FICHTNER
Consulting Engineers Limited

Viridor Dunbar Waste Services Ltd

Dunbar Energy Recovery Facility

TTGW Efficiencies for increased thermal capacity

1 Introduction

Fichtner Consulting Engineers Ltd (Fichtner) has been engaged by Viridor Dunbar Waste Services Ltd (here in referred to as Viridor) to produce a technical note which considers the efficiency of the ERF in relation to SEPA's Thermal Treatment of Waste Guidelines (TTWG) from the proposed increase in capacity of the ERF.

This technical note draws upon the information presented in the Heat and Power Plan, submitted to SEPA in February 2022.

2 Background

2.1 The Facility

Viridor engaged a joint venture comprising Babcock and Wilcox Volund (BWV) and Interserve Construction Limited (Interserve), to construct the Dunbar Energy Recovery Facility (ERF, the Facility) in Dunbar, East Lothian, Scotland. Commissioning of the Facility was completed in 28 June 2019, and commercial operation of the Facility commenced from this date.

The Facility is designed with a nominal design capacity of 300,435 tonnes per annum (tpa) of waste, assuming 7,800 hours operation per annum with a net calorific value (NCV) of 10 MJ/kg. In 2021, 307,237 tonnes of residual waste was processed in the Facility. The PPC Permit permits the Facility to process up to 325,000 tonnes of waste per year.

Allowing for variations in the net calorific value (NCV) of the waste, availability and the maximum hourly tonnage, the maximum annual capacity of the Facility could be up to 390,000 tpa. The Facility is capable of generating up to 36 MW of electricity.

Viridor is proposing to apply to SEPA for a variation to the PPC permit to increase the maximum capacity of the Facility to 390,000 tpa.

2.2 Energy consumption and export design parameters

The relevant energy consumption and export design parameters for the Facility for the nominal design case, in the Heat and Power Plan, and increased capacity case are presented in Table 1.

Table 1: Facility Energy Consumption and Export

Design Parameter	Unit	Nominal Design Value	Fuel thermal capacity increase
Operational hours	hours	7,800	8,760
Availability	hours/hours	89.04%	100%
Annual throughput (nominal design capacity)	tonnes/year	300,435	390,000
Average GCV	MJ/kg	11.6	10.42
Gross thermal input - fuel	MWh/year	966,400	1,129,050
	GJ	3,479,040	4,064,580
	MW_{th}	123.90	128.89
Gross electrical generation (fully condensing)	MWh/year	262,860	307,108
	(GJ)	946,296	1,105,589
	MW	33.70	35.06
Parasitic load (including electrical and support fuel)	MWh/year	22,138	24,265
	GJ	79,696	87,355
	MW	2.77	2.77
Heat export capacity[1] from the Facility	MWh/year	132,600	148,920
	GJ	477,360	536,112
	MW_{th}	17.00	17.00
Z factor	MW/MW	6.60	6.60
Net electrical export (CHP mode at heat export capacity of 17 MW_{th})	MWh/year	221,163	260,279
	GJ	796,187	937,005
	MW	28.35	29.71
[1] Calculated in accordance with system boundaries specified in Annex 3 of SEPA's TTWG 2014.			

3 Thermal Treatment of Waste Guidelines

The Thermal Treatment of Waste Guidelines (TTWGs) requires that within a period of seven years from cessation of commissioning, the Facility should recover enough energy to be considered high efficiency by SEPA. In order to demonstrate this, the overall energy efficiency of the plant and the Quality Index (QI) must be calculated and compared with relevant the thresholds in the TTWGs. For a waste incineration facilities processing more than 70,000 tpa relevant thresholds are as follows:

- QI value ≥ 93; or
- indicative overall efficiency ≥ 35%, in order to demonstrate best practice for thermal treatment of waste facilities.

The TTWGs state that the QI value should be calculated in accordance with the relevant Combined Heat and Power Quality Assurance (CHPQA) method for the relevant type of thermal treatment facility and fuel type. The CHPQA states that the QI for CHP schemes is a function of the heat efficiency and power efficiency, and is calculated in accordance with the following formula.

$QI = X \times \eta_{power} + Y \times \eta_{heat}$

where:

η_{power} = power efficiency;

η_{heat} = heat efficiency;

X and Y are parameters which are defined for each technology and vary depending on the size of the plant.

An assessment of the nominal design against the requirements of the TTWGs was undertaken and used in the Heat and Power Plan. The assessment considered the following heat export scenarios:

1. no heat export;
2. heat load required for QI value of 93;
3. average network heat load;
4. heat load required for indicative overall efficiency of 35%; and
5. maximum heat export capacity.

The assessment has been updated to take into consideration the proposed operation at the higher thermal capacity associated with the proposed increase in capacity. The following tables compares TTWGs efficiency parameters for:

1. Plant nominal design, used for the latest heat plan 2022
2. Fuel thermal capacity increase

Table 2: Heat and Power Export

Load Case	Annual Heat Export at Turbine (MW)	Gross Power Generation (MW)	Net Power Exported (MW)	Z Ratio[1]
Nominal Design case				
1. No heat export	0.0	33.7	30.9	N/A
2. Average heat load required for QI value of 93	0.60	33.6	30.8	6.60
3. Average network heat load	2.21	33.4	30.6	6.60
4. Heat load required for indicative overall efficiency of 35%	4.65	33.0	30.2	6.60
5. Maximum heat export capacity	17.00	31.1	28.4	6.60
Fuel thermal capacity increase				
1. No heat export	0.0	35.1	32.3	N/A
2. Average heat load required for QI value of 93	0.50	35.0	32.0	6.60
3. Average network heat load	2.21	34.7	31.6	6.60
4. Heat load required for indicative overall efficiency of 35%	4.80	34.3	31.6	6.60
5. Maximum heat export capacity	17.00	32.5	29.7	6.60

[1] The Z ratio, which is the ratio of reduction in power export for a given increase in heat export, can be used to calculate the effect of variations in heat export on the electrical output of the facility. A value of 6.6 was obtained following CHPQA Guidance Note 28, assuming steam extraction at a pressure of 2.4 bar(a), which is considered sufficient to meet the requirements of the consumers identified in this Heat and Power Plan.

Table 3: QI and indicative overall efficiency

Load Case	Gross power efficiency (%), GCV	Heat efficiency (%), GCV	Overall efficiency (%), GCV	CHPQA QI
Nominal Design case				
1. No heat export	26.4%	0.0%	26.4%	92.5
2. Average heat load required for QI value of 93	26.1%	1.5%	27.6%	93.1
3. Average network heat load	25.1%	5.5%	30.7%	94.7
4. Heat load required for indicative overall efficiency of 35%	23.9%	11.2%	35.0%	96.9
5. Maximum heat export capacity	18.6%	33.8%	52.5%	105.8
Fuel thermal capacity increase				
1. No heat export	26.5%	0.0%	26.5%	92.7
2. Average heat load required for QI value of 93	26.2%	1.2%	27.4%	93.2
3. Average network heat load	25.2%	5.3%	30.6%	94.8
4. Heat load required for indicative overall efficiency of 35%	23.9%	11.1%	35.0%	97.0
5. Maximum heat export capacity	18.9%	32.9%	51.8%	105.6

As demonstrated in Table 3, the Facility will exceed the QI threshold in all heat export cases, thereby exceeding SEPA's energy recovery targets for both nominal design case and fuel thermal capacity increase. Therefore, it can be concluded that if the Facility is operated on fuel capacity increase mode, it will comply with the requirements of the TTWGs when exporting 2.21 MWth. Subject to ensuring that all available heat export opportunities are appropriately considered and investigated, if the ERF was operated at the higher thermal capacity it would comply with the requirements of the TTWGs.

4 Waste Incineration BREF

The Industrial Emissions Directive (IED), which was adopted on 7 January 2013, is the key European Directive which covers almost all regulation of industrial processes in the EU. Within the IED, the requirements of the relevant sector BREF become binding as BAT Conclusions. The WI BREF[2] was published in 2019. This includes, as section 5, the BAT Conclusions.

BAT 20 states that the BAT-Associated Energy Efficiency Levels (referred to as BAT-AEELs) for Gross Electrical Efficiency for a an existing waste incineration plant is 20-35%. The Gross Electrical Efficiency of the Facility has been calculated in accordance with the requirements of BAT 20, refer to Table 4. The methodology for calculating efficiency is different between the TTWG and the Draft WI BATC; therefore, the reported efficiencies are different between Table 3 and Table 4.

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

Table 4: BAT 20- Gross electrical efficiency

Load Case	Annual Heat Export at Turbine (MW)	Gross electrical efficiency (%), NCV	BAT-AEEL (%) Gross electrical efficiency (NCV) New plant
Nominal Design case			
1. No heat export	0.0	31.50%	20-35
3. Average network heat load	2.21	31.18%	20-35
5. Maximum heat export capacity	17.0	29.09%	20-35
Fuel thermal capacity increase			
1. No heat export	0.0	31.50%	20-35
3. Average network heat load	2.21	31.20%	20-35
5. Maximum heat export capacity	17.0	29.18%	20-35

As shown in Table 4, the gross electrical efficiency (NCV) of the Facility for each heat load case and for both nominal design case and fuel thermal capacity increase cases is in accordance with the relevant BAT-AEEL efficiency ranges required by BAT 20.

5 Conclusions

This technical note considers the efficiency of the ERF in relation to SEPA's Thermal Treatment of Waste Guidelines (TTWG) from the proposed increase in capacity of the ERF.

As demonstrated in this technical note, the Facility will exceed the QI threshold in all heat export cases, thereby exceeding SEPA's TTWGs energy recovery targets for both nominal design case and fuel thermal capacity increase. Therefore, it can be concluded that if the Facility is operated on fuel capacity increase mode, it will comply with the requirements of the TTWGs when exporting 2.21 MW_{th}. Subject to ensuring that all available heat export opportunities are appropriately considered and investigated, if the ERF was operated at the higher thermal capacity it would comply with the requirements of the TTWGs.

The gross electrical efficiency (based on NCV of fuel) of the Facility for each heat load case and for both nominal design case and fuel thermal capacity increase cases is in accordance with the relevant BAT-AEEL efficiency ranges required by BAT 20.

We trust that the information contained within this note is acceptable to you.

Yours sincerely

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