JACOBS

Memorandum

32 Cordelia Street
PO Box 3848
South Brisbane QLD 4101 Australia
T +61 7 3026 7100
F +61 7 3026 7300
www.jacobs.com

Subject	**EfW "Design Waste"**	**Project Name**	AP EfW Project
Attention	Roger Winders	**Project No.**	RO097400
From	David Harridge		
Date	15 May 2018		
Copies to	Greg Hannah, David Jettner		

1. Background

Australian Paper (AP) submitted a Works Approval Application (WAA) to EPA Victoria on 24 April 2018 for an Energy from Waste (EfW) Project to be constructed at AP's Maryvale Pulp and Paper Mill. On 10 May 2018, EPA requested further information with regard to a back-calculated mass balance and the basis of waste that the proposed EfW Plant could accept (a "design waste"). The following paragraph is the EPA's request for further information:

"A mass balance back calculated from the modelled air emissions (which is set at the upper limits of the EU directive) that accounts for the removal efficiency of the air treatment equipment (based on the removal efficiency specified in your tendering documents). That mass balance should be included in the application and will give the authority confidence of what the upper limits can be for each chemical element. That will be the basis for the waste that the plant can accept and what it is able to process. That composition will be the ***design waste*** of the plant. The mass balance should be submitted together with a flow diagram."

This Memo provides a response to EPA's above query regarding a "design waste".

2. Back calculation to determine elemental limits

While there are methods and modelling tools to enable the calculation of emissions for given inputs to the EfW Plant, it is not possible to perform accurate and consistent back calculations based on emissions limits to determine maximum elemental waste inputs. This is because of the inherent variable nature of MSW waste and the non-homogenous composition based on the residual waste from households.

An accurate back calculation would require steady state interactions between the EfW plant's pollution control equipment and the pollutants. However, the level of removal of pollutants is dependent on the amount of Flue Gas Treatment (FGT) chemicals used and at times will not be under steady state conditions. The levels of pollutants in the flue gas will vary depending on the waste inputs and the FGT chemicals will vary accordingly.

For example, halogens (e.g. HCl and HF) are treated and removed through the use of an alkaline reagent (e.g. lime). More lime can be added to the FGT to treat flue gases that have a higher proportion of halogens (due to a higher proportion of halogens in the incoming waste), but the final halogen emissions from the stack would be the same. This controllable variability in lime dosing will also affect other pollutant levels in the exhaust, so that if lime dosing needed to be increased, the removal efficiency of heavy metals would also be incrementally improved.

It is not necessary to back calculate the ‘design waste’ for the facility as this has already been estimated for this project through waste compositional analysis and combined with available laboratory analysis and international and Australian waste quality information. This analysis of waste data has formed the waste fuel specification within the EPC (Engineer, Procure, Construct) Technical Specification. The specification defines a ‘design point’ which represents the current best estimate of typical waste composition, and also defines upper and lower limits or range of acceptable variability of key parameters like calorific value, ash content, moisture content, chlorine content and sulphur content which are important for effective combustion and flue gas treatment.

The development of EfW combustion and flue gas treatment technology in the world to date was initially through empirical techniques and trial and error. As EfW technology evolved from basic combustion with little flue gas treatment, over many decades it is now a very mature and evolved technology sector. The sector now has sophisticated combustion and flue gas treatment technologies that have led all industries in emissions management.

The word ‘empirical’ is a key consideration because, whilst many aspects of the combustion and flue gas treatment design can be calculated from first principles, there are still some aspects that are still very much empirical. This is due to the non-homogeneous nature of the incoming waste and the difficulties in measuring the chemical and physical properties in a repeatable, reliable and practical manner.

Calorific Value (CV) is an example of this for MSW (and MSW-like C&I) fuel. Much work has been conducted on this project to establish as best as possible what the waste calorific value may be during the operational life. But it is still necessary to specify for a wide range of waste CV for the EfW Plant due to remaining uncertainty over what will be typical CV level and the range of variability from day to day or hour to hour. Even during the plant performance testing phase at the end of the EPC contract period (when highly accurate measurements are taken all around the combustion process to establish that the plant is meeting its performance requirements in terms of efficiency, and compliance with the IED), it is not possible to directly sample and measure the incoming waste with any repeatability or accuracy that would comply with comparable test codes for other types of power plants.

As such a special EfW specific performance test procedure must be used that employs an empirical approach using the boiler as a calorimeter[1]. What this means is that boiler and incineration efficiency, and the waste CV, can only be determined from the measured plant losses and the steam generation rate, and the waste CV is then calculated from the estimated energy input (Output + Losses), and dividing by the waste crane feeding rate. This industry standard approach has been developed specifically for EfW, as other widely used power industry test codes for fossil fuels or even more homogenous biomass, do not meet the statistical accuracy tests required for their use, when applied to MSW and C&I waste feedstocks.

Thus if CV (which is a major fuel quality parameter) cannot be measured easily for incoming waste for a plant, then measurement of trace components like heavy metals in the incoming waste is completely impractical to any statistically representative certainty. To run an effective ‘first principles’ model, it is necessary to know accurately and consistently what is coming in (including quantities and

[1] FDBR Guideline ‘Acceptance Testing of Waste Incineration Plants with Grade Firing” Edition 04/2000

physical form such as particle size), to derive what will come out. No such first principles modelling tool exists for components of the waste such as trace heavy metals.

3. Management of incoming waste to meet IED and SEPP requirements

Given that the variability in MSW fuel makes it difficult to consistently and accurate characterise, the design and operation of the EfW Plant must be flexible. There are numerous aspects of designing and operating EfW plants that are being implemented for the AP EfW Project, as outlined in this section.

3.1 EPC (Engineer, Procure, Construct) contractual model

The most common delivery mechanism for the construction and commissioning of EfW plants around the world is through EPC contracts. This is where a provider of EfW technologies (EPC contractor) uses technical specifications from a client to conduct detailed design, engineering, procurement and construction of the EfW plant with eventual handover to the client.

As outlined within Chapter 4 of the WAA (EfW process description), the EPC Technical Specification will become the contractually binding requirement of the selected EPC contractor. If during the EPC period, anything about the contractor's design, performance or standards of construction that are found to be non-complaint with the EPC Technical Specification, it must be rectified by the EPC contractor or they will suffer material commercial penalties or be found in breach of contract.

The EPC Technical Specification, as well as detailing all of the plant's technical requirements, also specifies in detail all of the environmental performance requirements (i.e. European Union IED and Victorian SEPP) as 'make good' guarantees under the contract. The consequence of not 'making good' is a contract termination, a poor business outcome for an EPC contractor for an investment of this scale. If perceived as a risk of reasonable likelihood, it would be an immediate 'red flag' for their business.

There are three EPC tenderers who have committed to making a binding tender proposal to the project and they are fully cognisant of these contractual requirements. Due to their extensive prior experience successfully delivering hundreds of IED complaint EfW plants globally for a wide quality range of MSW and MSW-like fuels, the EPC tenderers have expressed no concerns about the MSW fuel specification and potential range of variability with respect to IED compliance.

3.2 Design parameters and technical specifications

Adoption of appropriate flexible EfW combustion and flue gas treatment plant design is imperative to deal with the ranges of waste qualities that will ensue during the project's operational phase. The design incorporates on-line emissions feedback control from the combustion gas analysers and the CEMS (continuous emissions monitoring system) which will allow optimisation of reagent dosing rate during operation, to account for waste quality and elemental changes. For example, the urea dosing rate can be adjusted for Selective Non Catalytic Reduction (SNCR) NOx control based on CEMS NOx and NH_3 emissions and the lime dosing rate for acid gas treatment based on incoming and outgoing HCl and SOx levels to the lime reactor system. This operational flexibility is considered BAT (Best Available Techniques) in accordance with the EC Waste Incineration BREF (European Commission Best Available Techniques Reference Document (BREF) for Waste Incineration (WI)).

For regulators such as government environmental agencies, uncertainty over waste inputs is controlled in the IED through:

- the prohibition of combustion of hazardous wastes (such as waste with chlorine levels > 1 wt%),
- through control of combustion conditions (i.e. 850 degrees C for 2 seconds), and
- through control of stack emissions (to be below the IED limits).

The IED does not try to impose controls over trace elemental composition for incoming waste, as this is impractical to monitor for the authority and for the operator.

The EPC Technical Specification requires flue gas output compliance with the IED and SEPP, which is standard practice for an EPC performance-based technical specification. A performance-based specification defines the input and output requirements, but does not specify every technical detail in the plant design, as the detailed design is the contractual responsibility of the EPC contractor, who brings to bear the necessary experience from many prior projects to achieve these requirements. The specification does not state what the removal efficiencies need to be for individual components or pollutants and it is up to the EPC to ensure they can achieve all the environmental performance requirements.

This is the industry standard approach adopted throughout the world for specifying EfW plant. The EPC Technical Specification for the AP EfW Project for the waste specification, emissions requirements and special requirements for flue gas treatment (to accept the worst case range of waste quality variability) are extracted in section 5 of this Memo for EPA's review to demonstrate the approach taken for the design of the EfW Plant (see sections 5.1, 5.3 and 5.4 below). This same approach of conservative design margin and allowance of a considerable range of ash variability is also taken to the specification of the ash handling systems (see section 5.5 below).

As part of the Technical Specifications, the EPC tenderers were provided with a Firing Diagram (provided below and also in section 4.6.4 in the WAA). The Firing Diagram shows the design operating parameters within which the EfW Plant could operate. The diagram correlates waste throughput (input), waste heat input (heat generated by the waste) and calorific value.

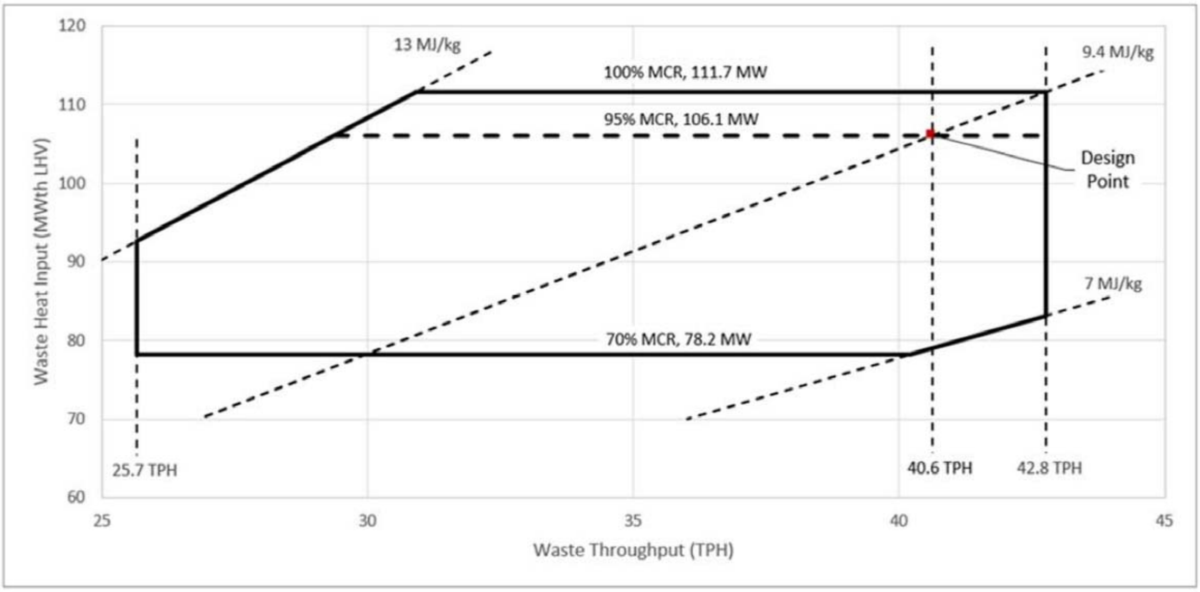

Figure 1: Firing Diagram

The diagram shows that the EfW Plant will be designed to handle waste in the following ranges:

- CV between 7 – 13 MJ/kg
- Waste throughput between 25.7 – 42.8 tonnes per hour
- Heat generated between 78.2 MW – 111.7 MW

Another useful diagram is the Design Waste Proximate Analysis Diagram, provided in section 10.4.7 of the WAA. This diagram correlates the percentage of combustibles, inerts, moisture and calorific value in the waste input to the EfW Plant. The grey shaded area in the diagram denotes the operating range of the EfW Plant, which is summarised in the table below.

Table 1: Design Waste Proximate Analysis Range

Design Parameter	Unit	Range
Composition		
Combustibles	wt%	18 – 85
Water	wt%	10 – 50
Inerts	wt%	5 – 32
Required Operational Range		
Heating Value	MJ/kg	7.0 – 13.0

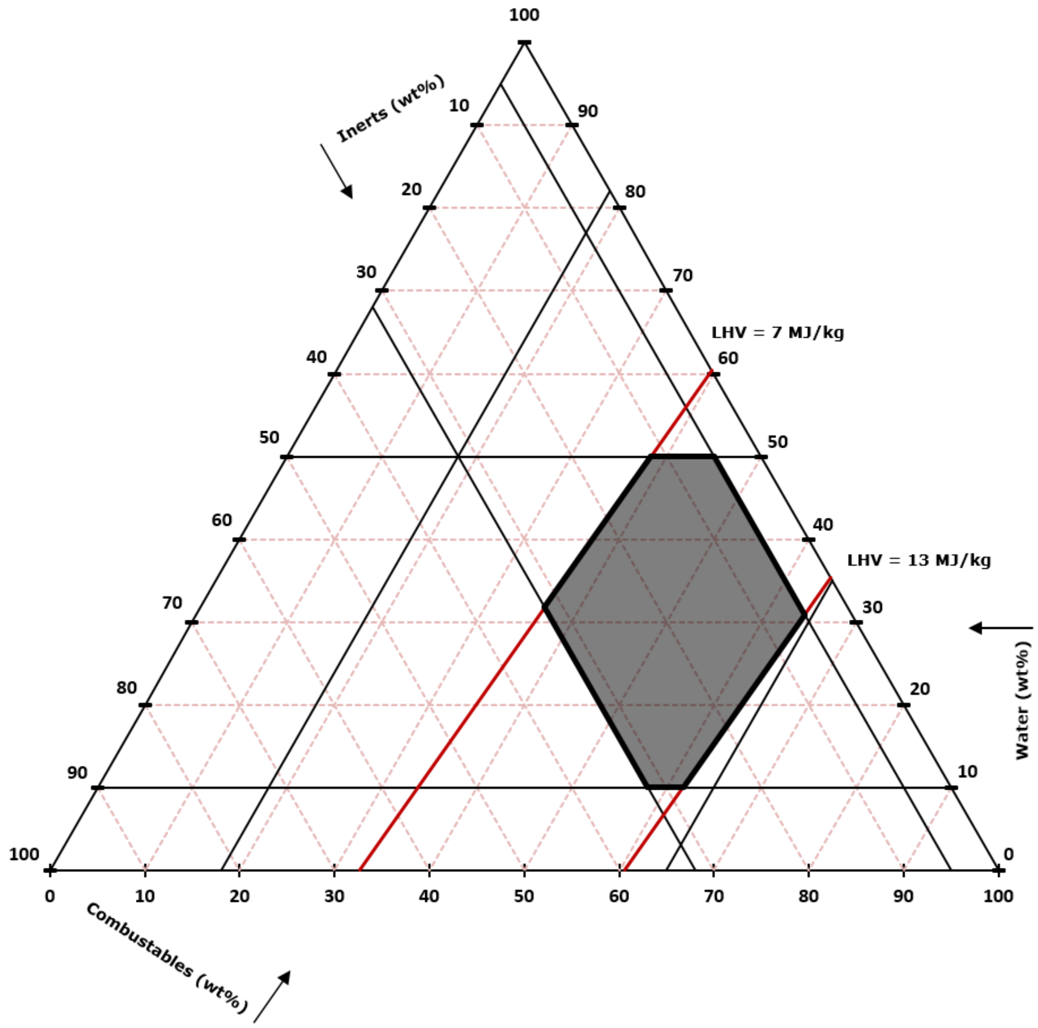

Figure 2: Design Waste Proximate Analysis Diagram

With the Firing Diagram and the Design Waste Proximate Analysis Diagram, it's important to note the wide operating ranges that the EfW Plant is being designed for. This is typical of the design of EfW plants around the world.

3.3 Waste supply and acceptance

The MSW for the EfW Project is intended to be supplied from Melbourne and Gippsland councils through long-term waste procurement contracts. As part of the contracts with councils, there would be waste quality specifications that the waste suppliers (councils) will need to adhere to. Councils will be obligated to supply waste to certain specifications so that the waste input to the EfW Plant can be homogenised as much as possible. As with the EPC Technical Specifications, the contracts with waste suppliers will give AP the ability to enforce strict waste supply protocols.

In addition to the contractual obligations on waste suppliers, the EfW Plant would implement Waste Acceptance Criteria, which are outlined in section 10.5.2.1 of the WAA document. This would guide the EfW Plant operators as to what can be brought in to the plant and what would need to be separated and otherwise disposed. The acceptable wastes would be subjected to checking and periodic auditing (see section 10.5.2.2, 10.5.2.3, 10.5.3 of the WAA) to ensure that the waste supplied meets the criteria. The checking and auditing process also enables any waste loads with higher impurities to be traced back to the origin of the waste which would help identify and rectify poor waste management practices.

As well as implementing Waste Acceptance Criteria, there would be a range of wastes that will not be accepted by the EfW Plant, as described in section 10.5.2.1 of the WAA. These wastes are the hazardous wastes that could lead to hazardous emissions if not controlled.

4. Conclusion

In conclusion, AP does not consider back-calculating and 'design waste' to be beneficial or practicable. AP considers that the following measures are more reliable and traceable to ensure the minimisation of pollution from EfW plants:

- EPC contractual requirements
- Design parameters, including
  - Flexible EfW plant design
  - BAT Air Pollution Control equipment
- Waste supply and acceptance including
  - Supplier contractual requirements
  - Waste Acceptance Criteria
  - Wastes not to be accepted

5. Additional information

The following sections 5.1 to 5.5 outline the EPC Technical Specifications that were provided to the prospective EPC tenderers as the basis of their design.

5.1 Waste Fuel specification

5.1.1 Waste types to be accepted

The Cogeneration Plant shall be designed to accept MSW and C&I waste collected from metropolitan and rural regions of Victoria via the following:

- Residential household waste (MSW) collected directly from residual waste collections by or on behalf of councils and excluding source segregated recyclate collections
- C&I waste collected by or on behalf of councils
- Residual MSW or C&I waste collected from waste transfer stations operated by or on behalf of councils
- Selected C&I waste collected by privately operated waste management companies, which has similar composition elements or properties to council generated residual MSW, which may include waste directly collected or routed via waste transfer stations operated by the privately owned councils.
- Selected non-prescribed industrial waste collected from specific industries, including plastic waste from Australian Paper's paper recycling process generated at Maryvale Mill
- MSW-like residual waste generated from Material Recovery Facilities that could not be recycled

5.1.2 Waste Composition and Fuel Analysis

The Contract Price shall be based on the following Waste Composition and Fuel Analysis Specification:

Tender Note: The Employer is undertaking waste compositional sorts and fuel laboratory analysis of waste samples collected during the Tender Period in Metropolitan Melbourne and in Gippsland.

As this additional information becomes available, this will be provided in the form of Tender Addendums, which may result in updates of the below Tender stage waste specification.

The expected ranges of Waste Proximate Analysis are presented in Figure 5.1 and Table 5.1.

Figure 5.1 : Design Waste Proximate Analysis Range

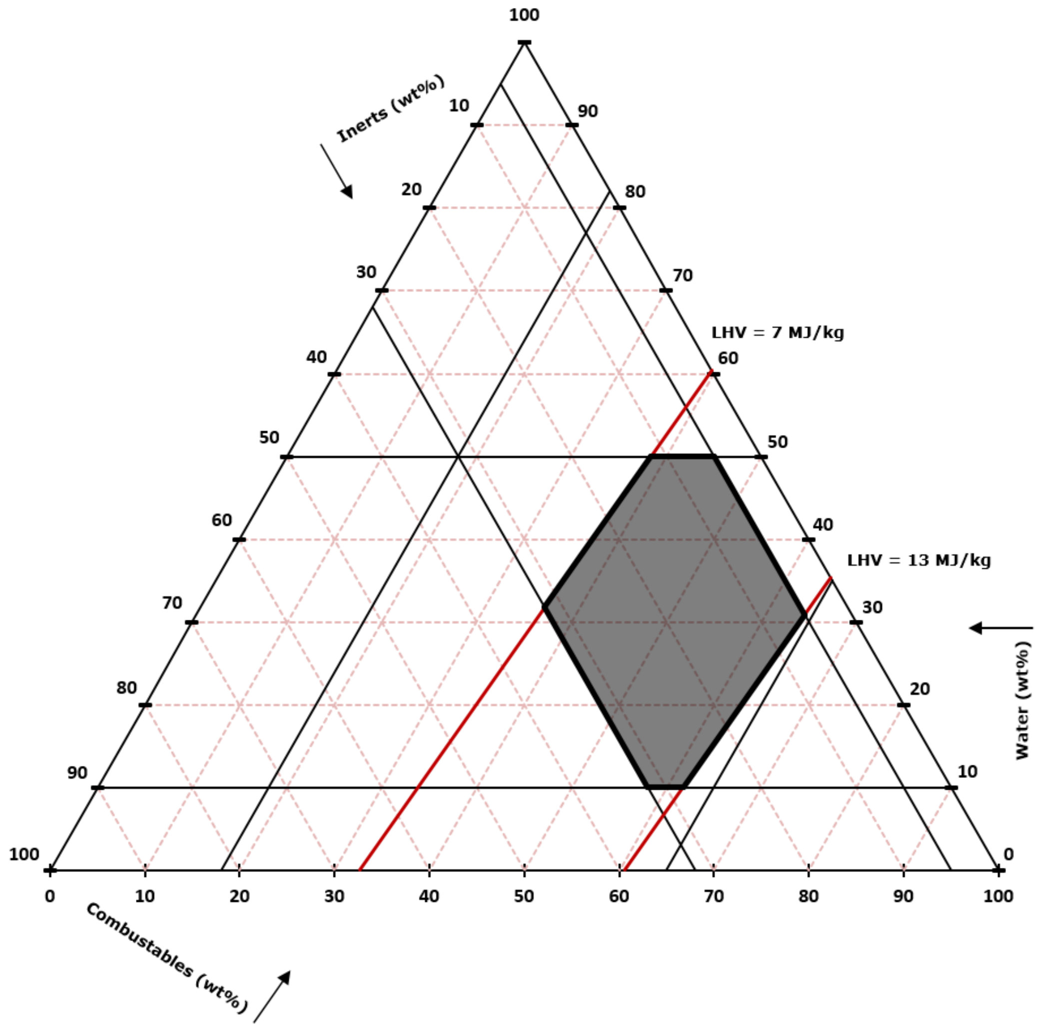

Table 5.1 : Design Waste Proximate Analysis Range

1)	Design Parameter	2)	Unit	3)	Range
•	**Composition**				
•	Combustibles	•	wt%	•	18 – 85
•	Water	•	wt%	•	10 – 50
•	Inerts	•	wt%	•	5 – 32
•	**Required Operational Range**				
•	Heating Value	•	MJ/kg	•	7.0 – 13.0

For the purposes of plant performance testing, the waste composition and fuel quality is that described as typical in Table 5.2.

The Contractor shall state the quantity of waste required for commissioning purposes.

Table 5.2 : Design Waste Composition, Ultimate Analysis and Calorific Value

4) Parameter	5) Unit	6) Design (Typical Waste)
7) **Waste Component**		
• Paper	• wt%	• 15.64
• Plastic	• wt%	• 12.56
• Glass	• wt%	• 2.52
• Ferrous	• wt%	• 1.65
• Non-Ferrous	• wt%	• 0.53
• Organic (Compostables)	• wt%	• 44.95
• Other Organic	• wt%	• 2.02
• Earth Based	• wt%	• 3.53
• Miscellaneous	• wt%	• 8.24
• Waste Electronic	• wt%	• 1.33
• Hazardous	• wt%	• 1.66
• Liquid	• wt%	• 0.00
• Fines	• wt%	• 5.40
• Total	• wt%	• 100.00
8) **Analysis of Design Waste (As Received)**		
• Total Moisture	• wt%	• 37.92
• Ash	• wt%	• 14.58
• Carbon	• wt%	• 26.92
• Hydrogen	• wt%	• 3.41
• Nitrogen	• wt%	• 0.77
• Oxygen	• wt%	• 15.89
• Sulphur	• wt%	• 0.11
• Chlorine	• wt%	• 0.40
9) **Calorific value from analysis**		
• Heat Value DAF	• MJ/kg	• 23.33
• GCV	• MJ/kg	• 11.08
• LHV AR	• MJ/kg	• 9.40

5.2 Natural Gas Specification

The Contract Price shall be based on the following specification for Victorian pipeline natural gas. The Contractor shall obtain any further samples or analysis required to satisfy themselves as to the suitability of the gas quality for their design.

Table 5.3 : Victorian Pipeline Natural Gas Specification at 15^{0}C and 101.325 kPa abs, dry basis

Parameter	Units	Normal Condition
Heating Value, gross	MJ/m^3	38.7
Heating Value, net	MJ/m^3	34.9
Wobbe Index, @ SG 0.61		49.4
Specific Gravity		0.61
Composition (dry basis)		
Methane	% vol	90.6
Ethane	% vol	5.6
Propane	% vol	0.8
Butane, Pentane etc	% vol	0.2
Nitrogen	% vol	1.1
Carbon Dioxide	% vol	1.7
Oxygen	% vol	0

In addition, the AEMO[2] maximum water content of Australian Natural gas at 15,000 kPa = 73 mg/m^3.

5.3 Environmental Emissions Specifications and Guarantees

The Cogeneration Plant shall comply with all of the environmental requirements of the Victoria EPA Energy from Waste Guideline, Publication 1559, December 2013.

5.3.1 Main Stack Emissions

The Cogeneration Plant's emissions to air from the main flues from each Line shall be fully compliant with the European Union Industrial Emissions Directive (IED), 2010/75/EU, as it pertains to the incineration of waste, and in particular shall comply with Chapter 4, and Annexe VI, Parts 1, 2, 3, 6, 7 and 8. The plant shall comply with IED requirements for steady state and non-steady state operation, as required by the EPA EfW guideline.

The Cogeneration Plant shall also comply with the requirements of the Victorian Government State Environment Protection Policy (Air Quality Management) no. S 240, December, 2001, (SEPP AQM), Schedule E (Stationary Source Emissions – Air Quality Management Regions) where it introduces additional pollutants regulated or more stringent pollutant levels than those required under the IED. The Cogeneration Plant is located in the Latrobe Valley Air Quality Management Region, and hence Schedule E applies.

The Guaranteed Stack Emissions for each Combustion Line are specified in Volume 3, Schedule N.

[2] AEMO Gas Quality Standard and Monitoring Guidelines (Declared Transmission System), 6th October 2016.

5.3.2 Furnace Temperature Residence Time

For the safe destruction of the majority of VOCs and dioxins and furans, each Line shall also comply with the IED Article 50, Clause 1, furnace temperature residence requirement of a minimum temperature of 850^{0}C for more than two seconds in the furnace after the last point of combustion air injection, in a controlled and homogenous fashion, as applicable for non-hazardous MSW and C&I waste with a chlorine content in the waste of less than 1% by weight. This requirement is applicable under all transient, part load, and start up and shut down operating conditions.

5.3.3 Solid Residues

As per IED article 50, clause 2, the Total organic carbon (TOC) content of the IBA shall be less than 3 % by weight and the loss on ignition (LOI) shall be less than 5% of the dry weight. This requirement is applicable under all transient, part load, and start up and shut down operating conditions.

The water content of the IBA shall not exceed the Guaranteed Moisture Content specified in Volume 3, Schedule N.

The APC residue production rate shall not exceed the Guaranteed APC Production Rate specified in Volume 3, Schedule N.

5.4 Flue gas treatment and emissions control systems

The Works shall include a complete flue gas treatment and emission control system for each Combustion Line which shall be capable of meeting the statutory compliance requirements of the Victoria EPA Energy from Waste Guideline, the IED, and the Victorian State Government SEPP AQM requirements for the Latrobe Valley Air Quality Management Region, as specified in Section 5.3. These requirements shall be met in all operating scenarios including steady state, unsteady state, all transient, part load, and start up and shut down operating conditions. and for the full range of waste specifications and firing envelope conditions defined in Sections 3.11 and 3.2.

The Contractor shall design all aspects of the flue gas treatment systems conservatively allowing for the full range of key design parameters as follows (the Tenderer shall clearly state all design assumptions made in the Tender):

- Flue gas flows shall allow for the worst case waste quality with the plant operating at the maximum short term rating of the plant above MCR (e.g. highest moisture content waste)
- SNCR design shall allow for the plant conditions that would be expected to generate the highest NOx levels (e.g. driest possible waste and highest furnace temperatures for thermal NOx generation)
- Design for the highest flue gas ash burden based on the highest ash content waste as indicated in the three axis composition diagram in Section 3.11
- Design for the highest expectations for flue gas HCl, SO_2 and HF plus an appropriate design margin (e.g. Allow for the chlorine content of 1 % in the waste which is the maximum level that can be processed under the IED regulation whilst also making a reasonable but conservative assumption for SO_2 based on a high sulphur level in the waste e.g. 2.5 times the design point Sulphur content of 0.1 wt % AR).

The entire flue gas treatment system, including the ID fan, but excluding the stack, and reagent and residue storage silos, shall be provided within an industrial building for the purposes of noise and dust emission control. The building shall allow practical access for maintenance of all plant contained within. The ID fan shall be located just inside the periphery of the building for noise control, but with a large doorway or removable wall and roof panels provided for major overhauls such as motor and rotor removal.

The emissions control and monitoring systems shall remain in service at all times when the plant is in operation, including during plant start-up, shutdown, and unusual or transient operation events. No bypass ducts shall be provided within the flue gas treatment gas path. The Works shall be provided with all ancillary systems and functionality required for this continuous operation requirement of the systems, such as any necessary trace heating systems, purge systems and functionality for pre-start bag sorbent injection for bag filter surface pre-start lining.

All flue gas emission controls adopted for the Works shall be selected by the Contractor based on an international Best Available Technology (BAT) review for waste incineration plants, and shall following the guiding BAT principles of the European Commission Integrated Pollution Prevention and Control Reference Document on BAT for Waste Incineration, August 2006 (EC BREF). The 2017 draft update for the EC BREF[3] shall also be considered in the evaluation where different for the 2006 version, to ensure the most up to date practice recommendations are considered in the assessment.

Consideration in the design shall allow for future changes in law with respect to the stack emission limit parameters that can be complied with. The plant shall be design for ease of upgrade in mind to achieve more stringent limits, if required in the future. In particular, it should be anticipated that oxides of nitrogen limits may be reduced to circa 100 mg/ Nm^3. Space shall be provided in the site layout and arrangement for location any additional equipment that may be required to achieve an emission limit of 100 mg/ Nm^3 for oxides of nitrogen, such as an SCR system.

The Contractor shall supply a turnkey solution for the entirety of the flue gas treatment systems adopted, with a scope of supply as specified in Section 2, starting at the defined terminal points of chemical reagent supply from delivery vehicles, including all unloading storage, handling and reagent dosing systems, and also including the supply of all necessary equipment up to the discharge point(s) from the APC residue silos, and from the chimney efflux point. The Contractor shall undertake their design for the flue gas treatment systems based on technical information from local reagent suppliers for details of vehicle deliveries and reagent chemical and physical specifications.

The scope of supply and technologies adopted shall be as follows:

- Flue gas recirculation for control of oxides of nitrogen generation in the furnace and for combustion control
- Online flue gas oxygen measurement at the boiler economiser exit for controlling adequate furnace air supply for complete combustion with a design excess oxygen target of 6 vol % or greater at all times. Provision of a carbon monoxide analyser for combustion tuning optimisation shall also be considered on a merit basis in the design.
- Selective Non Catalytic Reduction (SNCR) using Urea solution for oxides of nitrogen control in the upper zone of the furnace

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[3] http://eippcb.jrc.ec.europa.eu/reference/BREF/WI/WI_5_24-05-2017_web.pdf

- Semi-dry or dry lime acid gas injection (preferably with a recirculation system for APC residues to the bag filter inlet duct or sorbent reactor vessel for increasing efficiency of reagent use and for the reduction of APC residue generation. The acid gas sorbent may be burnt lime or hydrated lime
- Activated carbon injection prior to the bag filters in the flue gas duct or sorbent reactor system adjacent to the lime dosing point
- A single stage of bag filters for fly ash particulate control and removal of all spent lime and activated carbon residues in a combined waste stream.
- A NATA and MCERTS certified CEMS system for measuring all pollutant and duct process condition parameters as required for on-line measurement under the IED, and in addition, for the avoidance of doubt, to measure also ammonia (slippage) for SNCR dosing control optimisation.

All systems provided by the Contractor for flue gas treatment and emission control shall be supplied by well referenced equipment vendors with extensive experience in the supply of similar equipment to EfW plants process similar waste feedstocks to the Works. The entirety of the system shall be designed for 8,760 hours of continuous operation between major shutdowns

CCTV systems shall be provided at flue gas treatment reagent silo/tank loading areas providing clear pictures of the un-loading area operations transmitted to a screen located in the CCTV.

5.4.1 Flue gas recirculation

Where the design includes flue gas recirculation for temperature or NOx control:

- The boiler shall be equipped with a complete flue gas recirculation system, consisting of recirculation fan, nozzles and all necessary ducts dampers and accessories;
- The flue gas shall be recirculated from the clean side of the bag filter;
- Flue gas recirculation fan(s), dampers and ducting shall all be designed for the minimisation of acid gas and condensate/dew point corrosion
- Flue gas recirculation fan(s), dampers and ducting shall all be designed for the expected particulate loading plus safety margin and shall be designed with measures minimising erosion damage, and ease of maintenance for part subject to erosion.
- All ducts including flanged joints shall be gas-tight welded from the inside;
- The flue gas recirculation system shall be furnished with an air purge system for start-up and for downtime of the recycled flue gas system; and
- Consideration shall be given to the avoidance of corrosion in the system by suitable pre-heating, start-up and shut-down procedures.

5.4.2 Economiser Outlet Gas Analysis

A gas analyser shall be provided to measure the outlet gas composition from the boiler immediately following the economiser outlet. A zirconium oxide Oxygen analyser shall be provided, for use for boiler air control tuning, and any smart combustion control system where provided. A carbon monoxide analyser shall also be provided also at the economiser outlet to be used for on-line combustion control purposes. The Carbon Monoxide analyser shall be of robust design for the process conditions and shall have been proven previously in operation by the boiler OEM.

Analyser(s) measuring in the economiser outlet shall be located preferably in a straight length of duct with sufficient upstream mixing, and be position within the duct cross section so as not to introduce sample bias. The objective of the selection of the location shall be to provide the most representative sample location of the average composition of the flue gas. The upstream flow conditions turning vanes and baffles shall not introduce a sample bias error in the measurement.

The analysers may be in-situ or extractive type, depending on the most proven approach for the sensor type to enable accuracy and reliability of measurement without locational bias.

The analysers shall be a proven type with demonstrable references for use in EfW plant, in locations measuring hot, dusty and acidic gas streams.

5.4.3 Selective Non-Catalytic Reduction of NOx

The Contractor shall supply a complete SNCR system including storage tank, pumps, supply pipework and injection nozzles. The Contractor shall also provide continuous ammonia monitoring in the flue gas to control ammonia slip. The system shall include functionality for optimisation of reagent use by automatic control of injection rate and using emission levels feedback from the CEMS system.

The SNCR system shall use a commercially available 26% aqueous urea-based solution delivered by 25 tonne truck tanker (as defined in the scope and terminal points specified in Section 2) with on board loading pump, in pre-batched liquid form which is currently used at the AP Maryvale Mill. The Employer prefers not to introduce ammonia on-site for safety reasons as it is an additional dangerous goods risk. Ammonia solutions >26% would also have an impact on their Major Hazard Facility Safety Case and operating licence.

Each Combustion Line shall have an injection system located in the upper furnace, and shall be of proven design and will include urea solution storage tank, urea solution dosing pump, metering and distributing devices, back pressure control valve, heat insulation decomposition chamber, dilution fan and dilution air heating system.

The continuous emission monitoring equipment shall include an ammonia monitor to comply with the Environmental Permit requirements.

The urea injection distribution shall be optimised to minimise urea consumption whilst achieving high NOx reduction.

The system shall be provided with all facilities to enable safe filling, start-up, operation, draining and flushing.

The system shall be provided with sufficient valves to enable safe isolation of all necessary sections.

Openings to allow inspection of the urea distribution sprays shall be included as necessary. Access platforms and space for withdrawal will be provided to each injection lance.

Computational fluid dynamic (CFD) flow modelling of the furnace and first empty pass shall be undertaken for a range of load conditions to demonstrate the physical flow characteristics of the design and optimisation of the reagent injection locations. The location for injection nozzles shall be selected a point where the range of gas temperatures is optimal for high conversion efficiency for the reduction of oxides of nitrogen to nitrogen. Multiple levels of injection ports in the upper furnace shall be provided as necessary to allow optimal location of the nozzles during and after commissioning.

The Contractor shall undertake a HAZOP study of the installation and ensure that adequate safety features are provided. Given the proven nature of the proposed SNCR plant the Contractor shall be expected to have included all necessary features required for the safe and efficient operation of the SNCR plant within the Contract Price.

Urea storage and vehicle unloading

The urea solution storage shall be sized such that there is not less than 7 days worth of storage at Cogeneration Plant MCR rating from normal to low level.

The bunded or double skinned urea storage tank(s) shall be protected by barriers from road vehicle impact, shall be complete with all necessary instrumentation including level transmission to the DCS and high and low level alarming, PV venting and vents to the road tanker and road tanker earthing strap.

Urea tank(s) shall be fitted with overflow and drain connections. Overflow connections shall be at least one pipe size larger than the inlet connection.

Access for inspection purposes must be provided to the inside of the tanks. Manholes, where provided, will be at least 600 mm in diameter, fitted with safety harness attachment points and hinged to facilitate removal.

Stairs and ladders shall be provided on storage tanks as required to facilitate access to all instrumentation and for maintenance access.

The storage and transfer facility shall include provision for the containment, holding and pump out of any chemical release. Measures shall be provided to contain spillages of urea solution from the system and tanker unloading.

The Contractor shall ensure that adequate safety features are provided, as a minimum provision of items such as safety showers, eye wash bottles, leak detection and alarm equipment shall be provided at the tanker unloading point.

5.4.4 Dry or Semi Dry Acid Gas Treatment System

A complete turnkey semi-dry or dry lime acid gas sorbent injection system shall be provided to dose reagent at a suitable location in the flue gas path prior to the bag filters at an optimum gas temperature for the sorbent system type. The system shall be designed such that no waste waters are generated from the process, and that the volume of water spray into the duct shall be optimised to strike an appropriate balance between the acid gas neutralisation efficiency and Cogeneration Plant thermal efficiency.

The lime sorbent system shall use a commercially available burnt or hydrated lime powder delivered by a bulk B-double pneumatic tanker. Burnt lime (Quicklime) is currently delivered to the AP Maryvale Mill via this method for the paper production process.

A pneumatic bulk tanker unloading system to the reagent storage silo shall be provided within the works, as defined in the scope and terminal points specified in Section 2. The lime reagent storage silo shall be sized such that there is not less than 14 days' worth of storage at Cogeneration Plant MCR rating from normal to low level. When loading the silo, or in normal operation, there shall be no fugitive lime emissions from the silo or lime conveying process, with appropriate dust control and filtration systems provided where required.

The lime silo shall be fitted with a vent filter unit of the self-cleaning type to prevent dust being discharged to atmosphere from the silo. Suitable measures shall be taken to prevent rain or dampness ingress into the filter. The silo will also be equipped with an over-pressure and vacuum protection device.

The silo shall be fitted with a level sensor to provide measurement of the silo's contents, over the full range 0 to 100 per cent capacity. Mounting the silo on load cells is an acceptable alternative to the 0-100% level sensor. In addition, the silo shall be fitted with level sensor probes to provide Full, 75% and 50%.

The cone of the silo shall be fitted with suitable means of assisting lime flow, in the form of aeration pads, heaters, vibrators and manual rodding points.

Manholes shall be provided in the top of the silo and in the conical base – these manholes are to be equipped with safety harness attachment points. Manholes, where provided, will be at least 600 mm in diameter. Access ladders and platforms shall be provided to the top of the silo and to all manways, rodding points, instruments and valves.

The silo area shall be bunded with drains to the site dirty drains system, to avoid storm water run-off of lime residue.

The Employer's preference is that the system entails a sorbent reactor vessel in the gas path, such as the fluidised bed type, with an APC residue recirculation system from the bag filter discharge back to the reactor vessel for a proportion of the residues containing unspent lime. The acid gas treatment system shall achieve an efficient lime stoichiometric excess ratio and also minimise the reduction of APC residue generation from spent reagent.

The acid gas treatment system shall be provided by an equipment OEM with extensive experience in the design and supply of similar systems for EfW plant. The design basis for the Works shall be consistent with good practice designs previously undertaken by the OEM.

The method of conveying the lime to the injection point, the injection method and gas path design at the injection point shall all be based on a proven and reliable design, with consideration to minimisation of erosion, blockages, build-up of reagent, and corrosion. In order to provide reliable service, abrasion and corrosion resistant protective linings and materials of construction shall be designed and selected to prevent premature failure or blockage of components. Any water or slurry sprayed into the gas path shall be rapidly evaporated and water droplets shall not be carried through into the fabric filters. Gas temperature shall be maintained above gas dew point conditions at all times.

5.4.5 Powdered Activated Carbon Dosing System

A complete turnkey powdered activated carbon (PAC) sorbent injection system shall be provided to dose reagent at a suitable location in the flue gas path prior to the bag filters, allowing sufficient time and mixing to allow efficient use of the sorbent and effective control of heavy metals and VOCs. A dosing location upstream of the lime dosing point is preferred, or alternatively the dosing point may be provided within a well-mixed lime sorbent reactor vessel.

The PAC sorbent system shall use a commercially available PAC delivered in 40ft containers containing 500 kg bulk bags. At a pad suitable for unloading of the bulk bags from the container with forklift shall be provided. Bulk tanker delivery options for PAC have not been identified for suitable quality PAC supply at the time of Tender. As specified in Section 2, the Contractor shall supply a fixed hoist and over vessel rail lifting system to lift bags to top of silo, traverse over to the opening point, and shall also supply a mechanism for opening and discharge into silo with minimal dust generation during filling.

The silo area shall be bunded with drains to the site dirty drains system, to avoid storm water run-off of PAC residue.

A suitable fire detection and control system shall be provided over the PAC silo to detect and fight fires that may occur from carbon dust during the unloading operations. A fire safe method of dust clean up (e.g. intrinsically safe vacuum system) shall be provided for carbon spillages at the top of the silo and around the base. A hazardous area classification study shall be undertaken for the PAC system, and any electrical equipment located in the hazardous zone shall be AS60079 compliant.

The PAC storage silo shall be sized such that there is not less than 7 days worth of storage at Cogeneration Plant MCR rating from normal to low level. When loading the silo, or in normal operation, there shall be no fugitive PAC emissions from the silo or PAC conveying process, with appropriate dust control and filtration systems provided where required.

The PAC silo shall be fitted with a vent filter unit of the self-cleaning type to prevent dust being discharged to atmosphere from the silo. Suitable measures shall be taken to prevent rain or dampness ingress into the filter. The silo will also be equipped with an over-pressure and vacuum protection device.

The silo shall be fitted with a level sensor to provide measurement of the silo's contents, over the full range 0 to 100 per cent capacity. Mounting the silo on load cells is an acceptable alternative to the 0-100% level sensor. In addition, the silo shall be fitted with level sensor probes to provide Full, 75% and 50%.

The cone of the silo shall be fitted with suitable means of assisting PAC flow, in the form of aeration pads, heaters, vibrators and manual rodding points.

Manholes shall be provided in the top of the silo and in the conical base – these manholes are to be equipped with safety harness attachment points. Manholes, where provided, will be at least 600 mm in diameter. Access ladders and platforms shall be provided to the top of the silo and to all manways, rodding points, instruments and valves.

The PAC system shall be provided by an equipment OEM with extensive experience in the design and supply of similar systems for EfW plant. The design basis for the Works shall be consistent with good practice designs previously undertaken by the OEM.

The method of conveying the PAC to the injection point, the injection method and gas path design at the injection point shall all be based on a proven and reliable design, with consideration to minimisation of fire risk, erosion, blockages and build-up of reagent. Conveying fluid temperature shall be low and lower velocity systems are preferred to lower fire and erosion risks.

5.4.6 Particulate control

The plant shall be equipped with a baghouse for the control of particulate emissions. The baghouse shall be designed to ensure that under expected operating conditions, particulate emissions will not exceed the maximum allowable rate specified in Section 3.

The APC residues shall be pneumatically conveyed from the flue gas cleaning plant to a silo(s) for dry or conditioned disposal.

The hoppers in the base of the baghouse shall be capable of storing 12 hours of APC residues when burning the highest ash fuel without emission limit breach. All hoppers and silos shall be designed so that bridging will not occur and so that material will flow without manual intervention, with mechanical assistance, heaters and aeration being provided where necessary. The bag filter house and hoppers shall be designed to minimise air and moisture ingress into the system, in particular with consideration to the cementitious properties of APC residues which can set hard and plug when coming in contact with water.

Adequate provision shall be made for cleaning of blockages from the APC residue transport system, which includes provision of inspection holes, cleaning equipment and a vacuum cleaning system.

The dust extraction system shall be lagged and adequate trace heating provided on hoppers and conveyors to prevent the APC residues becoming damp.

The system shall be designed so that in the event of the APC residues containing high unburnt carbon content it will not result in uncontrolled fires or any other problem.

Lifting beams and tackle shall be provided to allow ease of maintenance and repair.

Bag material shall be selected so that discharge flue gas temperatures can be maintained without dilution air or cooling water sprays.

Access and section isolation shall be provided for in-service bag replacement. The baghouse shall be compartmentalized such that in the event of a bag failure a compartment can be isolated and the filter element replaced without requiring the unit to shutdown or reduce load. The expected performance of the bag filter house during bag failure events shall be specified in the design. Suitable weather protection shall be provided so that replacement of the bag filter elements can be achieved without them becoming damp due to inclement weather.

Electric heaters and an air circulation system shall be provided on the baghouse to pre-warm the filters to operating temperature prior to unit start-up and for maintaining them in a dry state during prolonged shutdowns. The baghouse and ash system shall be lagged and adequately trace heated on hoppers and conveyors to prevent the fly ash becoming damp.

Pulse jet cleaning shall be included with all necessary ancillary equipment. A minimum of two 100 per cent duty air compressors and two 100 per cent duty air drying systems shall be provided. The main air receiver shall be sized so that pulsing of a set of filter elements does not lower the main air receiver pressure by more than 10 per cent.

Operation of the filter cleaning cycle shall be automatic based on the pressure drop across the bag filters. The bag filter differential pressure used to control the filter cycle shall be displayed and recorded in the control room. A separate high differential pressure alarm shall also be provided.

Test points and appropriate safe access shall be provided for testing particulate content at both the inlet to and discharge from the baghouse.

The Contractor shall clearly identify the filter face velocity at MCR and the proposed bag filter material.

5.4.7 Chimney

The chimney shall be a freestanding structure housing the steel flues from boilers. The total height of the chimney (including flues) above grade will be 95 m. The structural design of the chimney shall account for wind load, based on the peak wind data provided by the Bureau of Meteorology for the site as stated in Section 3.10.

The stack exit velocity at MCR shall be a minimum of 15 m/s.

Galvanised ladders and platforms in accordance with AS 1657 shall provide access to required sampling and electrical equipment (e.g., sampling ports for online-flue gas sampling system, gas analysers, etc.). The ladder shall be caged, staggered with a vertical safety rail and have intermediate personnel resting platforms at least every 6 meters.

A hopper shall be provided at the base of the stack for the collection of deposits and shall include access for easy removal of deposits and rainwater when not in use.

Aircraft warning lighting shall be provided which meets all relevant authorities' requirements. The lights and power supply shall be easily accessible for maintenance.

The chimney shall be fitted with lightning conductors which are appropriately earthed.

The stack shall be constructed in such a way and with suitable materials to ensure that the internal surfaces are adequately protected against corrosion and erosion for the life of the plant, including periods of low-load operation. The Tenderer shall advise the corrosion allowances used in the stack design which is consistent with this design requirement.

A test/sampling gallery shall be provided at an appropriate level on the chimney with adequate sampling nozzles and sufficient room for safe operation of testing equipment. It is to be assumed that testing will be isokinetic with test methods and selection of sampling locations using latest AS4323 set of standards. Safe access shall be provided to this gallery and shall allow for lifting of any equipment required for testing – note that personnel carrying equipment up ladders is not permitted.

5.4.8 Continuous Emissions Monitoring System

The technical requirements of the Continuous Emissions Monitoring Systems (CEMS) are specified in Section 9.13.

5.5 Ash Collection and Removal

The fly ash (APC residues) and bottom ash (IBA) systems shall be sized for the boiler operating at MCR, firing the minimum calorific value fuel with the maximum ash, chlorine and sulphur content stated in this specification, plus a minimum margin of 50%, whilst meeting flue gas emission limits. The calculated ash generation based on these assumptions is deemed to be the maximum ash production rate.

The ash handling systems shall be capable of handling the heterogeneous and variable nature of the waste, which will result in rapid changes and variation in ash generation rates, particle dimensions and ash composition. The ash systems shall be designed to run 24/7 and shall be able to operate 8,760 hours continuously between Combustion Line maintenance shutdowns.

Provision shall be made for the safe removal and loading of the APC residues and IBA for disposal based on road transport haulage.

5.5.1 Incinerator Bottom Ash Handling

The Contractor shall provide an IBA extraction system located below the end of the grate at the bottom of each Combustion Line. Boiler and economiser pass fly ash shall also be conveyed from their respective collection hoppers to the IBA extraction system. The IBA extractor type (e.g. hydraulic pusher or drag chain type) shall be the boiler OEM's standard equipment choice and shall be well proven in multiple EfW reference plant

The IBA extraction system shall also be designed to receive grate riddlings via a robust chute and drag chain system, or alternately the grate riddlings may also be discharged to another dry ash receptacle or vessel provided in the works.

The combined IBA ash stream shall be conveyed using a conveyer appropriately designed for EfW bottom ash via an oversize screen such as a grizzly, or vibrating type, and passing through ferrous and non-ferrous metal recovery separators, before being discharged to a suitably dimensioned IBA storage bunker or bay.

The ash storage bunker/bay shall accommodate a minimum of 7 days storage of the IBA combined stream. Any ash leachate released from the stored ash shall be collected in sumps or bunds and returned to the process for re-use. The bunded ash storage bay or bunker bottom shall be inclined to promote leachate drainage to the sump where submersible pumps shall be provided to pump out the leachate on a continuous basis back to the process. The floor of the ash storage system shall be impermeable to leachate entering the soil or clean rainwater runoff drains.

Ash extractors and conveyers shall be of a robust design proven in many similar EfW plant and supplied by an OEM well referenced in EfW project. They shall be designed for ease of maintenance and have wear/damage resistant removable and replaceable components subject to wear or damage from oversized, heavy or unusually shaped ash particles. The conveyer and any chutes provided shall be designed to minimise blockages, and shall incorporate a method of access to free blockages manually, such as through rodding. All moving parts and drives shall be mechanically and/or electrically protected from damage due to blockages, erosion. Conveying distances, number of transfer points and directional changes shall be minimised in the design of the IBA conveying system.

A wet IBA quench and extractor system is preferred, however where a dry ash system is provided, conveyers shall be enclosed to minimise dust emissions.

IBA conveyors shall be operable in automatic, manually from the CCR and locally via a panel adjacent to the conveyer.

Overband and end roller magnetic separators shall be provided on the IBA conveying system to recover ferrous metals for recycling. The magnetic separator systems shall be designed to remove, under all design conditions across the complete range of input voltage, a ferrous metal test piece of 25mm diameter and 150mm length at least 90% of the time. The test piece shall be removed from the conveyor transferring the rated capacity of IBA pellets, either from the head chute or from the bottom of a bed of IBA, depending on the location of the magnetic separator.

All magnetic separator installations will be supplied with a separate chute and or conveying arrangement for the discharge of recycled metal into a skip or dedicated ferrous metal bay.

An eddy current separation system shall also be provided for removal of non-ferrous metal from the IBA conveying system. The eddy current separator system shall also be designed to perform to a similar separation requirement as above for the magnetic separators. The eddy current separator shall also be supplied with a separate chute and or conveying arrangement for the discharge of recycled metal into a skip or dedicated non-ferrous metal bay.

The IBA conveying system shall be designed for simple future retrofitting of a potential transfer chute and conveyer to an IBAA processing facility that may be located adjacent to the Cogeneration Plant site in the future.

A 2 by 100% maximum ash production rate automated ash vehicle loading system shall be provided capable of loading open topped ash road vehicles, or skips of a range of dimensions and heights shall be provided. The Employer's preference is an ash crane system which can be operated in full automatic, semi-automatic and full manual mode, with manual mode. Where an ash crane is adopted, a local manual crane operator station shall be provided in the works. If a crane is provided, mechanical and control system protection shall be provided to prevent the risk of damage to ash vehicles and containers from crane impact. Where another type of conveying system is provided for loading, a local push button operational panel shall be provided. A communication system such as an intercom of telephone to talk with the CRR shall be provided at the local ash loading operating panel.

The loading system shall have the throughput capacity of loading ash vehicles and containers so that the ash accumulated from 12 hours of operation with the maximum ash production rate can be transported in 4 hours to the vehicle or container. The loading system shall weigh the mass of IBA loaded into vehicles or containers

A CCTV system shall be provided at the ash storage area provided a clear picture of the contents of the storage bays/pits transmitted to a screen located in the CCTV. An operator/truck driver loading panel shall be provided at the IBA loading

5.5.2 APC Residue Handling

A dry APC residue handing system shall be provided for each Combustion Line. APC residues collected from the baghouse shall be pneumatically transported to the APC residue storage silo(s). The silo(s) will be capable of storing 7 days of APC residues when burning the highest ash fuel with highest sulphur and chlorine content.

The pneumatic transport system shall be sized so that the ash accumulated from 12 hours of operation with the highest ash fuel can be transported in 4 hours to the silo. A short conveying route to the silo with a minimum number of bends shall be provided. Dense phase pneumatic handling is preferred.

The APC residue transport lines shall be abrasion-resistant metal pipes with elbows constructed with replaceable wear back sections, or preferably ceramic lined/cast basalt with the lining continuing at least 10xD into the following straight. The pneumatic transport system shall comprise a number of branches, each collecting ash from several hoppers. Each branch shall have full-capacity blower(s), and there will be a cross-tie between the branches with a common spare blower.

The pneumatic transport system shall be of proven design and contain sufficient instrumentation reporting back to the plant control system in the CCR to monitor the correct operation, and alarm when there is a fault.

Any equipment necessary to facilitate the cleaning of blockages in the transport lines shall be provided, including suitably located pipe joints, access platforms, compressed air supplies, rodding points, etc.

The APC residue silo shall be fitted with a vent filter unit of the self cleaning type to prevent dust being discharged to atmosphere from the silo. Suitable measures shall be taken to prevent rain or dampness ingress into the filter. The silo will also be equipped with an over-pressure and vacuum protection device.

Manholes shall be provided in the top of the silo and in the conical base – these manholes are to be equipped with safety harness attachment points. Access ladders and platforms shall be provided to the top of the silo and to all manways, rodding points, instruments and valves.

The silo shall be fitted with a level sensor to provide measurement of the silos contents, over the full range 0 to 100 per cent capacity. Mounting the silo on load cells is an acceptable alternative to the 0-100% level sensor. In addition the silo shall be fitted with level sensor probes to provide Full, 75% and 50%.

The cone of the silo shall be fitted with suitable means of assisting APC residue flow, in the form of aeration pads, heaters, vibrators and manual rodding points.

In addition to the normal discharge the silo shall be fitted with an emergency bypass emptying point fitted with an isolation valve and blanked. Facility shall be provided for a discharge chute to be attached should the silo require emptying.

It shall be possible to discharge the APC residue accumulated over 24 hours firing of the worst waste fuel and at the maximum ash production rate in to trucks within an 8 hour period, either as a dry product or conditioned. For the avoidance of doubt, vehicle loading time for the despatch of APC residues shall be kept to a minimum and shall not ex. Dry product from the silo shall be discharged in a controlled manner into the top of a road tanker. A telescopic chute will be lowered forming a seal with the top of the road tanker. A vent pipe associated with the chute will transport air displaced from the tanker back into the top of the silo. The design shall allow adequate clearance between the base of the silo and the largest road tanker presently used for bulk fly ash disposal (b-double), so that the tanker driver can stand on top of the tanker to make the connection safely.

Conditioned APC residue shall be produced by two 100% ash conditioners, using waste water to condition the ash with approximately 15% moisture, and in any case suppress any fugitive dust emissions. The conditioned APC residue shall be discharged into trucks for disposal at the APC residue storage site. These trucks are assumed to hold a product weight equivalent to the maximum volumetric capacity of a b-double bulk powder tanker to form the basis for design of the truck bay.

Provision is required to wash out of the APC residue ash mixer and damp-ash conveyors. It shall be possible to wash down the floor of the tanker/truck loading area and the contaminated water shall be collected in a holding pond which can be pumped out into the bottom ash makeup water system.

A CCTV system shall be provided at the APC Residue silo truck loading area providing a clear picture of the loading area operations transmitted to a screen located in the CCTV.