FICHTNER

THE NEXT GENERATION NSW PTY LTD (TNG EFW)

ENERGY FROM WASTE FACILITY, EASTERN CREEK

CONCEPT DESIGN REPORT

Fichtner Consulting Engineers Limited
Kingsgate (Floor 3), Wellington Road North,
Stockport Cheshire SK4 1LW United Kingdom
t: +44(0) 161 476 0032 f: +44(0) 161 476 0618 www.fichtner.co.uk

THE NEXT GENERATION NSW PTY LTD
(TNG EFW)
ENERGY FROM WASTE FACILITY, EASTERN CREEK
CONCEPT DESIGN REPORT

Document Production & Approval Record				
ISSUE NO. 6	**NAME**	**SIGNATURE**	**POSITION**	**DATE**
Prepared by:	Stephen Othen		Technical Director	11/03/2015
Checked by:	James Sturman		Consultant	11/03/2015

Document Revision Record		
ISSUE NO.	**DATE**	**DETAILS OF REVISIONS**
1	22/11/2013	First issue to client
2	26/11/2013	Second issue based on the Client's comments
3	28/11/2013	Third issue based on the Client's comments
4	12/06/2014	Finalise report for consistencies with planning application
5	24/02/2015	Revisions for planning application submission
6	11/03/2015	Further revisions for planning application submission
7		

MANAGEMENT SUMMARY

The Next Generation NSW (TNG) are currently proposing to construct an Energy from Waste Facility (the Facility), in two phases, with the capacity to process up to 1.35 million tonnes per annum (tpa) of residual waste. The proposed development involves the construction of an Energy from Waste (EFW) Electricity Generation Plant for The Next Generation NSW Pty Ltd (TNG) in Eastern Creek, approximately 36km west of the Sydney CBD. A planning application will be made to cover the entire facility but construction will be in two phases.

The following residual waste fuel types are considered as the main sources of fuel for the Facility;

- Chute Residual Waste (CRW) from the Genesis Facility;
- Commercial and Industrial (C&I);
- Construction and Demolition(C&D);
- Flock waste from car and metal shredding;
- Paper pulp;
- Glass Recovery;
- Green Organics (GO);
- AWT; and
- MRF residual.

The fuel will be delivered to site by road and by conveyor from the RRF.

TNG have provided initial waste composition data, based on local waste, and based on this the design fuel will have a net calorific value (NCV) of 12.34 MJ/kg. Based on the design fuel NCV, the Facility will have capacity to treat up to 1,105,000 tpa of fuel.

Composition and NCV will vary for each fuel type. The Facility will need to be designed to operate efficiently within an NCV range to maximise operational flexibility. Currently the firing diagram is based on an NCV range from 10 MJ/kg to 16.5 MJ/kg. This will need to be discussed and agreed with potential technology suppliers. To maintain the planned generating capacity with the proposed NCV range the fuel requirement could vary from approximately 820,000 tpa to 1,350,000 tpa.

The Facility will be designed to have a thermal input of 469.6 MW (117.4 MW for each boiler line) at the design point. The Facility has an assumed net electrical efficiency of circa 30%. The Facility will be designed to export circa 140 MW_e (30% X 469.6MW). This value is considered challenging but deliverable based on the proposed design fuel and facility design. High net electrical efficiency is a priority for TNG, and there are a number of options which could be incorporated into the design to increase the efficiency further including steam reheat and flue gas cooling.

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

The technology proposed for the Facility is a moving grate system with water cooled grate bars. This system is likely to offer 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) which has been reviewed in section 4.5.4. ACCs are considered to be the preferred option as there are no major water courses nearby to the site which could be used for turbine cooling. The advantages of using an ACC are that it does not require large volumes of water and does not generate an effluent discharge. There is no visual plume impact of the ACC, as there would be for evaporative cooling.

The Facility would comply with the requirements of the European Commission's Industrial Emissions Directive (IED). We have assumed that the Australian planning and consenting regime is similar to that in the UK. Therefore, throughout this report, we have referred to the relevant guidance notes published by the UK's Environment Agency (EA).

The flue gas treatment system will be designed to achieve the emission limits as required by the Industrial Emissions Directive. The proposed flue gas treatment system will consist of Selective Non-Catalytic Reduction (SNCR) of NO_x, 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 if this is viable.

The Facility will generate three types of solid by-products:

- bottom ash, a non-hazardous waste;
- boiler ash; and

- flue gas treatment residues, which as a hazardous waste will require special handling and disposal arrangements.

The facility will produce no excess effluent during operation.

A Facility layout has been produced for a four stream facility. It has been assumed the Facility will be built in two phases with a number of common elements.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Introduction

The Next Generation NSW (TNG) are currently proposing to construct an Energy from Waste Facility (the Facility), in two phases, with the capacity to process up to a 1.35 million tonnes per annum (tpa) of residual waste. It will be sited on land adjacent to the Genesis Xero Waste facility, which is located at Honeycomb Drive Eastern Creek (off Wonderland Drive), Sydney.

TNG is in the process of developing a submission for a planning application to the Australian regulatory authorities, which will cover both phases of the facility. Phase 1 will be the construction of streams 1 and 2 and Phase 2 is the construction streams 3 and 4. These phases operate completely independently of each other but any overlapping infrastructure will be constructed in Phase one so no synergies and production benefits are lost. To support the planning process TNG has requested technical support in the development of the 'Concept Design' for the Facility.

This report is intended to outline the initial concept design for the Facility. Discussion will focus on initial considerations of the key engineering design and technology aspects of the project including the risks associated with design, construction and operation. It should be noted that this is purely a concept report created as a preliminary plain English document to establish a guide for other consultants in the project team to use and develop if appropriate to suit the actual environment and location of the EfW Facility.

1.2 Background

The site is located at Eastern Creek in the central western suburbs of Sydney NSW, approximately 36 km west of the Sydney CBD, 18 km west of Parramatta and 12 km east of Penrith. The site is wholly within the local government area (LGA) of Blacktown, situated in the area known as the M7 Business Hub. The site and surrounding lands to the north-east, east and south are zoned for future industrial redevelopment as part of the 'Eastern Creek Business Park'. The Business Park is planned to create a major employment hub for western Sydney.

The site is bounded by the Genesis Recycling Facility and Landfill to the north, Archbold Road to the west boundary and Department of Planning Land and open grazing land to the south owned by Jacfin Pty Ltd and along part of its eastern boundary. The Hanson & Fulton Hogan Asphalt Batching Plant and Fulton Hogan yard ("Hanson site") is located along the remainder of the eastern to the West and Seargants to the North West. An aerial photograph of the site and location layout plan is presented in Figure 1 and Figure 2.

Figure 1: TNG EfW Site aerial photograph

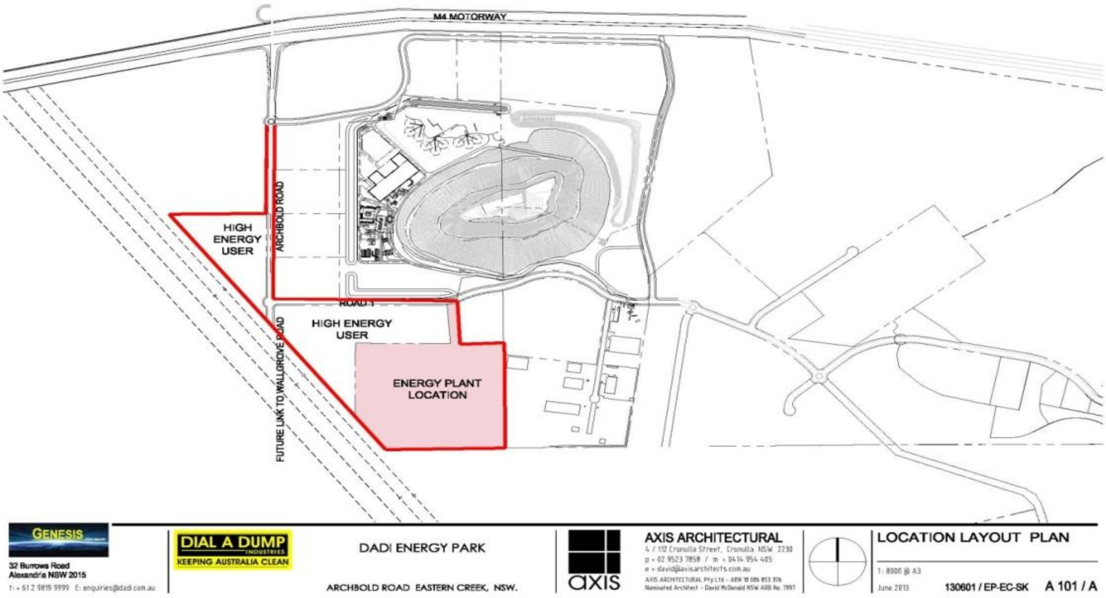


Figure 2: TNG EfW Site location

1.3 Objectives

This report covers the initial considerations of the key engineering design and technology aspects of the project. In particular the following topics are covered:

(1) description of EfW technology;

a) review of the possible fuel types to be treated in the Facility and the acceptable fuel range and presentation of a proposed design fuel mix;

b) review of the possible technology and facility's performance;

c) discussion of the main process equipment including but not limited to the:
- combustion system;
- boiler;
- flue gas treatment;
- stack;
- turbine; and
- electrical systems;

(2) requirements for the fuel, consumables, ash reception and storage;

(3) a summary of the operational and control philosophy for a "typical" EfW facility:
- Fuel Handling and Control;
- Process Control;
- Emission Control systems;
- Start-Up and Shut-Down; and
- Staffing levels.

(4) identification of "typical" consultation activities implemented on EfW schemes within the UK.

(5) design input information for developing the Environmental Assessment:
- inputs for air quality assessment; and
- inputs for noise assessment.

(6) provision of a "generic" layout for the facility for the development of the Concept Design.

2 CONCLUSIONS

This report suggests a basic design for the multi-fuel facility based upon the following parameters:

(1) A design residual waste fuel based upon a mix of 23% Chute Residual Waste Fuel from the Genesis Facility, 29% Construction and Demolition (C&D) residual waste fuel, 17% C&I residual waste fuel, 14% flock residual waste fuel, 5% paper pulp residual waste fuel and 12% other residual waste fuel is proposed, with a net calorific value of 12.34MJ/kg;

(2) The range of acceptable fuels needs to be as wide as practical, and the acceptable range will need to be discussed with technology suppliers. Based on an initial assessment of expected waste types, an initial design range is proposed with a NCV ranging from 10-16.5 MJ/kg. The grate size is determined by the lower NCV limit, and since it is possible to have waste with an NCV as high as 16.5 MJ/kg, it is better to maintain the maximum NCV range possible. Lower NCV waste could still be processed but power output would be reduced.

(3) A grate based system will provide the most flexibility. The possible options are either a vibrating grate or a reciprocating grate, with a reciprocating grate being recommended for the proposed scale.

(4) The Facility will consist of multiple streams which will provide a maximum combined capacity to treat approximately 1,350,000 tpa based on approximately 8,000 operational hours per year. The optimum combination is a four stream facility, with a thermal capacity of 117.4 MW_{th} each, exporting approximately 140 MW_e in total. At this size, each unit would be towards the top end of the demonstrated capacity and there may be limited suppliers capable of supplying such a facility.

(5) Each unit would be fitted with conventional flue gas treatment equipment, consisting of Selective Non-Catalytic Reduction (SNCR) of NO_x, lime abatement of acid gases, the addition of activated carbon to minimise the emissions of dioxins, mercury and other heavy metals and a bag filter to remove particulates, including the lime and activated carbon particles. The Facility would meet the requirements of the EU Industrial Emissions Directive (IED).

(6) It is proposed to construct the Facility in two phases, with two independent streams turbines being provided.

(7) The concept design is based on a fuel bunker sized to store approximately 5-7 days of throughput material.

(8) The electrical connection will be made into the electricity distribution network operator's voltage to match local HV network.

(9) Based upon the proposed maximum design, the Facility would process up to 1.35 million tpa of mixed residual waste.

(10) The Facility will generate up to approximately 321,000 tpa of wet bottom ash, although the ash production from the design fuel would be around 159,000 tpa. Much of this ash may be recycled as secondary aggregate after maturation and grading. In addition, approximately 51,700 tpa of flue gas treatment residue would be produced.

3 RECOMMENDATIONS

This report provides a preliminary design for the Facility. However, there are many variables and to optimise the design to match TNG's expectations, some decisions and further work are required as stated below:

Fuel

(1) A design fuel and fuel range are proposed. TNG should confirm that the assumptions made in this report match with the fuel specification of potential suppliers and their market understanding.

(2) The proposed firing diagram should be discussed with boiler/technology suppliers to understand the design and cost implications of the proposed range on individual boiler designs.

Boiler

(3) This report assumes a net electrical efficiency of approximately 30%. This is based on steam temperatures being limited to 425°C to reduce high temperature corrosion issues, and the assumption that air cooling condensers are selected as the cooling method. High ambient air temperatures may restrict the ability to achieve higher net electrical efficiencies.

Stacks

(4) There will be two stacks, one for each phase. Detailed air dispersion modelling will need to be carried out to confirm stack height and for inclusion in the Environmental Statement. The height of the stacks is important for planning and visual impacts. A preliminary height of 100m is currently assumed.

(5) The flue gas exit temperature will also impact on ground level emissions. This temperature will be influenced by any proposed measures to increase boiler efficiency by reducing the flue exit temperature.

Electrical

(6) TNG are in discussions with the electricity distribution network operator, to ascertain the feasibility and cost impact of connection options. TNG should seek a firm connection offer.

Environmental

(7) TNG are in discussions with the relevant NSW regulators. Based on this project description, TNG should seek to determine any key issues.

(8) Residue disposal will be important for planning and TNG need to consider disposal routes. The cost of residue disposal is also significant and TNG should ensure it is adequately allowed for in its financial model.

Fuel Reception

(9) TNG has confirmed that the existing site entrance and roads can cater for new traffic volumes. TNG has also confirmed the typical type of fuel delivery lorry to be used. A final traffic assessment will need to be carried out once all fuel sources have been confirmed.

Layouts

(10) Confirm the preliminary layouts are adequate for Planning purposes.

(11) Ground investigations have been commissioned to establish ground conditions and to gain greater certainty on conditions and their impact on construction. Once the results of the investigations are available, TNG should review the plant layout and in particular the bunker construction.

4 Discussion

4.1 General

The Facility will be designed using an established and proven technology. A grate based solution would provide most flexibility for the types of fuel considered for the Facility (as discussed in section 4.3). This report is therefore based on grate technology being employed.

The Facility will operate 24 hours a day, 7 days a week, with occasional offline periods for maintenance. Over the entire year, it is assumed that the Facility would be operational for 8,000 hours as an annual average, which is equivalent to an overall availability of 92%.

For this concept design, it is assumed that the Facility will achieve for 92% availability as newer plants are now proving to be more reliable. Availability is defined in this case as the number of hours that the Facility is available to operate at full load.

Fuel will be delivered to the site by road and via conveyor from the Genesis Facility, which is located adjacent to the proposed EfW facility and will be the primary fuel source for the EfW facility. Road transport will not involve any greater use of the state road transport network than presently occurs. Much of the fuel arriving at the EfW facility will have already been through processes at the Genesis Facility to ensure that recyclable materials are extracted to meet the proposed Environment Protection Authority (EPA) regulations for recycling. Residual waste from the recycling process will then be transported to the Facility via a covered conveyor system.

The Facility will need significant storage capacity for at least 4 days of fuel, so that the Facility can continue to operate if there are any short term supply issues and over a Public Holiday weekend.

4.2 Fuels

TNG require a facility with maximum fuel flexibility in order to be able to receive as many different types of waste fuels as possible. Realistically it is not feasible to have a facility that can accept almost unlimited types of waste fuel, as the technology required to process different types of waste fuel will vary. A compromise between different fuel types is inevitable, as increased flexibility in permitted fuel types increases costs and can reduce performance.

The following residual waste fuel types are considered as the main sources of fuel for the Facility.

- Chute Residual Waste (CRW) from the Genesis Facility;
- Commercial and Industrial (C&I);
- Construction and Demolition(C&D);
- Flock waste from car and metal shredding;
- Paper pulp;
- Glass Recovery;
- Green Organics (GO);
- AWT; and
- MRF residual.

The NCV for the above fuel types will each vary within a range and therefore the Facility will need to be able to process fuels having a range of NCVs.

4.2.1 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 is possible.

The data provided from TNG for each proposed fuel type shows that the moisture content is high, but the fuel should be analysed to confirm the actual fuel composition.

Table 1: Proposed design fuel analysis, as received basis

	Units	CRW	C&D	C&I	Flock 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 putrescibles	%	0.00	0.00	0.00	70.41	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	43.91	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	%	6.90	6.50	0.00	0.00	0.00	0.00	21.00	1.05	0.03	3.98
Hazardous	%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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
Chemical Analysis											
Carbon (C)	%	37.37	38.90	40.05	23.44	35.31	40.32	18.53	38.81	30.87	35.83
Hydrogen (H)	%	4.78	5.02	5.40	3.30	5.11	5.61	2.50	5.37	4.53	4.76
Nitrogen (N)	%	0.90	0.71	0.95	0.90	0.37	0.42	0.50	0.85	0.34	0.80
Sulphur(S)	%	0.12	0.12	0.12	0.12	0.12	0.11	0.18	0.17	0.12	0.12

Table 1: Proposed design fuel analysis, as received basis

	Units	CRW	C&D	C&I	Flock waste	Paper Pulp	Glass Recovery	GO Residual	AWT Residual	MRF Residual	Design Fuel Mix
Chloride (Cl)	%	0.17	0.66	1.09	1.03	0.39	2.35	0.39	1.73	0.41	0.75
Oxygen (O)	%	28.21	28.28	24.86	11.84	24.57	22.87	14.30	16.68	15.78	23.81
Water (H2O)	%	17.12	13.81	18.57	50.00	25.00	19.57	31.65	23.77	21.96	22.39
Ash	%	11.33	12.50	8.97	9.36	9.14	8.75	31.95	12.63	25.97	11.53
Total	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
NCV	MJ/kg	13.68	12.08	13.46	8.46	13.22	16.13	6.31	14.86	10.09	12.34

The analysis above is intended only to define the design point of the Facility. Suitable ranges for various key components such as the moisture, ash and energy content of the fuel are discussed in section 4.2.2. Based on the above design compositions, NCV of the nominal design fuel mix is calculated to be 12.34 MJ/kg.

As TNG develop their fuel markets, the composition and mix of the various fuels may change. Due to the nature of the proposed fuel, there will also be variation within the fuel streams themselves. The Facility must therefore be designed for a range of NCV rather than a specific design point.

4.2.2 Fuel Range

The Facility will need to be able to operate efficiently with fuel which deviates from the above design composition and with various blends of fuel. A proposed fuel range has been developed and is presented in Table 2.

Table 2: Proposed Design Fuel Range as received basis

		Minimum	Maximum
Nitrogen(N)		n/a	1.5%
Sulphur(S)		n/a	0.4%
Chloride (Cl)		n/a	1.0%
Ash		5%	20%
Water(H_2O)		10%	40%
NCV	MJ/kg	10.0	16.5

The NCV range above is used to produce a firing diagram, shown in Appendix D. The above ranges allow for a reasonable variation in each of the proposed fuels around the design composition, as moisture and ash contents will vary.

Further discussion with boiler suppliers is also suggested, so they can indicate if their standard boiler designs are capable of dealing with the fuel ranges listed and how adjustment to the firing diagram may affect the capital cost of the Facility.

4.3 Technology Overview

The following types of technology have been considered:

(1) grate based systems;

(2) rotary kilns;

(3) fluidised bed combustors, either of the bubbling bed or circulating bed type;

(4) gasification and pyrolysis; and

(5) anaerobic digestion (AD)

For the Facility envisaged by TNG, several of the options listed above can be discounted:

- Gasification and pyrolysis remains unproven at the scale required by TNG.
- Anaerobic Digestion is only suitable for non-wood organic waste;
- Rotary kilns are too small in scale.

At the scale required by TNG, and with a requirement that the technologies selected must be proven by similar reference plants, the most suitable solutions are:

- Grate based system – vibrating, reciprocating or travelling depending on size and fuel type. Grates are simpler and cheaper at a smaller scale, and offer greater flexibility for variable fuel quality, particle size, contamination such as glass and metal and lower ash fusion temperature. However, grate units are limited in capacity and are not suited to low calorific value or wet fuels i.e. fuels with an NCV < 7 MJ/kg.

- Fluidised bed – bubbling (BFB) or circulating (CFB), depending on capacity and fuel. Fluidised beds can be much larger units than grate based systems, and are very good for wet fuels or variable calorific value fuels. Fluidised beds are not good for coarse or low fusion ash material, untreated wastes and material with large amounts of metal, stones or glass.

Fluidised bed is likely to be a feasible option, however they offer less fuel flexibility. Fluidised beds cannot cope with large objects, metal and glass etc, which cause the bed to segregate and sinter. They also cannot cope with material which tends to clinker, as the whole bed can become one sintered mass. Fluidised beds also tend to have a higher capital cost than an equivalent grate system. However for large capacity plants this can be counteracted by the fact that multiple grate units would be required to give the same capacity as one large fluidised bed unit.

Based on the assumption that the fuel mix and composition is stated in section 4.2, a moving grate system is likely to offer the most flexible and cost effective solution and is well proven technology.

4.4 Performance

The following table highlights the anticipated overall performance of the Facility assuming the nominal design capacity. The Facility will be designed to export circa 70 MW_e in phase 1 and circa 70 MW_e in phase 2 to the grid at up to 132 kV. By discussion with the technology provider it may be possible to improve the net electrical export to a total of approximately 140 MW_e.

Table 3: Overall Facility Performance

		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	78.94		78.94		157.88
Auxiliary load	MW_e	8.5		8.5		17
Power Export	MW_e	70.44		70.44		140.88
Net Efficiency	%	30.0%		30.0%		30.0%
Fuel NCV	MJ/kg	12.34		12.34		12.34
Thermal load	MW_{th}	234.8	117.4	234.8	117.4	469.6
Availability	%	92%		92%		92%
Waste Throughput (based on assumed availability)	t/h	69.06	34.53	69.06	34.53	138.12
	tpa	552,500	276,250	552,500	276,250	1,105,000

It should be noted that to maintain the planned facility output with fuels within the fuel NCV range of 10 – 16.5 MJ/kg, the fuel requirement could vary from 810,000 –1,350,000 tpa (based on an availability of 92%). If the average annual NCV is at the lowest point of the range, the annual throughput would be 22% higher than the design throughput. In reality, it is not possible for the average NCV to be at the bottom end of the range continuously, as there will be a natural spread in the energy content.

4.4.1 Efficiency

High net electrical efficiency is a priority for TNG. For the type of fuel envisaged and the basic facility design, a net electrical efficiency of the Facility of 30% has been assumed for the concept design, as shown in Table 3.

A number of measures can be employed to improve the efficiency of the thermal cycle. Such measures are discussed below, listed in order of precedence for which Fichtner consider the greatest efficiency gain is achieved for the least capital expenditure.

4.4.1.1 Reduce the condenser pressure

Reducing the condenser pressure will increase the enthalpy drop across the turbine. This will however increase the wetness of the steam exiting the turbine which increases the risk of damage to the last stage blades. The maximum allowable wetness for the turbine exhaust is typically 15%. Increasing the boiler pressure without increasing the steam temperature, also increases the wetness of the turbine exhaust (see 4.4.1.8), so the two cannot be considered in isolation.

The Facility will operate an Air Cooled Condenser (ACC) to condense the steam output from the turbine to allow return of the condensate to the boiler. The options for the cooling system are listed in section 4.5.4 below.

Reducing the condenser pressure is achieved by increasing the size of the ACC.

4.4.1.2 Reducing the flue gas exit temperature from the economiser

By reducing the flue gas exit temperature, the boiler efficiency is increased since a greater quantity of heat is removed for the same fuel input. Because a greater quantity of heat is removed and the temperature difference between the incoming feed water and the outgoing flue gas is reduced, a larger surface is required in the economiser. This will therefore increase the capital cost of the boiler.

However, in practice, the flue gas exit temperature will be set by the requirements of the flue gas treatment (FGT) process. In general a wet or semi-dry process will require a higher flue gas temperature than a dry process. The flue gas exit temperature will therefore be determined by the contractor’s design, but it is worth noting that from a boiler efficiency point of view it should be set as low as possible.

One option is to remove more energy from the flue gas after the bag filter. This avoids affecting the efficiency of the flue gas treatment system. However, the consequence for the buoyancy of the flue gas leaving the stacks, and the potential for a visible plume, needs to be considered in the dispersion modelling process. Although the majority of acid gasses will have been removed in the FGT plant, they will not have been removed entirely, and if the temperature of the flue gas is reduced to below the acid dew point, then the risk of corrosion of the duct and flues downstream of the final cooler will be increased.

4.4.1.3 Addition of a high pressure feed water heater

If the minimum flue gas exit temperature is constrained by the FGT process, then another option could be to install a high pressure (HP) feed water heater. The HP heater uses steam extracted from the turbine to raise the temperature of the feedwater. This means that more of the heat available in the boiler can be used to generate steam rather than heat up the feed water. The result is a higher steam flow from the boiler. Because the steam used to heat the feedwater has already imparted work to the turbine, the overall cycle efficiency is improved.

The addition of a HP heater would also require a larger economiser surface area compared to the base case, since the temperature difference between the feed water and the flue gas is reduced.

In general it would be preferential to first reduce the flue gas temperature to the minimum allowable rather than adding a HP heater, since extracting more heat from the flue gas increases the boiler efficiency. However depending on the FGT process chosen a HP heater may be a viable option and could be added in addition to removing more energy from the flue gas after the bag filter, as discussed in 4.4.1.2.

4.4.1.4 Increasing the efficiency of the turbine

Section 4.5.8 discusses the benefits of a one turbine for each phase and total two turbines for the whole facility compared to independent smaller turbines for each boiler. A single turbine for each phase (each phase contains two boilers) will have a greater overall isentropic efficiency at full load than individual turbines for each boiler.

For a turbine with a capacity in the region of 77 MW, depending on the supplier and design conditions, isentropic efficiencies in the region of 85-90% can be achieved.

However the EPC contractor is free to choose the turbine supplier and provided the design guarantees are met, TNG will have little influence on the final turbine chosen. It is therefore important to start dialogue with the preferred suppliers, regarding the choice of turbine supplier and expected isentropic efficiency, at an early stage in the design process.

In addition to the isentropic efficiency, the mechanical and generator losses should also be considered as it may be worth pressing the contractor for a more efficient turbine generator design.

4.4.1.5 Increasing the number of feed heating stages

Typically Energy From Waste facilities are designed with a single low pressure (LP) condensate heater. As discussed above a HP feedwater heater could also be added. However to increase the cycle efficiency further multiple stages of HP and LP heating could be installed, such as in large coal fired power stations. By increasing the number of feed heating stages the efficiency of heat transfer can be increased, therefore less steam needs to be extracted from the turbine and the cycle efficiency is improved. However more pipework and heat exchangers would be required, which incurs a large capital cost for relatively small gains in efficiency. Additionally the number of feed heating stages possible tends to be limited by the number of extractions available on the turbine.

Multiple stage feed heating therefore tends to be only financially viable on large fossil fired power stations where small increases in efficiency equal large gains in revenue, and larger steam turbines have more stages and more physical space to accommodate large numbers of extractions.

4.4.1.6 Blow-down heat recovery

Water is blown down from the steam drum due to the fact that as steam is separated from water the entrained solids are left behind and would quickly become concentrated if some of the water was not replaced. Because this water is at the saturation temperature of the boiler operating pressure, there is a significant quantity of heat which can be recovered and used to increase the temperature of the make-up water. This reduces the quantity of steam which must be supplied to the deaerator therefore increasing the thermal cycle efficiency.

The main consideration when deciding whether to install blow-down heat recovery is likely to be the proposed facility layout and the pipework required in order to utilise the available heat in the blow-down water. Although the capital cost is likely to be small the level of efficiency gain will be strongly dependant on the quantity of blow-down envisaged.

4.4.1.7 Raised steam conditions

The greatest overall efficiency gains are achieved by raising the pressure and temperature of the superheated steam.

Raising the temperature of the steam increases its enthalpy. Since the Facility’s power output is determined by the enthalpy drop across the turbine, more power should be produced by raising the enthalpy of the incoming steam. However, since the turbine exhaust pressure is fixed by ambient conditions and the design of the cooling system, if the supply pressure is not increased the enthalpy of the steam leaving the turbine will also be increased. The change in enthalpy drop will therefore only be small. Hence for a fixed mass flow rate, raising the temperature alone will only result in a small increase in power output.

The measured boiler output is a function of enthalpy and flow rate. For the same quantity of heat released in the boiler (i.e. the fuel mass flow rate is kept constant), increasing the steam temperature for a fixed pressure will require the steam mass flow rate to fall since the enthalpy of evaporation (the latent heat) will remain the same. Since the power generated by the turbine is a function of enthalpy drop and mass flow, raising the steam temperature alone will not increase the efficiency of the Facility.

If the pressure and temperature of the inlet steam are raised together, the pressure ratio across the turbine is increased allowing more of the available energy in the steam to be utilised. The outlet enthalpy of the turbine can therefore be maintained at the same value as the base case, resulting in a greater enthalpy drop and therefore more power will be produced.

Additionally, as the pressure is increased, the enthalpy of evaporation (the energy required to convert water to steam) is reduced. This means that less heat (released from the combustion of fuel) is required to raise steam. Therefore by raising the pressure as well as the temperature, the enthalpy of the outgoing steam can be increased whilst maintaining the mass flow for the same fuel heat input. The efficiency of the boiler is thereby increased. Effectively more of the energy available in the boiler is going into superheating rather than merely producing steam.

However raising the steam conditions will also incur the greatest capital cost due to the increased risk of corrosion. This will require more expensive materials in the boiler such as Inconel cladding and the lifecycle costs of the Facility will be increased. There is therefore a trade off between increased electrical output and increased maintenance costs.

4.4.1.8 Increasing boiler pressure without increasing temperature

As discussed above, increasing steam temperature increases the risk of superheater corrosion. In Energy from Waste plants, the final steam temperature is therefore typically limited to 430°C. However the boiler pressure only has a marginal effect on the temperature of the membrane walls (due to the increase of the saturation temperature). These are at much less risk of corrosion, due to the lower temperatures, and this is therefore usually considered tolerable.

Increasing boiler pressure reduced the enthalpy of the inlet steam to turbine. However for a fixed condenser pressure, the pressure drop through the turbine is increased, and as a result the power output of the turbine is increased. Since the turbine does more work, the enthalpy of the exhaust steam is lower which means that it has a higher wetness. As discussed in 4.4.1.1, wetness of the turbine exhaust is typically limited to 15% to limit erosion damage to the final stage blades.

If final steam temperature is limited, increasing the boiler pressure is therefore an alternative means of increasing the pressure drop through the turbine, without reducing the condenser pressure. However, both cannot be done simultaneously otherwise the exhaust wetness could become too high.

Increasing boiler pressure (without also increasing temperature), is therefore unlikely to be an option with a wet cooling system. The decision whether to increase boiler pressure or reduce condenser pressure therefore requires a cost benefit analysis. However, it is usually more economic to reduce the condenser pressure as much as possible. As a guide, a reduction of condenser pressure of 10 mbar gives the same approximate power increase as an 11.5 bar increase in inlet pressure.

Additionally, increasing the boiler pressure has a much greater effect on exhaust wetness. For example, assuming an isentropic efficiency of 85%, and initial exhaust temperature of 90 mbar(a), increasing the boiler pressure from 60 to 71.5 bar(a), reduces the exhaust wetness to 0.86% and increases the power output by approximately 880kW. However, if the boiler pressure is maintained at 60 bar(a), the condenser pressure could be reduced to 60 mbar(a), increasing the power output by approximately 3 MW, before the same exhaust wetness is achieved.

4.4.1.9 Re-heat cycle

A re-heat cycle involves the expansion of high pressure steam to an intermediate pressure at which point it is returned to the boiler and reheated to the boiler exit temperature. The reheated steam is then expanded to the condenser pressure through the turbine as in a "simple" cycle.

This "additional" cycle increases power output from the Facility and also the cycle efficiency since a greater proportion of the heat generated in the boiler is used to superheat the steam rather than generate it. Re-heating also means that for a given turbine exhaust pressure, the enthalpy of the exhaust steam will be increased. This allows a higher pressure to be used in the boiler since the wetness at the turbine exhaust is reduced compared to that for a "simple" cycle.

To allow significant expansion in the first HP cycle, high steam temperatures and pressures are required. However, as discussed in 4.4.1.7, high steam pressures and temperatures increase the risk of boiler tube corrosion and require expensive materials. Additionally a re-heat cycle increases the amount of hot surface in the boiler, so material costs would be increased further. A more expensive turbine (or even two separate turbines) and additional pipework would also be required. The result is that re-heat cycles are very rarely financially viable in Energy From Waste plants and Fichtner are only aware of one operational European EfW plant that employs a re-heat cycle. This uses a special design incorporating an external re-heater which avoids locating extra high temperature superheater surface in the flue gas. There are also some relatively small European wood burning plants which use conventional re-heat cycles to improve cycle efficiency.

4.5 Facility Equipment

4.5.1 Combustion System

A moving grate system is likely to offer the most flexible and cost effective solution, for the fuel mix being considered.

Primary air for combustion will be fed to the underside of the grate by fans. Secondary air will also be admitted above the grate to create turbulence and ensure complete combustion with minimum levels of oxides of nitrogen (NOx) and carbon monoxide (CO). The volume of both primary and secondary air will be regulated by a combustion control system. Flue gas recirculation may be incorporated, but only if the grate designer believes it is required in the design.

The Facility will be designed to meet the requirements of the European Commission Directive on Industrial Emissions (IED). The combustion control system will regulate the combustion conditions, and thereby minimise the levels of pollutants and particulates in the flue gas before flue treatment. The furnaces will also be fitted with auxiliary burners, fired on low sulphur gas-oil, which will automatically, if required, maintain the combustion chamber temperature above 850°C to ensure the destruction of dioxins, furans and other undesirable combustion products. Combustion chambers, casings, ducts, and ancillary equipment will be maintained under slight negative pressure to prevent the release of gases.

During operation, the temperature in the combustion chamber will be continuously monitored and recorded to demonstrate compliance with the requirements of the IED. The combustion control system will be an automated system, including monitoring of and the steam flow, oxygen content, temperature conditions of the grate, modification of the fuel feed rates and the control of primary and secondary air.

It is likely that Selective Non Catalytic Reduction of NOx will be required to control emissions. Ammonia or urea solution is sprayed into the combustion chamber, reacting to break NOx down into nitrogen and steam.

Whilst fuel flexibility is required, it is noted that any technology will restrict some fuel types. Table 4 indicates suitable fuels for a moving grate system.

However, most grates are able to take small amounts of "unsuitable waste" by mixing it with other more suitable material.

A firing diagram has been produced to indicate the required performance of one grate unit to cater for the fuel range proposed. The firing diagram is included as Appendix D.

Table 4: Suitable and unsuitable wastes for grate technologies	
Suitable wastes	**Unsuitable wastes**
Moving Grate	
NCV 7 – 13 MJ/kg (air cooled)	NCV < 7 MJ/kg
NCV 7 – 20 MJ/kg (water cooled)	Moisture content >55%
Moisture content <55%	Virgin wood
Untreated municipal waste	Sawdust
Wood waste	Paper sludge and sewage sludge
CRW	Poultry litter
Paper, plastic waste	Straw
Combustible material contaminated with metal or glass	

4.5.2 Facility configuration

The capacity of the Facility cannot be treated in a single stream combustion system. This is because suppliers are unable to supply a single stream facility of the required size. Instead the Facility must be configured as a four or six stream system. Both the four and six stream system will have the same thermal input, however the throughput through each stream will be different. Table 5 below outlines the key advantages of four and six stream systems.

Table 5: Comparison of four and six stream combustion systems	
Four streams	**Six streams**
• Lower capital costs.	• Increased choice of suppliers
• Lower maintenance costs.	• Increased flexibility.
• Smaller footprint required.	
• Likely to lead to a more efficient layout and better access.	

Based on the summary in Table 5 the preferred option is to select a four stream facility.

4.5.3 Boiler

The priority for the Facility should be that it operates reliably with reasonable maintenance costs. CRW and C&I waste can be quite aggressive due to relatively large amounts of organic chlorine in the waste. This is liberated as HCl in the flue gas and can lead to significant high temperature corrosion. For this reason, the final steam temperature in an energy from waste facility of this type should be limited to 400-430°C. Measures for improving the efficiency of the boiler and the impact on adjusting the steam conditions, is discussed in section 4.4.1.

4.5.4 Cooling system

TNG EfW facility will require a cooling system to condense the turbine exhaust steam and provide cooling capacity across the Facility. There are a number of different options which can be selected for the cooling system. The options for the cooling system are listed below.

- **Air cooled condenser (ACC).** This option is typically seen on projects of this type and size, due to the fact that it does not require a water supply and will not produce a plume. The size of an ACC is dependent on the required turbine exhaust pressure and the ambient air temperature chosen as the design point.

- **Cooling towers.** They potentially offer efficiency benefits due to the lower condenser pressure that can be achieved at higher ambient temperatures. Hybrid cooling towers utilise elements of a dry cooling system to eliminate a plume down to given a given temperature and relative humidity. However the change of a plume occurring can never be eliminated completely. Evaporative condenser systems require large volumes of water. There is no local abstraction point so this would lead to significant potable water use. Chemical additives are also needed which means there would be a significant effluent flow to water or sewer.
- **Once through cooling.** Whilst this option is able to achieve the lowest condenser pressures with no risk of a plume, the high flow rate of cooling water required mean that this option is generally only practical for coastal sites. As there is no readily available supply of water once through cooling systems are not regarded as appropriate for this installation.

ACC can be considered to be the preferred option as there are no major water courses nearby to the site which could be used for turbine cooling. The advantages of using ACC are that it does not require large volumes of water and does not generate a discharge. There is no visual impact of the ACC, as there would be for evaporative cooling.

4.5.5 Flue Gas Treatment

The design of the flue gas treatment system will be fully compliant with current European legislation through meeting the requirements of the UK's Environment Agency (EA) Horizontal Guidance Note H1 and the Industrial Emissions Directive (IED).

The flue gas treatment system consists of Selective Non-Catalytic Reduction (SNCR) of NO_x, activated carbon injection, dry lime scrubbing and fabric filters. The system is designed to ensure that the Facility operates well within the emission limits in Part 3 of the IED shown in Table 6.

The Facility will be designed to ensure that the Facility operates within the emission limits set out in the IED with headroom should the limits be changed.

NO_x levels will primarily be controlled by careful control of the combustion air. SNCR will also be installed to reduce NO_x. SNCR involves the injection of a 25% ammonium hydroxide solution into the boiler which converts both nitrogen oxide (NO) and nitrogen dioxide (NO_2) to nitrogen and water. Urea can be used as an alternative to ammonia.

Acid gases produced during the combustion process will be removed by a scrubbing system, typically using hydrated lime as a reagent (although Sodium Bicarbonate can also be used). Neutralisation of the acid gases will take place as they react with the lime. The residual material will be recovered at the outlet of the flue gas scrubbing system. Activated carbon will also be injected into the flue gas duct to minimise the emissions of dioxins, mercury and other heavy metals. Some of the residual material will be recirculated to improve the gas clean up and reduce the amount of hydrated lime used.

Table 6: IED Emission Limits for an Incinerator				
Parameter	**Units**	**Half Hour Average**	**Daily Average**	**Periodic Limit**
Particulate matter	mg/Nm^3	30	10	None
VOCs as Total Organic Carbon (TOC)	mg/Nm^3	20	10	None
Hydrogen chloride	mg/Nm^3	60	10	None
Hydrogen fluoride	mg/Nm^3	4	1	None
Carbon monoxide	mg/Nm^3	100	50	None
Sulphur dioxide	mg/Nm^3	200	50	None
Oxides of nitrogen (NO and NO_2 expressed as NO_2)	mg/Nm^3	400	200	None
Cadmium & thallium and their compounds (total)	mg/Nm^3	None	None	0.05
Mercury and its compounds	mg/Nm^3	None	None	0.05
Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V and their compounds (total)	mg/Nm^3	None	None	0.5
Dioxins & furans ITEQ	ng/Nm^3	None	None	0.1

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

After flowing through the gas scrubber, the gases will be drawn through a fabric bag filter to remove particulates, including lime and activated carbon particles. Each fabric filter will be divided into compartments. The treated flue gas will pass through an induced draught fan into the stack for release. Regular bag filter cleaning will be performed on-line by pulsing compressed air through the filter bags. The residues will be collected in fully enclosed hoppers beneath the filters. Bag failure, albeit an infrequent occurrence would be identified by a sudden increase in particulate concentration at particulate meters installed immediately downstream of the bag filter. The plant would be able to continue operating following individual bag failures, as these bags could be plugged without a significant effect on the cleaning efficiency.

Following cleaning, the combustion gases from the combustion process will be released into the atmosphere via a gas flue within a chimney stack (see section 4.5.7).

4.5.6 Gas Analysis Systems

Emissions from the stack will be monitored continuously by an automatic computerised system and reported in accordance with the UK's Environment Agency's (EA) requirements for the operation of the Facility. Sampling and analysis of all pollutants will be carried out to 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.

The continuously monitored emissions concentrations will also be checked by an independent testing company at frequencies agreed with the relevant regulator.

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

(1) nitrous oxide;

(2) hydrogen fluoride;

(3) heavy metals; and

(4) dioxins and furans.

The methods and standards used for emissions monitoring will be in compliance with the UK EA guidance and the IED. In particular, the CEMS equipment will be certified to the MCERTS[1] standard and will have certified ranges which are no greater than 1.5 times the relevant daily average emission limit.

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

4.5.7 Stack

Flue gases will be emitted to atmosphere via a stand-alone stack for each phase. The appropriate height of the stacks will be determined by dispersion modelling.

Each boiler will have its own flue. The stacks will be constructed either with a windshield housing the flues or as separate flues tied together.

Typically, the top of the flues will be stainless steel lined to avoid corrosion.

Flue gases will be emitted from the flues with a velocity in excess of 15 m/s. Combined with the thermal buoyancy of the warm gas, the flue gases will rise before becoming dispersed. Dispersion modelling carried out as part of the Environment Impact Assessment (EIA) will need to demonstrate that even under worst case emission limits (i.e. assuming IED limits are achieved continuously), the dispersed pollutants are not significant.

4.5.8 Steam Turbine

The Facility will be capable of exporting approximately 140 MW of electricity, amounting to about 1,130,000 MWh per annum based on 92% availability. The export of electricity will be agreed as part of a separate connection study with the electricity distributed network operator.

---

[1] MCERTS is the UK's Environment Agency's Monitoring Certification Scheme. The scheme provides a framework within which environmental measurements can be made in accordance with the Agency's quality requirements.

Substation design should be designed for each phase by taking into account the two connection points for each turbine generator and also the ability to make a new connection for the second turbine generator of phase 2 without shutting down phase 1.

The concept design is based on one turbine for each phase which will serve two streams each. There are advantages and disadvantages as described below:

- A single large turbine is more efficient than independent smaller turbines operating with an equivalent cumulative steam flow. This is due to a combined higher isentropic and mechanical efficiency of the larger unit. Another advantage of a single turbine is the lower capital cost, when compared to the costs for smaller independent turbines. However, the turbines will be built in two phases. Therefore, a single, large turbine will have to operate at part load until phase 2 is built and commissioned. This means that the turbine would be running in a less efficient mode when it is on part load during this period.
- Commissioning would be more difficult and it may not be possible to obtain a performance guarantee.
- A single turbine also reduces the flexibility of the Facility since if the turbine is not operational there is no export of power.
- For a facility with two streams, if it is considered that there will be a planned outage of 7 days per year when both boilers are off-line, then for an overall availability of 92%, there would be 66 days where only one boiler was in operation. This means that the turbine would operate at 100% capacity for approximately 81% of the available time. Since the steam flow would be 50% of the design flow, the throttling losses across the governor valve (or alternatively efficiency losses across the first stage blades for partial arc admission) would be significant, partially reducing the benefit of option of a single turbine for each facility with two steams rather than having two turbines for each facility.

Energy From Waste facilities of the type and size proposed for each phase typically have only one turbine for the reasons outlined above.

Therefore, two turbines for the whole facility, a turbine for each phase, is concluded to be the optimum solution.

4.5.8.1 Export of heat

Without any changes to the main plant design, the Facility will be configured so that it will be possible to also export heat to nearby consumers for space heating or cooling or hot water. Depending on the requirements, it should be possible to export heat from the Facility as ether steam or hot water. In addition, for cooling purposes, the heat source can be steam or hot water depending on the technology of thermal chillers chosen.

The potential export of heat will need to be considered in the turbine design. Whilst a dedicated extraction is not necessarily required, allowance will need to be made for the additional steam extraction required for heat export.

Since at this stage, heat export is only a possibility the turbine should be optimised for the zero heat export case, but one or more of the bleed ports and connecting pipework will need to be designed to incorporate the additional steam flow for heat export.

If heat is required in the form of hot water, the typical temperatures are at 110-115°C. It would need to be confirmed that the turbine design allowed for sufficient steam extraction at sufficiently high pressure to provide the anticipated maximum quantity of hot water at these temperatures. Typically such schemes employ two separate extractions to raise the hot water temperature. During low loads it may be possible to use only a single extraction.

Increased steam extraction leads to increased mechanical loading on the upstream turbine blades and this would need to be modelled in the initial design. Adequate space for the installation of district heating scheme heat exchangers would also need to be allowed for in layout of the Facility.

4.5.8.2 Turbine bypass

It should be noted that most energy from waste plants incorporate a 110% turbine bypass. This allows the Facility to be operated and process waste fuel even if there is a problem with the turbine.

By-pass steam is sent to the condenser after passing through a de-superheating station. This reduces the temperature of the steam but overall the heat load on the condenser is increased compared to normal operation. This causes the condenser pressure to rise.

Since the turbine is not in operation a higher condenser pressure is not an issue. The provision of a turbine by-pass must be considered in the condenser design but typically does not increase the size of the condenser required. If island mode operation is to be employed, (whereby sufficient steam flow passes through the turbine to generate enough electricity for the house load, with the majority by-passed) then the condenser pressure is more critical and could impact the condenser design.

4.5.9 Auxiliary Equipment and facilities

The Facility will require various auxiliary equipment and facilities to operate. The main auxiliary equipment required is as follows:

- Site entrance. The preferred option for the Facility is to segregate HGVs and cars as much as possible.
- Weighbridges. Weighbridges will be required to record the fuel incoming directly to the Facility.
- Security. Security systems will be required to cover the proposed site.
- Fuel reception and storage. Facilities will be built, as described in section 5.4.
- Compressed air. A compressed air system will be installed in the facility.
- Demineralised water. A demineralised water system will be installed which will include storage of demineralised water.
- Gas oil system for starting up the Facility. A new system including storage will be installed.
- Fire detection and suppression system. Fire pumps and fire water storage system will be utilised.
- Cooling system. A cooling system will be required to provide cooling for the Facility. This will be an Air Cooled Condenser (ACC) as described in section 4.5.4.
- Stack. A stack will be built for each phase for emission of flue gases.

4.5.10 Buildings

The Facility will be built in two phases. Each phase would comprise of a main boiler house including the main elements of the process.

Each phase will have two combustion grates and boilers, together with auxiliary equipment, which will be located in the boiler hall. Each boiler will have its own flue gas treatment plant, which will be located outside, connecting to that phase’s stack. A steam turbine for each phase will be located in an adjacent turbine hall.

The main buildings of the Facility will be as follows:

- tipping hall and fuel storage (common to both phases);
- boiler hall ;
- turbine hall;
- substation;
- ash collection bay;
- workshop;
- stack; and
- control room, offices and amenities(common to both phases).

The main building indicative dimensions of the Facility are given in the table below.

Table 7: Main Building Indicative Dimensions for the Facility (metres)			
	Width (W)	**Length (L)**	**Height(H)**
Tipping Hall	109	50	20.5
Bunker Hall (bunker dimensions: W:105m, L: 18m, and D:11m)	127	32	49 (included 7.0m below ground level)
Control Room and admin block	20	31	8.5
Boiler Hall per phase	49	48	51
Flue gas treatment per phase	42	39	37
Two stacks with four flues	6.7	3.5	100
Turbine Hall per phase	33	46	26
Ash collection area per phase	48	14	17
ACC per phase	50	48	20
Circuit breaker, transformer and switchyard per phase	39	15	20
Workshops	20	31	8.5
Dimension W is measured across the Facility (ie Turbine Hall to Ash Collection Bay) Dimension L is measured along longitudinal axis of Facility (ie Tipping Hall to Stack)			

4.5.11 Electrical

4.5.11.1 Electrical Installation

The electrical installation is likely to comprise of the following voltage levels:

- 132 kV high voltage sub-station (housing metering circuit breaker);
- 20 kV medium voltage power distribution system;
- 690 V low voltage power distribution system (for large motors);
- 400 V low voltage power distribution system;
- 230 V utility power distribution system;
- 230 V uninterruptible power distribution system;
- 110 V dc voltage distribution system; and
- 24 V dc for control and instrumentation systems.

The steam turbine generator is expected to generate electrical power at 20 kV and will be connected on to the Facility’s 20 kV power distribution system and to the distribution network operator’s network through a step-up transformer. Two synchronising circuit breakers may be required to allow connection onto the grid from island mode or when the site is being supplied from the grid and the generator is coming back online.

The Facility’s auxiliaries will be supplied from the 11 kV distribution system through step-down MV/LV transformers with neutral three-phase 50 Hz alternating current.

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.

4.5.11.2 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.

4.5.11.3 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.

Emergency power will be supplied from a stand-alone diesel generator.

Alternating Current (AC) uninterruptible power supplies will be provided for essential functions such as Distributed Control System (DCS) and Visual Display Unit (VDU) monitor supplies that would not offer an adequate level of reliability if fed directly from the electrical auxiliary system. This includes loads that are required for post-incident monitoring and recordings following a main unit trip and loss of station ac supplies. The supplies will be maintained for a minimum period of 30 minutes.

Suitable earthing and lightning protection will be provided.

4.5.12 Existing Cables

A survey will need to be carried out to identify any existing cables within the available area before construction works starts.

4.6 Operational & Control Systems

The Facility will be fully automatically controlled and operated from a stand-alone control room.

The proposed main control and supervision system will consist of a Distributed Control System (DCS) organised on several levels. The Facility will be fully instrumented to allow safe and efficient operation.

4.7 By-Product Handling and Disposal

Three types of solid by-products and one type of liquid by-product will be produced from the operation of the Facility, each of which has separate handling and disposal arrangements.

Bottom ash is the burnt-out residue from the combustion process. The bottom ash will be discharged onto a conveyor system from the boiler. The conveyor passes under a magnetic separator to remove ferrous materials. The ash is then discharged to a bottom ash bunker or storage bay for storage. Bottom ash will either be landfilled or recycled as an aggregate.

Based on a maximum fuel input of approximately 1,350,000 tpa (8,000 hours operation at NCV of 10 MJ/kg) and the maximum assumed ash content of 20% (95% of which is bottom ash), the Facility would generate up to 321,000 tpa of wet bottom ash. This assumes that the bottom ash gains 25% additional weight due to water absorbed from the quench bath. The amount of bottom ash generated would decrease to 184,000 tpa for the design waste composition (8,000 hours operation at NCV of 12.34 MJ/kg and ash content 11.53%).

Ferrous metals will be removed from the bottom ash by means of magnetic separators and discharged to a storage area. Any ferrous material recovered will be recycled. Depending on the degree of pre-treatment carried out on the CRW, C&I and C&D waste, TNG may consider that magnetic separators are not required.

Boiler ash is collected from the boiler between the bottom ash and the FGT residues. If it is found to be hazardous, it will be directed to the FGT residue silos.

FGT residues comprise fine particles of ash and residues from the flue gas treatment process, which are collected in the bag filters. The FGT residue will be stored in sealed silos adjacent to the flue gas treatment facility. Due to the heavy metals contained in FGT residues, they are classified as hazardous waste. As a result, the residues will be transported by road in a sealed tanker to an appropriate treatment facility.

Based on a maximum fuel input of approximately 1,350,000 tpa (8,000 hours operation at NCV of 10 MJ/kg and ash content 20%), it is estimated that the Facility will generate approximately 51,700 tpa of APC residue. The amount of APC residue generated would decrease to 43,800 tpa for the design residual waste fuel composition (8,000 hours operation at NCV of 12.34 MJ/kg and ash content 11.53%).

Liquid effluents will be produced from the boiler water treatment system and from the boiler blow-down. All boiler blow-down and liquid effluent produced are fed to the ash discharger via the process water system. Under normal operating conditions, no effluents are disposed of to drain but returned to the Facility for re-use. In this way, the majority of liquid effluent produced on site will either be evaporated or absorbed into the ash for transport off site.

Liquid effluent will be collected in a storage tank to balance the amounts generated and disposed of to the ash quench. Any overflow from the storage tank could potentially be sent to a packaged effluent treatment system and onto a local foul drain. Alternatively, if the Facility is to be "zero discharge" then the liquid effluent could be collected and tankered off site for treatment in a centralised effluent treatment facility.

If such consent could be obtained, it may be beneficial from an operational point of view to have the ability to discharge some process effluent to sewer. This would consist of boiler blowdown, boiler water treatment, swilling down water occasional maintenance discharges and drain water from contaminated areas.

The discharge would be spot sampled for audit purposes and analysed for flow rate, pH, temperature, oxygen demand, toxic metals, grease/oil and suspended solids.

Additionally at a period determined by the Sewerage Authority, the effluent would be analysed for a broad spectrum of substances including dioxins, prescribed substances and any other determinants required by the authorisation.

5 Fuel, Consumables and Ash Reception and Storage

5.1 Transport to Site

Residual waste fuel will be delivered to the site by the public road system from third parties and via conveyor from the Genesis Facility which is located adjacent to the Facility and will be the primary fuel source for the Facility. Road transport will not involve any greater use of the state road transport network than presently occurs. Much of the fuel arriving at the EfW facility will have already been through processes at the Genesis Facility to ensure that non-compliant fuel is eliminated.

However, we are considering a worst case situation for traffic movements by assuming fuel delivery to site by road directly.

The following estimations for fuel deliveries assume the fuel received has the minimum NCV as shown on the firing diagram (10 MJ/kg). This assumption is conservative as it is unlikely the fuel will constantly have an NCV of 10 MJ/kg. Based on these assumptions, the Facility would receive up to 1,350,000 tpa, which will be sourced as follows:

- 136,000 tonnes via the conveyer from Genesis;
- 714,000 tonnes from third parties that already tip residual waste fuel at the Genesis Landfill and which would be re-routed to directly enter the TNG entrance; and
- 500,000 tonnes from other third parties with eligible residual waste fuel.

The majority of fuel will be delivered between 6am and 6pm but fuel deliveries will be 24 hours and seven days in a week.

These timings have been used when estimating the hourly flow of vehicles. This means that the facility could receive deliveries by road for 24 hours and seven days in a week (8760 hours per year).

It is assumed that material delivered by road will be in sealed containers which utilise walking floors. Such vehicles should be able to hold about 22 tonnes of material.

Table 8 shows the hourly traffic flows for various yearly tonnages, assumes a continuous stream of vehicles during the opening hours over the whole year. However, with all facilities of this type, there is likely to be a significant variation in deliveries throughout the day. For traffic flow purposes, it will also be necessary to consider the sources of the fuel. The facilities providing the fuel are also likely to have restrictions on when vehicles can leave the site. If the times do not match those of the Facility, the hourly traffic flow may be higher. These factors are considered when estimating the peak traffic flows in Table 12:

Table 8: Estimated fuel deliveries flows

Tonnes per annum	Average number of road vehicles (one-way)		
Road	**Yearly**	**Daily**	**Hourly**
1,350,000	61,364	168	7
1,250,000	56,818	156	6
1,000,000	45,455	125	5
950,000	43,182	118	5
850,000	38,636	106	4
750,000	34,091	93	4
650,000	29,545	81	3
550,000	25,000	68	3
300,000	13,636	37	2
250,000	11,364	31	1

5.2 Weighbridges

The Facility will require at least two new weighbridges to be constructed within the boundary of the facility (one on entry and one on exit). For layout purposes the concept site plan shows four weighbridges, but TNG may consider that two is sufficient.

Incoming bulk transport vehicles that are predetermined as carrying eligible residual waste fuel from external transfer and recycling facilities will enter the site through the main entrance for the Facility. They will proceed to the weighbridge where the quantity of incoming fuel is checked and electronically recorded. Vehicle loads will be inspected randomly 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. If required, 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.

Residual waste fuel from the Genesis facility will arrive at the Facility in two ways as described below.

- By a conveyor transport system which will carry the residual waste output of the Genesis MPC recycling plant. It will travel via the culvert under the precinct road (yet to be constructed) and will eject directly into the storage bunker.
- Some vehicle transport from Genesis may be required and when this occurs it will be via the archway under the precinct road (yet to be constructed).

5.3 Fuel Reception

After weighing, the vehicles will proceed to the tipping hall, where they will be directed to a vacant tipping bay to discharge into the bunker. On completion of the tipping operation, the vehicles will leave the tipping hall via a separate exit. A one way system will be operated where possible around the site to reduce the risk of congestion and collisions.

The fuel reception area will incorporate a number of tipping bays to allow multiple vehicles to discharge at the same time. The entry and exit doors to the tipping hall will be equipped with vertical folding or roller doors, which will be kept closed when delivery of waste is not taking place.

A three point checking procedure will be in place to ensure only eligible waste is unloading in the waste bunker.

Likely fuel deliveries based on average flows and estimated peak flows are detailed in section 5.9.

5.4 Fuel Storage

The design of the fuel store is key. The types of fuels under consideration have low energy densities, so the storage area required is large. Additionally, they do not flow particularly well and must be stored inside.

There are four main systems to be considered:

(1) Enclosed storage area using overhead crane to fill and remove material. Systems utilising cranes often store material in bunkers below ground, to increase depth and reduce footprint. This type of system is more compact and minimises the number of staff required as cranes can be automatic. Capital costs will be higher due to the use of expensive cranes. Consideration is needed for fire risks and construction costs, as extensive below ground excavations may be costly.

(2) Building with a flat floor utilising front end loaders (FEL) to move material around. This system is the simplest and easiest to construct. However, it requires a vast floor area and is demanding in labour terms as several front end loader drivers are required. Safety is also an issue, with potential vehicle clashes.

(3) Silos. Waste wood and similar material can be stored in round bottom silos. However, to provide several days' storage of CRW or C&I waste for such a large facility would require a large number of silos, and this option is not considered to be suitable for the Facility.

(4) A-frames. These are often used on biomass plants. Material is fed to the top of the building by conveyors and falls down onto a triangular heap. Reclaimer screws run along the bottom of the building, dragging material out onto feed conveyors. In order to achieve the required storage capacity the A-frame buildings would need to be very large. Labour requirements are low, but capital costs are higher.

5.4.1 Fuel Storage Considerations

It is assumed that the fuel delivered to the EfW facility will be such that no further pre-treatment will be required. However, the various fuels received by the Facility will need mixing prior to treatment to improve homogeneity of the fuel. Whatever system is selected, an appropriate mixing system will be required. It is possible to mix the fuel first and then store it, or store the fuels separately and mix them as they are sent to the Facility. As mixing will require equipment which could break down or need repair, it may be better to store mixed material. However, this means there is a long lag time if it is necessary to change the material fed to the Facility.

The amount of material to be stored is key in determining the fuel store type. The decision regarding fuel storage requirements needs to consider each fuel supply stream in terms of security of supply and potential breakdown in supply.

Storing such large quantities of flammable material inside inevitably introduces a significant fire risk. Use of water sprays may be possible, but for deep storage of waste, penetration can be a problem and water consumption very high. Directional water cannon are far better, but these may be difficult to operate in the fuel store. There is a risk that if a fire becomes established and the whole facility would burn down. The Facility should therefore be located away from other buildings and not near power lines.

Another issue to consider in the design of the fuel storage is ventilation. Whilst the fuels should not be too odorous, there will be dust and some odours requiring suitable ventilation and a filter. In many plants this is overcome by extracting the primary air for the boiler from above the bunker, thereby maintaining a negative pressure and reducing the release of dust and odours.

For maximum flexibility and minimum footprint, Fichtner would suggest that a bunker offers the optimum storage solution. Bunkers are used at the vast majority of Energy From Waste or waste plants in the U.K. and Europe. Table 9 shows the expected bunker dimensions required to provide over 4 days storage of the design fuel for both phases.

The bunker length has been assumed at 30m and the bunker depth is also 30m.

The bunker width in Table 9 is sufficient to provide 6.4 days storage of the design fuel. Even at the maximum throughput, the bunker would provide 5.2 days storage,

Table 9: Bunker Design Data

Facility & Fuel parameters		
Fuel flow	t/day	3315
Assumed Fuel Density	t/m^3	0.25
Volumetric fuel flow	m^3/day	13,259
Bunker parameters		
Length	m	30
Width	m	94
Height	m	30
Maximum fuel stacking height	m	30
Bunker capacity (with stacking)	m3	84,600
Maximum number of days storage	days	6.4

The required footprint for the fuel storage and its location are shown in the proposed layout (provided in Appendix B).

5.5 Fuel Transfer

There will be relatively little movement of materials after delivery to site. In unusual circumstances fuel may be stored outside the fuel store in sealed containers. The mode of transport for transfer within site would be trucks of a similar type to those delivering the material to site.

5.6 Consumable Materials Handling and Storage

The Facility will use various raw materials during operation. Primarily, these include hydrated lime, ammonium hydroxide, activated carbon, gas oil and water. These will be delivered to the Facility in bulk transportation vehicles (except for water). The minimum on site storage capacity should be set to reflect the process requirements and local delivery capability. Table 10 shows the approximate number of deliveries anticipated.

Based on the water balance from a typical EfW facility, the average water requirement is likely to be around 12.8 m^3 per hour per phase (25.6 m^3 per hour for the overall plant). This is process water only and assumes that ACC is the cooling system, therefore it does not require any make-up for a wet cooling system. Based on 8,000 operating hours a year this equates to approximately 102,470 m^3 per year per phase (205,000 m^3 per year for the overall plant). The primary requirement for water is to provide make-up for the steam cycle (to replace that which is blown down) and in the FGT plant. The quantity required in the FGT plant is dependent on the particular technology used and therefore the figures are liable to change for different contractors.

In addition, various other materials are used for the operation and maintenance of the Facility including:

- hydraulic oils and silicone based oils;
- gas emptying and filling equipment;
- refrigerant gases for air conditioning plant;
- glycol/anti-freeze for cooling; and
- boiler water dosing chemicals.

In order to minimise the risks of contamination to process and surface water, all liquid chemicals stored on site will be kept in bunded controlled areas with a volume of 110% of stored capacity. Gas oil will be held in a bunded storage tank and any spillages or leaks will be retained in this area and treated locally.

Table 10: Consumable requirements and estimated deliveries for the Facility[2]

Raw material	Process	Typical usage (tpa)	Typical delivery (tonnes)	Annual deliveries	Average weekly delivery
Hydrated Lime	Flue gas treatment – acid gas scrubbing	19,800	22	900	17
Ammonium hydroxide (25% solution)	Flue gas treatment – NO_x reduction	2200	22	103	2
Activated carbon	Flue gas treatment – dioxins/ heavy metal	420	22	19	0.4
Low Sulphur gas oil[3]	System firing	1,900	30	47	1
Totals by road		**24,000**		**1,080**	**20**
Water	Boiler & FGT	200,000	N/A	N/A	N/A

[2] Values are taken from a typical same capacity multifuel plant.

[3] 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.

5.7 Ash and Residue

The residue production from the Facility has been estimated and presented within Table 11:

Table 11: Ash Production			
		Design fuel	**Worst case fuel**
Fuel NCV	MJ/kg	12.34	10
Ash content	%	11.53	20
Fuel Flow	tpa	1,105,000	1,350,000
Bottom ash (dry)	tpa	127,400	257,000
Bottom ash (wet)	tpa	159,300	321,000
FGT/APC residue	tpa	43,800	51,700
Combined ash and residue	tpa	203,100	372,000

5.8 Road Deliveries

Table 12: 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.

As per section 5.1, the following is also assumed:

- the fuel received has the minimum NCV as shown on the firing diagram (10 MJ/kg);
- deliveries can be received 12 hours per day, 7 days a week (8,760 hours per year); and
- fuel and APC residues are transported in containers or bulkers with an average 22 tonne payload; and
- bottom ash is transported in containers with an average 18 tonne payload.

To estimate the peak hourly traffic flow, the following variables have been applied.

- Daily variation will occur due to sourcing and fuel suppliers. As an approximation, it is estimated that daily traffic flows might vary by ±20%. This imposes a 120% increase on the average daily flows.
- Hourly flows are difficult to control, depending on lorry drivers and loading times at other facilities. It is estimated that the hourly peak flow during a day is likely to be about twice that of the average flow required. This means the total hourly peak could be up to 140% of the total worst case flows stated in this report.

Table 12: Average and Peak Total Traffic Flows on worst case fuel						
		Fuel (NCV 10MJ/kg)	**Consumables**	**APC Residues**	**Bottom Ash**	**Total**
Average mass flows	t per year	1,350,000	24,300	51,700	321,000	1,750,000
	t per week	26,000	468	994	6,170	33,600
	t per day (Mon-Sun)	3,710	67	142	882	4,800
	per hour	155	2.8	6	37	200
Average deliveries	per year	61,360	1,110	2,350	17,800	82,650
	per week	1,180	21	45	343	1,589
	per day (Mon-Sun)	169	3	6	49	227
	per hour	7	0.1	0.3	2	9
Variability	Daily peak	120%	120%	120%	120%	
	Hourly peak	240%	240%	240%	240%	
Peak tonnage	t per day	4,450	80	170	1,060	5,760
	t per hour	371	6.7	14	88	480
Peak deliveries	Daily peak	202	3.6	8	59	272
	Hourly peak	17	0.3	1	5	23

5.9 Fuel Deliveries and tipping hall requirements

From the tipping hall, lorries empty their loads directly into the bunker, where it is managed, mixed and loaded into a hopper using overhead cranes.

It is assumed that all lorries 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 13: indicates that using the minimum fuel NCV (10 MJ/kg) and accounting for variability and peak flows, there would be a maximum of 17 deliveries per hour, requiring a minimum of 4 tipping bays.

Table 13: Tipping Bays requirement			
		Design fuel, average flow	**Maximum fuel throughput, peak flow**
Fuel NCV	MJ/kg	12.34	10
Peak hourly fuel	tonnes per hour	126	371
Delivery capacity	tonnes per delivery	22	22
Peak deliveries	Deliveries per hour	6	17
Unloading time per bay	minutes	12	12
Minimum bays required	(rounded up)	2	4

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

6 Operational and Control Philosophy

6.1 Fuel Handling and Control

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.

6.2 Process Control

The fuel is transported from the bunker onto the grate using an overhead grab. Primary air is controlled through the grate surface to allow the material to start to burn. As the material burns, the coarse inert content of the fuel, the ash, remains on the grate and slowly moves down the grate. The fuel feed rate, the grate control and the primary air flows are controlled to ensure that by the time the ash falls off the end of the grate it is completely burnt. The ash falls into a removal system where it is cooled and transported away to the ash handling system.

As the fuel burns on the grate, it releases gases which flow upwards into the combustion chamber. In this, more "secondary" air is added. The air flows are controlled to enhance mixing of the flue gas, thereby ensuring good combustion so that by the time the gases leave the chamber all combustible gases are burnt.

The combustion system is automatically controlled to optimise the process. The control system uses a number of parameters to do this. The gas temperatures and oxygen content, together with the load on the boiler (the steam flow), are primary control parameters and the speed of the grate, the amount of fuel and the various air flows are controlled from these measurements. In addition, the operator uses the emissions from the Facility and visual observation of the grate by cameras to override the automatic system if required.

Control of emissions from the Facility is given highest priority. Carbon monoxide and oxygen levels are continuously monitored to ensure combustion is good and the Facility is required to maintain a flue gas temperature of 850^{o}C automatically. If this is not met, auxiliary burners will start up to raise temperatures and if problems continue, fuel feeding will be stopped automatically.

The control process is fully automated with safety interlocks. If any parameter such as temperature, pressure or oxygen level reaches a set level, an alarm sounds and if the problem persists, the Facility will be stopped automatically.

6.3 Emission Control

The flue gas treatment process is continuously monitored to avoid operating at levels above the set limits.

Oxides of nitrogen are controlled using the SNCR system. More or less ammonia is dosed to adjust the NOx levels. The system responds within a few seconds of changing the ammonia level.

Acid gases are controlled by the addition of lime. If acid gas levels rise, more lime can be added. Heavy metals and dioxins are removed by adding activated carbon. As these elements cannot be accurately measured on a continuous basis, the Facility will be operated with too much activated carbon to ensure that emission limits will be met.

Dust is controlled by the fabric filter, which provides a barrier to remove fine particles carried over. As this is a physical barrier, dust removal is fixed. The only issue is if the fabric filter breaks. In this case, higher dust levels are immediately detected by the dust monitor. The operator would then shut off the area of the fabric filter which is leaking. The fabric filter is sized to allow one section of the bag filter to be isolated and still operate at full load. The leaking section of the filter can then be replaced by removing and replacing the leaking bag.

The Facility is regulated under tight control from the relevant regulator. Any problems, even if relatively minor, have to be reported and the regulator will often monitor the plant's performance on-line. The Facility operator has a very short time to fix any problems in operation, after which the Facility will be shut down for repair. This extends even to the emission monitoring system so that the Facility cannot be operated for any significant period without monitoring the emissions.

The following process variables have particular potential to influence emissions and will be monitored continuously.

- Waste throughput is recorded to enable comparison with the design throughput. As a minimum, hourly and annual throughput is recorded.
- Flue gas temperature after injection of secondary air.
- Oxygen content of the flue gases exiting the boiler.
- Differential pressure across fabric filters.
- Reagent feed rates.
- Upstream HCl concentration, in order to optimise the performance of the emissions abatement equipment.
- Ammonia concentration in flue gases, in order to optimise the performance of the SNCR system.

6.4 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.

These systems are well proven and are utilised in European and UK energy from waste plants.

6.5 Staffing

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 lead by experienced engineers who will have the responsibility for managing the operation of the Facility outside of office hours. The total number of staff required will be low for a variety of reasons. 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 at the busiest waste delivery times. The weighbridge will also be fully automated with a vehicle recognition system and traffic barrier control system. Table 14 outlines the anticipated staff members required.

Table 14 Staff 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**

7 LAYOUT

TNG has provided the preliminary facility layout as shown in Figure 3. However, for this concept design, we have developed a concept facility based on the assumptions stated throughout this report. The proposed layout for the Facility is presented in Appendix A. At this stage building elevations have not been developed. The layout provided will be constructed in two phases. It shows that a four stream facility easily will fit on the site available.

The layout includes fuel reception and storage, a boiler house and turbine and a flue gas treatment area with associated stack. The layout includes separate access roads and parking for staff.

The concept design is based on a fuel bunker sized to store approximately 5-7 days of material.

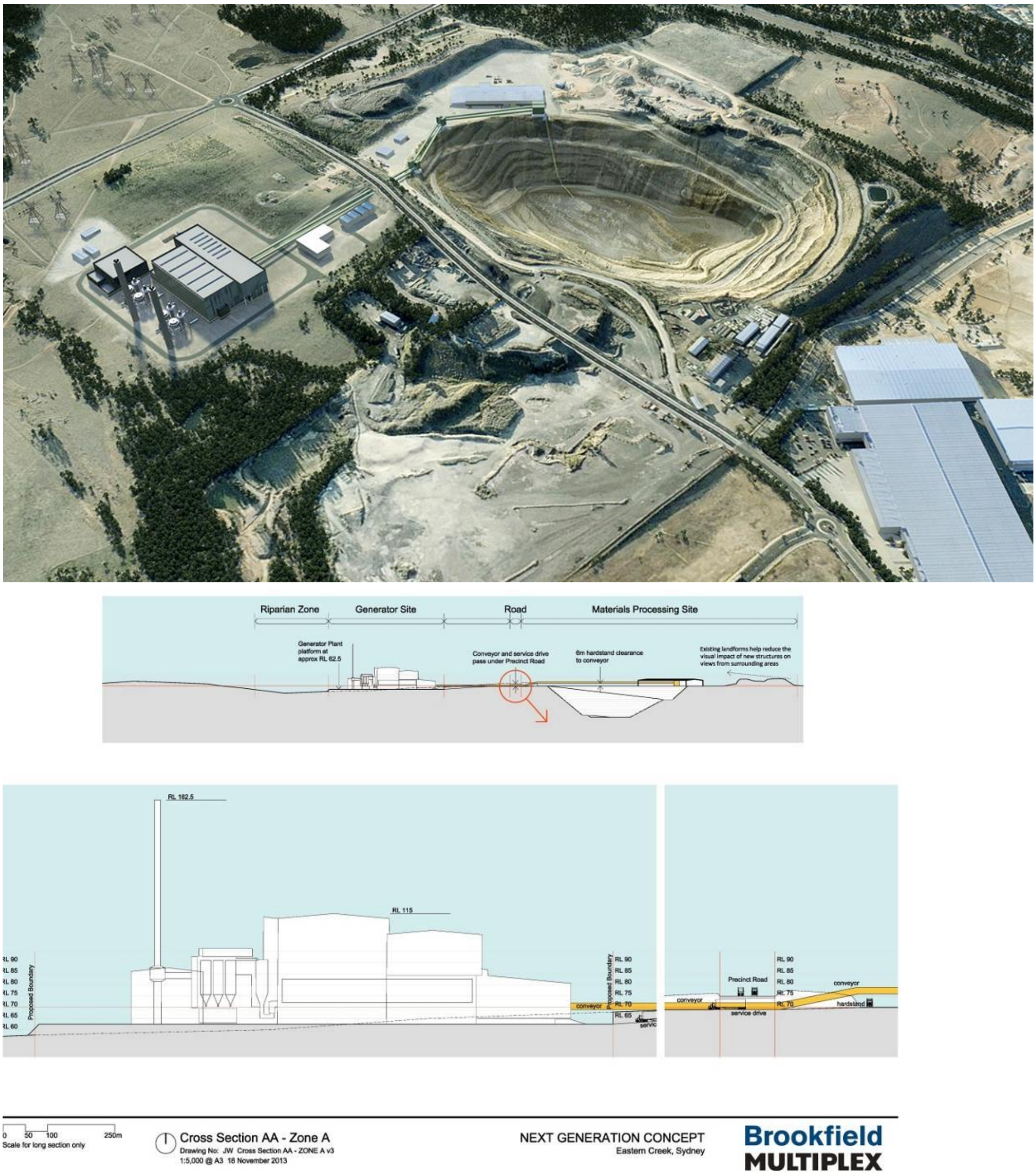


Figure 3: TNG EfW Site preliminary facility layout provided by TNG

8 Design input for the Environmental Assessment

Design inputs are required for the development of the applications for planning and operating licence.

The dimensions of buildings to be used in the air quality and noise assessments are presented in Table 7.

The design criteria for the air quality and noise model inputs are required by the planning consultants and their technical advisors.

8.1 Air Quality Modelling Inputs

The inputs required for the dispersion modelling for TNG based on a maximum fuel input of approximately 1.35 million tpa (8,000 hours operation at NCV of 10 MJ/kg). The air quality modelling will need to assume continuous operation (8,760 hours) at the proposed design criteria, presented in Table 15:

<table>
<tr><th colspan="7">Table 15: Overall Facility Performance</th></tr>
<tr><th></th><th></th><th colspan="2">Phase 1</th><th colspan="2">Phase 2</th><th rowspan="2">Overall facility</th></tr>
<tr><th>Items</th><th>Units</th><th>Total</th><th>Per stream (based on 2 streams)</th><th>Total</th><th>Per stream (based on 2 streams)</th></tr>
<tr><td>Temperature</td><td>°C</td><td colspan="5">140</td></tr>
<tr><td>Exit moisture content</td><td>% v/v</td><td colspan="5">16.38</td></tr>
<tr><td>Exit oxygen content</td><td>% v/v dry</td><td colspan="5">8.00</td></tr>
<tr><td>Reference oxygen content</td><td>% v/v dry</td><td colspan="5">11.00</td></tr>
<tr><td rowspan="2">Volume at reference conditions (dry, 11%v/v O2)</td><td>Nm3/s</td><td>139.28</td><td>69.64</td><td>139.28</td><td>69.64</td><td>278.56</td></tr>
<tr><td>Nm3/h</td><td>501,418</td><td>250,709</td><td>501,418</td><td>250,709</td><td>1,002,836</td></tr>
<tr><td>Flue gas volume (wet)</td><td>Nm3/s</td><td>127.98</td><td>63.99</td><td>127.98</td><td>63.99</td><td>255.96</td></tr>
<tr><td></td><td>Nm3/h</td><td>460,714</td><td>230,357</td><td>460714</td><td>230,357</td><td>921,428</td></tr>
<tr><td>Flue gas volume (dry)</td><td>Nm3/s</td><td>107.02</td><td>53.51</td><td>107.02</td><td>53.51</td><td>214.04</td></tr>
<tr><td></td><td>Nm3/h</td><td>385,256</td><td>192,628</td><td>385,256</td><td>192,628</td><td>770,512</td></tr>
<tr><td>Moisture content</td><td>kg/ kg flue gas</td><td colspan="5">0.105</td></tr>
</table>

Minimum emission criteria to be applied within the air quality assessment are presented in Table 6.

8.2 Noise Modelling Inputs

It is assumed that the noise specialist undertaking the noise assessment will make conservative assumptions within the modelling which are acceptable to the Australian regulatory authorities.

For the purposes of the assessment would want a noise assessment to include an assessment of the noise impacts associated with the process plant which generated the highest noise levels. The principal noise sources from an operational EfW are presented in Table 16:

Table 16: Principal Noise Sources from an Operational EfW

Item No.	Noise Source	Assumed Noise Level SWL dB(A)
1	Stacks (2 – 1 per stream)	
2	Turbine Hall (2)	95
3	Tipping Hall	95
4	Air Cooled Condensers (ACC's) (2)	104
5	Transformers (2)	73-74
6	Compressors (2)	80
7	Boiler Area (2)	75-95
8	Dry Flue Gas Treatment (4)	98
9	ID Fans (2)	100
10	Silo's & Bag Storage (2)	85
11	Ash Handling (2)	90

A layout drawing which indicates the location of all of the above noise sources to be included within the noise model for the Facility is presented in Appendix E.

9 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:

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

where:

E_p	*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)*
E_f	*means annual energy input to the system from fuels contributing to the production of steam (units of GJ/yr)*
E_w	*means annual energy contained in the treated waste calculated using the lower calorific value of the waste (units of GJ/yr)*
E_i	*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 above the threshold for new incineration plants. Therefore, the Facility will meet the definition of recovery. The calculation is shown in Appendix C.

10 Consultation Strategy

A successful planning application for an EfW will typically require a consultation strategy which encompasses all stages of community and stakeholder engagement. This will include providing information to empowering local residents and stakeholders.

The approach to community engagement and consultation will ensure that information about the development will be clear and concise, yet comprehensive and detailed.

TNG will need to use a range of publications to provide summary information and direct people to sources of more detailed information.

For projects in the UK the approach has been to supplement conventional media management with web-based resources to present the proposals positively, and provide a platform to develop relationships with the local community and stakeholders. Typically for consultation strategy will utilise a range of communication approaches, including the following:

(1) Media:
- Printed media; and
- Television and radio.

(2) Electronic communications:
- Websites.

(3) Community engagement:
- Events and exhibitions.

A successful communications programme will take advantage of all potential opportunities to disseminate information accurately and in a timely manner.

To develop a successful communications strategy to support the project Fichtner would recommend that TNG engage with local planning and consultation advisors that will be able to identify any regulatory consultation requirements to support the planning process within Australia.

10.1 Media

Working with local and regional media can assist in executing a successful consultation strategy. From our experience a successful media relations strategy will typically:

(1) provide an ongoing narrative to the 'story' of the proposal, and respond to any other narratives that develop over the proposal;
(2) demonstrate a commitment to openness and engagement;
(3) demonstrate a commitment to engaging with the local community;
(4) provide a platform for answering questions and concerns;
(5) provide a yardstick of public opinion; and
(6) raise knowledge and awareness of waste management issues and activities at both local and national level.

Building media relationships will be important to ensure that there is a positive message communicated to the local community and interested stakeholders.

The team need to will be open, accessible and professional, developing the best possible opportunities for balanced and fair coverage of the key issues. This may require working with the media to place the issues in front of the public through stories, supplements, features, broadcast discussions, etc.

To nurture ongoing media relationships it would be recommended to:

(1) identify and connect with key individuals on both reporting and editorial teams of broadcast and print media;
(2) hold a briefings with the local broadcast and print media; and
(3) provide named contacts and well-prepared spokespeople.

A detailed Q&A can be used for handling reactive press enquiries relating to the TNG.

10.2 Electronic communications

A project website can be used to provide essential information about:

- the company and the proposals;
- the consultation process and community involvement;
- the visitor centre and a virtual tour of the Facility;
- a description of the technology used;
- contact details and complaints procedures; and
- relevant documents including planning application documents and media releases.

We note that TNG has an existing website. This could be used to provide information relating to the TNG project.

10.3 Community Engagement

Public engagement events are a way of presenting proposals to the local community to educate them into the proposals and gain any feedback and identify their concerns and objections. Successful public engagement events will utilise require input from specialists that both understand the technology, the environmental issues and impacts associated with the proposed development.

Typically the major issue/concern raised by local communities relate to noise, air quality and traffic.

In the UK, typically two or three community engagement event sessions would be held on a project such as TNG's. This can be supplemented with target presentation to key interest groups if considered required.

Appendix A - Non-Technical Summary

The Next Generation NSW (TNG) are currently proposing to construct an Energy from Waste facility, with a capacity of up to 1.35 million tonnes per annum (tpa). The Facility will be designed to export circa 140 MW_e.

The Facility will be sited on land adjacent to the Genesis Xero Waste facility, which is located at Honeycomb Drive Eastern Creek (off Wonderland Drive), Sydney. Genesis Xero Waste site has had a planning approval for the construction and operation of a resource recovery facility (RRF) and landfill facility. The RRF includes a Material Processing Centre (MPC) and Waste Transfer Station (WTS) and landfill which have the ability to accept up to two million tonnes of waste per annum.

TNG is in the process of developing a submission for a planning application to the regulatory authorities. The purpose of this document is to provide a non-technical description of the Facility.

The Facility will be constructed in two phases. Each phase will have two combustion grates and boilers, together with auxiliary equipment, which will be located in the boiler hall. Each boiler will have its own flue gas treatment plant, which will be located outside, connecting to a common stack.

A.1 General

The Facility will be designed using an established and proven technology. A grate based solution would provide most flexibility for the types of fuel considered by TNG.

The Facility will operate 24 hours a day, 7 days a week, with occasional offline periods for maintenance. Over the entire year, it is anticipated that the Facility will be operational for 8,000 hours as an annual average, equivalent to an overall availability of 92%. Availability is defined in this case as the number of hours that the Facility is available to operate at full load.

Fuel will be delivered to the site by road and via conveyor from the Genesis Facility which is located adjacent to the proposed EfW facility and will be the primary fuel source for the Facility. Road transport will not involve any greater use of the state road transport network than presently occurs. Much of the fuel arriving at the Facility will have already been through processes at the Genesis Facility to ensure that recyclable materials are extracted to meet the proposed EPA regulations for recycling. Residual waste from the recycling process will then be transported to the Facility via a covered conveyor system.

The Facility will have significant storage capacity for approximately 5-7 days of fuel, so that the Facility can continue to operate if there are any short term supply issues and over a Public Holiday weekend.

A.2 Fuels

TNG requires a facility with maximum fuel flexibility in order to be able to receive as many different types of waste fuels as possible.

The following residual waste fuel types are considered as the main sources of fuel for the Facility.

- Chute Residual Waste (CRW) from the Genesis Facility;
- Commercial and Industrial (C&I);
- Construction and Demolition(C&D);
- Flock waste from car and metal shredding;
- Paper pulp;
- Glass Recovery;
- Green Organics (GO);
- AWT; and
- MRF residual.

The NCV for the above fuel types will each vary within a range and therefore the Facility will need to be able to process fuels having a range of net calorific values (NCV).

A.3 Facility Equipment

A.3.1 Combustion System

A moving grate system is likely to offer the most flexible and cost effective solution, for the fuel mix being considered.

Primary air for combustion will be fed to the underside of the grate by fans. Secondary air will also be admitted above the grate to create turbulence and ensure complete combustion with minimum levels of oxides of nitrogen (NOx). The volume of both primary and secondary air will be regulated by a combustion control system. Flue gas recirculation may be incorporated, but only if the grate designer believes it is required in the design.

The Facility will be designed to meet the requirements of the Australian regulatory authorities. The combustion control system will regulate the combustion conditions, and thereby minimise the levels of pollutants and particulates in the flue gas before flue treatment. The furnaces will also be fitted with auxiliary burners, fired on low sulphur gas-oil, which will automatically, if required, maintain the combustion chamber temperature above 850°C to ensure the destruction of dioxins, furans and other undesirable combustion products. Combustion chambers, casings, ducts, and ancillary equipment will be maintained under slight negative pressure to prevent the release of gases.

During operation, the temperature in the combustion chamber will be continuously monitored and recorded to demonstrate compliance with the requirements of the Australian regulatory authorities. The combustion control system will be an automated system, including monitoring of the steam flow, oxygen content, temperature conditions of the grate, modification of the fuel feed rates and the control of primary and secondary air.

It is likely that Selective Non Catalytic Reduction of NOx will be required to control emissions. Ammonia or urea solution is sprayed into the combustion chamber, reacting to break NOx down into nitrogen and steam.

A.3.2 Boiler

The Facility will include four boilers, two for each phase. The priority for the Facility will be that it operates reliably with reasonable maintenance costs. C&D and C&I waste can be quite aggressive due to relatively large amounts of organic chlorine in the waste. This is liberated as HCl in the flue gas and can lead to significant high temperature corrosion. For this reason, the final steam temperature in an energy from waste facility of this type should be limited to 400-430°C.

A.3.3 Cooling system

The Facility will require a cooling system to condense the turbine exhaust steam and provide cooling capacity across the Facility.

TNG will employ Air Cooled Condensers (ACC) as there are no major water courses nearby to the site which could be used for turbine cooling. The advantages of using ACC are that it does not require large volumes of water and does not generate a discharge. There will be no visual impacts from the ACC, as there would be for alternative cooling technologies.

A.3.4 Flue Gas Treatment

The design of the flue gas treatment system will be fully compliant with current European legislation through meeting the requirements of the Industrial Emissions Directive (IED) and therefore the requirements of the Australian regulatory authorities.

The flue gas treatment system will consist of Selective Non-Catalytic Reduction (SNCR) of NO_x, activated carbon injection, dry lime scrubbing and fabric filters. The system is designed to ensure that the Facility operates well within the emission limits in Part 3 of the IED shown in Table A1.

The Facility will be designed to ensure that the Facility operates within the emission limits set out in the IED with headroom should the limits be changed.

NO_x levels will primarily be controlled by careful control of the combustion air. SNCR will also be installed to reduce NO_x. SNCR involves the injection of a 25% ammonium hydroxide solution into the boiler which converts both nitrogen oxide (NO) and nitrogen dioxide (NO_2) to nitrogen and water. Urea can be used as an alternative to ammonia.

Acid gases produced during the combustion process will be removed by a scrubbing system, typically using hydrated lime as a reagent (although Sodium Bicarbonate can also be used). Neutralisation of the acid gases will take place as they react with the lime. The residual material will be recovered at the outlet of the flue gas scrubbing system. Activated carbon will also be injected into the flue gas duct to minimise the emissions of dioxins, mercury and other heavy metals. Some of the residual material will be recirculated to improve the gas clean up and reduce the amount of hydrated lime used.

Table A1: IED Emission Limits for an Incinerator

Parameter	Units	Half Hourly Average	Daily Average	Periodic Limit
Particulate matter	mg/Nm^3	30	10	None
VOCs as Total Organic Carbon (TOC)	mg/Nm^3	20	10	None
Hydrogen chloride	mg/Nm^3	60	10	None
Hydrogen fluoride	mg/Nm^3	4	1	None
Carbon monoxide	mg/Nm^3	100	50	None
Sulphur dioxide	mg/Nm^3	200	50	None
Oxides of nitrogen (NO and NO_2 expressed as NO_2)	mg/Nm^3	400	200	None
Cadmium & thallium and their compounds (total)	mg/Nm^3	None	None	0.05
Mercury and its compounds	mg/Nm^3	None	None	0.05
Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V and their compounds (total)	mg/Nm^3	None	None	0.5
Dioxins & furans ITEQ	ng/Nm^3	None	None	0.1

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

After flowing through the gas scrubber, the gases will be drawn through a fabric bag filter to remove particulates, including lime and activated carbon particles. Each fabric filter will be divided into compartments. The treated flue gas will pass through an induced draught fan into the stack for release. Regular bag filter cleaning will be performed on-line by pulsing compressed air through the filter bags. The residues will be collected in fully enclosed hoppers beneath the filters. Bag failure, albeit an infrequent occurrence would be identified by a sudden increase in particulate concentration at particulate meters installed immediately downstream of the bag filter or by a change in the pressure differential across the bag filter.

Following cleaning, the combustion gases from the combustion process will be released into the atmosphere via a gas flue within a chimney stack.

A.3.5 Gas Analysis Systems

Emissions from the stack will be monitored continuously by an automatic computerised system and reported in accordance with the requirements of the IED.

Sampling and analysis of all pollutants will be carried out to 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 bjectives;

(1) to provide the information necessary for the Facility's 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 at each stack and recorded continuously 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); and

(8) particulates.

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.

The continuously monitored emissions concentrations will also be checked by an independent testing company at frequencies agreed with the relevant regulator.

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

(1) nitrous oxide;

(2) hydrogen fluoride; (3) heavy metals; and (4) dioxins and furans.

The methods and standards used for emissions monitoring will be in compliance with the UK EA guidance and the IED. In particular, the CEMS equipment will be certified to the MCERTS[4] standard and will have certified ranges which are no greater than 1.5 times the relevant daily average emission limit.

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

A.3.6 Stack

Flue gases will be emitted to atmosphere via stacks. The appropriate height of the stack will be determined by dispersion modelling.

Each boiler will have its own flue. The chimney will be constructed either with a windshield housing the flues or as separate flues tied together.

Typically, the top of the flues will be stainless steel lined to avoid corrosion.

[4] MCERTS is the UK's Environment Agency's Monitoring Certification Scheme. The scheme provides a framework within which environmental measurements can be made in accordance with the Agency's quality requirements.

Flue gases will be emitted from the flues with a velocity in excess of 15 m/s. Combined with the thermal buoyancy of the warm gas, the flue gases will rise before becoming dispersed. Dispersion modelling carried out as part of the Environment Assessment (EA) will need to demonstrate that even under worst case emission limits (i.e. assuming IED limits are achieved continuously) the dispersed pollutants are not significant.

A.3.7 Steam Turbine

The Facility will be capable of exporting approximately 140 MW of electricity, amounting to about 1,130,000 MWh per annum of electricity. The export of electricity will be agreed as part of a separate connection study with the electricity distributed network operator

Substation design 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.

A.3.7.1 Export of heat

Without any changes to the main plant design, the Facility will be configured so that it will be possible to also export heat to nearby consumers for space heating or cooling or hot water. Depending on the requirements, it should be possible to export heat from the Facility as ether steam or hot water. In addition, for cooling purposes, the heat source can be steam or hot water depending on the technology of thermal chillers chosen.

The potential export of heat will need to be considered in the turbine design. Whilst a dedicated extraction is not necessarily required, allowance will need to be made for the additional steam extraction required for heat export.

Since at this stage, heat export is only a possibility the turbine should be optimised for the zero heat export case, but one or more of the bleed ports and connecting pipework will need to be designed to incorporate the additional steam flow for heat export.

Increased steam extraction leads to increased mechanical loading on the upstream turbine blades and this would need to be modelled in the initial design. Adequate space for the installation of district heating scheme heat exchangers would also need to be allowed for in the Facility layout.

A.3.7.2 Turbine bypass

It should be noted that most energy from waste plants incorporate a 110% turbine bypass. This allows the Facility to be operated and process waste fuel even if there is a problem with the turbine. As waste fuels receive a gate fee, it can be economic to continue to operate the Facility to get rid of the waste, even without turbines.

By-pass steam is sent to the condenser after passing through a de-superheating station. This reduces the temperature of the steam but overall the heat load on the condenser is increased compared to normal operation. This causes the condenser pressure to rise.

Since the turbines are not in operation a higher condenser pressure is not an issue. The provision of a turbine by-pass must be considered in the condenser design but typically does not increase the size of the condenser required. If island mode operation is to be employed, (whereby sufficient steam flow passes through the turbines to generate enough electricity for the house load, with the majority by-passed) then the condenser pressure is more critical and could impact the condenser design.

A.3.8 Auxiliary Equipment and facilities

The Facility will require various auxiliary equipment and facilities to operate. The main auxiliary equipment required is as follows:

- Site entrance. The preferred option for the Facility is to segregate HGVs and cars as much as possible.
- Weighbridges. The Facility will require weighbridges to record the fuel incoming directly to the Facility.

- Security. Security systems will be required to cover the proposed site.
- Fuel reception and storage.
- Compressed air. A compressed air system will be installed in the Facility.
- Demineralised water. A demineralised water system will be installed which will include storage of demineralised water.
- Gas oil system for starting up the Facility. A new system including storage will be installed.
- Fire detection and suppression system. Fire pumps and fire water storage system will be utilised.
- Cooling system. A cooling system will be required to provide cooling for the Facility. This will be an Air Cooled Condenser (ACC).
- Stack. A stack will be required for the release of treated flue gases.

A.3.9 Buildings

The Facility will be built in two phases. Each phase would comprise of a main boiler house including the main elements of the process.

Each phase will have two combustion grates and boilers, together with auxiliary equipment, which will be located in the boiler hall. Each boiler will have its own flue gas treatment plant, which will be located outside, connecting to that phase's stack. A steam turbine for each phase will be located in an adjacent turbine hall.

The main buildings of the Facility will be as follows:

- tipping hall and fuel storage (common to both phases);
- boiler hall ;
- turbine hall;
- substation;
- ash collection bay;
- workshop;
- stack; and
- control room, offices and amenities (common to both phases).

A.4 Operational & Control Systems

The Facility will be fully automatically controlled and operated from a stand-alone control room.

The proposed main control and supervision system will consist of a Distributed Control System (DCS) organised on several levels. The Facility will be fully instrumented to allow safe and efficient operation.

A.5 By-Product Handling and Disposal

Three types of solid by-products and one type of liquid by-product will be produced from the operation of the Facility, each of which has separate handling and disposal arrangements.

Bottom ash is the burnt-out residue from the combustion process. The Facility is expected to generate up to 321,000 tpa of bottom ash for the proposed maximum design capacity, although the expected ash generation from the design fuel is only 159,000 tpa. The bottom ash will be discharged onto a conveyor system from the boiler. The conveyor passes under a magnetic separator to remove ferrous materials which will be discharged to a dedicated storage area. The ash will then be discharged to a bottom ash bunker or storage bay for storage prior to further processing and to be recycled as a secondary aggregate.

Boiler ash is collected from the boiler between the bottom ash and the FGT residues. If it is found to be hazardous, it will be directed to the FGT residue silos.

FGT residues comprise fine particles of ash and residues from the flue gas treatment process, which are collected in the bag filters. It is estimated that the Facility will generate up to 51,700 tpa of APC residue for the maximum design capacity. The FGT residue will be stored in sealed silos adjacent to the flue gas treatment facility. Due to the alkaline nature of the FGT residues, they are classified as hazardous waste (in much the same way as cement). As a result, the residues will be transported by road in a sealed tanker to an appropriate treatment facility.

Liquid effluents will be produced from the boiler water treatment system and from the boiler blow-down. All boiler blow-down and liquid effluent produced are fed to the ash discharger via the process water system. Under normal operating conditions, no effluents are disposed of to drain but returned to the Facility for re-use. In this way, the majority of liquid effluent produced on site will be evaporated.

Appendix B - Provisional Layout

Issue	Description	Date
E	RE-ISSUED FOR SSDA	20-02-15
D	ISSUED FOR SSDA	18-06-14
C	ISSUED FOR INFORMATION	16-06-14
B	ISSUED FOR CLIENT REVIEW	14-05-14
A	ISSUED FOR COORDINATION	06-05-14

Bar Scales

0 30 60 90 120 150m

1 : 1500 @ A1 1 : 3000 @ A3

100mm on Original

Client: THE NEXT GENERATION (NSW) Pty Ltd — Energise Your Future

Scales	1 : 1500 @ A1	Drawn	TS
		Designed	TS
Grid	MGA	Checked	MM
Height Datum	AHD	Approved	

Project: ENERGY FROM WASTE ELECTRICITY GENERATION PLANT, EASTERN CREEK

Title: GENERAL ARRANGEMENT PLAN

Civil Engineers and Project Managers
at&l
Suite 702, 154 Pacific Hwy
St Leonards NSW 2065
ABN 96 130 882 405
Tel: 02 9439 1777
Fax: 02 9460 8413
www.atl.net.au
info@atl.net.au

Status: FOR APPROVAL — NOT TO BE USED FOR CONSTRUCTION — A1

Drawing No.	Project No.	Issue
C002	14-187	E

Date Plotted: 20 Feb 2015 - 05:09PM File Name: F:\14-187 TNG\Drgs\Civil\DA-Drawings\C002.dwg

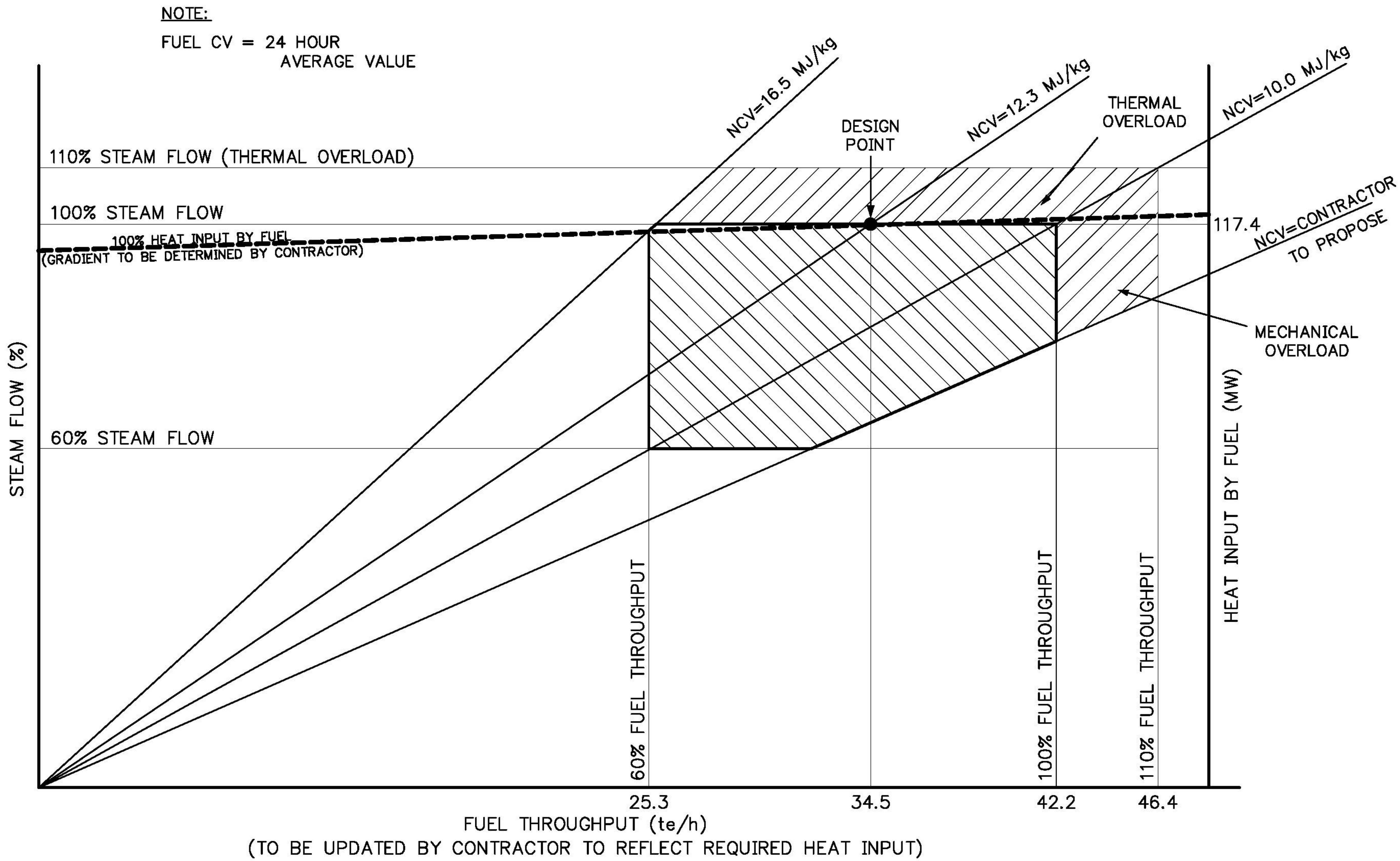
Appendix C - R1 Calculation

This R1 calculation follows the official EC guidance released in 2011

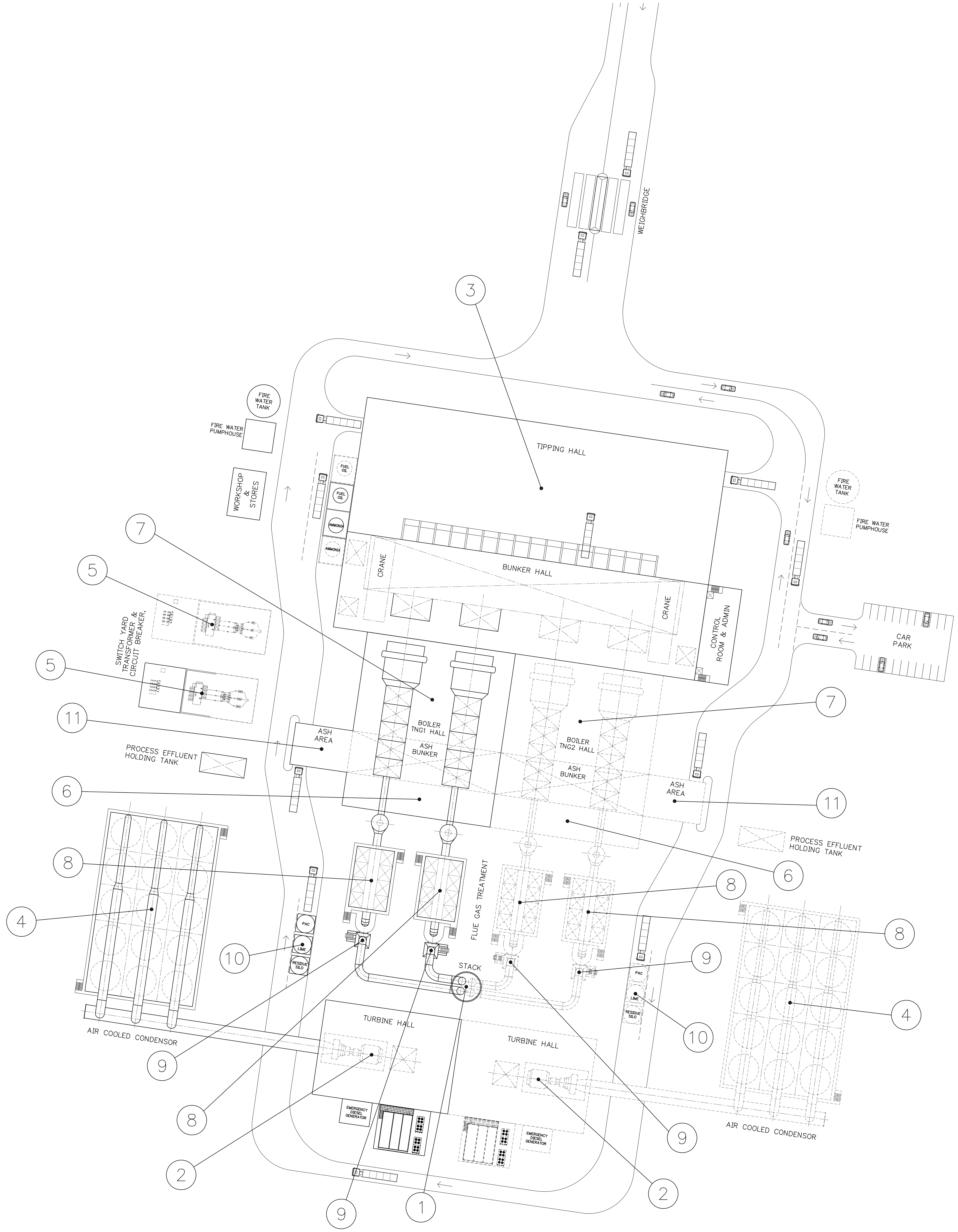
Waste Framework Directive energy efficiency calculation		
R1 formula		
number of streams	4	
Average through-life availability	91.32%	%
Equivalent full load operating hours per year	8,000	h/y
Feed stock		
Waste throughput per boiler	34.53	tph
Waste NCV	12.34	MJ/kg
Waste throughput	1,104,960	t/y
Waste Energy input	3,787,557	MWh/y
Waste Energy input	13,635,206	GJ/y
Electric exported		
Gross electricity production	153.18	MW
Net electrical output	136.2	MW
Total electricity produced	1,225,440.000	MWh/y
Total electricity produced	4,411,584	GJ/y
Heat exported		
Heat exported	0	MWh/h
Heat produced	0	MWh/y
Heat produced	0	GJ/y
Heat used internally (a)		
For steam driven turbo pumps for boiler water, backflow as steam	0	MWh/y
For heating of flue gas with steam, backflow as condensate	0	MWh/y
For concentration of liquid APC residues with steam, backflow as condensate	0	MWh/y
For sootblowing without backflow as steam or condensate	0	MWh/y
For heating purposes of buildings/instruments/silos, backflow as condensate	0	MWh/y
For deaeration - demineralization with condensate as boiler water input	0	MWh/y
For ammonia injection without backflow as steam or condensate	0	MWh/y
Heat used internally	0	MWh/y
Heat used internally	0	GJ/y
Total heat produced		
Total heat produced	0	MWh/y
Total heat produced	0	GJ/y
Fuel used		
LHV fuel	42.7	MJ/kg
Total Fuel consumed	1,126,190	litres/year
Fuel density	0.84	kg/litres
Total Fuel consumed	946,000	kg/y
	11,221	MWh/y
Energy in fuel consumed by start-up burners	40,394	GJ/y
Electricity imported		
Parasitic load	17,000	kW
	136,000	MWh/y
Parasitic load	489,600	GJ/y
Electricity imported	3,000	MWh/y
Electricity imported	10,800	GJ/y
WFD Calculation		
Ew	13,635,206	GJ/y
Ep(electricity)	11,470,118	GJ/y
Ep(heat)	0	GJ/y
Ep	11,470,118	GJ/y
Ef (1)	20,197	GJ/y
Ei(electricity)	28,080	GJ/y
Ei(heat)(2)	20,197	GJ/y
Ei	48,277	GJ/y
WFD ratio	**0.86**	
Pass or fail?	**pass**	

(1) assumes only 50% of fossil fuel used by start-up burners generates steam
(2) includes the 50% of fuel energy not contributing to steam generation
(a) the energy which is used inside the R1 system boundary, e.g.
for heating up the flue gas before the chimney, but not including energy uses influencing the steam/heat production

Appendix D - Firing Diagram



Appendix E - Location of Noise Source



Scale: NTS DO NOT SCALE	Original Size A1
Drawn By: AO	Date: 22.11.13
Checked By: JRS	22.11.13
CAD Ref.: 1624-003-A1	

Rev.	Amendment	Revised By	Checked By	Date
A1	PRELIMINARY	AO	JRS	22.11.13

Client	DIAL-A-DUMP
Site	ALEXANDRIA EfW
Project	CONCEPT DESIGN REPORT
Title	CONCEPT DESIGN LOCATION OF SIGNIFICANT NOISE SOURCES
Office of Issue: STOCKPORT	Telephone No.: 0161-476 0032

FICHTNER

CONSULTING ENGINEERS LIMITED
Kingsgate, Wellington Road North
Stockport, Cheshire SK4 1LW
Tel: 0161-476 0032 Fax: 0161-474 0618

Drawing No. 1624-003 SHT. 1 of 1 | Revision A1

FICHTNER

Fichtner Consulting Engineers Limited
Kingsgate (Floor 3), Wellington Road North, Stockport Cheshire SK4 1LW United Kingdom
t: +44(0) 161 476 0032 f: +44(0) 161 476 0618 www.fichtner.co.uk