4. EfW process description

4.1 Overview

This chapter provides a description of the engineering processes for the proposed EfW Plant (the Project) and the existing energy consumption and production infrastructure at the Maryvale Mill. The Project is to be co-located at the existing Maryvale Mill, and will supply the site with electricity and steam, thus reducing its dependency on grid supplied electricity and pipeline natural gas. This will reduce the carbon emissions of the Maryvale Mill as a whole and reduce Australian Paper’s exposure to energy price escalation for imported electricity and gas.

4.2 EPA requirements

Section 1, Part 5 of the Victorian EPA’s Works Approval Guidelines (Publication 1307) requires proponents to provide a description of their proposed development including a detailed outline of the technical processes to be used (EPA, 2015). This provides the basis for subsequent assessment of environmental risks associated with the Project (outlined in Chapter 3: Risk assessment) and provides context for AP to demonstrate where best practice has been applied in selecting the final concept design (outlined in Chapter 5: Environmental best practice).

4.3 Existing operations

AP is an integrated manufacturer of pulp, paper, envelopes and stationery. The organisation is Australia’s only manufacturer of office and printing papers, bag, sack, lightweight packaging and industrial papers, and is also a major supplier of Kraft liner board and the largest envelope manufacturer in Australia. The various pulp and paper production processes require significant amounts of energy in the form of electricity and steam.

AP operates in a highly competitive environment. The cost of energy is one of AP’s largest business input costs (after wood and labour). A number of events have combined recently to significantly increase the current prices and the price outlook for electricity and gas in the Victorian market (Figure 4.1). These include the closures of several large coal fired power stations including Hazelwood in Victoria (March 2017), the ramp-up of the export of LNG from plants at Curtis Island in Gladstone Queensland and the continual increase in energy demand supplied by National Grid. As these price increases flow through into term contracts for industrial users, such as the Maryvale Mill, significant increases in operating costs will continue.
The Maryvale Mill purchases approximately 6.7 Petajoules (PJ) of natural gas every year (one of Victoria’s largest consumers) and also purchases on average 30MW of electricity from the National Electricity Market (NEM) throughout the year. Over a long period of time, significant efforts have been allocated to improving the energy efficiency per net tonne of pulp and paper. Particular focus has been on natural gas consumption due to the rapidly escalating prices. Reduction in natural gas consumption usually results from reduction in steam demand, which can lead to reduction in electricity generated on-site. So despite the energy efficiency improvements, and with the relocation and subsequent operation of the recycling De-Inking Plant (DIP) in 2015 there has been an increase in purchased electricity usage at the site. Figure 4.2 shows the historical natural gas use at the Maryvale mill.

Figure 4.1 : Victorian wholesale spot prices – electricity and gas

Figure 4.2 : Historical pipeline natural gas use at Maryvale
Similarly, the site’s grid imported electricity usage is shown in Figure 4.3.

![Purchased Elec (MWH)](image)

**Figure 4.3 : Historical grid electricity imported from the NEM**

AP purchased 6.7PJ of Natural Gas and 243,405MWh of Electricity in 2016. The natural gas was primarily used to supply Gas Fired Boilers (GFBs) producing approximately 200tph of steam. Approximately 1PJ was used for other internal mill processes such as the Lime Kiln.

From the pulping process, the spent chemicals (Black Liquor – BL) which contains lignin, hemicellulose and extractives and inorganic chemicals, are used to fuel the chemical Recovery Boilers (RBs) to produce approximately 300tph of steam. Black liquor is an “eligible renewable energy source” under the *Renewable Energy (Electricity) Act 2000* (Cwth).

The summary of the existing operating boilers at Maryvale mill is given in Table 4.1. Each boiler generates Very High Pressure (VHP) steam which is superheated steam at nominally 450°C and 61.50 bar gauge (g). All the boilers feed into a VHP steam header system which distributes the steam to energy consumers within the mill, including steam turbo-generators producing electricity for site use.

**Table 4.1 : Existing boilers at Maryvale Mill**

<table>
<thead>
<tr>
<th>Existing Maryvale Boilers</th>
<th>Year Commissioned</th>
<th>Boiler Fuel Type</th>
<th>Max load (Tonnes per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5</td>
<td>1975 1991 (upgrade)</td>
<td>Black liquor recovered from the pulping process</td>
<td>97 130</td>
</tr>
<tr>
<td>R6</td>
<td>1983 2008 (upgrade)</td>
<td>Black liquor recovered from the pulping process</td>
<td>140 190</td>
</tr>
<tr>
<td>GFB8</td>
<td>1975 2008 (upgrade)</td>
<td>Natural Gas</td>
<td>115</td>
</tr>
<tr>
<td>GFB9</td>
<td>1986 1991 (upgrade)</td>
<td>Natural Gas</td>
<td>140</td>
</tr>
<tr>
<td>GFB10</td>
<td>1998 2008 (upgrade)</td>
<td>Natural Gas</td>
<td>140</td>
</tr>
</tbody>
</table>

During normal operation, the steam output from these 5 boilers is typically 500tph and is then fed into back pressure turbines that produce a range of steam pressures (i.e. high intermediate pressure (HIP), intermediate pressure (IP) and low pressure (LP)) which are used around the mill in various production applications. The mechanical work performed by the steam in the back pressure turbines during the process of letting down the steam pressure generates around 50MW for internal electricity use. The steam exhausted from the turbines is used beneficially in multiple processes, increasing the overall efficiency of energy usage, commonly called
“Combined Heat and Power” (CHP). This means that the Maryvale Mill does not need large cooling towers like stand-alone power plants, and also has an overall higher efficiency than typical power plants that are not CHP.

A simplified representation of the main energy flows for the Maryvale mill is given in Figure 4.4.

Figure 4.4 : Simplified energy flow diagram for Maryvale Mill

4.4 Proposed operations

It is the intention of AP to construct an EfW Plant which will be fuelled with a nominal 650,000 tonnes (+/-10%) per annum of Municipal Solid Waste (MSW). MSW is expected to make up 80% of the plant feedstock and 20% of the waste is expected to come from Commercial & Industrial (C&I) waste from Melbourne and Gippsland. Pipeline natural gas shall be used as the start-up fuel and for combustion stabilisation only.

EfW is the general term applied to the recovery of energy from a number of different waste types using a variety of energy recovery technologies. The technologies applied depend on the type and composition of the waste, whether it is pre-treated or sourced from a residual waste stream after materials recycling. The main technologies are:

- Combustion of solid waste
- Gasification of solid waste
- Anaerobic digestion of solid or liquid waste
- Pyrolysis of solid waste
Landfill gas collection from solid waste landfills.

A direct combustion process has been adopted for the Project which can produce a high temperature flue gas from which energy can be recovered by heat transfer in a boiler as hot water, low or high pressure steam. In the case of high-pressure steam, this can be converted to electrical power by the use of a steam turbine and generator. This electricity can be fed into the NEM or supplied to local industrial users - in this case, the Maryvale Mill. Such plants can also operate as CHP plants, producing heat in the forms of steam or hot water to neighbouring industrial users in addition to electricity production.

Gasification, anaerobic digestion, landfills and pyrolysis produce a gas which in principle could be burnt in a gas turbine or gas engine, producing electricity, and in some cases the gas could also be used to fuel a boiler. As for combustion technologies, gas engine or turbine based technologies can also operate as CHP plants. These technologies were not adopted for the Project due to a range of restricting factors including:

- Technologies such as gasification and pyrolysis are less proven than direct combustion and therefore offer considerably more technical risk

- Anaerobic digestion and landfill gas collection offer considerably lower landfill diversion performance and lower carbon benefits, whilst also generating significantly less energy from the same volume of waste input.

Most international EFW plants, of which there are more than a thousand examples worldwide (See Chapter 1: Introduction), accept MSW collected from residential properties and C&I waste, collected from commercial and industrial waste producers. However, there are a number of other specific waste types which are also used to produce energy such as sewage or industrial liquid effluent (most commonly by anaerobic digestion) and clinical waste (normally processed by combustion or gasification). A number of industrial processes also generate specific solid or liquid waste streams from which energy can be recovered but would potentially be deemed as prescribed waste under Victorian legislation.

This EFW Project will only combust and produce energy from non-prescribed MSW and C&I waste on a predicted ratio of 80% MSW to 20% C&I, dependent on availability. This is a standard feedstock mix for EFW plants elsewhere and therefore poses low technical and environmental risk.

4.4.1 Plant layout and site boundary

The EFW Plant is proposed to be located on the south eastern side of the Maryvale Pulp and Paper Mill site on land presently occupied by a plantation and a car parking area – these areas will be cleared and levelled during the construction phase of the project, as shown in Figure 4.5.
Figure 4.5: Proposed EfW Plant location within the existing Maryvale Mill site

A feasibility stage conceptual layout has been prepared (see Figure 4.6) on AP’s behalf, to inform potential Engineer Procure Construct (EPC) contractors of the general expectations of site location, plant orientation, road access and existing site interfaces. It is expected that this layout will be updated and refined by the EPC contractors at the tender and detailed design stages of the project.
4.4.2 Hours of operation

The EfW plant will operate on a baseload basis 24 hours per day, 7 days a week, with the exception of maintenance outages and is anticipated to operate for approximately 8,000 hours per annum. This is similar to the existing Maryvale Mill operation.
4.5 Design selection process

4.5.1 Pre-feasibility phase investigations

AP commenced pre-feasibility investigations for the project in 2016. In early 2017, representatives from AP conducted an international literature survey and EfW reference plant site visits to enhance knowledge within the company. A boiler technology “optioneering” study was also undertaken in the pre-feasibility work which compared the relative merits of moving grate combustion against fluidised bed combustion. That study concluded that the moving grate technology was the most commercially proven technology for treating MSW and C&I waste and would reduce the technical and environmental risk for the project.

4.5.2 Feasibility study phase investigations

In mid-2017, AP commenced a $7.5M feasibility study jointly funded by the Federal Government, the Victorian State Government and AP. This feasibility study is in progress and due to be completed in mid-2018 and at the time of writing of this WAA, considerable design development has been completed including agreement of a concept design and preliminary site layout, the development of a plant design basis and the preparation of a detailed technical specification for contractually binding procurement of the plant under an Engineer Procure Construct (EPC) contract. The EPC contract technical specification that has been completed and was issued for tender in December 2017 specifies in detail the requirements for detailed design, procurement, construction and commissioning for the plant that the EPC Contractor who will be selected (by the competitive tender process) must comply with or be in breach of contract.

The following are the main activities undertaken in parallel to date during the detailed feasibility study investigations:

- Site selection workshop
- Waste flow and composition assessment study for establishing potential waste volumes and composition
- EfW Main Plant Equipment Configuration Options Screening and Selection
- Best Available Technology (BAT) assessment for selection of preferred emissions control technologies
- Waste logistics study assessing the options for the delivery of waste to the EfW
- Residue re-use and disposal study for by-products/waste generated in the process
- Site and existing Mill Interface studies.

4.5.2.1 Site selection workshop

A site selection workshop was undertaken at Maryvale on 26 September 2017, to evaluate the options for positioning the proposed EfW plant on the Maryvale site. The workshop included both AP and Jacobs staff.

Of the five sites AP originally listed for consideration, the workshop reviewed the attributes of the three shortlisted sites against a matrix of scoring criteria that was jointly developed and scored. There were 30 criteria that each of the three sites was evaluated against, over the following broad categories:

- Available land
- Impacts on existing operations
- Logistics
- Schedule
- Services
- Site readiness
- Social and environmental impacts.
The clear recommendation of the evaluation process was to proceed based on “Site 3” shown in Figure 4.7 below. The primary drivers for this recommendation were as follows:

- Adequacy for the EfW Plant purposes and room for potential future expansion
- Access for rail and road without compromising existing operational infrastructure or storage areas
- Low interference between the proposed plant and the Maryvale Mill in construction and operation
- No poorly rated scores on any strong influencing factors in the analysis.

Site 3 does require a larger amount of earthworks in construction to create the project bench and the necessary construction laydown area will require more management than the next best option (Site 1). Site 1 had more significant issues attached with delivering the rail access relative to the preferred site. Site 2 was clearly not preferred due to complexities relating to brownfield construction and potentially negative impacts on mill operations, particularly during construction.

4.5.2.2 Waste flow and composition assessment study

A waste flow and composition assessment study has been significantly progressed and has achieved the following objectives:

- Identification of likely council sources of MSW from the Melbourne and Gippsland regions.
- Engagement with Melbourne Waste Resource Recovery Group (MWRRG), Gippsland Waste Resource Recovery Group (GWRRG), Sustainability Victoria and selected councils to seek data and to enhance understanding of existing waste management practices, and future plans and trends
- Literature review of waste volume and compositional data available for the target areas
- A desk based assessment of the potential availability and sources for C&I waste in the Melbourne and Gippsland regions
- Development of a waste flow model for the project using the ‘naus’ waste intelligence tool which provides a standardised methodology for modelling waste inputs and flows at a Local Government Area (LGA) level.
- Estimation of a ‘baseline’ waste composition to use for the project feasibility and tendering exercise, based on available literature data from Victoria, other Australian waste authorities and relevant international reference examples.
- Estimation of a preliminary project waste fuel specification to use for the EPC technical specification, based on the ‘baseline’ waste composition.
- The commencement of a waste sorting and fuel analysis campaign at relevant waste sourcing locations for the Project, to enhance the dataset available for the project waste composition and waste fuel analysis.
- Using the waste flow model developed in ‘naus’, the completion of an assessment of likely future changes in waste generation and collection practices that may be presently foreseen, such as separate food waste collection, the landfill ban for waste electrical equipment, and other future improvements in recycling and consumer/disposer behaviours, and how this will impact on waste quality and composition received by the facility.

The waste flow modelling and waste sorting and analysis campaigns will continue to further enhance AP’s knowledge of waste volume and compositional information over different seasons, to develop a more robust dataset to confirm the Project design basis.

4.5.2.3 EfW main plant equipment configuration options screening and selection

To clarify the various EfW plant configuration options for providing the electrical generation and steam flow to the Maryvale Mill, a configuration options screening exercise was undertaken. As part of this exercise, a review of the existing mill steam system was included to understand the operation of the existing boilers, turbines and steam distribution. A fault level assessment of the existing mill electrical systems and grid connection substation was also undertaken to consider any limitations in the context of various generator sizing and connection point scenarios.

There are a number of different configurations possible for providing the required electrical generation and steam flows from the EfW plant to the Maryvale Mill.

The key mechanical and electrical considerations for the EfW plant configuration and design that were considered as part of this exercise were as follows:

- Number of boiler lines and capacity to be installed.
- Main steam parameters (temperature and pressure).
- Process steam supply conditions (steam condition for supply to AP).
- Steam turbine sizing and number of turbines.
- Wet vs dry cooling for the steam turbine condenser.
- Electrical connection considerations:
  - Connection voltage and location.
  - Capacity of (each) generator.
- Existing and future AP Mill operations.

Along with the key mechanical and electrical considerations for the Project mentioned above, a detailed analysis of how to best supply the required process steam was undertaken. One of the key focus points for this part of the analysis was how to best minimise the gas and purchased electricity by optimising the Project’s available steam and electrical generation capacity. The options modelled were based on installing two EfW boilers, one turbine and a wet cooled condenser and cooling towers, although it was noted that supplier proposals of a three boiler system were to be considered.
This assessment made the following list of recommendations:

- The EfW generator will be connected to the electrical grid with at the existing 66kV electrical connection at the mill

- A single large turbine is specified, with a steam swallowing capacity equal to the maximum rate steam can be produced by all of the new boilers to be constructed within the Project

- The turbine should be sized to cater for the maximum continuous rating of steam generation which should result in a gross rated turbine size of approximately 67 MW. This allows maximum electricity production from the EfW plant at times when the AP mill is not operating

- The process steam from the EfW plant is supplied via an intermediate pressure (IP) extraction point on the EfW turbine with the allowance of a bypass system to be able to continue to provide steam while the turbine is not operating

- A main steam temperature at the EfW plant not greater than 430°C should be targeted unless the EPC tenderers are able to demonstrate long term boiler performance and reliability at higher temperatures.

- Operating with a higher main steam pressure of approximately 70-75 bar(a) is preferred if it can be supplied by the EPC tenderers

- Two boilers are preferred in terms of a reduced capital cost however there could be some limitations in terms of experience and capability with some of the EPC tenderers to supply two large sized of boilers. A three boiler system is also technically acceptable and can be considered as an alternative

- A wet mechanical draft cooling tower is selected as preferred as it offers significant capital cost advantages and also thermal efficiency advantages for situations when ambient conditions are hot, or when there is little steam flow to AP, and a greater cooling demand exists.

4.5.2.4 Waste logistics study assessing the options for the delivery of waste to the EfW

A waste logistics study was conducted to forecast the transport of MSW and C&I waste to the site, and also the despatch of process and rejected waste residues and recyclables from the site. Waste Collection activities are outside the scope of this study. The study has considered the following options for transport of waste to site:

- Delivery of waste from Gippsland region to be all by road including refuse collection vehicles (RCVs) used for locally generated waste currently disposed of at Hylands Highway landfill in the Latrobe Valley

- SE Melbourne and Melbourne CBD waste collections to deliver to new waste transfer station (WTS) hubs from where it will be bulk hauled to Maryvale.

- Compaction of waste into special sealed or enclosed ‘shipping’ containers, 20-foot or 40-foot (most likely) standard sizes, will reduce the carbon footprint and costs of bulk haul of waste to Maryvale from Melbourne

- AP have undertaken knowledge sharing site visits to similar bulk haul waste container logistics facilities in NSW and in the UK

- Bulk haul from Melbourne in part by rail to the Maryvale rail siding (assuming siding extension for waste trains) to reduce vehicle traffic

- Bulk haul from Melbourne in part by road in efficient A-double vehicles which can carry 2 x 40-foot compacted waste containers (or similar) per load, at least for some of the initial years of operation, and also during contingency events when the rail line to Maryvale is out of service for maintenance.

Despatch of residues, recyclables and rejected waste will consider back-haul options where materials are routed back to Melbourne for disposal/recycling/recovery, where cross contamination of materials does not preclude reusing same containers/truck trailers.
4.5.2.5 Residue re-use and disposal study for by-products/waste generated in the process

The EfW will produce Bottom Ash (BA) and boiler ash and air pollution control residues (APCr) in volumes dependent on the proportion of inorganic non-combustible content of the incoming waste. BA may be of the order of 12-25% of the feed waste quantity by weight, and APCr around 3-6%.

An investigation is underway to establish the end use/disposal options for these streams. It includes the following:

- International literature review and data gathering to understand the potential composition and chemical characteristics of BA and APCr from EfW facilities elsewhere in the world
- Recovery of metals from BA for recycling
- Investigation of waste classification of BA, boiler ash and APCr under Victorian prescribed waste/industrial waste legislation
- Identification of opportunities for BA recovery, treatment and re-use as construction industry aggregate, which would be a new industry in Australia, with no local precedent
- Alternate interim disposal option for BA as an inert material in a landfill classified as industrial waste, whilst a BA aggregate reuse industry is developed
- Preliminary assessment of the potential characteristics of boiler ash and APCr, which are likely to be categorised as prescribed waste under Victorian EPA regulations, and consideration of treatment options which may reduce the potential level of categorisation.

Further description of residue disposal and reuse options is provided in Chapter 10: Waste.

4.5.2.1 Site and mill interface studies

The following investigations of site specific issues have also been undertaken to inform the technical design of the EfW plant:

- Geotechnical study, including both desktop study and intrusive drilling investigations on proposed Project location
- EfW Plant water balance and the interfaces with the existing Maryvale water supply, wastewater and trade waste infrastructure. This has determined volume and connections points, particularly for the effluent discharges. Connections to potable water, domestic sewerage, storm water and the fire hydrant infrastructure are also being investigated. Details on this can be found Chapter 9: Water Use and Surface Water.
- Electrical interface studies with mill systems and grid, including fault studies, connection point and cabling route studies
- Other mechanical and process interface studies, including assessment and process modelling of mill steam energy demands, mill steam condensate return potential to the Project, studies assessing routing and connection/interface points for steam and condensate connections between the mill and the EfW, and the need for water demineralisation treatment and polishing to make up water losses to the EfW boiler water/steam cycle
- Assessment of likely routes, locations and connections between the EfW and the existing site rail infrastructure and the existing weighbridge road vehicle access to the Maryvale mill from the public road network.

4.5.3 Current design process (EPC tender design)

Based on the outline design outputs of the studies, a design basis and technical specification document has been prepared detailing a range of technical requirements for the Project. This technical specification has been developed for a competitive EPC tender where potential EPC companies are preparing competitive technical and commercial proposals to construct the Project. For power plant procurement, EPC contracting is the industry standard approach, and is an effective means of risk transfer from the project developer to the selected...
EPC contractor of cost, programme and performance risk during the detailed design and construction process for the plant.

The first step in this process, following finalisation of the plant outline design (as described above) is to prepare a detailed technical specification which 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 specification must be rectified by the EPC contractor or they will suffer material commercial penalties or be found in breach of contract. The EPC specification, as well as detailing all of the plant’s technical requirements, also specifies in detail all of the environmental performance requirements (i.e. IED and SEPP etc) as ‘make good’ guarantees under the contract.

The EPC technical specification for the Maryvale project is already complete and consists of hundreds of pages of detailed requirements that must be met during the EPC. The main body of the document in its entirety is more than 450 pages long, and is supported by a number of technical appendices. Not the least of these appendices are the Australian Paper in-house corporate engineering standards which entail more than 300 standards in their entirety, covering different aspects of engineering design and construction. It also includes conceptual design drawings prepared on behalf of Australian Paper to guide the potential EPC contractors in regards to some of the more significant aspects of the design more easily represented diagrammatically, such as the site land parcel available for the project.

Prospective EPC contractors received this EPC technical specification in December 2017 at the commencement of the formal tendering period, and they have 4 months from the issue date to complete their commercial and technical contractually binding tender proposals to build the facility.

Further details of this EPC tender process are outlined below.

**4.5.3.1 Preferred option technical specification and EPC tendering**

The EPC tender process has involved the following main stages as follows to date:

- AP prepared and issued an expression of interest (EOI) document to potential EPC Contractors and Original Equipment Manufacturers (OEMs) for the combustion grate and boiler EFW technologies
- EPC Contractors and OEMs for EFW technologies reviewed EOI and submitted responses to express interest in bidding for the project, giving an indication how they will deliver a ‘whole EPC’ scope within Australia and the Latrobe Valley. Reponses included details of proposed key partners and subcontractors and outline of the contracting structure between those parties.
- AP and their representatives reviewed and assessed EOI submissions based on credentials, capabilities, technology and regional experience. The evaluation shortlisted Contractors who were then formally invited to submit a binding fixed price EPC turnkey tender to undertake the EFW works.
- AP and their representatives prepared and issued a request for tender document package

This EPC Tender package was issued to the following three shortlisted Tenderers on the 22nd of December 2017, all of whom have extensive experience in the design and construction of grate EFW plant:

1. Martin Gmbh (Germany) - [http://www.martingmbh.de/en/startseite.html](http://www.martingmbh.de/en/startseite.html)

During the EOI stage, it was established that each of these three companies have very similar technology offerings, all of them using a well proven moving grate type as the core technology, and all adopting effectively equivalent designs for flue gas treatment in terms of emissions performance.

The three EPC tenderers are currently preparing their technical and commercial offers to construct the project on a turnkey basis. Tenderers must prepare their tenders in accordance with the tender requirements including the detailed technical specification issued by AP. Any significant non-complying tenders with respect to meeting
the requirements of the core technology design choices such as the type of boiler, and emissions control measures, will not be deemed acceptable for the project.

It is noted that this EPC process for designing and procuring the plant may result in some minor differences to the outline design presented in this Works Approval, as the EPC Contractor’s tender submissions and detailed designs are not complete at the time of writing of this submission. The E in EPC represents the detailed design engineering stage. The EPC contract award cannot occur without a works approval being granted as it is a substantial financial commitment expected to be more than $600 million, and those investing and lending money to the project will not do so without the works approval condition precedent being met.

4.5.3.2 Preferred EPC tender evaluation and selection

The EPC Contractor and tender design selection process will involve the following main stages as follows:

- Full and binding Tenders and Tender stage designs to be submitted in May 2018
- A formal tender evaluation will be made. Firstly, a detailed compliance check will be made of the tenders to identify any non-compliances with the technical specification. Then evaluation criteria and weightings will be used to objectively evaluate the tender proposals technically and commercially
- Two preferred tenderers will be selected for clarification discussions
- AP and their representatives will determine the preferred EPC tenderer to build the Project.

4.5.3.3 EPC execution phase detailed design and construction

The financial viability of the Project is dependent on securing a significant proportion of the nominal 650,000 tpa of feedstock waste. MWRRG and GWRRG are planning a waste treatment services procurement tender process, starting in mid-2018. Indications from MWRRG are that this process may take 18 months.

Successfully securing sufficient waste feedstock contracts is expected to be one of the conditions precedent for the notice to proceed with the EPC implementation phase of the project. This phase would involve the following activities:

- Detailed design
- HAZOP, Safety in Design and other risk studies which need to pertain to the detailed design developed in the EPC phase
- Equipment procurement
- Site clearing and preparatory works
- Site construction
- EfW plant commissioning and performance testing
- Handover and commencement of commercial operation.

A preliminary estimate of the time from the EPC notice-to-proceed to the handover for commercial operation is 30 to 36 months.

4.6 Detailed process description of EfW Plant

4.6.1 General overview

Based on a nominal waste feedstock of 650,000 tonnes per annum, and an average waste calorific value of 9.4 MJ/kg on a Lower Heating Value (LHV) basis, it has been estimated that the EfW plant will produce a nominal maximum gross electrical output of approximately 67 MWe (when not supplying steam to the Maryvale Mill), which will be generated in a condensing steam turbine generator. The plant will comprise two or three boiler lines utilising moving grate combustion technology, with electricity off-take to both the Maryvale Mill electrical system and, in the event of export, to the AusNet Services 66kV grid system.
The plant will also supply process steam to the Maryvale Paper Mill at 11.6 bar(a), connecting to the Mill IP steam header system, and will normally operate as a combined heat and power (CHP) plant, typically supplying approximately 130 to 145 tonnes per hour of IP steam. The gross power generation from the new EfW plant when supplying 130 tonnes per hour of steam to Maryvale Mill will be approximately 42 MW. Net electricity production after allowing for auxiliary loads at the EfW plant would be approximately 36.5 MW. These mass and energy balances show in graphical format the main process mass and energy flows for both the boiler air and gas system up to the chimney, and also for the water and steam systems for the core plant items.

The energy produced from the new EfW plant is expected to be approximately:

- Steam equivalent to 2.8 PJ of natural gas per annum
- 290,000 MWh per annum of electricity.

The transfer of steam to the Maryvale Mill will consequently reduce the electricity generation at the Mill by an estimated 15 MWe and reduce the natural gas usage at the Mill by 60 to 70% (by up to 4 PJ). Net imports of electricity by the Mill will reduce to typically 15 to 20 MWe. Actual operating conditions will adjust to the needs of the Mill with priority to deliver steam and/or electricity adjusting to the operational circumstances of the time.

This will significantly reduce the Mill’s reliance on purchased energy.

One of three well established technology providers will be selected to be responsible for the design, supply, commissioning and performance testing of the core process elements of the EfW plant through the competitive tender process

1) Martin Gmbh (Germany) – who have supplied more than 900 grate combustion lines worldwide.
2) Hitachi Zosen Inova (Switzerland) - who have supplied more than 600 projects worldwide.
3) Keppel Seghers (Singapore/Belgium) - who have undertaken more than 100 projects worldwide

EfW using grate combustion is a very established and proven technology and there are many similarities in what is offered by the most experienced vendors as prior project learnings have led to a convergence of design principles.

Note: Number annotations by Jacobs
Figure 4.8: Martin Gmbh - overall simple process schematic of the combustion plant

A simple overall process schematic of the Martin thermal treatment plant process, using MSW and C&I waste, is presented in Figure 4.8. Using this figure the process for electrical and steam generation is as follows.

The MSW and C&I material is delivered to the facility directly by Refuse Collection Vehicles (RCV) or other bulk solids handling vehicles (e.g. container tipping vehicles, bulk tippers and walking floor trucks) via waste transfer stations, and enters the enclosed tipping hall building (1).

The waste transport vehicles back up and tip into the waste bunker (2), and the waste is mixed and lifted by the overhead waste crane(s) (3) into the waste feed hopper (4).

For this Project, there is a preference for two independent combustion grate lines (although three lines is also under consideration), with the combined boiler output feeding a single steam turbine generator. It is expected that at least two or more cranes operating above the waste bunker will be required to process the necessary quantities of waste and deliver it to the waste feed hopper system, while providing redundancy in the feeding system.

Waste is pushed from the bottom of the hopper onto the combustion grate (6) via a hydraulically driven ram feeder (5). It is combusted on the topside of the grate. Air is introduced at various controlled points underneath the grate (primary air) and also above the grate (secondary and tertiary air) to promote good mixing of flue gases and optimum combustion. The movement of the grate is designed to promote complete combustion. This combustion control is very important to promote complete burnout of the waste at a high temperature. More than 2 seconds flue gas residence time at 850°C in the main furnace pass is required to ensure complete combustion of organic carbon compounds that are in the waste.

The primary air is drawn from the tipping hall, through the waste bunker, typically with some form of air preheating to promote waste drying on the grate. This approach maintains the tipping hall and waste bunker under negative air pressure, thus continuously controlling odour emissions whilst one of the boilers is operational.

Non-combustible material known as bottom ash (BA) falls off the end of the grate and is handled by the bottom ash extractor (19), where it can be cooled and subjected to metal separation systems to remove ferrous and sometimes also non-ferrous metals, and these recycled metals can be resold as a commodity. Once the metal is removed, the bottom ash may be 12-25% of the feed waste quantity by weight. The BA can then be loaded into vehicles and transported on or off-site for treatment to allow re-use as construction aggregate, or taken offsite for landfill disposal. This will depend on the industrial waste category and the successful development of a new BA local aggregate offtake market in Victoria.

The boiler has empty passes with water tube cooled walls between the furnace and the first superheater/evaporator tube bundles in the gas path (7), which allows the flue gases to cool, reducing the risk of ash build up on the superheaters and other convective heat recovery elements.

Heat is then recovered from the flue gas to generate steam in the boiler and economiser pass (8) which are made up of a number of convective tube elements designed for reliable and efficient heat transfer from the flue gases to the water/steam circuit. The Martin example diagram shows a horizontal boiler pass and vertical economiser pass, which is the current preference. A vertical boiler pass could also be adopted, allowing for smaller boiler house building dimensions, but it could present greater complexity for operations and maintenance.

Boiler ash is to be collected from the various boiler and economiser pass hoppers and transferred to either the bottom ash system or the air pollution control residue (APCr) system, depending on end use/disposal options that will be adopted for the Project.

Flue gases leaving the boiler are typically treated with powdered activated carbon to absorb toxic volatile organic components and heavy metals such as mercury, and with a dry or semi-dry lime dosing and reactor
system (9) to neutralise acid gas pollutants. The lime can either be dry quicklime (CaO) powder hydrated with water mixing or hydrated lime (Ca(OH)₂), and both types are available for bulk delivery to the site.

Mobile ash particulates and flue gas treatment residues entrained in the flue gases are captured in the bag filter plant (10). The residues collected in the bottom of the bag filters (20) are known as air pollution control residues (APCr) and are normally conveyed to a storage silo ready for disposal to an appropriate landfill capable of accepting hazardous waste.

For some EfW plants processing hazardous wastes, a second stage wet scrubber (11) may be used to further treat flue gases, however this is not considered BAT for MSW and C&I feedstock to meet the European air emission limits, nor is it required for the Project.

Oxides of Nitrogen emissions are normally controlled by Selective Non Catalytic Reduction (SNCR), which is the injection of ammonia or urea into the flue gases at the top of the furnace (12). The Project will use aqueous urea which is a less hazardous material than aqueous ammonia.

Safe vacuum conditions are maintained in the furnace and boiler so that hot combustion gases do not escape to atmosphere. Furnace pressure is controlled by the induced draft fan (13), which then draws the cleaned flue gases up the chimney (14). The chimney needs to be designed to a height to disperse the gases to achieve ambient air state environment protection policy (SEPP) requirements.

The high pressure steam produced in the boilers will be piped to a single steam turbine generator (15), with the turbine rated to accept steam from all the boilers operating at maximum continuous rating (MCR). In the turbine, the steam will drive the turbine blades converting the mechanical energy to electricity in the generator.

Steam exhausted from the turbine is cooled in a water cooled condenser (16) which generates a partial vacuum at the turbine exhaust, facilitating efficient energy extraction from the steam. The water cooled condenser is supplied by water from a semi-closed loop cooling tower system, which requires make-up water to account for evaporation losses and the water blowdown required to prevent excessive salt build up in the cooling water circuit.

Electrical power generated by the turbogenerator can easily supply the load, and the majority of the generator (17) output is stepped up in voltage in the generator transformer to 66kV for connection to the Maryvale Mill incoming substation high voltage busbar. This connection point allows the mill to import the power produced, and any excess generation to be exported to the NEM grid. Process steam can be efficiently generated by extracting intermediate pressure (IP) steam off the steam turbine at a stage appropriate for the desired pressure and temperature (18).

The critical and more unique aspects of the Project are the combustion grate, furnace, steam boiler and flue gas treatment systems which are discussed in more detail below. These elements of the plant are considered the most critical and challenging elements of the overall process to design and construct to deliver a reliable, efficient and environmentally sound energy generation and waste treatment solution.

The balance of the EfW plant (including steam turbine, generator, condensing and feed-heating plant, water treatment, turbine cooling systems and ancillary systems) is considered to be relatively standard equipment and present a low risk to the project. The solid waste treatment systems are less mature technologies and present some risk to the project.

There are some differences between the technology providers’ designs, but for the purposes of this process description, the Martin technology, being one of the most well established and well known international technologies, has been described here. The differences between Martin’s technology and the other technology providers under consideration for the project are not expected to have any significant performance differences which would result in a material variation in environmental impact.

The combustion technology that is proposed for the Project is generally described as a mass burn combustion grate technology, which is a long established and effective method for thermally treating MSW and C&I waste. The type of plant being offered by all of the technology providers under consideration is based on the proven...
moving grate technology, such as that supplied by Martin GmbH. Jacobs as lead consultant appointed for the EfW feasibility study, has had prior involvement in many EfW projects, including a number using the Martin grate technology, in other parts of the world. Jacobs’ experience is that the vast majority of these moving grate technology projects have been completed and commissioned successfully, meeting both the local authority (i.e. council or waste authority) and environmental agency requirements following commencement of operation.

4.6.2 Waste reception, tipping hall and storage bunker

4.6.2.1 General

All of the Waste receipt storage and feeding systems shall be capable of handling waste deliveries under the following range of scenarios:

- 40 foot containers hauled by rail to the adjacent siding on the Maryvale site, where the waste will be compacted into the containers before loading on to trains, with a gross container mass typically between 32–36 tonnes.
- “A” double vehicles carrying 2 x 40’ waste containers to a max GCM of 85.5 t which will be routed to the Maryvale rail siding area for container transfer.
- Special tipping skel trailer site based end tipping truck(s) which will tip 40 ft containers of compacted waste within the tipping hall into the waste bunker. Single semitrailer sized vehicles to 19 m length carrying 1 x 40’ waste container to a GVM of 50 t, shuttling between the rail siding area and the tipping hall.
- Compactor collection vehicles (also known as refuse collection vehicles, RCVs) carrying Gippsland sourced MSW and C&I waste, of which a typical payload is of the order of 6-7 tonnes. Collection compactors will discharge directly into waste bunker
- C&I waste delivery vehicles of the self-unloading trailer types (e.g. self-tippers or walking floor type), discharging directly into waste bunker.
- Roll on/roll off skip carrying vehicles for waste deliveries, recovered metals despatch, and tipping hall rejected waste disposal.

The project will also utilise the following mobile plant for waste handling to site and on-site:

- One or two reachstackers (5036 type or similar) capable of lifting at least 36 t 40’ containers from trains or A-double road trailers on to site based tipper-trailer trucks.
- Two or more site tipper prime movers and tipping skel trailers capable of end-tipping 40 ft containers, to be used for shuttling waste containers from the rail siding container areas, and for unloading those containers of compressed waste into the waste bunker within the tipping hall.
- Specially designed sealed and tippable 40 ft containers for longer distance road and rail transport

It is expected that the local deliveries of waste will be concentrated in afternoon times between 14:00 to 15:00 following local RCV collection rounds in Gippsland with a late morning peak between 10:00 to 12:00 also sometimes observed for transfer station and C&I waste deliveries.

For rail deliveries of waste in containers it is expected that one train a day containing up to 80 by 40’ containers will be sufficient, normally 5 days per week but with some weekend catch up movements.

4.6.2.2 Site access and waste reception

Access to site for waste vehicles from the public road will be via a Security gatehouse with adjacent barrier and ‘out of hours’ lock-able gate, provided within the EPC Works. The gate house will be located on-site sufficiently far from the public road to accommodate a number of waste vehicles queuing awaiting entry, without the risk of queuing occurring on the public road. Off road waste vehicle parking shall also be provided near the gate on the outside of the barrier, so that vehicles can be asked to wait before entry without blocking the flow of other vehicles into and out of the site.
All site roads and intersections within the site, and intersections with the public roads for carrying waste vehicles, shall be designed for safety, minimisation of external impacts, and time efficiency allowing for the transit of all of the waste vehicle types, waste quantities, waste qualities, and expected numbers of vehicle movements for ingress and egress of those deliveries in and out of the site.

All intersections and turning areas shall be designed with the longest possible vehicle types expected – currently 30m A-doubles. The road design will minimise the risks of vehicle collisions allowing good visibility at all intersections, minimising the chances of head on collisions, and where necessary, one way systems may be used to prevent vehicles encountering each other in head on scenarios.

The site road systems shall also be carefully designed with consideration for minimisation of the risk of collisions with pedestrians and other plant and equipment on-site. Areas frequented by pedestrians will be segregated from the main waste vehicle routes, and barriers, overpasses and safe crossing areas shall be provided as necessary where pedestrian access is unavoidable.

A waste vehicle quarantine area shall be provided for loads that are found to be outside the plant’s waste acceptance criteria (e.g. radioactive, clinical etc.) or for routine audit and inspection. The quarantine area shall be located adjacent to the waste road route within the site, and vehicles asked to wait in this bay shall be able to do so without blocking the flow of other vehicles.

4.6.2.3 Weighbridges

Three (3) bi-directional calibrated road vehicle weighbridges will be located within the site road network at an appropriate point to allow efficient weighing of incoming and outgoing heavy vehicles from site, to satisfy any regulatory requirements for waste load tracking. The weighbridges shall allow:

- Weighing of incoming waste carrying vehicles arriving either from the public road or from the adjacent rail siding
- Weighing of all major consumables such as lime, urea and activated carbon trucks etc.
- Weighing of outgoing empty waste vehicles, and empty plant consumables vehicles exiting to the public road or rail siding
- Weighing of incoming and outgoing BA and APC residue carrying vehicles entering and exiting either from the public road or the rail siding
- Provision of bypass lane(s) for vehicles that do not need to be weighed.

The weighbridges shall be calibrated and certified to a suitable accuracy to meet commercial and regulatory accuracy requirements. An automatic ticket printing system shall be provided with contingency system when main system is not operating to provide load documentation requirements. An automated system for recording weight and number plate data shall be provided, with data exported to the Plant LAN, and to the control system for recording tonnages of all incoming and outgoing wastes and residues processed or despatched from site. The weighbridge area shall be covered by CCTV camera(s), with connection to screens provided in the weighbridge office and the central control room.

4.6.2.4 Waste Tipping Hall

The waste tipping hall shall be a fully enclosed building maintained under negative pressure whenever one of the combustion lines is in operation, for the control of odour and dust. Ingress and egress for waste vehicles to the tipping hall shall be through automated fast acting (such as plastic or fabric types) roller doors which open when a vehicle approaches, and close when a vehicle has passed through. An automated traffic control system shall be provided notifying vehicles regarding which bay(s) to unload into, with manual intervention possible from the central control room or by the tipping hall operations supervisor. The tipping hall design shall also allow operation of a front end loader for cleaning up waste spillages from the tipping floor into the bunker. The building shall be designed to eliminate the need for pedestrians to enter the fuel reception area during normal operations.
Figure 4.9: Waste delivery vehicle exiting the enclosed tipping hall at Lakeside EfW in the UK

Access in and out of the tipping hall for waste vehicles through the roller doors shall be via a vehicle flow path designed with safety in mind, for the avoidance of vehicle to vehicle and vehicle to structure collisions. The floor of the tipping hall shall be suitably designed to provide the design life considering the static and dynamic loads of the vehicle traffic and other anticipated operations. A high quality abrasion resistant floor finish shall be provided suitable for front end loader operation for waste clean-up.

The layout and dimensions of the approach to the tipping hall, the access doors and the internal building area themselves shall be ample to accommodate all vehicle types, bearing in mind the vehicle dimensions and necessary turning circles. The height of the tipping hall shall be sufficient to allow a tipping skel trailer carrying a 40 ft container to tip waste at an 80° angle to horizontal.

A reject waste load out area shall be provided within the tipping hall building. The tipping hall shall extend at the side of the waste bunker to allow space for a waste rejects load out area. The quarantine area shall be provided with separate areas as appropriate for the segregation of untreated waste (large objects, rubble, soil, plasterboard etc.), and including adequate space for skips and containers to hold segregated hazardous materials (e.g. asbestos, paint and solvents, waste oils, gas cylinders, batteries (in plastic storage containers), fluorescent tubes, chemicals). The load out area shall be used if it is ever necessary to load waste from the waste bunker into articulated trailers by means of the bunker overhead cranes. Sufficient space shall be provided for a waste audit pad that allows up to 10t of waste to be spread and inspected.

Tipping bays shall be designed to prevent collisions of cranes with tipping vehicles and to prevent the risk of tipping and other vehicles backing or falling into the waste bunker during unloading.

Optimal visibility, inherent controls and guidance systems for waste vehicle drivers to navigate vehicle flow paths into, out of and within the tipping hall shall be provided in the design, through the following methods:

- Traffic control systems such as lights and automated door opening
- Appropriate location of doors and roads
- Adequate lighting
- Mirrors
- Painted lines on floor
- Vehicle reversing guides
Impact barriers.

Additional measures shall be provided to reduce the risk of tipping vehicles falling into the bunker as follows:

- Floor safety lines indicating distance from bunker
- Wheel kerbs to be mechanically protected against abrasion
- Safety barriers or beams
- Regular housekeeping and plant inspections.

4.6.2.5 Waste bunker

The waste bunker shall have a waste storage capacity of up to 7 days of nominal waste throughput below the height of the tipping hall floor. The bunker shall also be designed to allow stacking above the tipping hall height against the wall separating the bunker from the boiler house to give additional storage during emergency events.

The bunker shall be designed as a water retaining structure to prevent permeation of waste leachate into the ground below or adjacent to the bunker structure. The permeability of the bunker shall be tested with a water test prior to placing into service, and unacceptable permeability levels of moisture through the structure must be made good before commencement of commissioning. The design will ensure that the base and walls have sufficient mass and strength to resist groundwater uplift pressure when the bunker is empty.

The bunker shall be constructed of a robust concrete type on the walls and floor slab such that impact and abrasion from the crane grabs or tipped waste shall not result in significant damage to the structure during operation. The materials of construction shall also be suitably resistant to chemical attack from elements of the waste and waste leachate during its design life. It shall be possible to completely empty the waste from all areas of the bunker to ensure that the stock can be turned around to avoid decomposition from long periods in the bunker and to empty the bunker leading up to total plant shutdowns.

The fire detection and protection systems for the waste bunker shall comply with the Victorian Government Publication “Management and Storage of Combustible Recyclable and Waste Materials – Guideline”, Publication 1667, August 2017, and with the required Australian and NFPA codes and standards applicable.

Industry good practice systems for fire control for EfW waste bunkers shall also be adopted to control the risk of waste fires in the bunker. These shall at a minimum include the following measures:

- Infrared fire detection matrix system
- Carbon monoxide detectors appropriately located around the bunker area
- Remote control operated fire cannons mounted on the bunker walls which can pivot to cover the entirety of the bunker area, capable of both manual remote control from the central control room.
- Fire hose reels that can be manually operated to fight fires in the bunker
- Atomiser mist sprays for dust control to prevent build-up of dust on surfaces in the bunker and tipping hall.

Effective waste odour control systems shall be provided to manage odour during normal operations and partial and complete plant shutdown.

Waste odour and dust control systems to be provided are as follows:

- Maintenance of a negative pressure above the bunker at all times when one or more combustion line is in operation, the air from the tipping hall shall be ducted to the Forced Draft fan inlet of the combustion line(s) and combusted in the main furnace
- During the occasional event when no combustion lines are in operation, suitable systems and procedures shall be provided for the minimisation of odour generated from waste remaining in the bunker including at a minimum, a deodorant addition system for dosing to the dust atomiser mist sprays during overall plant outages.
The waste bunker shall be separated from the boiler house through a suitably rated fire wall meeting building fire code requirements.

4.6.2.6 Waste feeding cranes

The waste feeding cranes shall comply with the requirements of the design code set AS1418 and shall be of the grab type, and will be used for both mixing waste within the bunker before combustion to homogenise the waste, and to feed the waste into the boiler feeding system.

The cranes shall be suitably rated in terms of grab capacity and travel speed to allow feed of all waste types at the maximum feed rates required to each line on a continuous basis, from every part of the waste bunker. Each crane shall be capable of feeding each Combustion Line waste feed hopper. The cranes shall also be capable of operating for the purposes of mixing waste within the bunker to homogenise the waste fed to the Lines, and shall also be capable of removing rejected waste from the bunker and discharging it to a rejects area or skip within the tipping hall area. The cranes' travel and inertia shall be controlled and/or limited to prevent collision of the cranes with bunker walls, tipping bays, vehicles unloading in the tipping bay and fire cannons.

Each crane shall be capable of operation from its crane operation panel in the central control room (CCR), which will be located above the waste bunker with a clear viewing window allowing sight across the length and breadth of the waste bunker and crane travel range. CCTV shall be provided to cover crane travel areas more difficult to view from the CCR bunker viewing window, with signal relayed to the CCR crane operation panel CCTV viewing screens. The crane shall be capable of all operational modes typical of modern good practice waste feeding cranes at EfWs, including:

- Semi-automatic operation with some operator intervention from the CCR to position the grab, following which grab operation and waste hopper feeding is in automatic mode to the selected waste hopper
- Full Automatic operation for bunker feeding and mixing modes with waste bunker profile sensors and level control algorithms
- Full manual operation from the crane operator panels in the CCR.

The cranes shall each accurately weigh each grab load of waste fed to the hoppers of each line for the purposes of plant control and performance logging with the output signal provided to the DCS. A calibration weight shall be provided in the Works for regularly calibrating the weighing systems.

The cranes shall be designed for low noise and minimal vibration during all modes of operation.

4.6.2.7 Waste feeding hopper

The fuel feeding systems shall comply with all relevant NFPA fire protection requirements including NFPA 85 general (Chapter 4), and specific requirements for stoker fired boilers (Chapter 10).

The waste feed hoppers shall be designed with a safe and efficient means of emptying in the event of a line shutdown, for maintenance of the feeding system, or to clear waste blockages.

The volume of waste in the hopper shall act as a plug to prevent air ingress to the furnace from the bottom of the hopper. A hydraulically operated isolation gate shall also be provided to automatically cut off waste and air flow to the furnace in the event of low hopper level or other abnormal operating events in the furnace.

Waste feeding from the hopper to the furnace shall be via hydraulically driven ram stokers. The stokers shall meter waste onto the grate at a controlled and uniform rate with even distribution for optimal combustion, automatically controlled by the boiler controls system.

The hopper connection to the furnace shall have a water cooling system shall maintain the hopper bottom at a suitably low temperature to avoid waste combustion in the hopper. The fire detection and protection systems for the waste feed hoppers shall comply with the regulations, codes and standards including Australian and NFPA codes.
Industry good practice systems for fire control for EfW waste feeding chutes shall also be adopted to control the risk of waste fires in the hoppers. These shall at a minimum include the following measures:

- Automatic fire detection systems located over the mouths of, and within the hoppers
- The above detection system shall trigger automated fire water sprays into the top of the hopper
- A remote manual system for the abovementioned hopper sprays allowing operation from the CCR
- Fire hose reels that can be manually operated to fight fires within the hoppers.

4.6.3 The moving combustion grate

The moving combustion grate is a fundamental element in the waste treatment process in order to achieve effective and reliable waste burnout. The Martin Vario grate design is primarily described here, which is an air cooled, hydraulically driven, reverse acting reciprocating grate with a downward inclination angle from the feed end to the ash discharge chute of 24°. Waste is fed on to the grate via robust hydraulic ram feeders in the bottom chute of the waste feed hopper.

The grate is designed to maintain an even distribution of waste over the grate under varying load conditions and waste quality conditions. The hydraulically driven movement of the grate elements agitates the waste as it moves along the grate and down the incline by gravity, through the various combustion zones, including stages of a waste drying, gasification, ignition, combustion and ash burnout. The Martin grate is a typical example of the type of grate element expected to be used in the Project, as illustrated in Figure 4.10. The Martin grate is very well referenced and various other EfW plant boiler vendors and EPC contractors purchase it for their plants due to its reputation for reliability and effectiveness. The other tenderers in consideration, HZI and Keppel Seghers do not use the Martin grate but have their own very similar well proven and patented technologies with the most significant difference being their reciprocating motion is forward acting, rather than reverse acting. This general type of reciprocating grate is well suited for processing municipal waste with the range of MSW and C&I calorific values expected for this Project.

Figure 4.10: Diagram of the Martin Vario Grate Elements and Hydraulic Drive and Pusher Feeder Mechanism

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4.6.4 Waste feedstock sources and composition

An important consideration for the Project is the development and enforcement of a Waste Acceptance Criteria for the plant, which should match the regulations with regards to treatment of non-hazardous waste, and also meet the requirements of the grate in order that any unprocessable materials received at site can be rejected. The waste acceptance criteria document is under development and will become an important part of any waste supply contract or agreement with MSW and C&I suppliers to allow enforcement of the right to reject waste.

Some examples of the types of waste that would be rejected under the project waste acceptance criteria include:

- Bulky waste
- Large electrical equipment e.g. whitegoods
- Polychlorinated compounds such as PCBs
- Asbestos and other insulation materials
- Herbicides, insecticides, and fungicides
- Paints, solvents and their residues
- Gas cylinders
- Vehicle batteries;
- Plasterboard (gypsum); and
- Clinical/medical waste
- E-Waste.

It is reasonable to expect that ‘source-separation’ and changing habits of the householder may be an increasing requirement over the life of the Project, which will have the potential to change the quantity and composition of the municipal waste received. The moving grate technology is flexible and will be applicable under a wide range of compositional variations that might be expected for MSW and C&I waste, leading to variations in waste calorific value. The plant design should allow safe operation with varying waste composition within a specified net calorific value (NCV) firing envelope, as defined in the EPC technical specification waste firing diagram.

Figure 4.11 : EPC specification ‘per line’ combustion line waste firing diagram assuming a 2 line plant
The proposed plant should operate satisfactorily within the bounds of the proposed firing diagram which indicates safe operation without auxiliary burner firing between range of waste Net Calorific Values (NCVs) from 7 MJ/kg and 13 MJ/kg. The design point NCV point on the waste firing diagram is 9.4 MJ/kg. Further Melbourne and Gippsland waste compositional analysis work is ongoing, including physical waste sorts and lab analysis of samples, as well as desktop modelling of sensitivity cases looking at how waste composition may change in the future as a result of changing consumer habits, or different waste collection regimes (e.g. separate food waste collection bins). As more data becomes available the waste compositional assumptions for the project including the NCV design point may be adjusted to better tailor the plant design for the waste it is likely to receive.

EfW plants of this type are limited in processing capacity by thermal energy in the waste input (calculated by multiplication of waste NCV and waste tonnage consumed per unit of time). Hence, the waste firing or stoker diagram is very useful for assessing possible plant throughput for a facility. The 100% Maximum Continuous Rating (MCR) maximum design thermal capacity of the plant equates to 42.8 tonnes per hour of waste at 9.4 MJ/kg (100% MCR firing rate), and normal operation design point of 40.6 tonnes per hour of waste at 9.4 MJ/kg (95% MCR firing rate).

The design capacity of the plant is 650,000 tonnes per annum of waste. Based on the 95% nominal operation point, which is a realistic assumption for the average thermal load of the plant achieved over a year (assuming waste supply is not a constraint), the plant will operate 8,000 hours per annum to achieve the necessary waste processing throughput if the waste NCV is 9.4 MJ/kg. This is equivalent to a plant availability between 91.3% or an annual plant capacity factor 86.8% for a waste NCV of 9.4 MJ/kg. The grate typically can also operate on a short term above this design point by circa 5-10% based on the grate’s design heat release rate, which allows capability to sit stably on a set point of 100% MCR on a continuous basis, whilst allowing some headroom for safe load and pressure control of the boiler with varying waste quality.

4.6.5 The furnace and heat recovery steam boiler

The design of the furnace and the heat recovery boiler is another very important aspect of the plant in terms of reliability, efficiency and environmental performance. In particular, the chemical composition of MSW and C&I fuel is such that it has a high potential for boiler tube slagging and corrosion. The chlorine, sulphur and alkali metal contents of the waste feed to the boiler are very important parameters to consider in the design. Chlorine content is also a factor in the production of chlorinated pollutants in the flue gases leaving the boiler.

Initial waste compositional estimates indicate an estimated average chlorine content of the waste as between 0.3 and 0.4%. This chlorine content is lower, in the comparison with many other MSW EfW projects. Chlorine levels for MSW EfW plants in Europe can be up to 1.0% (the limit under the IED for a non-hazardous thermal treatment process), with typical values being between 0.5 and 0.8%. If the Maryvale project does indeed have a lower chlorine content than typical, the risks of boiler gas side corrosion may be reduced and the generation rate of chlorinated pollutants before treatment (e.g. HCl) in the flue gases will also be lower. It is noted that waste compositions can change during a project and therefore a prudent to design the boiler and flue gas treatment systems for potentially higher chlorine levels than those expected has been adopted in the EPC technical specification.

The furnace is designed as a fully enclosed membrane tube wall water-cooled chamber. There are a number of boiler passes, with the first pass of the boiler consisting of the water-cooled gas tight welded tube walls of the furnace. Following this pass, the second (and sometimes third) pass(es) will be ‘empty’, employing radiative heat transfer on the wall surfaces only. The first convective pass (and sometimes the third or fourth pass) will include the first tube bundle elements across the gas flow path, typically the evaporation and high temperature convective superheater elements. The convective passes generally also include a further two stages of low and medium temperature superheater elements. The final pass is generally a vertically downward pass which contains a number of stages of convective economiser elements.

In order to clean boiler convective elements, various methods are generally employed including water soot blowing in the high slagging furnace and empty radiant passes, rapping devices along convective passes is orientated horizontally, or steam sootblowing if a vertical convective pass is adopted. Shot ball cleaning in the vertical economiser pass is sometimes adopted also. Each of these tube cleaning techniques promote ash to fall off tubes, when cleaned in service, into collection hoppers below. A horizontal convective pass design allows
relatively simple removal and replacement of those tube elements as will be required during the life of the plant when corrosion or erosion reduces tube thickness below safe margins. A vertical convective pass design is more complex for tube element replacement, but allows a smaller boiler overall footprint.

The objective of the empty boiler passes and the horizontal boiler is to cool the flue gases from the high gas temperatures needed for good burnout of the waste and for the minimisation of formation of dangerous organic pollutants in the flue gases. Typically, the target is to cool the gases down from above 850°C in the upper furnace to below 650°C before the gases reach the metal tube surfaces of the high temperature superheater elements, thus reducing the fouling and corrosion risk of the superheater tubes. By employing an evaporator screen tube before the first convective superheater, it can be possible to allow the gas temperature into the evaporator element to exceed the 650°C level, as the temperature of the water in this tube is considerably lower than the main steam temperature so the slagging and corrosion risk for the evaporator is lowered.

The flue gas is maintained at 850°C for more than two seconds with adequate excess oxygen, in excess of 6 vol%, to destroy persistent volatile organic compounds including dioxins and furans and their precursors by oxidation in the radiant pass of the furnace. Then the gas is cooled as it passes though the boiler empty passes (with water cooled walls) down to less than 650°C, and then through the convective evaporator passes including the economiser down to circa 160-180°C. The thermal energy is recovered during the gas cooling to generate steam by heat transfer from the gas path into boiler water/steam tubes (no direct water contact). This is one of a number of key differences between modern EFW plants and old waste incinerator plants that formerly used water quenching to cool the flue gas with no heat recovery, with little other emission control technologies employed, and with limited effectiveness in overall pollutant mitigation.

The temperature zone where dioxins and furans can potentially reform (known as de novo synthesis) from their precursors is between 450°C and 250°C. In the Maryvale EFW boilers, this will occur in the convective evaporator and economiser passes of the boiler, with combustion gases having residence times of seconds only in these passes. The probability of dioxins reforming here is limited as many of precursors have already been destroyed in the furnace through effective combustion control.

The residence time for flue gases and dusts in this 450 to 250°C region is minimised by effectiveness of heat transfer to cool the gases rapidly to below 250°C. Residual dusts on these elements will be removed by proven tube cleaning systems such as mechanical rappers and sootblowing. Ash collected in the bottom of these passes is discharged continuously to the ash handling systems to avoid residence time issues.

Chapter 4 (parts 4.13.19 and 4.4.5) of the EC BREF for Waste Incineration confirms these approaches as good practice design that is adopted across Europe to meet the requirements of the IED for waste incineration with respect to dioxin and furans emission control.

Any residual dioxins and furans in the flue gases leaving the economiser are then treated in the flue gas treatment system as described further in Section 4.6.6.

The final steam temperature selected for the plant is also an important parameter for mitigation of slagging and corrosion risk for EFW plants. Higher steam temperatures are more energy efficient, but also raise the gas side surface metal temperatures of superheater elements, thus increasing the slagging and corrosion risk. For this reason, EFW plants typically adopt conservative steam temperatures and pressures. The expectation for the boiler outlet steam conditions for the Project used for the feasibility study are 430°C and 72 bar(a), and these numbers may be refined following selection of the preferred EPC Contractor’s tender proposal.

During the EOI stage it was identified that both Martin and Hitachi Zosen Inova have constructed a number of plants operating at similar steam conditions. This temperature should allow a good level of thermal efficiency and support reasonable superheater life by limiting high temperature corrosion and ash fouling.

The design of the boiler for the Project will adopt a conventional design which has been proven to be effective for combusting MSW. This general type of combustion technology requested in the EPC technical specification is a technology that is successfully used at the majority of EFW plants in the world, and is not expected to prove problematic in handling the MSW and C&I waste types proposed.
4.6.6 Flue gas emission control systems

Air emissions from the main stack are the most regulated and controlled emissions from an EfW facility, and a facility is required to have continuous (24/7) emission monitoring systems (CEMS) to ensure compliance. Within the flue gases emitted from the stack, the following types of emissions are found in low concentrations for MSW and C&I feedstock and for each emission type the techniques typically used to control these emissions (known as best available techniques (BAT)) which can achieve effective emission control:

- Oxides of Nitrogen (NOx) – controlled by combustion control and selective non catalytic reduction (SNCR) with the injection of ammonia or urea into hot flue gases
- Oxides of Sulphur (SOx) – controlled by the injection of lime (alkaline) reagent into the flue gas to absorb and neutralise the acid gas compounds
- Halogens (e.g. HCl and HF) – also controlled by lime (alkaline) reagent injection, neutralisation and adsorption
- Particulates – these ash and APC residues are filtered out in the bag filter system
- Heavy Metals – controlled by the injection of activated carbon into the flue gas which is subsequently collected in the bag filter system
- Volatile organic compounds including dioxins and furans – which are destroyed by high temperature in the furnace, the reformation inhibited by controlling the flue gas cooling and using activated carbon injection and bag filters to absorb and remove any residuals.

In Europe, emissions to air from EfW plants are tightly regulated by the Industrial Emissions Directive (IED), which has subsumed the regulations that were formerly known as the Waste Incineration Directive (WID). This legislation sets out stringent emissions levels for the following pollutants and is considered a tougher compliance standard than the regulations applying to non-waste burning, large combustion plants such as coal and biomass power stations. Table 4.2 below outlines the main emission limits for waste burning plant under the IED. When using the above mentioned BAT emission control techniques, modern EfW plants can comfortably comply with the IED.

Table 4.2: Average emission limits for waste burning plant under the IED

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Units</th>
<th>Emission Limit</th>
<th>Averaging &amp; Sampling Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dust</td>
<td>mg/Nm3</td>
<td>10</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Organic substances or VOCs</td>
<td>mg/Nm3 as TOC</td>
<td>10</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Hydrogen chloride, HCl</td>
<td>mg/Nm3</td>
<td>10</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Hydrogen fluoride, HF</td>
<td>mg/Nm3</td>
<td>1</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Carbon Monoxide, CO</td>
<td>mg/Nm3</td>
<td>50</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Sulphur dioxide, SO2</td>
<td>mg/Nm3</td>
<td>50</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Nitrogen Monoxide &amp; Dioxide, expressed as NO2</td>
<td>mg/Nm3</td>
<td>200</td>
<td>Daily, Continuous</td>
</tr>
<tr>
<td>Cadmium and Thallium, Cd+Tl</td>
<td>mg/Nm3</td>
<td>0.05</td>
<td>30 minutes to 8 hours</td>
</tr>
<tr>
<td>Mercury, Hg</td>
<td>mg/Nm3</td>
<td>0.05</td>
<td>30 minutes to 8 hours</td>
</tr>
<tr>
<td>Other Trace Metals</td>
<td>mg/Nm3</td>
<td>0.5</td>
<td>30 minutes to 8 hours</td>
</tr>
<tr>
<td>Dioxins</td>
<td>nano g/Nm3 I-TEQ</td>
<td>0.1</td>
<td>6 to 8 hours</td>
</tr>
</tbody>
</table>

Note: Emission limits are standardised to normal conditions defined as 273°K, 101.3 kPa, dry gas at 11% volume of oxygen.

The IED also includes half-hourly emission limits for total dust, TOC, HCL, HF, SO2, NO2 and CO to regulate transient operating conditions.

The Project shall comply with all of the environmental requirements of the Victoria EPA Energy from Waste Guideline, Publication 1559, December 2013. This guideline has adopted the IED as the requirement for an
EfW plant in Victoria. The EPA guidelines are applicable under all transient, part load, and start up and shut down operating conditions.

The Project 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 EfW Plant is located in the Latrobe Valley Air Quality Management Region, and hence Schedule E applies.

The EPC technical specification for the Project reflects these emission limit requirements. The Martin, HZI and Keppel Seghers flue gas treatment systems include the described gas emissions controls, which are all designed to achieve the European IED requirements, and have been proven to do this effectively in numerous operating EfW plants in Europe. As proof of these technologies achieving the required emission standards in practice, the following publically available data from operating United Kingdom EfW plant are provided in Table 4.3, Table 4.4, Table 4.5 and Table 4.6

- Leeds is a single line 165,000 tpa Martin Grate plant for which Jacobs acted as Independent Certifier for the Waste Authority (Leeds City Council) and Veolia throughout construction and commissioning
- Newhaven (East Sussex) is a single line 200,000 tpa HZI grate plant for which Jacobs acted as Owner’s Engineer and Independent Certifier for the and Veolia Waste Authority (East Sussex Council) throughout construction and commissioning
- Four Ashes (Staffordshire) is a 2 line 320,000 tpa Martin Grate plant for which Jacobs acted as Independent Certifier for the Waste Authority (Staffordshire Council) and Veolia throughout construction and commissioning
- Riverside (Belvedere, London) is a 3 line 670,000 tpa HZI grate plant for which members of Jacobs’ Maryvale project team acted as Lender’s Engineer during construction during previous employment in the UK, which included multiple site visits during construction and commissioning.

Table 4.3 : Last 12 months historical average daily emissions data for Martin Grate Plant operated by Veolia in Leeds, UK

<table>
<thead>
<tr>
<th>Period</th>
<th>Particulates % of IED limit</th>
<th>Total Organic Carbon % of IED limit</th>
<th>Hydrogen Chloride % of IED limit</th>
<th>Carbon Monoxide % of IED limit</th>
<th>Sulphur Dioxide % of IED limit</th>
<th>Oxides of Nitrogen % of IED limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 2018</td>
<td>4%</td>
<td>0%</td>
<td>76%</td>
<td>12%</td>
<td>30%</td>
<td>87%</td>
</tr>
<tr>
<td>Jan 2018</td>
<td>4%</td>
<td>1%</td>
<td>67%</td>
<td>3%</td>
<td>21%</td>
<td>82%</td>
</tr>
<tr>
<td>Dec 2017</td>
<td>4%</td>
<td>3%</td>
<td>77%</td>
<td>9%</td>
<td>45%</td>
<td>86%</td>
</tr>
<tr>
<td>Nov 2017</td>
<td>4%</td>
<td>2%</td>
<td>73%</td>
<td>19%</td>
<td>57%</td>
<td>83%</td>
</tr>
<tr>
<td>Oct 2017</td>
<td>4%</td>
<td>3%</td>
<td>65%</td>
<td>22%</td>
<td>53%</td>
<td>83%</td>
</tr>
<tr>
<td>Sept 2017</td>
<td>4%</td>
<td>0%</td>
<td>76%</td>
<td>18%</td>
<td>45%</td>
<td>82%</td>
</tr>
<tr>
<td>Aug 2017</td>
<td>4%</td>
<td>0%</td>
<td>73%</td>
<td>22%</td>
<td>30%</td>
<td>79%</td>
</tr>
<tr>
<td>Jul 2017</td>
<td>5%</td>
<td>0%</td>
<td>69%</td>
<td>23%</td>
<td>42%</td>
<td>79%</td>
</tr>
<tr>
<td>Jun 2017</td>
<td>2%</td>
<td>0%</td>
<td>66%</td>
<td>22%</td>
<td>51%</td>
<td>80%</td>
</tr>
<tr>
<td>May 2017</td>
<td>2%</td>
<td>2%</td>
<td>58%</td>
<td>25%</td>
<td>56%</td>
<td>80%</td>
</tr>
<tr>
<td>Apr 2017</td>
<td>2%</td>
<td>1%</td>
<td>42%</td>
<td>17%</td>
<td>62%</td>
<td>72%</td>
</tr>
<tr>
<td>Mar 2017</td>
<td>2%</td>
<td>1%</td>
<td>33%</td>
<td>20%</td>
<td>66%</td>
<td>80%</td>
</tr>
</tbody>
</table>

* [https://www.veolia.co.uk/leeds/our-proposal/our-proposal/leeds-emissions-air-data](https://www.veolia.co.uk/leeds/our-proposal/our-proposal/leeds-emissions-air-data)
Table 4.4 : Last 12 months historical average daily emissions data for HZI Grate Plant operated by Veolia in Newhaven, UK

<table>
<thead>
<tr>
<th>Period</th>
<th>Particulates % of IED limit</th>
<th>Total Organic Carbon % of IED limit</th>
<th>Hydrogen Chloride % of IED limit</th>
<th>Carbon Monoxide % of IED limit</th>
<th>Sulphur Dioxide % of IED limit</th>
<th>Oxides of Nitrogen % of IED limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 2018</td>
<td>12%</td>
<td>4%</td>
<td>44%</td>
<td>5%</td>
<td>0%</td>
<td>95%</td>
</tr>
<tr>
<td>Jan 2018</td>
<td>10%</td>
<td>3%</td>
<td>47%</td>
<td>3%</td>
<td>0%</td>
<td>95%</td>
</tr>
<tr>
<td>Dec 2017</td>
<td>10%</td>
<td>3%</td>
<td>51%</td>
<td>4%</td>
<td>0%</td>
<td>95%</td>
</tr>
<tr>
<td>Nov 2017</td>
<td>10%</td>
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<td>53%</td>
<td>3%</td>
<td>0%</td>
<td>97%</td>
</tr>
<tr>
<td>Oct 2017</td>
<td>7%</td>
<td>2%</td>
<td>63%</td>
<td>3%</td>
<td>0%</td>
<td>95%</td>
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<td>7%</td>
<td>3%</td>
<td>53%</td>
<td>7%</td>
<td>1%</td>
<td>93%</td>
</tr>
<tr>
<td>Aug 2017</td>
<td>13%</td>
<td>4%</td>
<td>38%</td>
<td>4%</td>
<td>1%</td>
<td>97%</td>
</tr>
<tr>
<td>Jul 2017</td>
<td>18%</td>
<td>3%</td>
<td>37%</td>
<td>3%</td>
<td>1%</td>
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</tr>
<tr>
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<td>20%</td>
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<td>95%</td>
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<td>30%</td>
<td>4%</td>
<td>0%</td>
<td>93%</td>
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<tr>
<td>Mar 2017</td>
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<td>2%</td>
<td>35%</td>
<td>4%</td>
<td>0%</td>
<td>96%</td>
</tr>
</tbody>
</table>

Figure 4.12 : Photo of Newhaven EfW, East Sussex, UK

Table 4.5 : Last 12 months historical average daily emissions data for Martin Grate Plant operated by Veolia in Staffordshire, UK

<table>
<thead>
<tr>
<th>Period</th>
<th>Particulates % of IED limit</th>
<th>Total Organic Carbon % of IED limit</th>
<th>Hydrogen Chloride % of IED limit</th>
<th>Carbon Monoxide % of IED limit</th>
<th>Sulphur Dioxide % of IED limit</th>
<th>Oxides of Nitrogen % of IED limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 2018</td>
<td>1%</td>
<td>1%</td>
<td>66%</td>
<td>7%</td>
<td>52%</td>
<td>77%</td>
</tr>
<tr>
<td>Dec 2017</td>
<td>1%</td>
<td>1%</td>
<td>57%</td>
<td>6%</td>
<td>53%</td>
<td>76%</td>
</tr>
<tr>
<td>Nov 2017</td>
<td>1%</td>
<td>0%</td>
<td>62%</td>
<td>6%</td>
<td>56%</td>
<td>76%</td>
</tr>
</tbody>
</table>

10 https://www.veolia.co.uk/southdowns/emissions-expertise
11 https://www.veolia.co.uk/staffordshire/emissions-air-data
<table>
<thead>
<tr>
<th>Period</th>
<th>Particulates % of IED limit</th>
<th>Total Organic Carbon % of IED limit</th>
<th>Hydrogen Chloride % of IED limit</th>
<th>Carbon Monoxide % of IED limit</th>
<th>Sulphur Dioxide % of IED limit</th>
<th>Oxides of Nitrogen % of IED limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2017</td>
<td>1%</td>
<td>1%</td>
<td>78%</td>
<td>6%</td>
<td>59%</td>
<td>81%</td>
</tr>
<tr>
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<td>1%</td>
<td>66%</td>
<td>3%</td>
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<td>74%</td>
</tr>
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<td>1%</td>
<td>65%</td>
<td>3%</td>
<td>42%</td>
<td>73%</td>
</tr>
<tr>
<td>Jul 2017</td>
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<td>1%</td>
<td>65%</td>
<td>3%</td>
<td>42%</td>
<td>73%</td>
</tr>
<tr>
<td>Jun 2017</td>
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<td>54%</td>
<td>3%</td>
<td>47%</td>
<td>73%</td>
</tr>
<tr>
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<td>2%</td>
<td>56%</td>
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<td>73%</td>
<td>N/A</td>
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<td>76%</td>
<td>3%</td>
<td>38%</td>
<td>77%</td>
</tr>
<tr>
<td>Mar 2017</td>
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<td>3%</td>
<td>71%</td>
<td>5%</td>
<td>38%</td>
<td>77%</td>
</tr>
<tr>
<td>Feb 2017</td>
<td>0%</td>
<td>2%</td>
<td>70%</td>
<td>6%</td>
<td>44%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Table 4.6: 2014 Annual performance report for HZI Grate Plant operated by RRRL in London, UK

Modern EFW plant that are designed to meet the IED emissions limits for particulates are also very effective at removing fine particulates from the exhaust gases such as the size fractions PM2.5 and PM10. In 2015, the UK Department of Environment, Farming and Rural Affairs (DEFRA) commissioned Ricardo AEA Technologies to undertake an emissions inventory of particulate matter emissions from EFW plant in the UK. The work reported the results of specific extractive particulate emissions tests undertaken at five EFW plant in the UK (four of those being of the grate type, and one being an oscillating kiln type. The four grate combustion plants tested in the study included the Riverside and Newhaven HZI plants described above, and also the following two additional facilities:

- **Stoke-on-Trent (Hanford)** is a 180,000 tpa Martin grate constructed in 1998 for which Jacobs undertook a reasonably detailed plant condition and life extension assessment for in 2012 for Stoke on Trent City Council.

---

Note 1: Quote from report “The cause of these incidents was thought to be volatile waste which caused combustion conditions in the furnace to rapidly change for a short period. Procedures are in place to minimise the possibility of such volatile items entering the waste stream where possible and these procedures have been reviewed and improved as a result. There have been no resultant negative environmental effects associated to these incidents and the Environment Agency is satisfied with the actions taken and the procedures in place at Riverside to prevent environmental breaches”

---


Lakeside (near Heathrow Airport) which is a 2 line 410,000 tonne per annum Takuma grate that commenced operation in 2010, for which Jacobs supported the Japanese EPC Contractor and main equipment manufacturer Takuma, providing technical advice on specific UK and local engineering aspects for their first EfW project undertaken in the UK.

The fine particulate tests were undertaken according to the standard BS EN ISO 23210 (Stationary source emissions -- Determination of PM₁₀/PM₂.₅ mass concentration in flue gas -- Measurement at low concentrations by use of impactors). Multiple test runs were undertaken for each installation and the results are reproduced in Table 4.7 and Table 4.8.
Table 4.7: DEFRA Ricardo AEA PM\textsubscript{10} results for 5 UK Grate EfW Plant\textsuperscript{13}

<table>
<thead>
<tr>
<th>Run</th>
<th>Units</th>
<th>Riverside</th>
<th>Lakeside</th>
<th>Newhaven</th>
<th>Stoke-on-Trent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.281</td>
<td>0.008</td>
<td>0.07</td>
<td>0.014</td>
</tr>
<tr>
<td>2</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.016</td>
<td>0.042</td>
<td>0.009</td>
<td>0.012</td>
</tr>
<tr>
<td>3</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.033</td>
<td>0.027</td>
<td>0.03</td>
<td>0.059</td>
</tr>
<tr>
<td>4</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.015</td>
<td>0.034</td>
<td>0.021</td>
<td>0.088</td>
</tr>
<tr>
<td>5</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.084</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.081</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Minimum</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.015</td>
<td>0.008</td>
<td>0.009</td>
<td>0.012</td>
</tr>
<tr>
<td>Maximum</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.281</td>
<td>0.042</td>
<td>0.07</td>
<td>0.088</td>
</tr>
<tr>
<td>Average</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.085</td>
<td>0.028</td>
<td>0.033</td>
<td>0.043</td>
</tr>
</tbody>
</table>

Note: All Normalised to a dry gas condition at STP (0°C, 101.3 kPa) and at 11% oxygen

Table 4.8: DEFRA Ricardo AEA PM\textsubscript{2.5} results for 5 UK Grate EfW Plant\textsuperscript{13}

<table>
<thead>
<tr>
<th>Run</th>
<th>Units</th>
<th>Riverside</th>
<th>Lakeside</th>
<th>Newhaven</th>
<th>Stoke-on-Trent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.008</td>
<td>0.005</td>
<td>0.056</td>
<td>0.005</td>
</tr>
<tr>
<td>2</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.008</td>
<td>0.006</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td>3</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.007</td>
<td>0.003</td>
<td>0.008</td>
<td>0.01</td>
</tr>
<tr>
<td>4</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.008</td>
<td>0.006</td>
<td>0.009</td>
<td>0.02</td>
</tr>
<tr>
<td>5</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.008</td>
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<tr>
<td>6</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.029</td>
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<tr>
<td>Minimum</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.007</td>
<td>0.003</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td>Maximum</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.029</td>
<td>0.006</td>
<td>0.056</td>
<td>0.048</td>
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<tr>
<td>Average</td>
<td>mg/Nm\textsuperscript{3}</td>
<td>0.011</td>
<td>0.005</td>
<td>0.019</td>
<td>0.017</td>
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</tbody>
</table>

Note: All Normalised to a dry gas condition at STP (0°C, 101.3 kPa) and at 11% oxygen

The data collected was used to inform the development of new UK EfW industry standard emission factors for annual emissions inventory reporting. The new factors proposed based on this assessment were more than 95% reductions (in some cases > 99%) from previous standard emission factors used for the UK EfW industry. Measurements were found to generally be close to the lower limits of detection. The report concluded that PM emissions from EfW in the UK, where there is a high uptake of EfW plants for MSW and C&I treatment, is minor in comparison to other PM sources.

The data shows that the EfW technology that will be adopted for the Maryvale project which employ the same or similar vendor equipment (i.e. bag filters) as the above UK plants, will also be a minor contributor in terms of PM10 and PM2.5 stack emissions.

Air emission controls begin with combustion control in the furnace. Secondary combustion air is heated and injected above the grate in order to promote mixing to maximise the destruction of volatile organic compounds and minimise carbon monoxide in the flue gases. There are secondary combustion air nozzles provided on the front wall and on the back wall of the furnace, normally offset to promote mixing and turbulence in the furnace to encourage complete combustion. It also allows for the staging of combustion such that on the grate, the waste is combusting in a reducing environment, which means less air than is required for full combustion of the waste, which reduces the production and subsequent emissions of oxides of nitrogen (NOx).

Most EfW plants achieve compliance with the NOx emission limit with a SNCR system. This process injects ammonia or urea solutions though rows of nozzles into the top of the furnace where the temperature is around 800\textdegree to 1000\textdegree C. For the Project, aqueous urea is already used on-site and will be adopted for use. The urea
reacts with NOx in the combustion gases, reducing it to water and N2, which is a major component of air. To avoid overdosing the reagent ammonia (NH3) is monitored in the flue gas. This SNCR approach has been specified for the Project.

Each of the three tenderers have their own preferred dry and semi dry lime sorbent systems, with many similarities in the general principal of operation. The Martin Gmbh approach, used as an example here, involves the injection of dry burnt lime (CaO) and activated carbon and recirculated dust residues into an entrained loop gas reactor vessel located immediately before the bag filters Figure 4.15. The burnt lime reacts with steam to form hydrated lime, which in turn allows subsequent faster reaction times with the acid gas pollutants in the flue gases, such as HCl, SOx, and HF. These pollutants are neutralised and then collected in solid form within the bag filter house. The recirculation of the collected dust residues which contain some unspent reagent allows a reduction in the amount of lime used and thus reduces operating costs, and also allows a significant reduction to the volume of APCr residues generated, reducing the volume for subsequent treatment and disposal.

![Figure 4.15: Martin dry lime recirculating entrained loop reactor and bag filter flue gas treatment system](image)

Flue gas treatment equipment provided by HZI and Keppel works in a very similar fashion, however there are some subtle differences around the design of the sorbent reactor and use of water or steam for hydration and gas conditioning. The choice of a semi dry or dry system, which has been specified for the Project, means that any water or steam used will be fully evaporated within the gas duct, which operates at a minimum of 130°C up to the chimney, such that no liquid effluent will be produced from the flue gas treatment system. The choice of burnt lime or already hydrated lime generally comes down to availability and economics of supply of reagent. Already hydrated lime is generally more expensive per tonne than burnt lime, but simplifies the injection and reactor system design, as less water or steam is required for hydration in duct, and the reagent reacts more quickly. Either reagent is suitable for the Project as both approaches are very well proven and effective to achieve IED emission limits in EfW plants.

The activated carbon injection is also an important step to absorb volatile heavy metals found in trace levels in the waste such as mercury, lead and also toxic volatile organic species such as dioxins and furans. The spent carbon dust containing the absorbed pollutants is also collected in bag filters, capturing the majority of the heavy metals released during the combustion of the waste.
The above approaches for acid gas, dioxin and furan and heavy metal control from MWS fuelled EfW plants are considered Best Available technologies in Europe (EC BREF document for waste incineration)\(^\text{14}\) and can achieve the air emission limits required by the IED and SEPP AQM.

The bag filters to be employed for the Project can typically achieve particulate emission levels less than 10 mg/Nm\(^3\) which meet the IED, SEPP AQM criteria, and is a considerably more stringent emission target than those particulate limits required to be met by coal fired power plant around Australia, including those in the Latrobe Valley. Bag filter APCr residues collected in the bag filters will be stored in a contained silo with dust control filtration prior to dispatch in suitable enclosed vehicles for safe disposal off site.

A NATA (National Association of Testing Authorities, Australia) and MCERTS (UK gas analyser accreditation scheme) certified Continuous Emissions Monitoring System (CEMS) will be provided on each boiler for measuring all pollutant and duct process condition parameters as required for on-line measurement under the IED and SEPP AQM, as well as ammonia for SNCR dosing control optimisation.

The CEMS will monitor, time average, and report emissions in accordance with Industrial Emissions Directive 2010/75/EU (IED).

The CEMS will provide indication and recording of the following corrected concentrations of gases in the chimney, as a minimum, on a continuous basis:

- Stack gas flow
- Temperature
- Pressure
- Gas moisture content
- Oxygen
- Carbon Dioxide
- Total dust
- Total organic carbon (TOC)
- Hydrogen chloride (HCl)
- Hydrogen fluoride (HF)
- Sulphur dioxide
- Oxides of nitrogen (NOx) as nitrogen dioxide (NO2)
- Carbon monoxide (CO)
- Ammonia
- Mercury (Optional item when extensive supplier proving in EfW plants can be demonstrated)

A ‘hot’ spare CEMS will be also provided which can be switched into service when the duty CEMS on a combustion line chimney is not operating for maintenance, calibration or instrument faults.

In summary, for the Project, gas emission control technologies and monitoring equipment will be provided that can achieve stringent levels of flue gas emissions such as those required by the EU IED\(^\text{14}\). The three Contractors tendering for the EPC role on the project all have proposed emission control technologies have been proven in many reference plants worldwide combusting MSW and C&I waste. The emission limits required for the project (i.e. the IED) have also been included as “make good” performance guarantees under the EPC contract and technical specification, which is standard practice to mitigate the risks of these requirements not being achieved for the project.

\(^\text{14}\) Integrated Pollution Prevention and Control Reference Document (BREF) on the Best Available Techniques for Waste Incineration, August 2006
4.6.7 Steam turbogenerator

Whilst the specific steam turbine supplier for the project has not been selected the following generic description is representative of a typical design for this piece of equipment.

The steam turbine will be a single casing unit rated at circa 67,000 kW linked to a 2 or 4 pole 74,000 kVA generator via a gearbox. The turbine is rated for approximately 270 tonnes per hour of steam at 72 bar(a) and 430°C. It will discharge steam to the condenser at approximately 80 mbar(a) after it has passed through a number of turbine stages. The turbine will include an emergency stop valve and control valves, extractions for the feed heating and steam air heater system, a controlled IP extraction for process steam supply to the mill, a gland steam system and a drain system. It is common for steam turbines of this size to rotate at speeds above the grid frequency of 50Hz, or 3000 rpm (for a 2-pole generator), via a gearbox mounted between the steam turbine and the generator.

The steam turbine will also include a control system including instrumentation, vibration monitoring, an automatic start-up system and transfer of the required signals to the plant control system via the bus system.

The turbine lube oil system is used to support the rotor journals in the bearings, it will include: a lube oil tank; a lube oil cooler and oil purification system; one main oil pump; and auxiliary oil pump and an emergency DC lube oil pump.

The generator will have an air cooled rotor and water cooled stator and will produce electricity at 11kV and 50 Hz. The generator will also include:

- A brushless excitation device with rotating rectifiers
- Generator protection
- Current and voltage transformers
- Synchronization
- Voltage controller
- Air-water coolers to cool the water that cools the stator.

A 100% turbine steam flow bypass system to the condenser allows the boiler to start up independently of the steam turbine or the boiler to be operated with the steam turbine without exhausting the steam to atmosphere. In normal bypass-operation the bypass system controls the initial pressure of the live steam of the boiler. The bypass system consists of a HP reduction station that reduces HP steam from 72 bar(a) to a pressure sufficiently low to be acceptable for the condenser, and spray water (condensate water) injection attenuates the steam. An IP-LP bypass system is also included to reduce the IP steam pressure and temperature to a condition suitable to be condensed in the condenser. The bypass allows operation of the boilers at full load without the turbine being on-line, which allows the EfW boilers to continue operations if the turbine is out of service for planned or unplanned maintenance.

4.6.8 Condensate and feedwater systems

The steam turbine will have various steam extractions, including low to medium pressure extractions for the condensate feedwater heater, deaerator and steam air preheaters, and a controlled extraction port to supply process steam to the mill at an intermediate pressure of 11.6 bar (a). This arrangement is common for industrial scale steam turbines and does not represent any notable technological or environmental risk.

The feedwater deaerator will operate at a temperature of around 130°C or higher which should adequately deaerate the water to mitigate the risk of pressure parts corrosion, as well as mitigating gas side dew point corrosion risk in the boiler economiser. The deaerator feedwater storage tank will have 30 minutes water volume between normal operation level and low water level trip, which is typical for a plant of this nature, operating as a CHP plant with variable steam supply and condensate return rates.
A water cooled two pass surface (shell and tube) condenser will condense the steam exhausting from the steam turbine, and shall conform to the Standards of the Heat Exchange Institute (HEI) Standard for Steam Surface Condensers. Materials used in the construction of the tubes, tube plate and shell shall be of industry standard quality and shall be selected to be compatible with the water/steam cycle chemical dosing and control regime. The condenser will be of the divided water box type which allows cleaning of one side on-line while maintaining a minimum of 50% load. This requirement allows maintenance of heat transfer performance if the condenser scales up in service.

Two by 100% duty, constant speed electrically driven condenser condensate extraction pumps shall be supplied.

Air extraction equipment pumps will be provided to remove all non-condensables from the condenser to maintain vacuum conditions. Two by 100% duty air extraction systems shall be provided designed to the HEI standards.

The main boiler pumps provided within the condensing and feed heating plant will be two by 100% electrically driven which is an appropriate choice and level of redundancy for a plant of this type.

The boiler feedwater system is also to be equipped with a chemical dosing system for pH regulation (alkaline reagent) and a drum anion buffering reagent dosing system such as phosphate or caustic, both to mitigate the risk of boiler corrosion. This is typical for plants of this type. The need for oxygen scavenger injection should also be considered in line with the chemical regime for the boiler water adopted for the project. Hydrazine will not be used if an oxygen scavenger is deemed to be required.

A condensate polishing system will also be provided to ensure that the water quality of the condensate returned from the mill steam system does not introduce any trace chemicals that could be harmful for the boilers or the environment. The polishing system will be of the ion exchange resin type.

4.6.9 Cooling water system

The cooling tower system requested in the EPC technical specification is an induced mechanical draft counter flow wet cooling tower with multiple cells, each with a low noise variable speed fan ventilator.

Biocide and anti-scaling dosing systems are proposed for the cooling tower, which will minimise biological organisms or scale build-up within the cooling water system. The cooling towers shall comply with statutory requirements of the Victorian Public Health and Wellbeing Act 2008 and the Victorian Public Health and Wellbeing Regulations 2009 and the National Construction Code (NCC).

A raw water make-up and blowdown system shall be provided as part of this system. Raw water supply will be via the Mill’s existing Moondarra intake. Blowdown water discharge will be minimised with blowdown water being recycled where possible. Excess blowdown will be discharged to the existing Maryvale Mill waste water treatment system. The blowdown water will be essentially clean water but with elevated levels of its original salt content due to evaporation in the cooling towers. The large capacity of the mill wastewater system shall ensure no discernible impact on the waste water discharge temperature.

The plant will employ, three by 50% cooling water pumps for cooling the condenser from the cooling towers. Two by 100% auxiliary cooling system pumps will also be provided for the auxiliary plant.

4.6.10 Balance of plant

A boiler demineralised makeup water system will make up water lost to the mill through the steam supply, and other EfW plant steam and water cycle losses such as boiler blowdown and steam blowing.

The plant will comprise of the following steps of water treatment for treating the Moondarra raw water to the very low level of impurities required for safe boiler operation:

- Sand filtration
• Activated carbon filtration
• Cation, Anion and Mixed bed ion exchange
• Water treatment chemical dosing systems complete with appropriate storage containment systems

This type of system is considered typical for a plant of this nature.
• Other balance of plant equipment will include: Gas supply from the Mills existing pressure reducing station for start-up and flame stability gas supplementary firing
• Air compressors for the provision of instrument air and service air
• Emergency diesel generators (black start and black top type both to be provided)
• Fire pumps (electric and diesel) and a fire pump and hydrant ring main system
• Fire detection, alarming and suppression systems in higher risks areas such as the transformer area, the turbine lube oil system area, the waste bunker, and the waste feeding systems into the boiler
• An overhead crane in the turbine hall
• Weighbridges for recording waste and other consumable deliveries, and despatched volumes of residues and recyclables
• Mobile plant for waste handling such as reach stackers for moving containers and front end loaders for moving loose waste and bottom ash
• Separated dirty and clean site drains systems, each respectively and independently directed to the Gippsland Water trade waste system and the Mill’s existing river discharge system.
• Clean storm water run-off drains system directed to the mill’s existing storm water holding system.

4.7 Energy efficiency

Modern EfWs generally recover energy by generating steam in a boiler which can then either be used for the generation of electricity in a steam turbine, for heating purposes, or both. For CHP or heat only plants, the energy efficiency is reliant on there being a heat demand available near the EfW site (e.g. industrial or commercial heating demand, or in cooler climates large district heating systems supplying a network of domestic users).

If a large and constant heat demand is available the energy efficiency of an EfW could be as high as 80% for a heat only plant, and 60-70% for a CHP plant. An EfW plant only exporting electricity will have energy efficiency levels of the order of 20 to 28%, with efficiency dependent on the capacity utilisation.

European Union’s Waste Framework Directive 2008/98/EC defines a criterion for EfW plants to be considered recovery operations as opposed to disposal (incineration only). For a plant to be considered a genuine energy recovery facility, the R1 calculated is expected to be equal or above 0.65. If R1 is below 0.65 proponents are expected to provide a justification as to why this value cannot be reached.

A preliminary estimate has been made of the expected efficiency of the Project, which will be subject to minor revision following the selection of the preferred EPC Contractor’s design.

The overall plant efficiency and R1 calculation for two scenarios based on the current modelled waste heating value of 9.4 GJ/t (LHV), and is presented in Table 4.9. The preliminary calculation shows the plant will easily meet the European R1 criteria to be deemed a recovery operation in either mode of operation. It also shows that the operation of the plant in CHP mode, which will be the normal condition throughout the year, allows more than twice the amount of useful energy to be produced from the waste than if the plant were a stand-alone electricity production plant with no heat demand.
Table 4.9 : Preliminary plant efficiency and R1 calculation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Steam to mill</th>
<th>No steam to mill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross power</td>
<td>42.3 MWe</td>
<td>67.4 MWe</td>
</tr>
<tr>
<td>Process steam to mill</td>
<td>130 t/h</td>
<td>0 t/h</td>
</tr>
<tr>
<td>Overall thermal efficiency</td>
<td>60.2%</td>
<td>27.4%</td>
</tr>
<tr>
<td>R1</td>
<td>0.87</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Key assumptions used in the R1 calculation include:
- Figures are preliminary and based on the Thermoflow™ thermal modelling estimates
- Assumes 8000h operation per annum with 95% load factor during this time
- Annual gas usage of 1% (GJ(gas) / GJ(waste)) of waste throughput.

4.8 Ash residue characteristics

The Maryvale EfW plant will operate with waste being fed on to a reciprocating grate, where it is combusted whilst air passes through the grate to sustain the combustion process. Waste travels along the grate until it is completely combusted, resulting in an ash residue made up of coarse particles, which then falls off the end of the grate into a water quench system to cool, before being conveyed onto a bottom ash storage system.

The air passing through the grate can also lift lighter or finer particles of waste up and out of the bottom of the combustion process, and the ashes formed once these finer particles are combusted are known as fly ash. Fly ash is mixed with flue gas treatment chemicals in the exhaust of the boiler and the subsequent mixed residue is generally known as air pollution control residue (APCr). APCr is collected in a fabric filter system which cleans the boiler flue gases leaving the combustion process. Figure 4.16 indicates the points in the EfW process where the ash residues are removed from the process. These two types of ash residues that will be produced are described in the following subsections.

![Figure 4.16](http://www.sita.co.im/our-facility/electricity-production)

15 Sita Isle of Man EfW website: [http://www.sita.co.im/our-facility/electricity-production](http://www.sita.co.im/our-facility/electricity-production)
4.8.1 Bottom ash

Bottom ash (BA) is a relatively coarse material with a chemical composition that is generally inert (primarily mineral oxides). This obviously depends on the characteristics of the waste materials that are fed into the EfW. The volume of bottom ash produced for a typical MSW and C&I feedstock will depend on the level of inert material in the waste. In the UK, plants typically produce a volume of bottom ash which is between 12 and 25% of the waste feedstock to the EfW. It is possible also to recover metals from the bottom ash using magnetic and eddy current separation techniques, and the Project is investigating how to employ these technologies to recover metal from the bottom ash.

In Europe, EfW bottom ash is required by law to have low levels of unburnt combustibles which necessitate an efficient combustion process. As per IED article 50, clause 2, the Total organic carbon (TOC) content of the IBA for the Project shall be less than 3% by weight and the Loss On Ignition (LOI) shall be less than 5% of the dry weight. This is applicable under all transient, part load, and start up and shut down operating conditions.

In Europe, plants designed for municipal waste are not licensed to accept hazardous wastes which may contain high levels of heavy metals or other toxins that could concentrate in the bottom ash. It is therefore possible to recover municipal waste EfW BA for reuse in applications such as construction aggregate. In the UK a number of operating and future EfW plants have BA treatment on or off site to stabilise the ash, before it can be recovered as aggregate material and used for applications such as road base. Alternatively, BA in the UK is generally suitable for disposal at a non-hazardous landfill due to its inert characteristics. A literature review of a number of international EfW plant BA chemical composition and leachability data sets indicates this ash will be deemed as Industrial Waste under Victorian EPA industrial waste resource guidelines. Further testing of locally generated waste ashes from the ongoing waste compositional sorting activities for the project are expected to reinforce this preliminary assessment.

The Project will endeavour to develop a new market within Victoria for BA aggregate production and reuse in the construction industry (e.g. material for road base). It is expected that aggregate and construction industry stakeholders and the EPA will need to see ash physical and chemical analysis from the operating plant before offtake contracts for the material can be finalised and approval of its use from a regulatory perspective can be finalised. It is AP’s intention to reuse BA in the construction industry, subject to physical and chemical analysis.

4.8.2 APCr residues

APCr from EfW plants generally contains fine mineral inert material that is found in the waste processed, as well as some chemicals that are used within the flue gas cleaning process such as lime and activated carbon. Lime and activated carbon are introduced into the flue gases prior to the bag filter dust cleaning system to absorb acid gases such as hydrogen chloride, oxides of sulphur, heavy metals and volatile organic compounds. The bag filter system collects the fly ash and these spent flue gas cleaning reagents which have captured these pollutants. A typical EfW may produce between 3 and 6% of the EfW waste tonnage processed as APCr residues.

APCr is significantly different to bottom ash and is generally considered a hazardous material to handle and dispose of in most international case studies. APCr is generally a dry fine alkaline (high pH) dust although the alkalinity is not the only reason it is hazardous to handle. In addition, it will contain leachable pollutants such as VOCs and heavy metals. For this reason, it is more difficult to recover as a useful by-product and will need to be disposed of appropriately at a hazardous or prescribed landfill facility.

Some more advanced processes are now beginning to be applied to process APCr and render it to a more inert by-product that could be recovered as a construction material. Plasma temperature is one such technique, which subjects the residue to an extremely high temperature plasma torch, which fuses the ash into a form which binds potentially leachable compounds within a glassy slag product. This technique requires significant electrical energy to generate the high temperature plasma arc, which in turn reduces the overall energy efficiency of the EfW process, so has not been considered for the Project.
Another technique is stabilisation using cement like products, similar to a process undertaken at Taylors Road landfill in Melbourne for contaminated soils. Further techniques for rendering this material less leachable and hazardous include a carbonation process and also an acid washing process.

A preliminary assessment of the potential chemical and leachability characteristics of APCr has been undertaken for the Project using international literature and vendor supplied data. This review’s interim conclusion is that APCr are likely to be categorised as prescribed waste under Victorian EPA industrial waste resource guidelines regulations. The project feasibility work to date has given consideration to treatment options including some of those mentioned above, which may be effective in reducing the potential level of categorisation. As with the bottom ash, it is expected that prescribed waste landfill operators and the EPA will need to see chemical and leachability analysis from residue sampled from the operating plant before approval of its classification and disposal/reuse destination from a regulatory perspective can be finalised.

4.9 EfW Plant commissioning

There are two main phases of commissioning typically expected for the EfW Project as follows:

- Cold commissioning (before introduction of fuel)
- Hot commissioning.

The procedures and timescales for these commissioning periods will be dependent on the selected EPC Contractor’s preferred approaches and designs, which are not available at this stage of the project development. The following technical description is indicative only and is based on plans for similar EfW plant located outside Australia, using similar moving grate combustion technology.

Refer to Chapter 12.7 for details of the Commissioning Management Plan to be developed.

4.9.1 Cold commissioning

Cold commissioning commences when construction of all major plant, equipment and structures are complete. An EPC Contract milestone such as a Mechanical Completion certificate is often necessary to be issued by the Owner, or an Independent Engineer who must be satisfied with the status of the Works being safe to commission before cold commissioning can commence.

Cold commissioning involves a systematic and thorough checking process for electrical, safety interlocks, controls, and control loop functions for each system of plant throughout the entire facility. The process starts for individual plant items one by one and works up to plant systems or packages that can be effectively tested without requiring hot commissioning.

Initial energisation of electrical boards and equipment systems supplying power to the EfW plant auxiliary systems is undertaken, without subjecting those systems (e.g. motors) to loads or temperatures (e.g. boiler) typical of normal service. This allows confirmation that equipment power supply systems, including protection systems, has been undertaken correctly, e.g. motors spinning in the correct direction etc.

Loop checks of control systems are undertaken to establish instrument sensors are working and control actuators are functioning correctly. Control logic and safety interlocks and protection systems within the plant control system are also testing for correct operation to operate safely.

During cold commissioning some other activities may take place in readiness for the commencement of hot commissioning, for the avoidance of delays once the relevant certificate is issued, such as:

- Cleaning and flushing of equipment internals in readiness for operation, removing mill scale, rust, and similar, in some cases, using cleaning chemicals for this purpose. This will include the boiler chemical clean which is the most significant item requiring internal cleaning
- Installation of final consumable parts in preparation for hot commissioning, e.g. filters including bag filters
Supply to site and filling of tanks and silos for main consumables such as lime, activated carbon, urea, and water treatment chemicals.

The overall duration of cold commissioning is typically of the order of four months. During this time there are expected to be few significant environmental impacts, but there may be some spent cleaning chemicals and residues generated in the internal equipment cleaning processes, which will be contained and disposed of appropriately.

Checks undertaken are documented and the documentation and some tests are generally sample audited by the Owner or their representative, or sometimes by an Independent Engineer. Generally, an EPC contract milestone, such as a Readiness Certificate, or Construction Complete Certificate, needs to be formally issued to the satisfaction of the appropriate representative (for Owner or Independent party) for the contract before hot commissioning can commence, allowing checking of document records and plant condition before sign off.

4.9.2 Hot commissioning

Commencement of hot commissioning for an EfW plant generally is associated with the first combustion of fuel, starting with auxiliary fuel (natural gas in the case of Maryvale), and later followed by the introduction of the first waste firing, but also involves operating and testing all other plant and equipment systems, subjecting them to conditions for the first time representative of the normal range of operating conditions, and testing the plant systems as a whole for functionality and correct operation.

During the hot commissioning, deliveries of MSW and C&I waste will commence to the waste bunker in preparation for the first waste firing. Waste will be sourced for the commissioning that is a representative sample of the feedstock the plant will burn over its operating life. Timing and the volumes of deliveries needs careful planning to match the commissioning schedule to ensure sufficient volume without long storage times in the bunker, and this detailed schedule will be developed by the EPC contractor during the detailed design and construction phase of the works. Waste bunker and tipping hall fire, dust and odour control systems will be operational before the first delivery of waste.

The following phases are generally the principal steps in hot commissioning of the EfW plant:

1) Refractory dry out and boiler boil-out

This process is actually two steps in parallel or directly in sequence which both involve part capacity firing of the gas burners in the boiler to complete. Refractory is a ceramic material and the process is comparable with the firing process for other ceramic products. The refractory dry out is a key step to ensure that this furnace and boiler internals lining critical for protecting equipment and achieving necessary combustion temperatures can be cured or set, following installation, to remove water content, so that it does not fail in service. The Boiler boil-out is a heated washing and draining process undertaken to clean the inside of boiler tubes, piping, headers and vessels to ensure they are free from contaminants, scale, grease etc. which could cause operational problems in normal service, such as corrosion. The duration of the refractory dry out and boiler boil-out is expected to be up to two weeks. Emissions to air during this time will be natural gas combustion products only. The CEMS will be operational during this period. Waste water generated from the boiler boil-out will be directed to the Gippsland Water trade waste system. The demineralised water treatment plant will also be in service during this period.

2) Steam blowing

Steam blowing is an essential part of hot commissioning for which the purpose is to clean the boiler and steam systems leading up to the steam turbine and including the steam turbine bypass piping to condenser, of mill scale, corrosion products, and foreign bodies and impurities introduced into the piping during the fabrication and construction stages. These systems must be completely cleaned as if they pass into the steam turbine when it is placed into service it will be severely damaged. The steam blowing must be undertaken at high steam pipe velocities (known as disturbance factors) in order to ensure appropriate removal of contaminants. For this process, temporary pipework needs to be installed to an outdoors steam vent with silencer, in order that steam can be safely released from the process on an intermittent basis. A target plate system is also installed on the steam outlet to monitor the levels of foreign material removed during the blows. Steam chemical impurity parameters are also monitored. The process is repeated intermittently until satisfactorily low levels of foreign
material and impurities are observed impacting the target plate or in the steam samples. The duration of the steam blowing is typically 2 weeks and involves significant intermittent noise emissions which do not occur during normal operation. This noise is minimised as much as possible though the use of the temporary silencer. Emissions to air during this time will be natural gas combustion products only. The CEMS will be operational during this period. The demineralised water treatment plant will also be in service during this period as considerable volumes of ultrapure water are required for the process.

3) First waste firing and overall steam system testing

Before waste is first introduced to the first boiler ready for this hot commissioning stage, all CEMS and flue gas treatment systems will be fully operational. During this phase, waste is gradually introduced on a cyclical and ramping up basis to the first boiler, with a number of plant start-ups and shut downs expected. As for normal operation, for start-up and shut down, natural gas fuel will be used to ensure the furnace temperature is maintained above 850°C whenever waste is present, and before it is introduced to the combustion chamber. The amount of waste consumed during this period will ramp up as the plant is proven at greater capacity. Once the first boiler is proven, the commissioning will start on the second boiler, and continue until all boilers are tested running simultaneously at full load. The steam turbine will commence operational tests when the boiler(s) have been proven to operate stably. When the turbine is first operated, once up to full turbine speed it will be synchronised with the grid frequency, and the first electricity will be produced. Electricity production and waste consumption will initially be intermittent and variable in rate, until the later stages of testing. During this time the CEMS and flue gas treatment systems will be in operation, but it is possible that there will be some short term emissions excursions as the flue gas treatment equipment is ‘tuned’ to operate effectively. All other plant auxiliary equipment will also be tested in operation at this time. The duration of this testing period is expected to be around one month.

4) Operability and throughput tests

During this period the plant will be run for the first time at close to full capacity for an extended period of time. Both boilers will be in operation and the steam turbine, although tuning and testing of systems will be ongoing during this period. Generally, a formal operability test will be undertaken during this period when the plant operates continuously under the supervision of the EPC contractor for circa 2 weeks, at high waste throughput e.g. > 90% maximum. During this period, statutory and Contractual testing requirements that need to be undertaken with SP Ausnet in relation to the electrical system, grid connection and power export are normally undertaken. The ongoing testing of the flue gas treatment and CEMS systems to achieve correct operation during this period means that it is possible that there will be some short term emissions excursions. The completion of the operability and throughput testing is generally an EPC milestone which is significant to allow commencement of the main plant performance tests. The overall period of operability and throughput testing is expected to be around one month including the formal operability test period.

5) Trial Operation testing period

The trial operation testing period is when the main overall EfW performance and reliability tests occur. The EfW performance tests will include a wide range of tests including the following tests significant from an environmental perspective:

- Third party stack emissions tests for contractual guarantees i.e. meeting IED emission limits
- Combustion residence time tests (850°C for 2 seconds)
- Demonstration that the bottom ash is an inert residue (Total Organic Carbon and Loss On Ignition)
- Noise tests
- Waste throughput tests and industrial residue waste testing
- Power and steam output tests demonstrating the plant efficiency and proof that it is a recovery operation under the EU Waste Framework directive R1 guidance.

The performance tests are expected to take around 1 week if successful.
The reliability test is expected to be a month duration, during which the plant should be demonstrated to operate reliability, being available for greater than 90% of the period. Operation will be at a range of loads demonstrating plant flexibility, but will overall operate at high capacity during this period. The CEMS must be in operation during this period or the plant will not be considered available. The plant must also comply with guarantee levels of emissions during this period, or be deemed not available under the test calculations. Some occasional emission exceedances may occur however as final adjustments to plant settings are made.

Once the reliability test has passed, a final plant inspection will be undertaken by the owner, their representative or an independent engineer to verify that operation hasn’t damaged the mechanical integrity of the plant. Following this inspection, and passing all the above tests, the Taking-over Certificate will be issued, which transfers responsibility for the plant and its operation from the EPC contractor to the Owner. This Taking-Over date is sometimes referred to as the Commercial Operation Date (COD). The trial operation period will be a minimum of one month, and up to three months if some of the tests need to be repeated due to unforeseen problems.

6) Availability test after taking over

A final test related to the EPC contact occurs after Taking-over, to demonstrate that the plant operates reliably with high availability to process waste and produce energy, with commercial consequences under the EPC contract if the plant availability does not meet expectations. This test may be up to a year long, but effectively is considered normal operation from an environmental perspective, with all systems functioning normally and in compliance with permit requirements.