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THE NEXT GENERATION NSW PTY LTD
PROJECT DEFINITION BRIEF

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1. INTRODUCTION

The purpose of this document is to define the key design parameters which are to be used in the documents for the new Waste-to-Energy plant owned by The Next Generation (hereafter TNG).

The Next Generation NSW Pty Ltd, a stand-alone company, has been formed by Dial a Dump Industries and Genesis Xero Waste Facility to develop a low carbon electricity generating plant that will be fuelled by waste derived fuels.

The project can be divided into the following primary systems, which will be described below in this order:

- Delivery, tipping and feeding
- Furnace/boiler
- Flue gas treatment (APC)
- Turbine/Condensers
- Ancillary equipment
- Control and monitoring system
- Electrical systems
- Civil works and layout
- Operation

2. KEY FACTS OF THE PLANT

2.1 General

The proposed Development involves the construction and operation of an Electricity Generation Plant (the proposed Facility). The proposed Facility will generate electrical power from unsalvageable and uneconomic residue waste which would otherwise be land filled. It will be a 'green' electricity generation facility, and NSW's first (and Australia's largest) Energy from Waste Facility. The proposed Facility will be compliant with NSW Emissions Requirements and in line with the NSW EfW Policy.

The design fuel has been calculated based on the expected waste fractions and has a Net Calorific Value (NCV) of 12.3 MJ/kg (equivalent to 12,300 kJ/kg). Based on the design fuel NCV the Facility will have capacity to treat 1,105,000 tpa (34.53 t/h, 4 streams, 8,000 h) of fuel.

Composition and NCV will vary for each individual fuel fraction. The Facility is designed to operate efficiently within an NCV range to maximise operational flexibility and high efficiency. The combustion diagram is based on an NCV range from minimum 8.5 MJ/kg to maximum 16.5 MJ/kg.

To maintain the planned generating capacity with the proposed NCV range the fuel requirement can vary from approximately 810,000 tpa (25.31 t/h, 4 streams, 8,000 h) to 1,350,000 tpa (42.19 t/h, 4 streams, 8,000 h).

The proposed Facility has a capacity to generate net 137.3 Mega Watts of electrical energy (MWe). The Fuel will be sourced from the neighbouring Genesis MPC, which will enter the proposed Facility via conveyor and the private under pass culvert, as well as from third parties via the public road system.

Construction and operation will take place in two phases, as follows:

- **Phase 1** will include the complete construction of the Tipping Hall and Waste Bunker and combustion Lines 1 and 2 comprising of two independent Boilers, Flue Gas Treatment (FGT) systems, Stack as well as one Turbine and one Air Cooled Condenser (ACC) and all other auxiliary equipment.
- **Phase 2** will comprise the installation of combustion lines 3 and 4 with again two independent Boilers, Flue Gas Treatment (FGT) systems, Stack as well as one Turbine and one Air Cooled Condenser (ACC) and all other auxiliary equipment.

This two Phase approach has been adopted after receiving feedback from the various government agencies. Lines 3 and 4 will be constructed once the Department of Planning and Environment is satisfied that the required amount of eligible residual waste fuel is available to the TNG facility.

The technology proposed for the Facility is a moving grate system with water and air cooled grate bars. This system offers the most flexible and cost effective solution for the fuel mix being considered. The proposed turbine exhaust cooling system for the Facility is an Air Cooled Condenser (ACC). ACCs are considered to be the preferred option as they not require water and do not generate an effluent discharge. Furthermore there is no visual plume impact through the ACC, as there would be for an evaporative cooling tower.

The flue gas treatment system is designed to achieve the emission limits as required by the Industrial Emissions Directive. The flue gas treatment system will consist of a Selective Non-Catalytic Reduction (SNCR) of NOx, activated carbon injection, dry lime scrubbing and fabric filters.

Without any changes to the main process, the Facility will be configured so that it will be possible to export heat to nearby consumers.

Operation of the Facility will generate three types of solid waste by-products:

- bottom ash;
- boiler ash; and
- flue gas treatment residues (APC residues).

The facility will produce no excess effluent during operation.

2.2 Fuels

A moving grate system offers TNG the greatest flexibility in the range of waste fuels that may be processed at the Facility. The following fuel types have been identified as the main sources of fuel for the Facility;

- Chute Residual Waste (CRW) from the Genesis MPC;
- Commercial and Industrial (C&I);
- Construction and Demolition(C&D);
- Floc waste from car and metal shredding;
- Paper pulp;
- Glass Recovery;
- Garden Organics (GO);
- Alternative Waste Treatment (AWT); and
- Material Recovery Facility waste (MRF waste) residual

As the NCV of waste fuels vary depending on type, the facility will operate within a range of NCVs to support operational flexibility.

2.2.1 Design Fuel

Based upon the fuel types listed above, a design fuel composition has been developed. This is based on typical values for each of the proposed fuels and an estimated fuel mix. Input fuel will always be mixed as part of the normal operational process to produce as homogenous an input as possible.

	Units	CRW	C&D	C&I	Floc waste	Paper Pulp	Glass Recovery	GO Residual	AWT Residual	MRF Residual	Design Fuel Mix
Fuel Mix	%	**23.37%**	**28.69%**	**16.84%**	**14.43%**	**4.81%**	**1.72%**	**2.06%**	**6.87%**	**1.20%**	100
Compositional Analysis											
Paper/Card	%	4.30	14.05	22.44	3.93	78.40	62.00	30.00	21.05	38.54	16.75
Plastic Film	%	10.20	6.37	10.90	10.90	21.60	3.80	2.50	20.00	26.94	10.47
Dense Plastic	%	0.00	6.37	10.90	10.90	0.00	34.20	2.50	21.05	0.00	7.32
Textiles	%	5.30	0.00	12.89	0.18	0.00	0.00	0.00	10.53	0.00	4.16
Glass	%	0.00	0.00	1.81	0.00	0.00	0.00	4.00	0.00	8.50	0.49
Vegetation	%	8.30	0.00	1.70	0.00	0.00	0.00	35.00	3.16	0.00	3.16
Other combustibles	%	0.00	0.00	0.00	70.40	0.00	0.00	0.00	0.00	0.00	10.16
Metal	%	1.80	1.12	0.37	0.00	0.00	0.00	5.00	0.00	7.59	1.00
Fines	%	0.00	0.94	0.18	0.00	0.00	0.00	0.00	11.58	0.00	1.10
Wood	%	58.20	43.90	21.53	0.85	0.00	0.00	0.00	4.21	0.00	30.24
Combustibles	%	0.00	0.00	2.84	2.84	0.00	0.00	0.00	2.11	0.00	1.03
Non-Combustibles	%	4.50	0.00	0.00	0.00	0.00	0.00	21.00	1.05	0.03	1.56
Hazardous	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gyprock	%	2.40	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.42
Other	%	5.00	20.75	14.44	0.00	0.00	0.00	0.00	5.26	18.40	10.14
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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	Units	CRW	C&D	C&I	Floc waste	Paper Pulp	Glass Recovery	GO Residual	AWT Residual	MRF Residual	Design Fuel Mix
Chemical Analysis											
Carbon (C)	%	31.34	27.02	35.00	29.65	42.90	41.01	16.98	38.96	32.63	31.44
Hydrogen (H)	%	4.21	3.51	4.29	3.80	5.84	4.63	2.12	4.98	4.84	4.07
Nitrogen (N)	%	0.34	0.06	0.59	0.18	0.00	0.00	0.12	0.47	0.00	0.26
Sulphur(S)	%	0.42	1.04	0.05	0.11	0.12	0.09	0.06	0.04	0.06	0.43
Chloride (Cl)	%	0.09	0.66	1.15	1.78	0.19	3.27	0.26	2.18	0.23	0.88
Oxygen (O)	%	21.11	21.50	17.50	7.04	24.64	26.69	12.58	13.77	12.11	18.06
Water (H2O)	%	28.47	21.51	21.68	22.62	22.58	20.81	36.20	18.40	15.20	23.38
Ash	%	14.03	24.70	19.74	34.82	3.73	3.50	31.68	21.20	34.93	21.49
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
NCV	**MJ/kg**	11.95	9.97	13.84	12.59	17.22	15.24	5.67	16.33	14.23	**12.30**

Table 1 Proposed design fuel analysis, as received basis

The analysis above defines the design fuel of the Facility. Suitable ranges for various key components such as the moisture, ash and energy content of the fuel are discussed in section 2.2.2. Based on the above design compositions, NCV of the nominal design fuel mix is calculated to be 12.30 MJ/kg.

2.2.2 Fuel Range

Despite the identification of a design fuel mix and the homogenisation process of mixing fuels prior to incineration the facility operates within a fuel range to allow for operational flexibility.

The minimum and maximum fuel ranges as basis for calculation and design of the plant are shown in Table 2 . Within this range the facility will still operate efficiently.

		Minimum	Maximum
Nitrogen(N)		0.19%	0.34%
Sulphur(S)		0.31%	0.57%
Chloride (Cl)		0.64%	0.96%
Ash		13%	26%
Water(H_2O)		14%	34%
NCV	MJ/kg	8.5	16.5

Table 2 Fuel range

2.3 Special waste fractions and contaminants

2.3.1 Chlorine

In view of the APC design the chlorine content of the waste is relevant. The main contribution to the chlorine content of the waste is PVC. PVC (C_2H_3Cl) itself contains approx. 57% of chlorine. In municipal waste typically approximately 50 % of the chlorine comes from PVC, in C&I waste the contribution of PVC to the overall chlorine content is expected to be even higher.

In the EU regulation the following is stated: "*If **hazardous waste** with a content of more than 1 % of halogenated organic substances, ...*" . We are aware that the EFW policy from NSW only states: "*If **a waste** has a content of more than 1% of halogenated organic substances, ..*". Nevertheless PVC is **not** considered a hazardous material.

During combustion PVC is fully decomposed to CO_2, HCl and water vapour. The HCl will be eliminated by the Air Pollution Control (APC) system which is designed, controlled and operated to capture such substances even when occurring as a spike. The chosen APC technology for this facility is standard in modern WTE plants with comparable feedstock and with continuously very low emissions.

The waste composition of the Facility is well within the range of other facilities operating in Europe. Many facilities have average chlorine concentrations of above 1% (some even 1.7%) and all categorised as facilities with a necessary furnace temperature of 850°C according to EU regulation.

The effect of waste mixing

The fuel of TNG has some fractions containing PVC and their chlorine content will be slightly above 1%, nevertheless the waste in total and as an average will not contain more than 1% chlorine. Main reason for this is the extensive mixing of waste before feeding it to the combustion process.

The mixing and homogenisation of the different waste streams is a very important aspect of the operation of a waste-to-energy plant and therefore it is given a very high importance. When the waste is tipped in to the bunker it has to be picked up by the crane grab so to keep the delivery area free and allow further waste deliveries. During times with low delivery it is the duty of the crane driver (or in the case of an automatic crane of the automation system) to thoroughly mix the waste by picking it up and dropping it in a different place of the storage area in the bunker. This ensures a thorough mixing of the different waste fractions. To be fed to the combustion system the waste is again picked up by the crane grab.

As a result any waste is picked and offloaded at least 2 to 3 times before being fed into the combustion process and therefore is well mixed. As a conclusion it is reasonable to assume that the contaminant concentrations of the different waste streams will be well homogenised when being fed to the combustion process.

2.3.2 Waste wood

Treated wood waste (TWW) represents a large proportion of the arising waste wood. TWW can be defined as wood that has been treated with at least one of the following:

- Copper, Chromium, Arsenic (CCA)
- Copper Organics
- Creosote
- Light Organic Solvent Preservatives (LOSP)
- Micro-emulsion
- Paint / stain
- Varnish

Several studies are available on the impact of processing TTW in an EfW plant. The most important results are summarized below:

- Thermal treatment is suitable for all types of TWW as there is in any case there is an effective control of the emissions.
- Co-incinerating of impregnated wood along with the basic waste brings an increase of the average arsenic content in the waste, whereas the concentrations of copper and chromium do not differ significantly from the basic waste. The increased arsenic content will primarily end up in the residues from the flue gas cleaning process, and to some extent the concentration in the bottom ash is also increased. It is, however, probable that the concentration of arsenic in leachate will not increase.
- Full-scale tests with co-incineration of impregnated wood, has not shown significant increase of arsenic emissions to air. Air emissions of arsenic (and trace metals in general) are mainly dependent on the APC technology and only to a small degree on the input concentration.

2.3.3 Shredder residue (floc waste/shredder floc)

Processing floc waste in EfW facilities is widespread and a preferred recovery option in Europe. The European End-of-Life Directive requires a reuse and recovery rate for end-of-life vehicles of at least 85% by 1.1.2006 and 95% by 1.1.2015 at the latest. In Germany the recovery rate was 99.1% in 2012 compared to the European average for reuse and recovery of 89% in 2012. Metals contribute approximately 75% to this number, the rest is achieved by recovery of shredder residues. In 2012 45% of the German floc waste went to energy recovery (mainly EfW).

According to the Australian Federal Chamber of Automotive Industries the reuse and recovery rate of end-of-life vehicles in Australia is 75% (data published 2011) which obviously represents the metals.

In Australia the current recycling practice for the end-of-life vehicles is to drain fluids and to dismantle for saleable parts (wheels, batteries, engines, alternators, body panels, etc.). Approximately 65-75% of the rest of the vehicle are ferrous and nonferrous metals.

Macroscopic composition of European floc waste
The following graph shows the average composition of European floc waste.

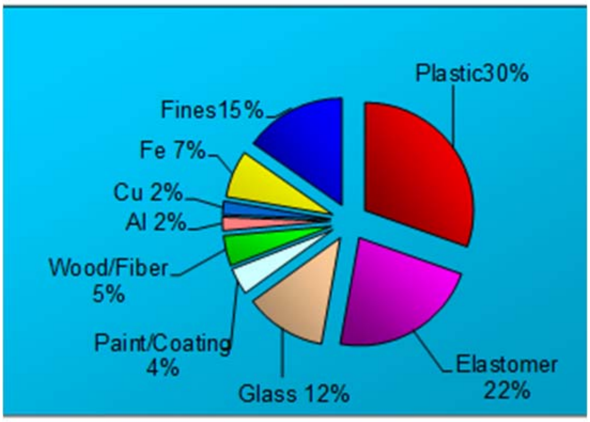

Figure 1 Average Composition of Floc Waste Europe

Macroscopic analysis of Australian floc waste
The average Australian floc waste composition range is shown below.

Material type	Average composition range (% weight)
Plastics	35 – 55%
Rubber	10 – 20%
Metals	6 – 13%
Textiles	7 – 15%
Fines (paint, glass, sand)	10 – 20%

Figure 2 Range of Composition of Floc Waste Australia

Chemical analysis of European floc waste
The composition of floc waste can vary widely depending on the input to the shredder, on the shredder process, the floc removal (wet or dry) as well as the amount of water-spray used for dust abatement. The following table shows the variation of the composition of European floc waste.

Parameter		Average	Range
Moisture	%-Weight	6.7	0.1 - 18
Ash	%-Weight	52.7	25 - 80
NCV	MJ/kg	13	7 - 20
C	%-Weight	32.6	20 - 47
H	%-Weight	4.1	2 - 6
N	%-Weight	0.9	0.2 – 1.8
O	%-Weight	7	3 - 11
S	%-Weight	0.6	0.1 – 1.4
Cl	%-Weight	1.8	0.5 - 3

Table 3 Range and average chemical composition of Floc Waste Europe

As the above table shows, the variation in composition is significant. The main factors contributing to the variation are the water and the ash content. The water content depends on the process (as described above) or the transport conditions (open containers, rain). The measured ash depends on two factors: the sampling and the material fed to the shredder. The feed material often contains sand/dirt or is very rusty. As a result the ash of floc waste always has a very high SiO_2 (quartz sand) and Fe_2O_3 (rust) content. More important however is the sampling. Depending on how the sample is taken (bottom or top of heap, one small or several partial samples, etc.) the result from one single floc waste can vary widely. Further rust and sand (often mixed with rests of liquids) stick to plastic sheets and affect the final result.

Nevertheless one can say that typical European floc waste has a composition similar to the values given as "Average" in Table 3.

Analysis of floc waste to be processes at TNG

To have a clear picture of the expected composition of the floc waste to be processed at TNG (referred to as "floc waste TNG"), 17 samples of nearby floc waste producers where collected. These samples were then individually analysed to determine the macroscopic composition, the chemical components and the calorific value. 1

The following results refer to dry basis (db): The majority (58%) of shredder floc is inert material. There are also substantial amounts of non-polystyrene plastics (21%) and textiles (11%). These three materials make 90% of shredder floc. The rest is rubber/leather (5%), wood waste (3%), metal (1%), polystyrene (1%) and paper/cardboard (0.4%).

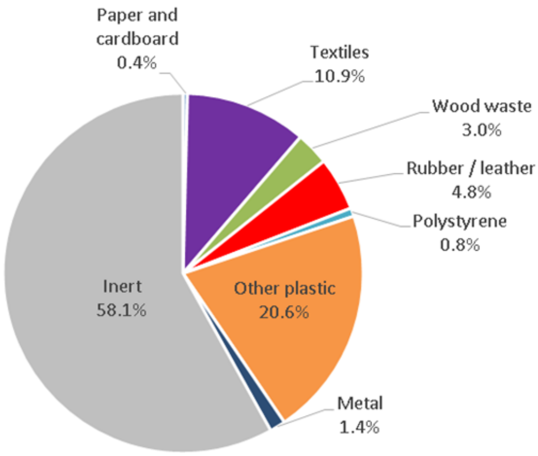

Figure 3 Average macroscopic composition of "floc waste TNG" (dry basis)

The analysed net calorific value (NCV) of the 17 samples varies from 7.8 to 15.7 MJ/kg (as received). The average value is 11.6 MJ.

[1] Reference Audit of potential feedstock for The Next Generation energy-from-waste facility for Dial A Dump Industries, by apc waste consults, dated August 2016

Comparison of "floc waste TNG" with European values

The chemical profile of "floc waste TNG" is summarised in Table 4 and compared with the European values.

	unit	TNG	Europe
Carbon (C)	% (db)	27.0*	32.6
Hydrogen (H)	% (db)	4.8	4.1
Nitrogen (N)	% (db)	1.1	0.9
Sulphur (S)	% (db)	0.3	0.6
Chloride (Cl)	% (db)	0.6	1.8
Bromine (Br)	% (db)	0.01	0.02
Oxygen (O)	% (db)	9.2	7.0
Ash	% (db)	57.0	52.7
Water (H_2O)	% (ar)	13.2	6.7
Total PAH	mg/kg (db)	20	-
Total PCB	mg/kg (db)	14	120
NCV	**MJ/kg**	**11.6**	**13.4**

Table 4 Comparison of "floc waste TNG" and average European values

*Note: Value corrected to allow for uncertainties of the chosen analytical method

In general the chemical profile of the "floc waste TNG" and European values is considered to be comparable. In "floc waste TNG" the ash content is higher and as a result the carbon content and NCV is lower. The chlorine and sulphur contents" are lower, Bromine is comparable. The average PCB value for TNG is substantially lower than in Europe, however the European value is based on only one source in the 1990ies.

A major difference is the higher moisture content in the "floc waste TNG". As described earlier, the water content depends on the shredder technology and the methods used for dust abatement. The higher moisture content also contributes to the lower NCV of "floc waste TNG"

[2]The effects of co-processing floc waste with other waste streams/sources have been evaluated in several European studies. These studies have concluded the following benefits:

- By incinerating 10% shredder residue along with the basic waste, there is an increase of metals in bottom ash when compared to incinerating basic waste only. The primary increase can be assigned to the elevated metal content in the incoming waste, which, to a large degree, can be extracted and recycled. There is a slight increase of trace metal content, even after the sorting process, but actual full scale tests show no indication of increased concentration of trace metals in leachate.
- The concentration of trace metals in flue gas cleaning residues is increased when co-combusting shredder residue. But full scale tests show, that there is no increase of trace metal in the emissions compared to incinerating basic waste only.

[2] Ministry of Environment and Food of Denmark, Environmental Project No. 1654, 2015 "Vurdering af metalholdigt affald til forbrænding" (Abstract in English) http://mst.dk/service/publikationer/publikationsarkiv/2015/mar/vurdering-af-metalholdigt-affald-til-forbraending/

Conclusion
The results of the analysis of 17 samples of floc waste which could be considered to be processed in the TNG facility (referred to as "floc waste TNG") show, that "floc waste TNG" is comparable to European floc waste. The concentration of chlorine and sulphur of "floc waste TNG" is substantially lower. The chlorine content is below 1% and even lower than assumed in the design fuel.

There is a long-term positive experience in processing floc waste in Europe in EfW plants. Having a comparable composition of this waste in Australia supports the utilization in the TNG facility.

<u>References</u>

Figures 1 and 3 Table 3	http://rcswww.urz.tu-dresden.de/~deut/Homepage_IAA_ab_Dez2006/L&D/SS2009/Uebung_Grundl_Abfw09/Stoffliche_und_brennstofftechnische_Charaktng_SLF.pptx
Figure 2	www.sustainabiity.vic.gov.au
Figure 3 and Table 4	Reference Audit of potential feedstock for The Next Generation energy-from-waste facility for Dial A Dump Industries, by apc waste consults, dated August 2016

2.4 Performance

The Facility is designed to have a thermal input of 471.9 MW (117.98 MW for each combustion line) at the design point. The Facility has an assumed net average annual electrical efficiency of 29.1%. The Facility is designed to export 137.3 MWe (29.1% x 471.9 MW). High net electrical efficiency is a priority for TNG and there are a number of options which have been incorporated to maximize the efficiency.

The export voltage will be set to match the requirements of the local high voltage electricity grid.

		Phase 1		Phase 2		Overall facility
Items	Units	Total	Per stream (based on 2 streams)	Total	Per stream (based on 2 streams)	
Gross Power	MW_e	76.0		76.0		152.0
Auxiliary load	MW_e	7.3		7.3		14.6
Power Export	MW_e	68.7		68.7		137.3
Net Efficiency	%	29.1%		29.1%		29.1%
Fuel NCV	MJ/kg	12.30		12.30		12.30
Thermal load	MW_{th}	235.96	117.98	235.96	117.98	471.9
Availability	%	91.3%		91.3%		91.3%
Waste Throughput (based on assumed availability)	t/h	69.06	34.53	69.06	34.53	138.1
	tpa	552,500	276,250	552,500	276,250	1,105,000

Table 5 Overall Facility Performance (LPN, Design point)

2.5 Combustion Diagram

A combustion diagram is used to show the correlation of throughput in tons/hour, the calorific value in kJ/kg and the thermal output in MW for the plant. Combustion diagrams are a useful tool to identify the operational area where all guarantees, environmental and functional requirements are fulfilled.

Continuous operation shall preferably be at loading points near the nominal loading point to have an efficiently operating plant. Continuous operation outside the limits of the diagram is not possible.

Figure 4 shows the combustion diagram for one line of the proposed TNG facility.

As shown in the diagram the nominal design point (Load Point, LPN) is 34.53 tons per hour at a NCV of 12,300 kJ/kg (which is equivalent to 117.98 MW).

The line (LP6) – (LP1) represents 100% thermal load and the plant will mostly be operating along this line, in practice done by operating the boiler on a fixed steam flow rate set point (MCR: 144.7 t/h steam flow at boiler outlet). This implies that the amount of waste is reduced if the calorific value exceeds 12,300 kJ/kg and similarly increased if the calorific value decreases.

The diagram allows a range for the calorific value between 8,500 kJ/kg (line between (LP2) and (LP3)) and 16,500 kJ/kg (line between (LP5) and (LP6)). This allows variations between +34% and -31% of the nominal value of 12,300 kJ/kg.

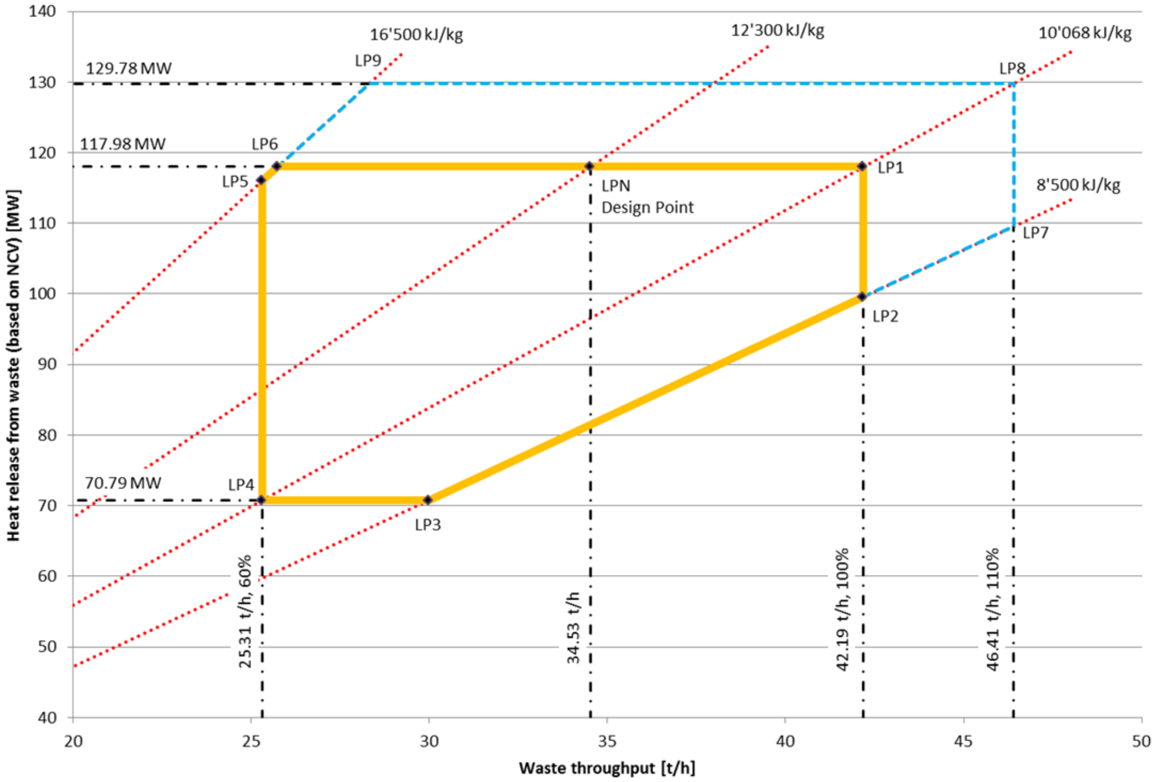

Figure 4 Combustion diagram

For short time overload (during less than one hour) a throughput of 46.41 tons per hour, corresponding to 110% of the nominal throughput is allowed.

The minimum amount of waste throughput is 25.31 tons per hour represented by the line (LP4) – (LP6), corresponding to 60% of the nominal throughput (mechanical load).

To maintain the planned generating capacity with the proposed NCV range the fuel requirement could vary from approximately 810,000 tpa ((LP4), (LP6): 4 streams, availability 8,000 h) to 1,350,000 tpa ((LP1), (LP2): 4 streams, availability 8,000 h).

However, it must be noted that operation on either the maximum or the minimum amount of waste is only possible during a very short period of time in order to absorb variations in the amount of waste and the calorific value of the waste. Continuous operation outside the limits of the diagram is not possible.

Inside the area made up by the lines (LP1), (LP2), (LP3), (LP4), (LP5) and (LP6) the plant shall be able to be in continuous operation (Table 6).

The line (LP8) – (LP9) is the maximum short time thermal overload (129.78 MW), which is 110 % of the nominal thermal load. The area constituted by the lines (LP1), (LP8), (LP9) and (LP6) represents a thermal load of 100–110 % of the nominal load, is designed to manage inevitable fluctuations from the preferred operational line (LP1) – (LP6). Continuous operation at thermal overload is not possible.

The line (LP3) – (LP4) is the minimum allowable thermal input (fuel firing) where all guarantee values have to be fulfilled without use of the auxiliary gas burners. The line is representing 60 % of the nominal thermal load (70.79 MW).

Load Point	Capacity [tonnes/h]	Capacity [tonnes/a/line]	CV [kJ/kg]	Energy input (burnt fuel) [MW]
LPN	34.53	276,240	12,300	117.98
LP1	42.19	337,520	10,068	117.98
LP2	42.19	337,520	8,500	99.62
LP3	29.98	239,840	8,500	70.79
LP4	25.31	202,480	10,068	70.79
LP5	25.31	202,480	16,500	116.09
LP6	25.74	205,920	16,500	117.98

Table 6 Load Point table, normal operation

2.6 Availability Requirement

The plant is designed to ensure operation minimum availability of 8,000 h/a. 8,000 h/a is a usual availability standard within the EfW industry and a Standard guarantee required in EfW contracts. This allows for 760 hours a year of operational management that may include inspection stops, a maintenance period and some hours of unplanned stop of main components. The total number of hours per year is divided as follows:

Plant availability:	8,000 h
Scheduled plant stop, 14 days:	336 h
Scheduled inspection, 2 days:	48 h
Unplanned stops:	376 h
Total:	8,760 h

To meet the overall availability of 8,000 h/a, each system/component in the plant will have a significantly higher availability or redundancy.

The operator will ensure that fully redundant solutions are developed and implemented for all relevant equipment/components, in particular the components that lead to plant shut-down, in case of failure of the particular component. This also includes appropriate consideration of redundancy in relation to electrical and control and monitoring system. To a high extent all parts will be able to be maintained without stopping the plant / boilers, this is achieved by applying process bypass options (for example turbine bypass), and/or duplicate components (for example feed water pumps or multiple fabric filter chambers).

3. ENVIRONMENTAL STANDARDS

3.1 Background

The Facility design has been developed to align with the relevant environmental, operational and safety requirements of Australian and NSW Regulatory Framework. Key performance requirements have been used to inform the development of the design and operation of the TNG Facility.

The main statutory instruments are summarised in Table 7:

FRAMEWORK LEVEL	PLANNING INSTRUMENT
Legislation and Regulations	▪ Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) ▪ *Environmental Planning and Assessment Act 1979* ▪ Environmental Planning and Assessment Regulation 2000 ▪ *Protection of the Environment Operations Act 1997* ▪ Protection of the Environment Operations (Waste) Regulation 2014 ▪ Protection of the Environment Operations (Clean Air) Regulation 2010 ▪ Waste Avoidance and Resource Recovery (WARR) Act 2001 ▪ Water Management Act 2000
Environmental Planning Instruments – State	▪ State Environmental Planning Policy (State and Regional Development) 2011 ▪ State Environmental Planning Policy (Infrastructure) 2007 ▪ State Environmental Planning Policy (Western Sydney Employment Area) 2009 ▪ State Environmental Planning Policy No. 33 – Hazardous and Offensive Development ▪ State Environmental Planning Policy No. 55 – Remediation of Land ▪ State Environmental Planning Policy No. 64 – Advertising and Signage.
Environmental Planning Instruments – Local	▪ Blacktown LEP 2015
Local Planning Policies	▪ Blacktown DCP 2006

Policies and Guidelines – State	▪ NSW State Rivers and Estuary Policy (1993); ▪ NSW State Groundwater Policy Framework Document (1997); ▪ NSW State Groundwater Quality Protection Policy (1998); ▪ NSW State Groundwater Dependent Ecosystems Policy (2002); ▪ NSW Energy from Waste Policy Statement 2015 ▪ Waste Avoidance and Resource Recovery Strategy (WARR) 2014 – 2021 ▪ Aquifer Interference Policy (2012); ▪ Department of Primary Industries Risk Assessment Guidelines for Groundwater Dependent Ecosystems (2012); and ▪ Guidelines for Controlled Activities (2012). ▪ Waste Classification Guidelines (EPA, 2014) ▪ Environmental guidelines: Composting and Related Organics Processing Facilities (DEC) (2004) ▪ Environmental guidelines: Use and Disposal of Biosolid Products (NSW EPA)

Table 7 Legislative Framework

The implementation of the relevant legislative and policy framework is achieved through the following key processes:

- Environmental Impact Statement (and supporting documents) and the associated Development Approval (granted under the *Environmental Planning and Assessment Act 1979*).
- Environment Protection Licence (issued under the *Protection of the Environment Operations Act 1997*)

The granting of Environment Protection Licences (EPL) for Waste-to-Energy plants would be carried out by the Environment Protection Authority (EPA). The EPL requirements effectively drive key performance design decisions, and the EPL itself sets out operational requirements in respect of the environmental performance of the process, including the process emissions.

The starting point for the environmental performance of the Facility has been the compliance with legislative standards which are required of Waste-to-Energy plants in Europe. The European Industrial Emissions Directive IED 2010/75 EC has also been used as the basis for the development of the NSW Energy from Waste Policy, which is the legislative framework for the proposed Facility.

Furthermore the environmental permits sets out which waste types can be treated and gives directions to the reception, handling and storage of waste.

3.2 Proposed basic design parameters

In NSW EfW policy states "The process and air emissions from the facility must satisfy at a minimum the requirements of the Group 6 emission standards within the Protection of the Environment Operations (Clean Air) Regulations 2010. The EU regulations for EfW plants (part of the Industrial Emission Directive IED) are generally considered to be the most stringent requirements for EfW plants worldwide. Therefore the IED standards, including emissions, process performance and design and emissions monitoring will form the starting point for the process design along with the current Best Available Technology (BAT) reference note.

3.2.1 Process guarantees

In accordance with the decision to commence design on the basis of achieving compliance with the IED (above), process guarantees will be set to ensure compliance with the IED, as a minimum.

3.2.2 Emissions monitoring requirements

The Facility will be designed to meet the emission limits contained within the Chapter IV and Annex VI of the Industrial Emissions Directive (IED) (Directive 2010/75/EU) for waste incineration and waste co-incineration plants.

3.2.3 Continuous emission monitoring

Emissions from the stack will be monitored continuously by an automatic computerised system and reported in accordance with NSW EPA protocols. Sampling and analysis of all pollutants will be carried out to NSW Approved Methods, European Committee for Standardization (CEN) or equivalent standards (e.g. International Organization for Standardization (ISO), national, or international standards). This ensures the provision of data of an equivalent scientific quality.

This monitoring has three main objectives;

1. to provide the information necessary for the facilities automatic control system to ensure safe and efficient facility operation;
2. to warn the operator if any emissions deviate from predefined ranges; and
3. to provide records of emissions and events for the purposes of demonstrating regulatory compliance.

The following parameters will be monitored and recorded continuously at each stack using a Continuous Emissions Monitoring System (CEMS);

(1) oxygen;
(2) carbon monoxide;
(3) hydrogen chloride;
(4) sulphur dioxide;
(5) nitrogen oxides;
(6) ammonia;
(7) VOCs (volatile organic compounds);
(8) Particulates; and
(9) Flue gas volume

In addition, the water vapour content, temperature and pressure of the flue gases will be monitored so that the emission concentrations can be reported at the reference conditions required by the IED or as required by the NSW EPA.

The continuously monitored emissions concentrations will also be checked by an independent auditor at regular interval or as required by NSW EPA.

The following parameters will be monitored by means of spot sampling at frequencies agreed with the relevant regulator.

(1) dioxins and furans;
(2) mercury;
(3) cadmium and thallium; and
(4) heavy metals.

The methods and standards used for emissions monitoring will be in consistent with the IED or as directed by with NSW EPA.

There will be duty CEMS (one per line) and one hot stand-by CEMS per two lines. This will ensure that there is continuous monitoring data available even if there is a problem with one of the duty CEMS systems.

3.2.4 Noise

There will be a general sound pressure level requirement of max. 85 dB(A) for noise emissions inside the plant.

Most equipment within the plant will fulfil the 85 dB(A) requirement without further measures, except for the turbine during bypass operation, some larger pumps and fans and possibly conveyers for bottom ash transport, air coolers and steam condensers.

Where possible such equipment shall be place in dedicated noise areas (rooms) or be acoustically insulated/covered by noise hoods.

Item No.	Noise Source	Assumed Noise Level SWL dB(A)
1	Stacks (2 – 1 per block)	91
2	Turbine Hall (2)	88
3	Tipping Hall	85
4	Air Cooled Condensers (ACC's) (2)	102 (per section of 6 units)
5	Transformers (2)	102
6	Compressors (2)	97
7	Boiler Area (2)	85
8	Flue Gas Treatment (4)	98
9	ID Fans (4)	100
10	Silo's & Bag Storage (2)	85
11	Bottom Ash Handling (2)	93

Table 8 Noise requirements in various areas and development zones

4. WASTE AND RESIDUE LOGISTIC

4.1 Reception Hall and Bunker Storage Capacity

The EfW facility will operate continuously, 24 hours a day and 7 days a week. Fuel will only be delivered to the site at the operators' specified times, where it will be unloaded and stored inside the bunker. Sufficient storage for 5-7 days at full load will be provided to provide a buffer to cater for disruptions in fuel supply or with unplanned outages of the Facility. The fuel will be mixed in the bunker using the overhead cranes to try and ensure homogeneity in the fuel.

Checking and auditing the various fuels forms are an important first step in the control process. Upon arrival at the Facility, all fuels will be weighed, visually checked with CCTV and if necessary sampled. Any deviation from the fuel specification will be noted, and if significant, fuel loads will be rejected. During unloading, facility operators will carry out further visual checks of the fuel.

The bunker is an important component of any Waste-to Energy plant as it functions as the recipient and storage of the waste supply. The waste will be delivered by trucks (rear tipping). However, there is normally considerable diurnal variation in the supply of waste.

For this reason the tipping hall, as well as access and queuing areas shall be able to accommodate this variation in flow of vehicles, also during periods with adverse weather, around public holidays etc.

The bunker and tipping hall are significant civil works items and therefore the volume of the bunker and the area of the reception hall and number of unloading bays need to be balanced against costs and with due attention to the need to minimise queuing and waiting time for vehicles.

The tipping hall will be of sufficient width to ensure easy access for all types of trucks.

There will be a one bunker with two compartments, each compartment serving two incineration lines. The bunker will have a maximum capacity of approximately 68,950 m^3. The bunker will have an approximate footprint of 30 m x 94 m, with a stacking height up to 30 m. Even at the maximum throughput the bunker size described in Table 9 is sufficient to provide 5.9 days storage. Fill and removal of material will be via the waste cranes.

Facility & Fuel parameters			
		LP1	LPN
Fuel flow (4 combustion lines)	t/day	4,061	3,315
Assumed Fuel Density	t/m^3	0.35	
Volumetric fuel flow	m^3/day	11,602	9,471
Bunker parameters			
Length	m	30	
Width	m	2 x 47 = 94	
Height	m	30	
Maximum fuel stacking height	m	30	
Bunker capacity (with stacking), waste volume	m^3	68,950	
Maximum number of days storage	days	5.9	7.3

Table 9 Bunker Design Data (Parameter for the 2 bunkers together)

4.2 Number of unloading bays

It is assumed that all trucks will be walking floor type, although it may be possible to take tipping bulkers if required. It is assumed that the average unloading time for a 22 tonne load is 12 minutes, which is the total time occupying a bay, including reversing and leaving.

Table 10 indicates that in case of the maximum fuel throughput NCV (10 MJ/kg) and accounting for variability and peak flows, there would be a short term maximum of 17 deliveries per hour, requiring a minimum of 4 delivery bays.

Parameter	Unit	Design fuel, average flow	Maximum fuel throughput peak flow
Fuel NCV	MJ/kg	12.3	10
Peak hourly fuel	t/h	132	374
Delivery capacity	t/h	22	22
Peak deliveries	Deliveries /h	6	17
Unloading time per bay	minutes	12	12
Minimum bays required	(rounded up)	2	4

Table 10 Unloading bays requirement

To provide flexibility in operations (i.e. bunker management) the design layout has allowed for 16 delivery bays.

4.3 Trucks (size and frequency)

The waste will be transported to the plant in predominately Semi-trailers, Trucks and Dog trailers. Likewise, the bottom ash and the residual products from the flue gas cleaning will be picked up in semi-trailer trucks.

Trucks are anticipated to carry an average load of 22 tonnes. The plant will operate 24 hours a day, seven days a week. The proposed plant is to have a maximum total capacity of 1,350,000 tonnes per annum. As such, the plant will receive a maximum of up to 168 truck deliveries per day associated with input waste material. However, the planned nominal operational input of 1,105,000 tonnes per annum will result in only 138 trucks per day.

Tonnes p.a.	Weeks per Year	Days per Week	Truck Capacity (t/veh)	No. of Trucks (per day)	Truck Movements (per day)	Hours per Day (hrs)	Truck Movements per Hour (veh/hrs)
1‘350’000	52	7	22	**168**	336	24	14
1’105’000	52	7	22	**138**	276	24	11.5

An additional 20 truck movements per week are expected for miscellaneous deliveries such as hydrated lime, activated carbon and other materials required for the various processes involved in the power generation. Assuming these will be trucks with an average load of 22 tonnes, delivered over a standard 5 day week, results in a demand for up to 4 additional trucks per day.

Tonnes p.a.	Weeks per Year	Days per Week	Truck Capacity (t/veh)	No. of Trucks (per day)	Truck Movements (per day)	Hours per Day (hrs)	Truck Movements per Hour (veh/hrs)
24’300	52	5	22	**4**	8	24	0.3

The total ash residue waste (APC Residues and Bottom ash) for worst case fuel will be in the order of 451,700 tonnes per annum (please refer to Chapter 6.8.5, table ash production). As a worst case, it is assumed that this waste is to be carried on trucks with an 18 tonne capacity, removed over a 12 hour period, 6 days a week. On this basis, the removal of ash residue equates to an additional 80 ash truck per day, as outlined in Table below.

Tonnes p.a.	Weeks per Year	Days per Week	Truck Capacity (t/veh)	No. of Trucks (per day)	Truck Movements (per day)	Hours per Day (hrs)	Truck Movements per Hour (veh/hrs)
451'700	52	6	18	**80**	160	12	14

Table 11: shows the estimated average and peak road deliveries by type, assuming the worst case scenario that all fuel and consumable deliveries, and residue removal from site takes place by road.

		Fuel (NCV 10MJ/kg)	Consu-mables	APC Residues	Bottom Ash	Total
Average mass flows	t / a	1,350,000	24,300	51,700	400'000	1,826,000
	t / week	25,960	467	994	7,690	35,115
	t / d (Mon-Sun)	3,710	78	166	1,282	5,233
	per h	155	3.3	7	53	218
Average deliveries	per a	61,360	1,105	2,870	22,220	87,555
	per week	1,180	21	55	427	1,683
	per day	**168**	**4**	**9**	**71**	**252**

Table 11 Total Traffic Flows on worst case fuel

4.4 Effluent discharge

Under normal operating conditions, no effluent is disposed of to the sewer or stormwater systems but returned to the Facility for re-use. In this way, the liquid effluent produced on site will either be evaporated or absorbed into the bottom ash discharger via the process water system.

Liquid effluent will consist of boiler blow down, boiler water treatment, swilling down water, occasional maintenance discharges and drain water from contaminated areas.

The re-use of the different water streams within the process results in a liquid effluent free EfW Facility during normal operation.

5. BOILER/FURNACE

5.1 EfW grate technology

The EfW plant is based on advanced moveable grate mass burn technology.

A moving grate EfW incineration facility has been preferred due to the robustness and its proven ability to treat a very wide range of wastes. EfW grates show little technical processing sensitivity to the vast majority of variations normally seen in wastes e.g. physical dimensions and chemical composition.

5.2 "Vertical" and Horizontal "Tail-End" Boiler

An important consideration is the fundamental boiler concept. The Facility will use of a 5-pass horizontal boiler incl. vertical economiser pass as shown in Figure 5.
Below the most important topics with regard to the design of the boiler/furnace are discussed.

In principle, the boiler is either designed as a so-called "vertical boiler", i.e. a boiler with vertical passes in both the radiation and the convection parts (incl. the economiser),or as a so-called horizontal, "tail-end" boiler where the boiler has one or more vertical radiation passes followed by a horizontal convection pass with pre-evaporator, superheater, evaporator and economiser sections, see Figure 5.

The horizontal boiler type (the "tail-end") is characterised by the radiation pass being followed by a horizontal convection pass and economiser.

The "vertical" boiler is characterised by the radiation pass being followed by one or two vertical convection passes and an economiser.

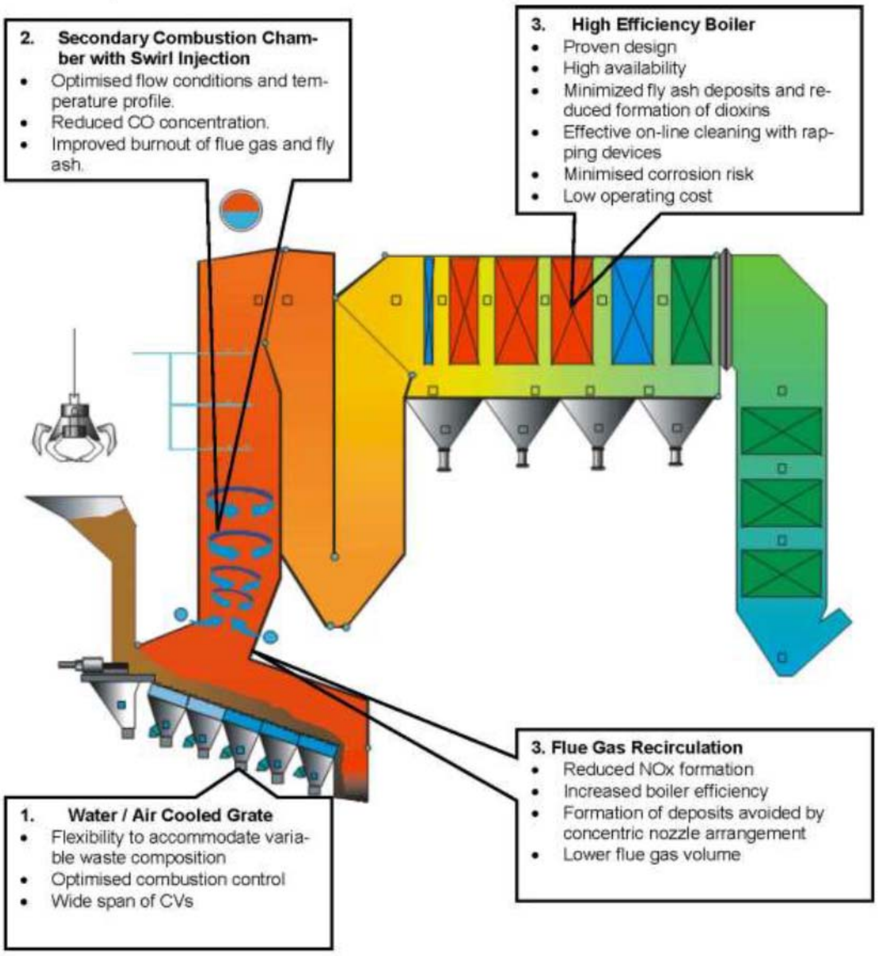

Figure 5 5-pass boiler configuration

Cleaning, Operation and Maintenance
The horizontal convection pass is equipped with a mechanical rapping device, which at a pre-set frequency (typically 4-6 cleaning sequences of 2-5 minutes per day) raps the tubes in the convection pass and thereby removes dust and ash from the tube bundles which fall into the collection hoppers.

A water spray cleaning system is installed in the vertical radiation parts. The radiation part is without baffle walls as it ensure a more conservative or spacious design of the boiler. The boiler is dimensioned for moderate flue gas velocities (3.5 – 5.5 m/s, lowest in the first pass).

The temperature in the cross section at the inlet to the convection part is an important factor and should not exceed 625°C at the beginning of the operation time after manual boiler cleaning.

The convection part consists of superheater sections, the evaporator and the economiser. In between the superheater sections water injections are used to control the temperature of the live steam.

The economiser, evaporator and superheater sections is designed as fully de-mountable tube bundles dedicating special attention to easy replacement of the super heater section subject to the highest thermal load.

The following maintenance and operating conditions speak in favour of selecting a horizontal convection pass:

- A smaller extent of fouling due to more effective cleaning. Soot blowing and shot ball cleaning generally do not result in a uniform cleaning of entire tube sections.
- With the horizontal "tail-end" boiler very long operating intervals between manual boiler cleanings can be achieved. Thus, a guaranteed, continuous operating time of up to 8,000 hours for horizontal boilers against 4,500 hours for vertical boilers leads to less downtime.
- Mechanical cleaning with rapping devices is a considerably gentler and effective and also simpler method compared to steam or compressed air soot blowing. Maintenance of the rapping devices is primarily limited to replacement of parts, which are accessible from the outside of the boiler.
- The horizontal boiler will have a better working environment at the manual cleaning process of the pipe bundles. In a horizontal boiler, the manual cleaning can be performed in an up-right position, whilst in a vertical boiler; the cleaning must be made lying down, thereby exposing the worker to dust and ashes.
- There is no steam consumption for the cleaning and hence no reductions in the power production or operational problems with the turbine due to momentary relatively large steam consumption for soot blowing.
- Generally, fewer corrosion and erosion problems can be expected of a mechanically cleaned horizontal convection pass, mainly because of a smaller extent of fouling and ash deposition and because the protective oxide coating of the tubes is not damaged when using this cleaning method.
- Future replacement of tube bundles in the superheater is easier.

Thermal Conditions
A higher thermal efficiency (0.5-1 %) can be expected of the horizontal boiler as the smaller extent of fouling leads to a better heat transfer of the super-heater tubes of the boiler.

Construction and Operating Costs
A boiler with a horizontal convection pass is more expensive than a boiler with a vertical convection pass.

As, however, the average annual operating and maintenance costs during the life time of the facility are normally expected to be lower for the horizontal boiler the full life cost of the horizontal is generally expected to be lower than the vertical boiler.

Summary
From the above it can be concluded that the horizontal boiler is technically and also from environmental/efficiency point of view the best solution. It requires, however, a bigger up-front investment than a vertical boiler solution
As a result of these considerations the Facility will use of a 5-pass horizontal boiler incl. vertical economiser Figure 5.

5.3 Combustion control system

Given the thermal output increases with greater waste throughout (see Figure combustion control system), a cooling system is used to condense the steam from the turbine exhaust for re-use. Large variations of the calorific value (CV) may require an adaptation of the parameters of the different control loops. The adaptation of all control parameters is executed manually by the adjustment of one single input value. This is the so called 'CV- correction'; a feature that is fully integrated in the control system. The CV-correction effects an automatic adjustment of up to ten parameters of the combustion control system.

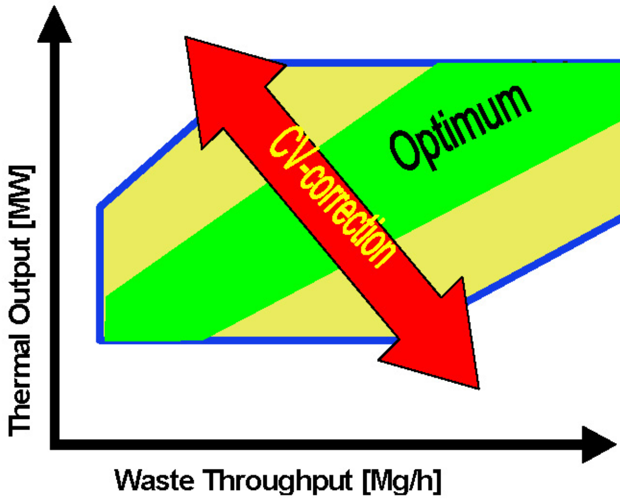

Figure 6 Combustion control system

5.4 Furnace and Secondary Combustion Chamber

The furnace and secondary combustion chamber shall comply with the 2 s retention time and 850°C temperature requirements of the IED and be equipped with auxiliary burners.

5.5 Steam Parameters and Corrosion

Steam parameters have been fixed at 70 bar/430ºC, as this allows for high energy efficiency and at the same time keeping the risk of corrosion at an acceptable level.

Corrosion is a significant issue in waste fired boilers. Corrosion increases with higher temperatures. Steam parameters for boilers are therefore determined to achieve the optimal balance between boiler corrosion and plant efficiency.

In addition to the risk of high temperature corrosion in the superheaters, experience has shown that there is a risk of corrosion in the evaporator part of the boiler, particularly where the unprotected membrane tube walls in the first and second passes of the boiler are exposed. Therefore Inconel[3] cladding are foreseen at some parts of membrane walls furnace, membrane walls top of pass 1 and 2 and some tubes of superheater 3.2

5.6 Combustion Air Excess (λ)

All systems are designed for all load situations according to the combustion diagram, Figure 4. The combustion air systems are designed to ensure a correct amount of excess air in the flue gas, both in order to ensure high combustion efficiency and to avoid a reducing (corrosive) atmosphere, incomplete burnout of the flue gases etc.

5.7 Primary Air Intake

Maintaining a negative air pressure in the tipping hall is critically important to avoid odour problems from the waste bunker. Therefore, all primary air required for the combustion process are drawn from the bunker. During stand still negative air pressure is maintained and air goes directly to stack.

5.8 Secondary Air Intake

Secondary air shall be drawn from the top of the furnace/boiler hall, and will be injected into the furnace and at the inlet to the first boiler pass through 2 rows of nozzles.

5.9 Flue Gas Recirculation

To increase the overall efficiency of the boiler and reduce NO_X formation (by reducing the amount of excess air) it is beneficial to recirculate the flue gas. Further by flue gas recirculation the flue gas treatment plant will have to treat less flue gas increasing the removal efficiency.

5.10 Feed Water Pumps

The feed water pump is a critical component that secures operation and needs redundancy in case of failure. It is especially important to avoid boiling off all water in the water-steam system, thus avoiding damaging the pressure part in worst case conditions. The Facility will have 2 x 100 % feed water pumps for each line (one pump in operation, one in stand-by mode).

5.11 Make-up Water System

A water treatment plant, producing the make-up water for all combustion limes, is able to fill the tank in 72 hours with all combustion lines in operation whilst maintaining Plant supply at MCR. The capacity of the make-up water tank shall be 125% of the volume required to completely fill one respectively two boilers including superheaters (depending on 2 or 4 combustion lines).

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[3] Inconel alloys are oxidation and corrosion resistant materials well suited for service in extreme environments subjected to pressure and heat.

5.12 Proposed Design Data

For proposed overall design data refer to table below.

Waste-to-Energy with waste utilization Preliminary Process and Design Data Boiler/Furnace		
Plant Component / Parameter	**Value / Description**	
Input and Output		
Gross Heat Release	117.98 MWth	
Throughput nominal	34.53 t/h	
Calorific Value nominal	12.30 MJ/kg	
Steam flow 100 %, at 70 bara, 430 °C	144.7 t/h	
Steam pressure nominal	70 bara	
Steam temperature nominal	430 °C	
Flue gas Temperature		
Flue gas temperature exit boiler	Nom 170 °C	
Bottom ash Handling System		
Water content bottom ash nominal	19 %	
Max. Ignition loss bottom ash	5 %	
Max. TOC bottom ash dry	3%	
Bottom ash Bunker parameters (per phase)		
Length	m	13
Width	m	47
Height	m	9 (included 7m below ground level)
Maximum ash stacking height	m	9
Ash bunker capacity	m^3	5,499
Bottom ash flow (4 combustion lines)	t/day	1,282 (see Table 11)
Assumed Bottom ash Density	t/m^3	1.8
Volumetric Bottom ash flow	m^3/day	712
Maximum number of days storage (at LP1)	days	7.7

6. FLUE GAS TREATMENT

6.1 Flue Gas Cleaning System

The flue gas will be cleaned in the Flue Gas Treatment plant to control emissions of acid gases, particulates, dioxins and furans and heavy metals.

The semi-dry flue gas cleaning process is designed to remove acidic gaseous contaminants by chemical absorption with hydrated lime. Heavy metals and organic contaminant compounds (i.e. dioxins and furans) are reduced by adsorption on activated carbon. Features of this system are illustrated in Figure 7.

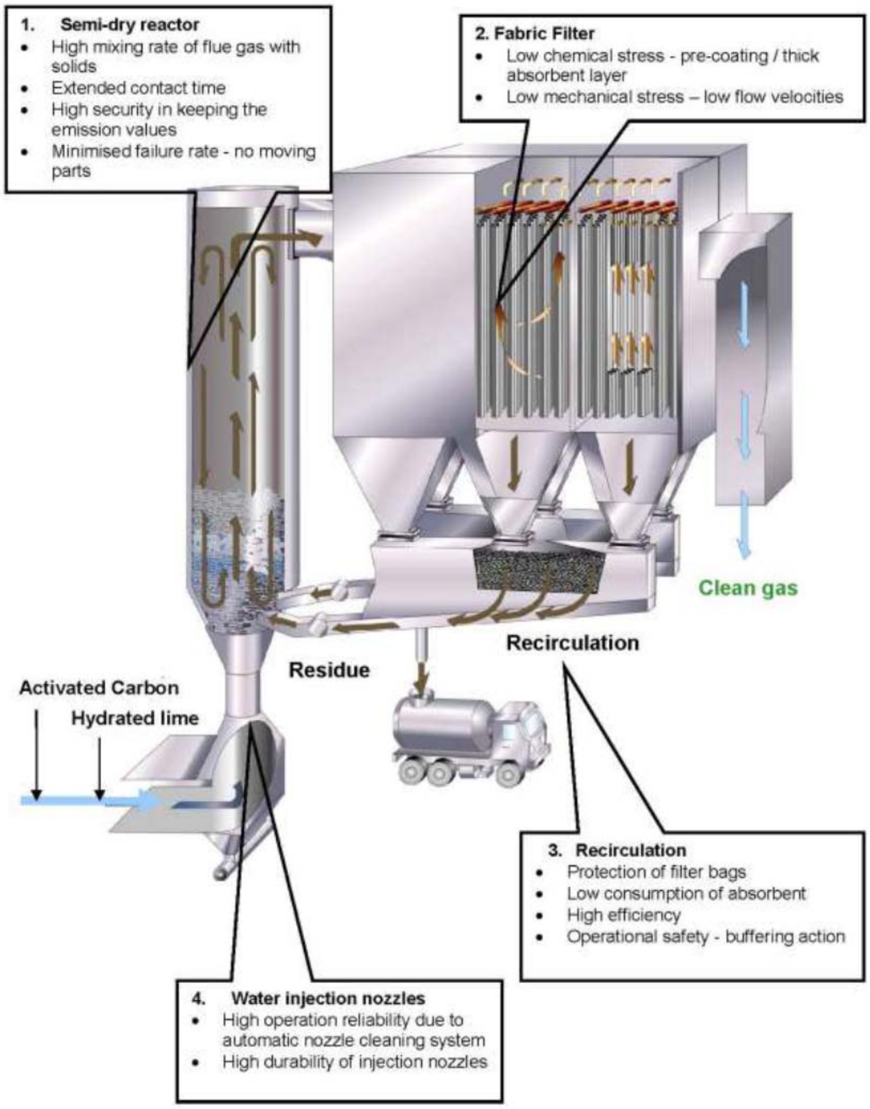

Figure 7 Semi-dry Flue Gas System

In this process the flue gas and solids move turbulently through the semi-dry reactor with partial inversion of the solid flow. The pollutants react with the injected hydrated lime and the activated carbon at a temperature of approximately 145 °C.

The separation of solids from the flue gas takes place in the fabric filter downstream of the reactor. Precautions are considered for water contacted parts, generally water-proof insulation is applied. All maintenance and inspection areas are encased in order to protect against rain during maintenance work.

The flue gas cleaning process is characterised by the following features:

- Flexible to load changes and changes in gas contaminant concentrations;
- Efficient use of adsorbent and minimised residue quantities;
- Designed for high Hydrogen Chloride (HCl) and Sulphur Dioxide(SO_2) inlet concentrations;
- Dry injection of Calcium Hydroxide ($CaOH_2$) and Powdered Activated Carbon (PAC);
- Separate injection of water for conditioning and reactivation of recycled lime particles;
- Compact design; and
- Low manpower requirement.

6.2 Nitrogen Oxide (NO_x) Removal System

The NO_x Removal system is a selective non-catalytic reduction, SNCR.

With an SNCR system, ammonia water is injected into the first pass of the boiler at a temperature level of approximately 900°C. Here the chemical reaction takes places, converting NO_X to harmless N_2 and water. The system requires 2-3 levels of injection nozzles in the first pass of the boiler and a system based on water or air to atomize ammonia water into the boiler. With a SNCR system the requirement of 200 mg/Nm^3 NO_x can be comfortably reached.

The SNCR technology can be optimised to reach 120 mg/Nm³ for a sophisticated SNCR (as daily average). The increased efficiency comes with a modest increase of CAPEX and additional consumption of ammonia.

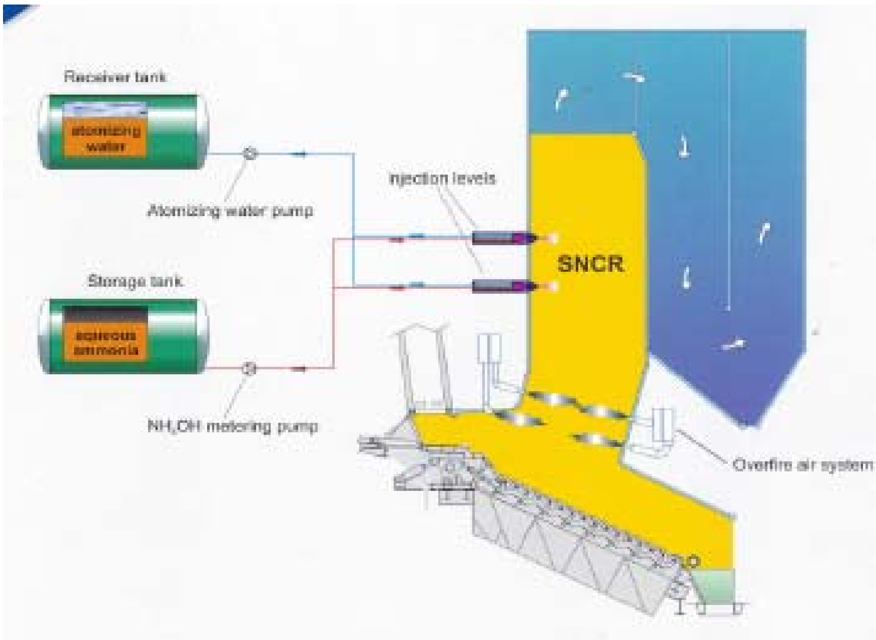

Figure 8 Schematics, SNCR system.

6.3 ID-fan

The ID-fan is designed for boiler operating at 110 % MCR in a fouled condition after 8,000 hours of operation. In order to keep the wear and noise level down the air fan speed shall be below 80% of the maximum speed for which the fan is designed for sustained operation. The ID-fan is electrically driven.

Spare capacity of air and flue gas systems with respect to flow rate is necessary for several reasons. The ID-fan shall always have sufficient capacity to ensure negative pressure in the furnace, also during short term variations. During the life time of the plant the waste composition, quality and quantity might change, leading to different requirements of air and flue gas flows.

6.4 Stack

Flue gases will be emitted to atmosphere via a stand-alone stack for each phase.
The final stack height was selected based on a combination of compliance of ground level concentrations and reference to the US EPA document "Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations)" (US EPA Good Engineering Guideline).

Treated flue gases will be emitted to the atmosphere via two separate twin-flues within the standalone stacks, located to the south of the Flue Gas Treatment Areas.

Each stack will be built to the minimum height necessary to ensure adequate dispersion of the emissions and excessive concentrations of any air pollutant in the immediate vicinity of the stack (as defined through air quality dispersion modelling). The US EPA Good Engineering Guideline states the general rule of thumb for good engineering practice stack height is ‘Height of building + 1.5 times the lesser of building height or projected width’.

With height being the less of these two dimensions; a stack height of 125 m was initially identified. Dispersion modelling was then used to refine and identify a project specific stack height, based on achieving compliance with ground level concentrations. Dispersion modelling found that a stack height of between 80m and 100m would be suitable. A final stack height of 100m was selected due to consistency with the good engineering practice guide and modelled emissions concentrations at ground level.

6.5 Chosen Emission Standard

Under the EfW Policy Statement the stack emissions from the facility are required, as a minimum, to meet the Group 6 standards of concentration set out in the *Protection of the Environment Operations (Clean Air) Regulation 2010* ("the Clean Air Regulation"). The Clean Air Regulation sets emission standards for various industrial activities and those that are applicable to an EfW facility are outlined in Table 12.

Pollutant	Standard (mg/Nm^3)	Source	Activity
Solid Particles (Total)	50	Electricity generation	Any activity of plant using liquid or solid standard fuel or non-standard fuel
HCl	100	General standards	Any activity or plant
HF	50	Electricity generation	Any activity of plant using liquid or solid standard fuel or non-standard fuel
SO_2	No applicable standard		
NO_2	500	Electricity generation	Any boiler operating on a fuel other than gas, including a boiler used in connection with an electricity generator that forms part of an electricity generating system with a capacity of 30 MW or more
Type 1 & 2 substances (in aggregate)	1	Electricity generation	Any activity of plant using non-standard fuel
Cd or Hg (individually)	0.2	Electricity generation	Any activity of plant using non-standard fuel
Dioxins or furans	1×10^{-7} (0.1 ng/m^3)	Electricity generation	Any activity of plant using non-standard fuel that contains precursors of dioxin or furan formation
VOC	40 (VOC) or 125 (CO)	Electricity generation	Any activity of plant using non-standard fuel
Cl_2	200	General standards	Any activity or plant
H_2S	5	General standards	Any activity or plant

Reference conditions defined as dry, 273.15 K, 101.3 kPa and 7% O_2 for all air impurities when burning a solid fuel, with the exception of dioxins and furans where the required O_2 concentration is 11% for waste incineration.

Table 12: POEO Clean Air Regulation Standards of Concentration

However, the proposed flue gas treatment will be designed to employ Best Available Technology (BAT) and achieve the emission limits specified by the European *Industrial Emission Directive IED 2010/75/EU* (IED). The IED emissions limits (refer Table 13) are generally more stringent that the Clean Air Regulation limits. The proposed technology is based on existing facilities operated throughout Europe, which are designed to meet the IED limits.

The European limit values for emissions in waste incineration plants are defined within the IED. The specific emission limits for WtE are found in Annex VI, part 3 of the Directive.

Parameter	Daily Average	Half Hour Average	Units
Continuous measuring			
Total Dust	10	30	mg/Nm³
Total Carbon (TOC)	10	20	mg/Nm³
Inorganic chlorine compounds (HCl)	10	60	mg/Nm³
Inorganic fluorine compounds (HF)	1	4	mg/Nm³
Sulphur dioxide (SO_2)	50	200	mg/Nm³
Oxides of nitrogen (expressed as NO_2)	200	400	mg/Nm³
Carbon monoxide (CO)	50	100	mg/Nm³
Discontinuous measuring			
Dioxines and furanes	0.1	ng/Nm³	average of 6-8hours
Hg	0.05	mg/Nm³	average of 0.5-8hours
Cd+Tl	0.05	mg/m³	average of 0.5-8hours
Total of heavy metals	0.5	mg/m³	average of 0.5-8hours

All emissions are dry basis, 11% O_2 and at normal temperature and pressure.

Table 13 IED Emission Limits for an Incineration

6.5.1 Continuous Emission Monitoring System (CEMS)

Consistent with the requirements of the EfW Policy Statement, there will be continuous measurements of NO_x, CO, particles (total), total organic compounds, HCl, HF and SO_2. This data will be made available to the EPA in real-time graphical publication and a weekly summary of continuous monitoring data and compliance with emissions limits will be published on the internet. Further, the emission monitoring shall comply with the requirements of European Industrial Emissions Directive. Continuous monitoring is therefore installed for the pollutants CO, HCl, SO_2, NOx, NH_3, VOC and particulates. Auxiliary parameters are also measured: Flue gas flow rate, temperature, pressure, moisture content and oxygen.

6.6 Plume Visibility

For the proposed semi-dry flue gas treatment, a stack exit temperature of around 120 °C and moisture of the flue gas of 15-18% is expected. Calculations show that that plume formation will not occur at ambient temperatures above 12 °C and a relative humidity of 75%.

The mean relative humidity (9am) is between 65 and 75% all year. In the months May to October the mean maximum temperature is 17-23 °C, which is well above the 12 °C threshold. The mean minimum temperatures of May-Oct are 7-11 °C, indicating that there will be a number of hours where plume visibility is possible.

It can be concluded that the plume will not be visible the vast majority of the time, and even under adverse conditions, the plume will be light (not dense) and it will disappear quickly. The plume will most likely occur only at night and in early morning hours in the coldest 6 months of the year and have very limited height.

6.7 Consumables Handling

The Facility will use various raw materials during operation. Primarily, these include hydrated lime, ammonium hydroxide, activated carbon, Low Sulphur gas oil and water. These will be delivered to the Facility in bulk transportation vehicles (except for water, Low Sulphur gas oil and oil). The minimum on site storage capacity will be set to reflect the process requirements and local delivery capability. Table 15 shows the approximate consumable requirements.

Various smaller amounts of materials are used for the operation and maintenance of the Facility. These are:

- hydraulic oils and silicone based oils;
- Low Sulphur gas oil emptying and filling equipment;
- boiler water dosing chemicals.

All liquid chemicals stored on site will be kept in bunded controlled areas with a volume of 110% of stored capacity.

6.8 Residue Handling

The facility will generate the following residues:

- bottom ash
- boiler ash
- APC residue;
- Ferrous material residue;
- Staff waste;

6.8.1 Bottom ash

Bottom ash is the burnt-out residue from the combustion process. Bottom ash from the grate is quenched with water and moved by conveyor to the enclosed ash storage bunker where it is stored prior to being transported off-site. The conveyor passes under a magnetic separator to remove ferrous materials.

6.8.2 Boiler ash

The characterisation of boiler ash is dependent upon in which boiler pass it is accumulated in. Boiler ash of the horizontal pass will be conservatively disposed of with the APC residues. The composition of the ash from the first vertical passes is similar as the bottom ash and can be disposed of with the latter.

6.8.3 Air pollution control (APC) residue

Flue Gas Treatment (FGT) residues, also known as APC residues, comprise fine particles of ash and residues from the FGT process. APC residue is collected in bag filters and will contain fly ash and reaction products from the hydrated lime scrubber and spent activated carbon. Due to the heavy metals involved in FGT, this material is classified as restricted solid waste. It will be stored in dedicated enclosed silos located adjacent to the flue gas area before being transported via a sealed tanker to an appropriate offsite disposal facility.

6.8.4 Ferrous material residue

Ferrous metals will be removed from the bottom ash by means of magnetic separators and discharged to into bins which are then transported offsite to metal recycler.

6.8.5 Mass Balance

The residue production from the Facility has been estimated and presented within Table 14:

Parameter	Units	Design fuel	Worst case fuel
Fuel NCV	MJ/kg	12.30	10
Ash content	%	21.49	20
Fuel Flow	tpa	1,105,000	1,350,000
Bottom ash (dry)	tpa	237,465	324,000
Bottom ash (wet)	tpa	293,166	400,000
FGT/APC residue	tpa	43,800	51,700
Combined ash and residue	tpa	336,966	451,700

Table 14 Residue production

Raw material	Process	Typical usage (tpa)
Hydrated Lime	Flue gas treatment – acid gases	19,800
Ammonium hydroxide (25% solution)	Flue gas treatment – NOx reduction	2,200
Activated carbon	Flue gas treatment – dioxins/ heavy metal	420
Low Sulphur gas oil [4]	System firing	1,900

Table 15 Consumable requirements

6.9 Water Balance

Based on the water balance from a typical EfW facility, the average process water requirement is likely to be 23.25 m^3 per hour for the overall plant. Based on 8,000 operating hours a year this equates to approximately 186,000 m^3 per year for the overall plant. The primary requirement for water is to provide make-up for the boiler and steam cycle (to replace that which is blown down) and the FGT plant.

[4] Based on 10 starts per year per boiler (assuming 4 boilers), each start using 43 t gasoil. 10% has been added to the total figure to account for other uses e.g. maintaining the temperature above 850°C. Delivery size is nominal.

6.10 Proposed design data

For proposed overall design data please refer to table below.

Waste-to-Energy with waste utilization Preliminary Process and Design Data Flue Gas Treatment	
Plant Component / Parameter	**Value / Description**
Raw Flue Gas	
Referring to flue gas downstream the boiler.	
Nominal data [1]	
Flue gas flow rate, dry flue gas at 11% O_2	279,900 Nm^3/h
Temperature	170 °C
Pressure	– 1,000 Pa
H_2O	14.5 % vol.
O_2	7.4 % vol., dry
Dust	1,850 mg/Nm^3, 11% O_2, dry
Σ Cd + Tl	3 mg/Nm^3, 11% O_2, dry
Σ Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	70 mg/Nm^3, 11% O_2, dry
HCl	900 mg/Nm^3, 11% O_2, dry
SO_2 and SO_3 (as SO_2)	530 mg/Nm^3, 11% O_2, dry
HF	20 mg/Nm^3, 11% O_2, dry
NO_x as NO_2 [3]	200 mg/Nm^3, 11% O_2, dry
NH_3 [3]	3 mg/Nm^3, 11% O2, dry
N_2O	~ 0 mg/Nm^3, 11% O_2, dry
Hg	0.7 mg/Nm^3, 11% O_2, dry
Dioxins and furans (tox. equivalent 2,3,7,8 TCDD) [3]	5 ng/Nm^3, 11% O_2, dry
[1] Nominal values to be used as reference for guarantee values (at nominal) of consumables, residues, and energy production and consumption etc. Values apply at boiler exit [2] Wet flue gas at actual O_2 content [3] after SNCR-deNOx	
Emission limits, Outlet stack	
Emission limits	Clean Air Regulation Group 6, and where more stringent, IED 2010/75/EU (Please refer to Chapter 0)
Absorbents/adsorbents silos	
Minimum capacity, lime	7 days' consumption + 30 tonnes
Minimum capacity, activated carbon	20 days' consumption + 30 tonnes
Silo for Flue gas Treatment residue	
Minimum capacity	5 days' production at nominal conditions

7. TURBINE/CONDENSERS

7.1 Energy recovery, water steam cycle

The Facility will be capable of exporting approximately 137.3 MW of electricity, amounting to about 1,040,000 MWh per annum of electricity. For the export of electricity there will a separate connection to the electricity distributed network.

The/A Substation will be designed for both phases by taking into account two connection points for each turbine generator and also ability to make a new connection for the second turbine generator at phase 2 without shutting down the phase 1 facility.

The Facility will have one turbine for each phase which will serve two streams each. The principle of water steam cycle is sown below in Figure 9.

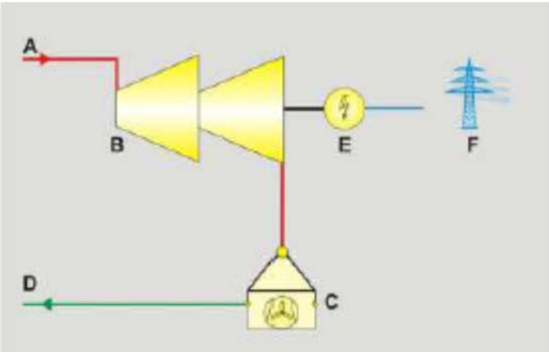

Figure 9 Steam Turbine set generating electricity

By means of a pressure controlled steam extraction, low pressure steam is taken for internal consumers in the plant. The expanded steam is then led to an air-cooled condenser to completely condensate the steam. Also part of this cycle are general steam and condensate systems, water treatment and feed water preparation systems as well as a closed-loop cooling system for all general cooling purposes of the plant.

7.2 Condensing System

The EfW plant will require a cooling system to condense the steam from the turbine exhaust for re-use. A Best Available Technology (BAT) assessment has concluded that the use of ACC represents BAT for this installation based on its geographical location.

ACCs condense steam from the turbine exhaust by transferring heat to the air. The steam travels down the inside of finned metal tubes whilst air is blown by fans across the outside of the tubes. As the steam loses heat it cools and then condenses. The condensate is collected in a condensate tank below the ACC unit and then pumped to a feed water tank ready for recirculation back to the boilers.

7.3 Power Generation

As previously mentioned the steam parameters are 70 bar at 430ºC. With these parameters processing of 34.53 tonnes/hour with at a calorific value of 12,300 kJ/kg the plant has a thermal power of 117.98 MW per combustion line.

The estimated nominal steam turbine power output is 76 MW (gross power). The net power output is estimated at 68.7 MW.

The power generation from the Facility is presented within Table 5. The Facility will be designed to export 68.7 MWe in phase 1 and a further 68.7 MWe in phase 2 a total of 137.3 at full operation to the grid.

7.4 Turbine

The steam turbine shall be designed to swallow 110% of the maximum boiler steam production. This allows for sufficient turbine capacity for slight overshoots and variations in steam flow, as well as givens margin if the boiler is performing better than expected.

In order to achieve a flexible operation of the plant and for safety reasons and for start-up/shutdown it is necessary to provide the plant with a possibility of operation without passing the steam through the turbine: This is done with a turbine bypass system.

The turbine bypass system function is designed to allow operation of the combustion during maintenance on the turbine without having to shut down the complete Facility.

Bypass operation is used, when the turbine cannot receive the steam due to internal malfunction (turbine trip) and maintenance works or at start-ups and shut-downs, where the condition of the steam is outside the operational range.

The bypass is able to swallow steam corresponding to 20-110% boiler load. During bypass operation (that is, operation without the steam turbine), a live steam reduction valve shall provide the necessary steam for deaerator and air preheating.

The bypass station produces slightly superheated steam of such conditions, that the condenser works properly in the whole load range.

Typical load point of bypass operation could be: steam turbine producing only house load (~2 MW) or steam turbine completely out of operation.

7.5 Export of heat

Without any changes to the main plant design, the Facility is configured so that it is possible to export heat to nearby consumers for space heating or cooling or hot water.
The turbine is constructed to export up to 20MW heat per turbine.

TNG is very interested to use this technical possibility and is actively exploring potential heat export possibilities.

7.6 Proposed design data

The proposed overall design data is summarised in the table below.

Waste-to-Energy with waste utilization Preliminary Process and Design Data Turbine/generator/condensers	
Plant Component / Parameter	**Value / Description**
Turbine design steam data	
Nominal (100%) Steam flow	Maximum continuous flowrate (MCR) in boiler combustion diagram
Steam flow nominal	144.7 tonnes/h
Steam flow rates possible	Island mode – 110% of boiler MCR
Steam pressure (inlet of Emergency shut-off valve, controlled by turbine inlet nozzle group)	70 bara
Steam temperature nominal at boiler exit	430 °C
Swallowing capacity for turbine	Corresponding to operation at 110% MCR
Swallowing capacity for bypass system	Corresponding to operation at 110% MCR
Island mode	
Electricity demand, Island Mode (preliminary for tendering)	3,0 – 6,0 MW (final value to be given during detailed engineering)
Turbine bleeds (design)	
	Approx. 5 bara to supply steam to: - air preheater - de-aerator Further bleeds foreseen for heat export if later required.
Turbine bypass station	
Steam downstream turbine bypass station Temperature	[Saturation + 5-10 °C]
Air cooled condenser	
Operation pressure	0.1 bara at 22°C ambient temperature and turbine operating at 100% MCR
Temperature inlet / outlet	46/46°C

8. ANCILLARY EQUIPMENT

8.1 Waste Cranes

Two duty and one standby waste crane with integrated weighing cells will be installed capable of operating in automatic as well as manual mode.

Full redundancy will be secured via two identical waste cranes that each alone is sufficient for feeding the hopper. The cranes shall be able to operate in automatic mode, feeding/mixing/moving, thus programmed for random homogenisation and mixing of waste when feeding is not required. The cranes shall be fitted with automatic weighing cells that feed data on the amount of waste placed in the hopper to the CMS system. A spare grab shall be present to ensure a high degree of reliability.

The waste crane grabs size and the speed of operation shall be appropriately sized to service two process lines with the duty cranes operated in semi-automatic mode, the regime being:

- The Contractor will define the unproductive time in the bunker management procedure;
- Maximum 30 minutes per hour to remove mixed waste from the bunker and feed the waste hoppers to enable the plant to operate at 100% MCR at the maximum fuel throughput as defined on the firing diagram (waste CV of 10 MJ/kg).;
- During the lorry and conveyor delivery time period the remaining time shall be sufficient to allow clearing of the tipping area and stacking, such that waste deliveries are not disrupted.
- Outside the main delivery time period the remaining time shall be sufficient to allow sufficient mixing and stacking and clearing of the tipping area.

8.2 Bottom Ash Cranes

Three bottom ash cranes will be installed with integrated weighing cells for run and standby operation, with the facility to operate both cranes simultaneously in either manual or automatic modes.

8.3 Component Cooling System

The component cooling system will supply the necessary amount of cooling water (water/propylene glycol mixture) at a specified pressure- and temperature level to the cooling water consumers connected to the system, for example the turbine.

The cooling system and its components are dimensioned for the maximum cooling need in the entire system at the most critical supply conditions.

8.4 Cranes and Ancillary Hoisting Equipment

To ensure efficient lifting of main equipment during operation and maintenance, two permanent cranes are installed:

- Workshop Crane, load capacity 5 tonnes
- Turbine Hall Crane; load capacity 72 tonnes
- Lifting hoists in boiler hall

Ancillary hoists will be installed in such a way that all major pieces of equipment and plant can be serviced and replaced efficiently throughout the plant where major equipment and components are installed.

It is important that maintenance and repair can be carried out efficiently at any given time to maintain the high plant availability. For this reason, cranes as well as galleries etc. are planned and established throughout the facility to ensure that all components can be serviced and replaced quickly and safely.

8.5 Proposed design data

For proposed overall design data please refer to table below.

Waste-to-Energy with waste utilization Preliminary Process and Design Data Ancillary Equipment	
Plant Component / Parameter	**Value / Description**
Waste	
Waste density within closed grab to be used for crane cycle calculations.	500 kg/m^3
Average density of the waste in the bunker before compression to be used for calculation of capacity	350 kg/m^3
Crane construction for waste cranes (both phases)	
Number of cranes	3 semi-automatic waste cranes
Crane capacity (per crane in semi-automatic mode)	
Charging waste hopper (nominal)	34.53 t/h
Compressed Air (per phase)	
General	
Total installed compressor capacity for process and instrument air	4x37% or 5x28% of total demand of one phase
Process and Instrument air	
Maximum size of particles:	0.1 µm
Maximum concentration of particles:	0.1 mg/m^3
Dew point:	-40 °C
Maximum oil content:	0.01 mg/m^3

9. CONTROL AND MONITORING SYSTEM

In order to control and monitor all the processes and components and to support automatic operation of the EfW Plant, a Control and Monitoring System (CMS) is required.

The CMS is an automated system used to operate the plant and ensure the safety of personnel and equipment. The CMS operates the Facility processes, machinery, and drives. It also covers information management, quality control, and mechanical and field device condition monitoring.

The CMS replaces the following equipment:

- Operator Level
- Server stations
- Process stations
- System network (redundant Ethernet network)
- Bus systems to Remote I/O stations
- Communication to HV system
- Link to Turbine package unit

The CMS consists of the following levels:

- Plant level: Process equipment, sensors, actuators, probes and analysis devices
- Automation level: Process control, automated devices and autonomous systems, safety systems (SIL = Safety Integrated Level)
- Process control level: Monitoring and controlling of process, data acquisition, programming tools
- Plant control level: Management, maintenance and supervision
- Interface to management systems and the office network.
- Interface for remote access
    - CEMS (Continuous Emission Measuring System)
    - Remote maintenance
    - Data and trends

The CMS will perform the dedicated control and monitoring tasks for specific equipment in the plant and support operator control of the said equipment, and support full-automatic and semi-automatic operation and control of the various process sections of the plant, and support plant operation staff in operation, control and monitoring of the entire plant. Furthermore, the CMS shall support plant operation staff in reporting to internal as well as external parties (e.g. supervising authorities) and support plant maintenance staff in planning, organisation and performance of maintenance of the plant. The CMS shall also enable automatic generation of environmental reports and provide maintenance schedules in accordance with license requirements.

The CMS overall configuration is illustrated in the topology drawing, Figure 10.

The CMS-system will be constructed with a number of operator stations from where operation and monitoring of all the facilities are performed. The operator stations shall mainly be located in the control room. If a specific process demands a local operation, it should be possible to place local operator screens at the process. The operator stations shall communicate with the process control stations through a safe redundant process network.

The process control stations will be established as autonomous processor-based units, which independently of any fault in the overall process network or operator stations shall be able to control, monitor and protect the facility equipment.

An engineering station will be established for configuration, programming, analysing, etc. the system. Furthermore, a common report server for operational and environmental reporting shall be established. Printing facilities, including colour laser printer, shall be available in the control room, to be used for printing of reports and documentation. A connection to the operation and maintenance system (O&M system) will be established, to update the O&M system with plant information, information from electrical components of the facility, for scheduling of preventive maintenance work. Access to the O&M system shall be provided from the control room and administration areas.

All electronic equipment, except monitors, keyboards and printers, will be installed in a dust-free and temperature-controlled environment. It is common to have an air conditioned server room close to the control room, where all the electrical equipment can be located safely.

A redundant control network for communication between all process stations will be established. It must be possible to access all information from each operator station. This process network will also be the interface to the network of the administrative system. The network must be constructed with intelligent firewalls, routers and switches to separate the process network with the administrative network. The network must be constructed with optical cable or cobber cable. Wireless network is not allowed, except for maintenance purpose (Service Laptops). The routers and the components on the network shall be based on the technology Simple Network Management Protocol (SNMP), which entails that diagnosis and operational information from the individual (SNMP) components can be transferred to further processing in the O&M system.

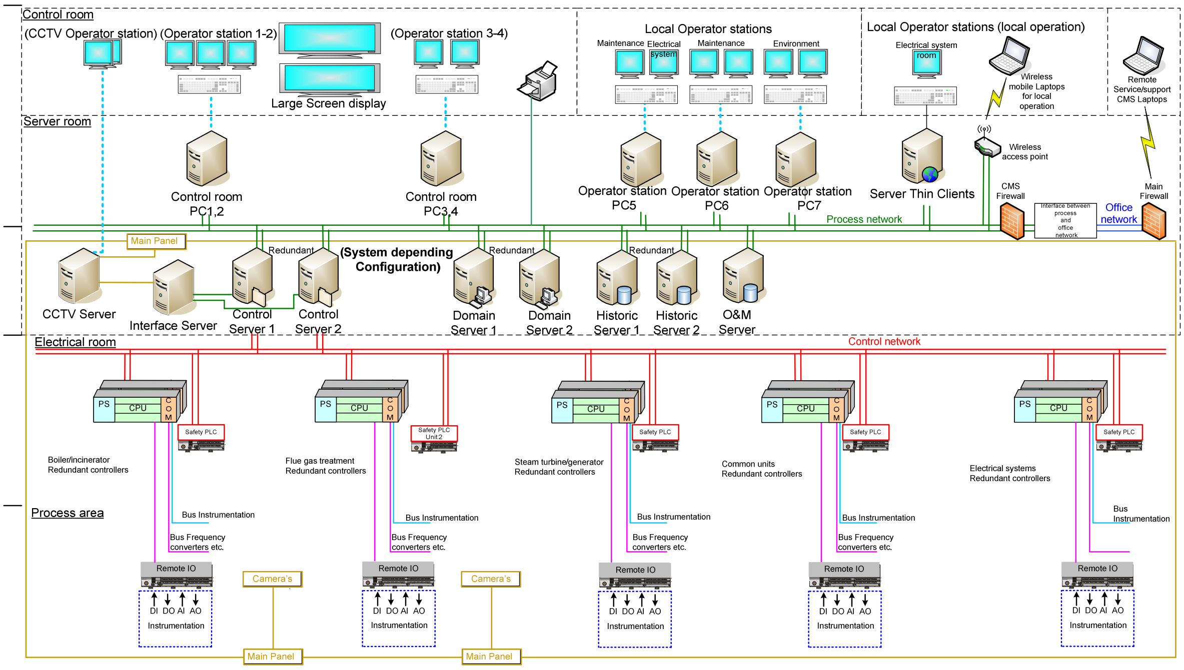

Figure 10 CMS configuration

9.1 Overall CMS Operation Philosophy

The following requirements regarding operation philosophy shall be observed:

- The total plant will be controlled and monitored from the operator stations in the control room. It shall be possible to carry out all control and monitoring functions by means of the operator stations. Under normal conditions it shall be possible for one operator to control and monitor the entire plant from the operator stations in the control room.
- Independent of the chosen level of operation and control, the CMS will ensure that the total plant can be controlled and operated in a secure and satisfactory manner. This includes personnel safety, plant safety and operational reliability. All operator actions shall be subordinate to the safety systems of the CMS. In case of faults in the plant, or in the CMS itself, partially or totally, the CMS shall ensure that the faulty part of the plant is brought into a controlled and secure condition.
- The operator will have full information from the entire plant available in the CMS, to help with decision making and issuing commands through the CMS. The operator is the person in charge and it is the obligation of the system to provide adequate and correct information, presented in an easily understandable manner. To do this, the CMS must be able to produce the following lists:
  - Presentation of the plant processes and object status
  - Indication of historical trends
  - Event and Alarm handling
  - Reporting system, for different reports.

Access shall be limited. It shall be possible to limit access to all or part of the system through the use of password protection.

9.2 CCTV

A common camera surveillance system (CCTV) with monitors in the control room, to which all cameras for the plant area are connected, shall be installed in the server room. It shall be possible to operate and select cameras from a position close to each operator stations in the control room.

10. ELECTRICAL SYSTEM

10.1 Electrical Installation

The following voltage levels shall be in use in the Facility:

Rated operating voltage	Maximum voltage of equipment	Neutral treatment	Purpose
11 kV AC	12 kV	Insulated high resistance earthing	Generator voltage and high voltage distribution.
710/415/240 V AC	+10%,-6%	Solidly earthed	Mains power distribution.
110 V DC	110 V	Isolated	Control voltage only where 24 V cannot be used and only available with the written approval of the Company's Representative.
24 V DC	24 V	Earthed negative	Control voltage, fire alarms.
24 V AC	24 V	Safety insulation	Safety voltage for lighting.

Table 16 Plant voltage levels

The steam turbine generator is expected to generate electrical power at 11 kV and will be connected on to the Facility 11 kV power distribution system and to the distribution network operator's network through a step-up transformer.

Each turbine generator will provide the electricity to operate the rest of the Facility. Electricity will normally be exported to the grid, but the grid connection will also allow for import of electricity back to the turbine halls for start-up of the whole Facility.

In addition, it shall be possible to supply power from one Power Island to the other via appropriate switching, including all necessary synchronisation and automatic controls. This should enable either power island to supply the other, whether operating in island mode, in the event of an emergency, or as desired during normal operation. An appropriate power management system shall be provided enabling all the necessary functionality.

All switchgear, control gear and fuse gear will be located indoors, in metal-clad sheet steel cubicles with front access doors. The equipment will be selected from manufacturers' standard product range and be fully type tested in accordance with relevant Australian, European and International Standards.
The equipment will be rated to withstand the mechanical forces and thermal effects of the maximum prospective fault current at the point of application.
In normal operating conditions, the power requirements of the Facility will be supplied by the steam turbine generator with the balance exported to the grid.

In the event of a breakdown of the steam turbine generator, the power for the site parasitic load will be supplied from the grid.
It is anticipated that the steam turbine will be capable of operating in island mode. In the event of a loss of grid connection, this would allow the Facility to continue processing fuel with the auxiliary load supplied form the turbine generator.
Emergency diesel generators will also be available for safe shut down of the Facility in the event of a loss of grid connection and failure of the steam turbine to transfer to island mode operation.

10.2 Transformers

Following transformers are used in the facility:

- Power transformers – 132/11 kV;
- Auxiliary transformers – 11/0.415 kV or 11/0.71kV;
- Unit transformers – 11/11 kV

10.3 Protection

The protection system will be designed that in the event of faults occurring, the faulty plant is safely disconnected, whilst continuity of supply consistent with system stability is maintained. The selection and setting of protection devices for the auxiliary system will be based upon the following major requirements:

- Faults on facility items will be disconnected as quickly as possible to minimise damage;
- Faults external to major power sources, e.g. unit transformers, will only open the circuit breaker controlling these power sources after all other protection nearer the fault has failed;
- Faults internal to major power sources shall cause their circuit breakers to open as fast as possible to ensure that the transmission system can restore itself within the limits of stability;
- The protection will be designed to be stable in transient conditions such as motor starting and will not operate for current surges caused by faults external to the auxiliary system, for which the main generator would recover and the item of plant protected would not be damaged; and
- Protection of plant is designed to match the plant operating characteristics and provide discrimination with other plant.

All circuits will have lockable isolating facilities so that they can be disconnected and worked upon in complete safety.

10.4 Electrical Works

The Facility will include standard electrical equipment, selected based upon safety, reliability and quality.

No single failure of a major part of the auxiliary plant should result in the total shutdown of the main generating plant.

Essential supplies systems will be provided to maintain unit output and to protect plant from damage, due to a loss of supply. The systems will be sized to enable the station to be shut down in a safe manner on loss of transmission supplies and afterwards to allow normal supplies to be re-instated following reconnection.

Suitable earthing and lightning protection will be provided.

10.5 Emergency Power/UPS

It is critically important that failure of the grid or other power failure does not result in either damage to the plant or in excessive emissions to the atmosphere. Therefore, uninterrupted power supply (shall be supplied in order to maintain control of the plant at power supply failure) and emergency diesel generator (the UPS can only supply power for smaller components - primarily the CMS) are installed in order to slowly run-down the plant at failure of the grid. The diesel generator will require suitable housing / positioning to limit the risk of noise impacts.

The main emergency power supply shall be from the emergency generators and shall be sufficient to permit the re-start of all necessary Plant control systems and equipment following a full Plant trip to permit the safe shut-down of the Facility. The emergency diesel generators are specified in chapter 10.5.1.

In addition battery back-up emergency systems (DC, UPS), as required for the safe shut-down of Plant components, shall be supplied.

10.5.1 Emergency Power

The two emergency diesel generators shall supply Emergency power to the selected items of Plant as required by TNG for the four incineration lines. They will not be used for shutting down and starting up the plant in the case of planned (scheduled) outages, or forced (unscheduled) outages.

The emergency generators shall be designed for continuous operation. In addition to providing emergency power supplies to essential users, the generators shall be designed for operation when:

1. synchronised to the grid;

2. synchronisation of the diesel generation set with the Site distribution system for testing purposes; and
3. automatic switching of the diesel generation set to the Site electrical connection so that the Site supply can be restored without disruption of the essential services.
4. Black start of one incineration line

In case of a complete breakdown of the normal auxiliary power supply, the emergency generators shall be sufficient to meet the electrical demand of at least the following consumers:

1. essential air conditioning, including boiler house/turbine hall chiller equipment and air conditions units for all main LV/HV switchgear/distribution rooms, Plant control room, relay rooms, and the CEMS rooms;
2. all drives and electrical devices necessary for the safe control and shut-down of the entire Facility and its associated systems;
3. 110 V DC and 240/415 V UPS systems;
4. Plant control room lighting and air conditioning systems;
5. radiator fan, diesel oil transfer pump and all other drives required for diesel generator operation;
6. ventilation fan of diesel engine room;
7. oil pump and turning devices for turbine shut down;
8. generator shut down heaters;
9. emergency lighting system, including in all main LV/HV switchgear/distribution rooms, central control/relay rooms, escape routes, exits, etc;
10. essential task and access lighting systems;
11. HV and LV switch-gear and switch-gear rooms;
12. weighing systems in weigh-bridge area;
13. Site access barriers;
14. passenger lifts, goods lifts;
15. Site fire pumps and fire detection, protection and alarm systems;
16. all other essential services/equipment/areas.

10.5.2 UPS

Supplies for protection, tripping, alarm, control, instrumentation, emergency drives, emergency lighting, communication equipment etc. as defined, shall be maintained by means of batteries for a period of not less than 1 hour in the event of loss of all normal means of supply.

Each DC system shall be supplied by one 100% battery and one associated 100% charger. Each charger shall be capable of simultaneously float charging the battery and supplying the total load.

The UPS requirements are:

	Parameter	Requirement
i	Output voltage	As required by the particular application
	Static tolerance	+ 1
	Dynamic tolerance	+ 4% for 100% load change
ii	Output frequency	50 Hz
	Tolerance	+0.2 to + 0.3% adjustable, synchronised to mains
iii	Harmonic distortion	<2% for linear load
		<5% for non-linear load
iv	Overload capability	150% for 1 min, 125% for 10 min
v	Short circuit current	2 x rated current for 10 seconds
vi	Ambient temperature range	$0\text{-}40^{0}C$
vii	Cooling	Forced ventilation (redundant)
viii	Noise level	60dB (A) max

Table 17 UPS requirements

11. CIVIL WORKS AND LAYOUT

11.1 Background

The capacity of the Facility cannot be treated in a single combustion system. As single combustion system of the required size cannot be supplied. Therefore, the Facility will be configured as a four combustion line system.

The Facility will be built in two phases. Lines 1 & 2 being built in Phase 1 and Lines 3 & 4 being built in Phase 2 when the applicant can demonstrate the required quantity of Fuel is available to the Facility.

Each phase will comprise of two combustion grates and two boiler systems housed in one building and each boiler has its own independent Flue Gas Treatment system and connecting to one turbine enclosed in the adjacent Turbine Hall, connecting to one air cooling system and one emission Stack and the other auxiliary elements connecting the process.

In Phase 1 the entire Tipping Hall, Waste bunker Administration and workshop will be constructed as well as full sized underground infrastructure, substation, detention basins and back-up systems, to ensures no synergies or efficiencies of the facility are lost with the two phase approach and the external appearance is not altered between the construction of the two phases.

The Development will include the following elements:

- Four combustion lines and associated boilers;
- Cooling systems comprising air cooled condenser (ACC) units;
- Flue gas treatment systems, including residue and reagent storage silos and tanks;
- Emissions stacks and associated emissions monitoring systems;
- Steam turbines and generator housed within a turbine hall;
- Two auxiliary diesel generators.
- Buildings:
    - tipping hall and fuel storage (common to both phases);
    - boiler hall x2 ;
    - turbine hall x2;
    - substation;
    - bottom ash collection bay x2;
    - workshop (common to both phases);
    - stack x2; and
    - control room, offices and amenities (common to both phases).

- Control room, offices and worker amenities;
- Hard-standing, internal vehicular access roads, vehicle turning and waiting areas;
- Fuel reception and storage facilities, consisting of a tipping hall and vehicle ramps,
- Fuel storage bunker and cranes;
- Consumable Materials Handling and Storage area for raw materials including hydrated lime,
- ammonium hydroxide, activated carbon, Low Sulphur gas oil , oil, and water, bottom ash handling systems, compressed air systems;
- Process effluent storage tanks;
- Demineralised water treatment plants;
- Fire water and fire protection facilities;
- Administration and control buildings; and substation.

Associated and supporting components of the development will include:

- Subdivision of the land;
- Pedestrian footpaths and routes;
- Internal roadways and weighbridges (x 2);
- Direct underpass connection (Precast Arch and Conveyor Culvert) between the proposed Facility and the Genesis MPC;
- Staff car parking for 40 vehicles (including 3 visitor parking spaces);

- Water detention and treatment basin; and
- Services (Sewerage, Water Supply, Communications, Power Supply);
- Signage;
- CCTV and other security measures;
- External lighting; and
- Hard and soft landscaping and biodiversity measures.

The proposed buildings have varying footprints and heights, with the maximum height reaching 52 metres above ground level, and the stacks reaching 100m. The indicative dimensions of the buildings and various components of the facility are outlined within the table below.
Various components of the facility are outlined within the Table 18.

Building	WIDTH (W)	LENGTH (L)	HEIGHT (H)
Tipping Hall	109	50	20.5
Waste Bunker	94	30	50 (included 7m below ground level)
Boiler House (per phase)	50	60	52
Flue Gas treatment (per phase)	45	47	37
Stack with two inner flues (per phase)	Outer diameter 3		100
Turbine Hall (per phase)	34	46	26
ACC (per phase)	50	50	23
Bottom Ash collection area (per phase)	47	13	19
Sub Station ($4000m^2$) common	63	63	20
Office Block	15	31	11
Workshop	32	35	16.5
Control Room	10	38	38
Weighbridge (in)	40	16	10
Weighbridge (out)	38	15	10
Fire water Tank	14.7	13.7	9
East Amenities	30.5	7	4.5
West Amenities	19	6	4.5

Table 18 Main Building Dimensions for the Facility (meters)

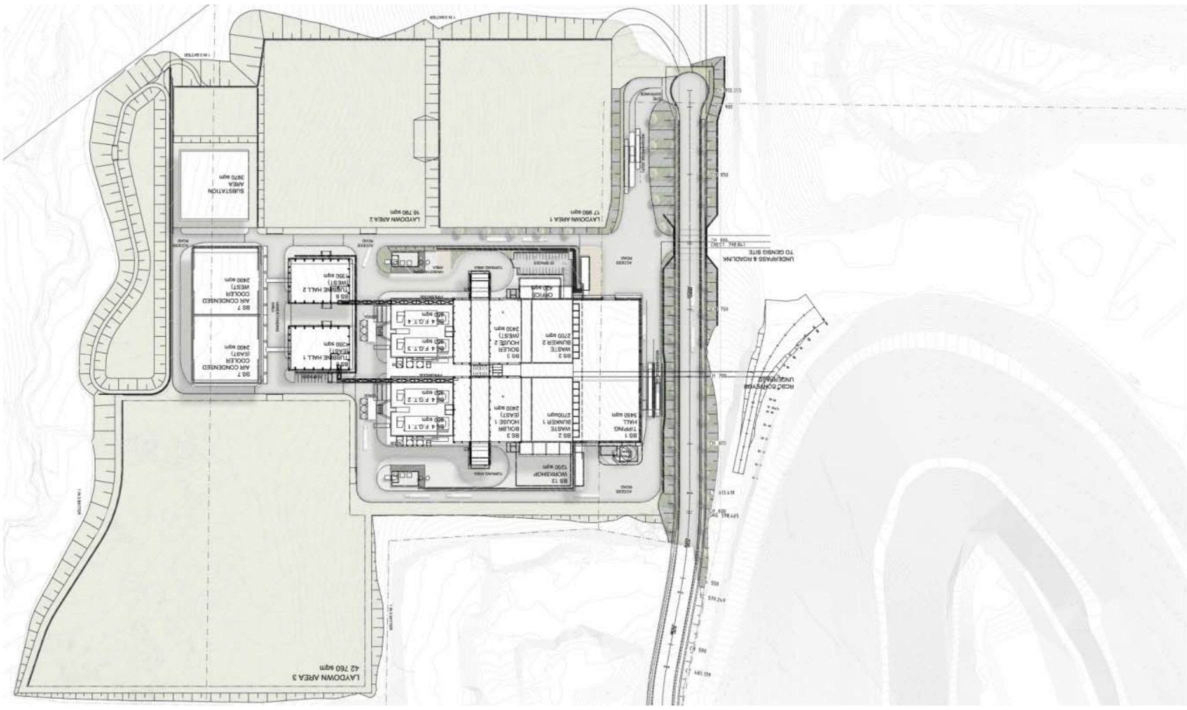

Figure 11 Site Layout

The above dimensions have been developed based in consultation with the technology provider (HZI) and the appointed construction company (Brookfield Multiplex) to ensure optimal functionality of the Proposed Development taking into consideration the unique site typography.

Figure 12 Building layout

11.1.1 Site Layout

Traffic areas are designed in accordance with the national regulations. The design takes into account the peak vehicle movements and any associated queuing or standing time in order to avoid trucks/cars cueing onto the public road. Furthermore, the design will separate the heavy traffic from the light traffic for safety reasons.

11.1.2 Entrance/Weighbridge

The proposed Facility will provide two new weighbridges to be constructed within the boundary of the Site on Precinct Road (one on entry and one on exit).

Fuels from external transfer stations and recycling facilities will be delivered via road vehicle. These vehicles will enter the Site through the main entrance off Precinct Road which is being constructed as part of this proposal.

Once vehicles have entered the site they will proceed to the weighbridge where the quantity of incoming fuel is checked and electronically recorded. Vehicle loads will be inspected at the weighbridge to confirm the nature of incoming fuel and only authorised fuel will proceed to the fuel reception area.

Loads will be nominally 22 tonnes for all fuel types. Fuel can be sampled from the vehicle at the weighbridge. The weight of the outgoing vehicles will be recorded on a separate weighbridge as they leave the Site.

Fuel from the Genesis MPC will arrive at the proposed Facility in two ways as described below. The incoming fuel will be pre-weighed and its details recorded at the Genesis Xero Waste Facility before transported to the Facility:

- By a conveyor transport system which will carry the residual waste output of the Genesis MPC. It will travel via the culvert under Precinct Road and will eject directly into the storage bunker.
- Some vehicle transport from Genesis MPC will be required and when this occurs it will be via the archway under the Precinct Road (to be constructed as part of the DA consent). Vehicle transport via the culvert under Precinct Road will also be used in the event the conveyor is out of service.

Out bound movements along the road may include unrecyclable wastes that are extracted from mixed waste stream at the pre-sort stage prior to be feed into the recycling plant

11.1.3 Process Building

The layout of the facility has been informed by a range of operational requirements of key components including the furnace boiler and flue gas treatment that are required to have a linear arrangement.

Below a number of issues which have impact on the layout of the facility and which are reflected in the proposed layout of the plant:

<u>Tipping Hall:</u>

- Full enclosed tipping hall through individual tipping gates
- Number of tipping bays (please refer to Chapter 4.2)
- Width and geometry to allow for efficient use and safe traffic manoeuvring
- Inspection area

Waste Bunker:
- Volume (please refer to Chapter 4.1)
- Depth (ground conditions/foundation/required tipping height)
- Diversion (sorting)
- Direct view from control room into waste bunker
- Waste crane maintenance area

Boiler Hall:
- Boiler configuration (horizontal/vertical)
- Boiler support integrated in primary building structure
- Bottom ash storage below the horizontal part of the boiler
- Combustion equipment arrangement and accessibility

FGT area:
- Flue gas treatment equipment arrangement
- Consumables silos
- Residue silos

Turbine Hall:
- Arrangement of turbine and water-steam cycle equipment
- Crane accessibility
- Area needed for maintenance and laydown area for turbine casing/rotor etc.

Bottom Ash Handling:
- On-site storage
- Storage capacity
- Crane accessibility
- Safe loading

Workshops:
- Maintenance philosophy (own staff/external)
- Separate mechanical and electrical workshop
- Needed area (closely linked to philosophy)

General:
- Crane accessibility
- Area for operation and maintenance
- Escape routes

Control Room/Offices/Staff Rooms
- Reception area
- Toilet/welfare facilities
- Employee mess room and kitchenette area
- Lift and stair access to all floors of the plant
- Office areas and meeting rooms
- Control Room

12. OPERATION

12.1 Start-Up and Shut-Down

The Facility will be started and stopped automatically, but under the supervision of trained operators. This means that the control system will start the Facility in a controlled and safe manner, but the operator will have various "hold" points where checks are made before proceeding to the next stage. The Facility will be started using fuel oil to reach safe combustion temperatures before any solid fuels are added. The flue gas cleaning system and emissions monitoring will be in operation before any solid fuel is added.

If the operator wishes to turn the Facility off, this is carried out in a controlled manner by reversing the start-up process. Solid fuel feeding is stopped, but the Facility continues to operate to ensure that all material is burnt and any flue gases are cleaned out of the system. Air flows are left on to allow the boiler to cool down before the Facility is fully shut off.

If any emergency condition is reached, or if a rapid facility shut down is required, the Facility will stop automatically in a rapid manner. Fuel flows and air flows are stopped instantly which causes combustion to stop very quickly. The boiler can be depressurised via safety valves if required. This system is fully interlocked to prevent manual intervention unless it is safe to do so.

The Facility is also protected in case of a complete loss of power, a "black plant" trip. In this case, the Facility will stop as under an emergency stop. The Facility will be provided with a secure electrical supply to provide power to essential consumers such as oil pumps, feedwater pumps, instrument air, fire pumps and emergency lighting. Control systems are supplied from a UPS system (Uninterruptable Power Supply) to ensure the operators are aware of what is happening.

12.2 Staff

The Facility will be operated and managed by suitably qualified and trained personnel. It is anticipated that a total of 55 staff will be employed of which 4 will be managers and 3 will be supervisors.

The shift teams will be led by experienced engineers who will have the responsibility for managing the operation of the Facility outside of office hours.

.As detailed in section 9 there will be a high degree of automation in the facility with the plant and key processes controlled from a central control room using a state of the art control system based on programmable logic controllers.

A fully automatic waste grab crane is to be installed which removes the need to man the grab crane except during peak waste delivery times. The weighbridge will also be fully automated with a vehicle recognition system and traffic barrier control system. Table 19 outlines the anticipated staff members required.

Role	Number of staff (Indicative)
	Overall Facility
Facility Manager	1
Operations Manager	1
Engineering Manager	1
Supervisor/Engineer – Mechanical	2
Supervisor/Engineer – Controls;	2
Supervisor/Engineer – Electrical;	2
Shift Engineers	6
Process Operatives	15
Day Team Supervisor	1
Weighbridge Operatives	2
Multi Skilled Labourers	9
Maintenance Technicians	10
Administrators	2
Compliance Manager	1
Total	**55**

Table 19 Staff required

13. R1 CALCULATION

The NSW Energy from Waste Policy Statement of Environment Protection Authority (EPA) states that:

"This Policy Statement is restricted in its scope to facilities that are designed to thermally treat waste for the recovery of energy rather than as a means of disposal. The net energy produced from thermally treating that waste, including the energy used in applying best practice techniques, must therefore be positive.
The R1 energy efficiency formula from the European Waste Framework Directive has been adopted with R1 to be ≥0.65 as the minimum total system efficiency threshold that must be met for a facility to qualify as an energy recovery facility.
Where these criteria are met, the facility will be licensed as 'Energy Recovery' under Schedule 1 of the Protection of the Environment Operations Act 1997, and therefore the waste and environment levy will not apply to waste received at the facility."

European Commission has produced a revised Directive on waste, which has replaced the old Waste Framework Directive (WFD) as of 20th October 2008. In this revised Directive, incineration facilities for municipal waste can be regarded as "Recovery" operations if the energy efficiency of the plant is greater than 0.65 for plants permitted after Jan 2009. Plants which do not meet this criterion are classed as "Disposal" operations and therefore lie on the same hierarchical level as landfill.
The definition of energy efficiency used in the revised Directive is:

$$\text{Energy Efficiency} = \frac{\left(E_p - \left(E_f + E_i\right)\right)}{\left(0.97 \times \left(E_w + E_f\right)\right)}$$

Ep	*means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (units of GJ/yr)*
Ef	*means annual energy input to the system from fuels contributing to the production of steam (units of GJ/yr)*
Ew	*means annual energy contained in the treated waste calculated using the lower calorific value of the waste (units of GJ/yr)*
Ei	*means annual energy imported excluding Ew and Ef (units of GJ/yr)*
0.97	*is a factor accounting for energy losses due to bottom ash and radiation.*

The interpretation of the R1 formula has proved to be difficult. Accordingly, the European Commission set up an expert panel to discuss this. The panel has prepared a guidance note "for the use of the R1 energy efficiency formula for incineration facilities dedicated to the processing of Municipal Solid Waste", which has now been adopted by the European Commission.

We have therefore used the formula, interpreted in accordance with the guidance, to assess the energy efficiency of the Facility. The calculation is based on predicted design figures and predicted levels of fuel consumption and electricity usage.

The R1 efficiency is predicted to be 0.86 (based on gross generated power) which is well above the threshold for new incineration plants. Therefore, the Facility will meet the definition of recovery.