (W_e + Q_he + Q_de + Q_i)/Q_th	72-91	%	Incineration plant that produces only heat OR produces electricity using a back- pressure turbine and heat with the steam leaving the turbine
Existing plant			Range	Unit	
Gross electrical efficiency	$\eta_e = (W_e/Q_{th}) * (Q_b/(Q_b - Q_i))$	n_e = (W_e/Q_th) * (Q_b/(Q_b - Q_i))	20-35	%	Incineration plant that produces electricity using a condensing turbine
Gross energy efficiency	$\eta_h = (W_e + Q_{he} + Q_{de} + Q_i)/Q_{th}$	n_h = (W_e + Q_he + Q_de + Q_i)/Q_th	72-91	%	Incineration plant that produces only heat OR produces electricity using a back- pressure turbine and heat with the steam leaving the turbine

Key variables:

	Symbol	Symbol cont.	Unit
Electrical power generated	W_e	W_e	MW
Thermal power supplied to the heat exchangers on the primary side	Q_{he}	Q_he	MW
Directly exported thermal power (as steam or hot water) less the power of the return flow	Q_{de}	Q_de	MW
Thermal power produced by the boiler	Q_b	Q_b	MW
Thermal power (as steam or hot water) that is used internally	Q_i	Q_i	MW
Thermal input to the thermal treatment unit (Energos: Furnace) expressed as the lower heating value ("innfyrt effekt")	Q_{th}	Q_th	MW

Appendix B R1 Calculation

R1 efficiency for Energos 2-Line Facility

<u>Reference documentation:</u>
EU Waste Framework Directive 2008/98/EC (WID)
EPA Publication 1559: EPA Guideline 1559. Energy from Waste

A. Definition of R1 efficiency:

For a plant to be considered a genuine energy recovery facility, R1 should be equal to or greater than 0.65

R1 definition

$$R1 = \frac{E_p - (E_f + E_i)}{0.97 \times (E_w + E_f)}$$

Symbol	Description	Unit	Comment
E_p	Annual energy produced as heat or electricity. Calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (GJ/year)	GJ/year	Total enery produced by the plant
E_f	Annual energy input to the system from fuels contributing to the production of steam (GJ/year)	GJ/year	Ref. EU BAT definition for : Energy used continuosuly (excluding start-up)
E_w	Annual energy contained in the treated waste calculated using the net calorific value of the waste (GJ/year)	GJ/year	
E_i	Annual energy imported excluding E_w and E_f (GJ/year)	GJ/year	
0.97	**0.97**: Factor account for energy losses due to bottom ash and radiation	GJ/year	

B. Energos plant design characteristics:

		Value	Unit		
Fuel throughput:		12.8	ton/h		2 lines @ 6.4 ton/h (corresponding to 99 840 ton/year @ 7 800 h/year)
Net calorific value / NCV - cases:	NCV / Nominal operating point	12.0	MJ/kg	**Scenario 1**	NCV @ nominal operating point
	NCV / Net calorific value of MSW from HRL report	7.2	MJ/kg	**Scenario 2A**	NCV in HRL report
		7.2	MJ/kg	**Scenario 2B**	NCV in HRL report; 80% of the nominal annual throughput; i.e. 0.80 x 12.8 ton/h = 10.24 ton/h
	NCV / Minimum Net calorific value in Energos Firing diagram	8.0	MJ/kg	**Scenario 3**	Minimum NCV in firing diagram
Operating time	Operating hours per year	7800	h/year		
Consumption of aux. burner fuel	(Part of E_f; see above)	2.4	GWh/y		Average annual consumption of energy related to auxiliary burner usage.
<u>Other parameters:</u>					
"hours_to_second"	Number of seconds per hour	3600	s/h		
"ton_to_kg"	Number of kg per ton	1000	kg/ton		
Scaling factor for $E_{p,electricity}$	E_p - scaling factor for electrical production	2.6	<no unit>		
Scaling factor for $E_{p,heat}$	E_p - scaling factor for heat produced	1.1	<no unit>		
Internal thermal heat usage	Recirculated Flue Gas	2.04	MW	4.78%	
	Feedwater (product of condensate, furnace cooling and turbine bleed recovery)	5.62	MW	13.17%	
	Thermal Recovery	**7.66**	**MW**	**18%**	

C. R1 calculations for Energos plant:

R1 Calculation for Case_01: NCV = 12 MJ/kg

Parameter	Description / comment	Value	Unit	Value	Unit	Comment / unit conversions)
W_e	Electrical power generated (P_th_gross)	10.0	MW	280,800	GJ/year	MW -> MW*0.001 i.e. GW = GJ/s **_and_** GW = GJ/s -> (GJ/s) x (# h/year) x (3600 s/h) = GJ/year
Q_b	Net thermal power; two lines	35.8	MW			
Q_{th}	*18% of net thermal input Q_b.*	6.4	MW	180,948	GJ/year	MW -> MW*0.001 i.e. GW = GJ/s **_and_** GW = GJ/s -> (GJ/s) x (# h/year) x (3600 s/h) = GJ/year
$E_{p,electrical}$	Scaling factor for electricity is applied. Factor for electricity is 2.6			730,080	GJ/year	
	Scaling factor for thermal heat is applied. Factor for thermal heat is 1.1.			199,042	GJ/year	
E_p	Annual energy produced as heat or electricity (electric & heat scalings applied)			929,122	GJ/year	
E_f	No other fuel contributing to production of steam (other than the solid waste (fuel))			2.4	GJ/year	
E_w	Fuel net calorific value; 1 year operating time	12.0	MJ/kg	1,198,080	GJ/year	MJ/kg -> (GJ/kg) **_and_** (GJ/kg) -> (GJ/kg) x (# ton/h) x (1000 kg/ton) x (# h/year) = GJ/year
E_i	No other energy imported to plant (other than energy of solid waste (fuel) stream)	0.0	MW	0	GJ/year	
R1	**R1 = (E_p - (E_f + E_i))/(0.97*(E_w + E_f))**	**0.80**	**1**			**Scenario 1**

R1 Calculation for Case_02A: NCV = 7.2 MJ/kg

Parameter	Description / comment	Value	Unit	Value	Unit	
W_e	Electrical power generated (P_th_gross). Factor for electricity is 2.6; see above	5.5	MW	154,440	GJ/year	
Q_b	Net thermal power; two lines	19.6				
Q_{th}	*18% of net thermal input Q_b.*	3.5	MW	99,066	GJ/year	
$E_{p,electrical}$	Scaling factor for electricity is applied. Factor for electricity is 2.6			401,544	GJ/year	
$E_{p\text{-}heat}$	Scaling factor for thermal heat is applied. Factor for thermal heat is 1.1.			108,973	GJ/year	
E_p	Annual energy produced as heat or electricity (electric & heat scalings applied)			510,517	GJ/year	
E_f	No other fuel contributing to production of steam (other than the solid waste (fuel))			2.4	GJ/year	
E_w	Fuel net calorific value; 1 year operating time	7.2	MJ/kg	718,848	GJ/year	
E_i	No other energy imported to plant (other than energy of solid waste (fuel) stream)	0.0	MW	0	GJ/year	
R1	**R1 = (E_p - (E_f + E_i))/(0.97*(E_w + E_f))**	**0.73**	**1**			**Scenario 2A**

R1 Calculation for Case_02B: NCV = 7.2 MJ/kg. Throughput reduced to 80% of nominal production.

Parameter	Description / comment	Value	Unit	Value	Unit	
W_e	Electrical power generated (P_th_gross). Factor for electricity is 2.6; see above	4.2	MW	117,936	GJ/year	
Q_b	Net thermal power; two lines	15.0				
Q_{th}	*18% of net thermal input Q_b.*	2.7	MW	75,816	GJ/year	
$E_{p,electrical}$	Scaling factor for electricity is applied. Factor for electricity is 2.6			306,634	GJ/year	
$E_{p\text{-}heat}$	Scaling factor for thermal heat is applied. Factor for thermal heat is 1.1.			83,398	GJ/year	
E_p	Annual energy produced as heat or electricity (electric & heat scalings applied)			390,031	GJ/year	
E_f	No other fuel contributing to production of steam (other than the solid waste (fuel))			2.4	GJ/year	
E_w	Fuel net calorific value; 1 year operating time	7.2	MJ/kg	**575,078**	GJ/year	
E_i	No other energy imported to plant (other than energy of solid waste (fuel) stream)	0.0	MW	0	GJ/year	
R1	**R1 = (E_p - (E_f + E_i))/(0.97*(E_w + E_f))**	**0.70**	**1**			**Scenario 2B**

R1 Calculation for Case_03: NCV = 8.0 MJ/kg

Parameter	Description / comment	Value	Unit	Value	Unit	
W_e	Electrical power generated (P_th_gross). Factor for electricity is 2.6; see above	6.3	MW	176,904	GJ/year	
Q_b	Net thermal power; two lines	22.4				
Q_{th}	*18% of net thermal input Q_b.*	4.0	MW	113,219	GJ/year	
$E_{p,electrical}$	Scaling factor for electricity is applied. Factor for electricity is 2.6			459,950	GJ/year	
$E_{p\text{-}heat}$	Scaling factor for thermal heat is applied. Factor for thermal heat is 1.1.			124,540	GJ/year	
E_p	Annual energy produced as heat or electricity (electric & heat scalings applied)			584,491	GJ/year	
E_f	No other fuel contributing to production of steam (other than the solid waste (fuel))	0.0	MW	2.4	GJ/year	
E_w	Fuel net calorific value; 1 year operating time	8.0	MJ/kg	798,720	GJ/year	
E_i	No other energy imported to plant (other than energy of solid waste (fuel) stream)	0.0	MW	0	GJ/year	
R1	**R1 = (E_p - (E_f + E_i))/(0.97*(E_w + E_f))**	**0.75**	**1**			**Scenario 3**

Appendix C Heating Degree Days

Descriptioı Celsius-based 20-year-average (2000 to 2019) heating degree days with a base temperature of 18 C
Source: www.degreedays.net
Accuracy: Estimates were made to account for missing data: the "% Estimated" column shows how much each figure was affected (0% is best, 100% is worst)
Station: Melbourne Airport, AU (144.83E,37.67S)
Station ID: YMML

	HDD 18	% Estimated
Jan	40	0.1
Feb	35	0.2
Mar	60	0.09
Apr	110	0.09
May	182	0.08
Jun	241	0.1
Jul	264	0.1
Aug	248	0.4
Sep	187	0.09
Oct	149	0.1
Nov	96	0.08
Dec	68	0.08
Total	1680	0.1

Appendix D Waste Audit (HRL, 2020) – Commercial in Confidence