Technical report D

Best available techniques assessment report

Cleanaway & Macquarie Capital

Western Sydney Energy and Resource Recovery Centre

Best Available Techniques Assessment Report

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Contents

1 Introduction

The purpose of this document is to set out the Western Sydney Energy and Resource Recovery Centre's (WSERRC) (the proposal) compliance with the Best Available Techniques as presented in the European Union Best Available Techniques (BAT) Reference (BREF) Document for Waste Incineration as published in December 2019 and available publicly at the following link https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/best-available-techniques-bat-reference-document-waste-incineration-industrial-emissions.

The NSW Energy from Waste Policy Statement (NSW EfW Policy) requires that a facility of this type uses "current international best practice techniques". The generally accepted best practice for waste incineration are those adopted by the European Union under the Industrial Emissions Directive 2010/75/EU. The directive prescribes legal requirements for facilities.

BAT was introduced in the European Union by the IPPC-directive (Integrated Pollution Prevention and Control of 1996; 2000/76/EC) and subsequently has been moved into the IED (2010/75/EU), which requires the EU commission to adopt the BREF.

The drafting of BREFs is led by the European Commission's Joint Research Centre (JRC) through its European Integrated Pollution Prevention and Control Bureau (EIPPCB). Thirty different BREFs are issued all having the same standard table of contents of which chapter 5 outlines Best Available Techniques. The 'Best Available Techniques (BAT) Reference Document for Waste Incineration' (2019) (WI BREF) provides 37 BAT conclusions based on the IED and information shared between EU member states. The EU has issued an Implementing Decision (Commission Implementing Decision 2019/2010) which contains the key BAT conclusions.

This document provides a summary of the BAT conclusions as listed by the WI BREF and illustrates how the design of the WSERRC meets these requirements. It should be read in conjunction with the WI BREF and the Directive where appropriate. Each conclusion has been outlined in bold and evidence of WSERRC compliance has been provided below for each conclusion in Section 4 of this document.

The WI BREF provides a variety of parameters that constitute BAT. Not all techniques are appropriate in all situations and not all techniques can be used together, techniques are chosen that best suit the technology being utilised.

There are a variety of BAT conclusions that are not relevant to WSERRC, these have also been included and described in this technical report.

The WSERRC has been designed such that it is compliant with the definition of Best Available Techniques used by the European Union and set out in the WI BREF, 2019. The facility therefore meets the requirements of the NSW EfW Policy with respect to design in line with international best practice.

2 Energy from Waste Technology Options

Cleanaway and Macquarie Capital reviewed operational EfW facilities around the world to identify a technology that was reliable and had a proven track record in terms of operational, technical, human health and environmental performance. This EfW technology review was focused on the following criteria:

- Technologies able to process residual Municipal Solid Waste (MSW) and residual Commercial and Industrial (C&I) waste streams.
- Technologies commonly used in the European Union (EU) given the similarities with the NSW waste market and the close alignment between the two jurisdictions in their approach to regulating EfW.
- Established technology with available reference facilities.
- Ability to achieve strict environmental performance standards and be compliant with BAT conclusions and NSW EfW policy.
- Reliability and proven technology at scale.
- Ability to be flexible and manage a variable waste feedstock.
- Whole of life costs.

This section sets out the finding of this review in detail and sets out the reasoning for the selection of moving grate combustion technology for WSERRC. It should be noted that this section is not intended to provide detailed process description, it is intended to set out standardised industry options to guide the key decisions made for WSERRC which have then been further refined to suit the context of WSERRC itself.

There are a variety of different thermal treatment technologies that exist for energy from waste applications. For WSERRC, the following Energy from Waste technologies could be relevant:

1. Moving gate combustion;
2. Fluidized bed combustion;
3. Gasification;
4. Pyrolysis; and
5. Two-Stage combustion.

Below is a short description of each of the five technologies.

2.1.1 Moving Grate Combustion

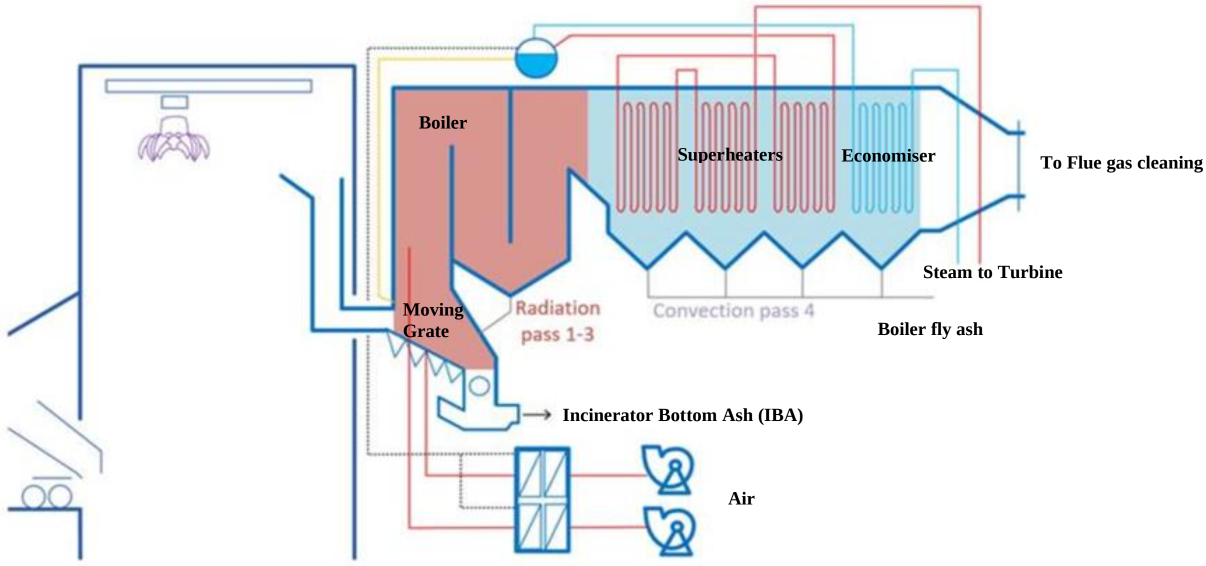

Figure 1 - Moving grate combustion, schematic of boiler

Moving grate is an established and proven EfW technology that has been used globally for over 50 years. In that time the technology has been subject to continual improvement responding to regulatory, industry and public demands. Over 95% of facilities that thermally treat MSW and C&I waste to produce electricity worldwide use moving grate technology.

The waste is typically fed by crane from the waste bunker to the waste chute. No pre-treatment of the incoming waste is required apart from mixing of waste within the waste bunker using the crane. The waste is then pushed by ram-feeders onto a grate where combustion occurs. The overall grate consists of grate bar with slits through which the preheated combustion air is added.

Combustion proceeds as the waste travels, by the mechanical movement of the grate bars, down the stepped grate before the ash drops into an ash pit at the end of the grate. This is known as Incinerator Bottom Ash (IBA). For the purposes of this report, bottom ash (as it is referred to in the BREF) is referred to as IBA in this EIS.

At modern facilities the grate is divided into several sections. The fully automated combustion system secures a highly efficient combustion process. The complete combustion process typically takes a couple of hours. The energy within the hot flue gas is efficiently recovered within a steam boiler. The steam is typically used for power production in a steam turbine.

The energy efficiency is maximized by selection of high steam parameter (temperature and pressure) with due consideration to the associated corrosion issues.

The flue gas then passes through a dedicated flue gas cleaning system typically consisting of a series of treatment steps to clean the flue gases to legislated levels. Flue gas treatment options are discussed in Section 3.2.

There are a variety of options for treatment of different ash streams. The IBA can, after maturation and metal recovery, potentially be used as base-material for road construction or similar. This does depend on regulatory context. The flue gas treatment residues (FGTr) from the flue gas treatment (FGT) system requires suitable disposal.

2.1.2 Fluidized Bed Combustion

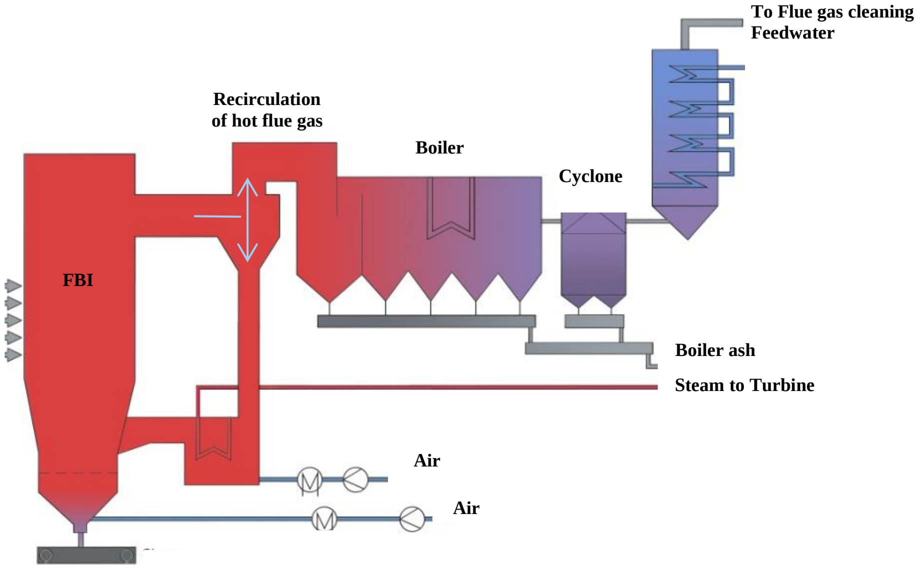

Figure 2: Fluidized bed combustion, schematic of boiler.

In fluidized bed combustion, the grate furnace is replaced by a fluidized bed furnace where pre-treated and pre-sorted waste is combusted instantaneously in a reactor with hot sand fluidized by an upwards gas flow. The fluidization gas is a mixture of recirculated flue gas and combustion air.

The fluidized bed furnaces are more compact than the grate counterpart and can change thermal output significantly faster than grate furnaces.

High temperature heat can be recovered from the hot sand instead of the flue gases which, in principle, facilitates higher steam temperatures thus enabling a higher gross electrical efficiency than the moving grate furnace. However, erosion from the hot sand makes it impractical to realize this advantage. Hence most waste fired fluidized beds have similar steam temperatures, and therefore a similar gross electrical efficiency as moving grate combustion.

Fluidized bed furnaces require significant pre-treatment including shredding of waste to small homogenous particle sizes and removal of under-sized particles as well as inert materials such as stone, metals and glass. This adds both construction and operational cost and increases the overall energy consumption of the plant itself. Since the waste is combusted in seconds, fluidized beds are sensitive to sudden changes in the waste properties. Fluidized beds handle a narrower range of calorific value (CV) waste than moving grates, especially if designed for low CV levels and are therefore less flexible.

The FGT system is similar to the systems for the grate fired technology. However, it is noted that fluidized beds produce larger amounts of boiler fly ash and FGTr.

2.1.3 Gasification

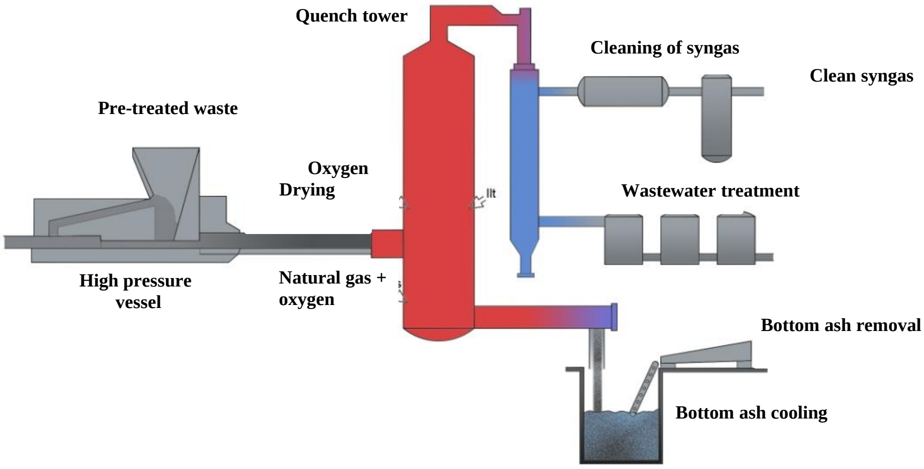

Figure 3: Example of gasification implementation, schematic of reactor and boiler part.

Gasification and Pyrolysis are similar processes. In a gasification process, waste is thermally treated under low oxygen conditions to create a syngas. The process is similar to the generation of towns gas using coal fired power plants. The syngas can then either be directly combusted to provide heat within a boiler section (see two stage combustion) or, theoretically, can be cleaned and combusted within a reciprocating gas engine. Pyrolysis occurs in the absence of oxygen but otherwise is similar to gasification.

In recent decades, alternative processes based on pyrolysis and gasification have been proposed to potentially offer technical benefits such as:

1. The potential for higher energy efficiencies;
2. Flexibility to produce gaseous or liquid fuels, or power via gas engines or fuel cells;
3. Generation of less NOx, HCl and SO2 within the process; and
4. Vitrification of the ash, encapsulating toxic solids in glassy granules.
5. Flexible modular units.

Several plants have been erected since 1990 in Europe, Japan and Canada with different implementation approaches for gasification and pyrolysis of a variety of waste types.

In Europe, there has been very little proven track record for gasification or pyrolysis plants related to thermal treatment of residual MSW and residual C&I waste, with the technology still in the early phases of adoption. There are several plants under construction and some that are operating however none have operated for a sufficient period of time in Europe (and thus subject to EU international best practice requirements) to satisfy the requirements of the New

South Wales authorities for providing proven examples for reference. In addition, there have been several high-profile failures of pyrolysis and gasification technologies seeking to thermally treat waste.

In Japan, several waste gasification plants have continued to operate for more than a decade. This is done at a high operational cost with low energy recovery and less reliable performance (including availability) driven by a national requirement to vitrify the ash at extreme temperatures.

Generally, the potential technical benefits listed above have not been realized:

1. The net power production efficiency has not been proven over a sufficient timescale when compared to modern moving grate combustion plants when the necessary pre-treatment efforts are considered;
2. Due to technical challenges it has not proven economic to operate gas engines or fuel cells at waste gasification and pyrolysis plants. Hence all waste gasification plants (with exceptions in Japan) were built to recover energy in a steam cycle essentially similar to that of a moving grate combustion-based plant;
3. The potentially lower production of NO_x, dioxins, HCl and SO2 does not affect actual facility emissions from the stack as emissions are legislated on the same basis as other thermal treatment options; and
4. Vitrification requires extreme temperatures and a significant energy consumption and hence significant operational costs. With vitrification, the net energy recovery becomes insignificant or even negative. It is therefore only implemented in Japan where it is legally required.

2.1.4 Pyrolysis

Only a few pyrolysis plants have been built for the thermal treatment of waste. The ones built outside Japan have not had a strong track record and have been closed down due to accidents, operational issues and exceeded emission limits. Several pyrolysis plants have been built in Japan, but it is uncertain if any of these process similar wastes to that proposed for WSERRC.

Recently, pyrolysis technologies to produce pyrolysis oil from specific pre-sorted waste fractions such as plastic waste and rubber tyres are emerging. Research and development is ongoing to improve and demonstrate the product quality by way of catalysts and refining operations. This technology is still in its development and demonstration phase and the technology is not suitable for residual MSW and residual C&I waste.

2.1.5 Two-Stage Combustion

Some technology providers offer a two-stage combustion process. The first stage is a gasification process within limited oxygen conditions. The generated syngas is immediately combusted in the second stage in a combustion zone or chamber with excess air injection. Energy is recovered from the flue gas to a steam turbine in the same way as is used for moving grate combustion technology.

Two-stage combustion suppliers advertise lower NO_x production in the furnace due to tighter temperature control in the divided combustion process. Since NO_x is easily abated in modern flue gas cleaning systems, this does not translate into lower emissions. The legislated emissions levels are the same for all thermal treatment technologies.

Two-stage combustion has no significant technical advantages compared to moving grate combustion. However, in subsidy driven markets such as the UK, where two-stage combustion can be awarded subsidies targeting gasification technology.

2.2 Initial screening and Selection of Technology

The initial technology screening was based on following criteria:

- **In commercial operation**: Number of reference plants of relevant size and waste type in commercial operation for more than one year;
- **Waste treatment cost:** To establish whether this is competitive with regard to treatment cost, disposal costs and energy revenue; and
- **Environmental Performance:** Ability to fulfil the conditions set out in the New South Wales Energy from Waste policy.

Table 1 below sets out the screening criteria used to narrow down on the preferred technology.

Table 1: Summary of thermal treatment technologies considered for WSERRC

Parameter	Moving Grate Combustion	Fluidised Bed Combustion	Gasification (Thermal and Plasma)	Pyrolysis	Two Stage Combustion
Short description	Combustion of waste on a moving grate furnace.	Combustion of waste on a fluidised bed (usually fluidised using sand).	Gasification of waste to generate a synthetic gas which can be combusted either in a boiler or a gas engine.	Pyrolysis of waste to generate a synthetic gas, char and synthetic oil.	Gasification process immediately followed by combustion above the fuel bed or in an adjacent chamber.
Operation - At least 12 months fully operational at design loads	Yes - well proven with over 2,000 lines in Europe, US, Japan and China combined.	Yes – well proven but less than 100 facilities (at scale) and mostly based in Europe and US.	Yes, mostly in Japan with a few operational in Europe. Relatively high operational cost and low energy recovery.	Yes, mostly in Japan. Relatively high operational cost and low energy recovery.	Some facilities under construction in Europe and some operational in Japan. Some European facilities currently being commissioned.
Historical Track Record	Good – Operating data available over many years showing successful operation.	Good – Operating data available over many years showing successful operation.	Emerging technology, several failed projects in Europe. Track record poor.	Emerging technology, several failed projects in Europe. Track record poor.	Emerging technology, insufficient data for long term track record with some technical issues noted.
Waste Streams – suitable for mixed MSW and C&I from the Sydney area	Yes	Yes	No, without significant pre-treatment.	No, without significant pre-treatment.	No, without significant pre-treatment.
Waste pre-treatment required prior to thermal treatment?	No	Yes	Yes	Yes	Yes
Emissions – Compliant with EU BAT	Yes	Yes	Yes	Yes	Yes

IBA slag/ash has Total Organic Carbon ≤3% and Loss on Ignition ≤5% (dry basis)	Yes	Yes	Yes	Yes	Yes
Flue gas retention time (Minimum 850°C for 2 seconds)	Yes	Yes	Not applicable, generates syngas and oil	Not applicable, generates syngas and oil	Yes
Energy Efficiency (greater than 25% achievable on a gross basis)	Yes	Yes	Yes	Yes	Yes

Gasification, pyrolysis and two stage combustion technologies were not considered appropriate for WSERRC for the following reasons;

- Unproven commercial viability;
- Poor historical performance;
- Not as mature a technology as moving grate or fluidised bed;
- Not suitable for non-homogenous waste streams that have not been pre-treated (shredded);
- Unreliable when treating varying waste compositions; and,
- Less reliable technical performance based on historical use.

Based on the assessment, two technologies were shortlisted;

1. Moving grate combustion; and,
2. Fluidised bed combustion.

These two technologies were shortlisted because they are both compliant with emissions regulations and have a proven track record. Based on our assessment, it was concluded that the other options were not suitable at this time due to the relative immaturity of the gasification, pyrolysis and two stage combustion processes.

The two short-listed technologies are almost identical. The combustion concept for the grate technology and fluidized bed technology is different, but the remaining plant of these two different technologies are essentially the same including steam cycle, steam turbine power generation, flue gas cleaning system and emissions. The costs of the thermal treatment facility themselves are also similar.

A more in-depth analysis of moving grate combustion and fluidised bed combustion was undertaken. The following key findings were made:

- There are significantly more (see Table 1) operating plants globally for moving grate combustion technology (for mixed MSW and C&I waste)
- Although fluidised bed combustion can process a wider array of fuels from an energy content (calorific value) perspective (6MJ/kg to 40MJ/kg compared to 6MJ/kg to 15MJ/kg for moving grate), the fluidised bed combustion process requires a more homogenous waste stream meaning pre-treatment in the form of shredding is required to a smaller particle size than moving grate technology requires, making fluidised bed unsuitable for the heterogeneous nature of residual MSW and C&I waste. The calorific value range for moving grate systems is considered sufficient to deal with the planned feedstocks of residual MSW and C&I waste streams.
- Fluidised bed technology uses hot sand as a fluidising medium. This is broken down and must be replaced over time generating a solid waste stream which would have to be disposed of to landfill.
- Operational availability of a fluidised bed facility is lower than a moving grate facility (7,500 hours vs 8,000 hours).

After careful consideration, moving grate technology was selected as the preferred technology given that it is the most established and proven technology used globally (for over 100 years) with thousands of operational examples and had a few operational advantages to fluidised bed technology as described above. The fluidized bed technology does not offer any obvious advantages for the treatment of the foreseen MSW and C&I waste streams in Sydney when compared to the moving grate technology.

The reference facilities for this proposal, Dublin and Filborna, both utilise moving grate technology, treating like waste streams. Both reference facilities are fully described in **Chapter 5 EfW policy** alongside commentary on treatment of like wastes.

3 Flue Gas Treatment (FGT) Technology

The aim of the FGT on an EfW facility is to clean the flue gasses that are created through the combustion of waste. The purpose of this section of the report is to set out the different FGT technology options to decide which are most suitable for WSERRC.

Section 1 of this report sets out the different legislation and best practice documents with respect to emission limits. This formed the basis of design with respect to FGT technology evaluation and selection.

FGT technologies can be split into two distinct areas for consideration;

1. Treatment for dust, acid gases, heavy metals, dioxins and furans (referred to as FGT); and,
2. Treatment for Oxides of Nitrogen (NO_x) (referred to as NO_x Reduction).

The options for treatment technologies have been set out in Section 3.2 and Section 3.3 respectively.

3.1 Emission limit values

Emission limit values set out the legislative context for limiting emissions of various compounds within the cleaned flue gases. A detailed overview of emissions legislation and emission limit values is provided within Technical Report A: Air Quality and Odour Assessment Report. As summarised in Section 1 of this report, there are three key legislative documents that need to be considered;

1. The NSW Government Protection of the Environment Operations (Clean Air) Regulation 2010 (**POEO, 2010)**
2. European Directive 2010/75/EU of the European Parliament and the Council on Industrial emissions (**IED, 2010**)
3. The Best Available Techniques (BAT) Reference Document (BREF) for Waste Incineration (**BREF, 2019**)

Each of these documents provide emission limit values and, in some cases, emission limit ranges. Table 2 sets out these limits contained within each set of legislation.

Table 2 - Air emission limits (mg/m³)

Pollutant	NSW POEO Limit(1)	EU IED Limit(2)	BREF (low – high)(3)
CO	125	50	10 – 50
Total organic carbon (TOC)	-	10	<3-10
Dust	50	10	<2-5
HCl	100	10	<2-6
HF	50	1	<1
SO_2	-	50	5-30

NO_x	500	200	50-120
NH_3	-	-	2-10
Hg	0.2	0.05	<0.005 - 0.02(4)
			0.001 - 0.01(5)
Cd + Thallium (Tl)	0.2 (Cd only)	0.05	0.005 - 0.02(4)
Sb + As + Pb + Cr + Co + Cu + Mn + Ni +V	-	0.5	0.01 - 0.3(4)
Dioxins and furans	1.00E-07	1.00E-07	-
Polychlorinated dibenzodioxins and furans (PCDD/F)	-	-	<1.00E-08 - 4.00E-08(4)
	-	-	<1.00E-08 - 6.00E-08(5)
PCDD/F + dioxin-like PCBs	-	-	<1.00E-08 - 6.00E-08(4)
	-	-	1.00E-08-8.00E-08(5)

(1) Protection of the Environment Operations (Clean Air) Regulation 2010 – Group 6 [POEO], Sampling period of 1 hour or the minimum sampling period specified in the relevant test method referred to in the POEO. HF has a sampling period over a daily average
(2) European Union Industrial Emissions Directive 2010/75/EU – Air Emission Daily Limit Values
(3) European Union Industrial Emissions Directive 2010/75/EU – Best Available Technique (BAT) conclusions for waste incineration, for new plants (*).
(4) Average over the sample period – Metals (Cd+Tl, Hg, Sb + As + Pb + Cr + Co + Cu + Mn + Ni +V) have sampling period of a minimum 30 minutes and a maximum of 8 hours. Dioxins and furans have a sampling period of a minimum 6 hours and a maximum of 8 hours (*).
(5) Long-term sampling period average (*).
(*) It is noted that the long term criteria for dioxins are less stringent than the short term criteria in Table 7 in the newly released (BREF, 2019), hence it appears that the averaging periods have been inadvertently switched in the table.

The most stringent limits, and where applicable ranges, were set out within the BREF, 2019 document. Therefore, the plant design has been based on achieving, or exceeding, the limits and ranges set out in BREF, 2019. These limits are set out in Technical Report A – Air Quality and Odour where further commentary on emissions modelling is provided.

3.2 Flue Gas Treatment (FGT) Options

In this section, the treatment options for dust, acid gases, heavy metals, dioxins and furans are discussed. There are two main FGT concepts available on the market. One is referred to as a dry system and the other is a wet system. Numerous variations and combination of the two principles exist.

The dry system is characterized by the fact that that the treatment residues leave the facility as a dry product, such that no wastewater stream occurs. The dry concept comprises baghouse filtration to collect the solid residue from the FGT system. Often, dry systems are considered semi-dry due to the injection of water with the treatment consumables.

The wet system comprises of scrubbing systems which are characterised by having several process steps including a wet scrubber from which a wastewater stream is generated holding the majority of the FGTr. This waste water requires further treatment followed by disposal.

Between these two options sits the combined wet/dry option. Often the combined dry-wet process is included in the group of dry systems, as the effluent from the scrubber can be evaporated to produce a solid residue hence no wastewater outlet is generated.

The following three FGT concepts were therefore considered for WSERRC in line with the different options available on the market;

- Semidry system (type of dry system);
- Semidry system with additional installed scrubber (type of combined dry/wet system); and,
- Wet system.

It should be understood that each of these systems is capable of achieving the emission limit values set out in Section 3.1 and each of the technologies are outlined as different forms of BAT within the Waste Incineration BREF, 2019. Therefore, each of the technologies represents different forms of international best practice. There are many examples globally of facilities using each of these technologies. Consideration has been made based on which technology is suitable for WSERRC.

3.2.1 Semi-dry system

A semi-dry system is a type of dry system. It is classified as semi-dry as a small amount of water is used in the FGT process to condition the flue gases prior to treatment. The use of water is however low, and the process generates no effluent waste water. The water is evaporated into the flue gases. There are forms of dry system that use no water however these systems are relatively new to the market and not widely utilised globally therefore were not considered suitable for WSERRC.

Two semi-dry based systems were considered for WSERRC

1. Base Semi-dry system
2. Semi-dry system with additional wet scrubber (combined dry/wet system)

The two technologies are described below.

3.2.1.1 Base semi-dry system

A base semi-dry system includes the following key equipment:

- Water spray for conditioning of flue gases
- Reactor for injection of either hydrated lime or sodium bicarbonate and activated carbon for reduction of acid gases and capture of heavy metals, dioxins and furans
- Filter bag house to remove dust and FGTr.

As illustrated in Figure 4 in a semi-dry system, flue gases leave the boiler section of the facility and flow into a reactor vessel. Hydrated lime and activated carbon are injected into the reactor. Water is either injected directly into the reactor or is injected alongside the hydrated lime into the reactor. The lime and activated carbon are recirculated around the reactor to optimise usage of these consumables. The consumable dosing rate is determined by the Continuous Emissions Monitoring System (CEMS) and associated real time feedback control to make sure emission limits are adhered to. The flue gasses and spent consumables flow out of the reactor and into the bag filter section. The bag filter removes the mixture of dust and spent lime and activated carbon from the flue gases. The dust includes the remaining boiler fly ash entrained within the flue gases from the combustion process.

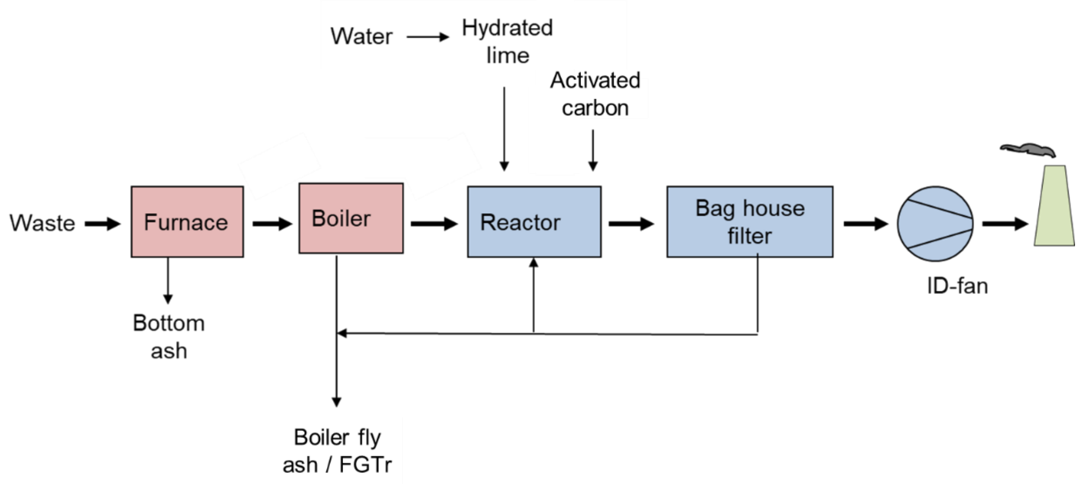

Figure 4: Base semi-dry system

3.2.1.2 Semi-dry System with Additional Wet Scrubber

The first part of this process train is identical to that described for the base semi-dry system in Section 3.2.1.1 however included an additional treatment step after the bag filter. After the base semi-dry system bag filter, a wet scrubber is installed. The wet scrubbing section uses water and injection of sodium lye (NaOH) to clean the flue gases and achieve lower emission levels than is possible with the base semi-dry system alone. The primary function is to reduce acid gases however there is also a noticeable reduction in heavy metals, dust and ammonia in comparison to the base semi-dry case.

As the waste water stream from the wet scrubber can be used for conditioning of the flue gas in the semi-dry stage, the system can be designed to operate with no discharge of wastewater. This means that the overall water use of the facility is like a semi-dry solution. The benefit of the wet scrubbing system is that it provides greater emission control and thus provides an element to future proofing the plant without contributing to increased water use. The process for the system is illustrated in Figure 5.

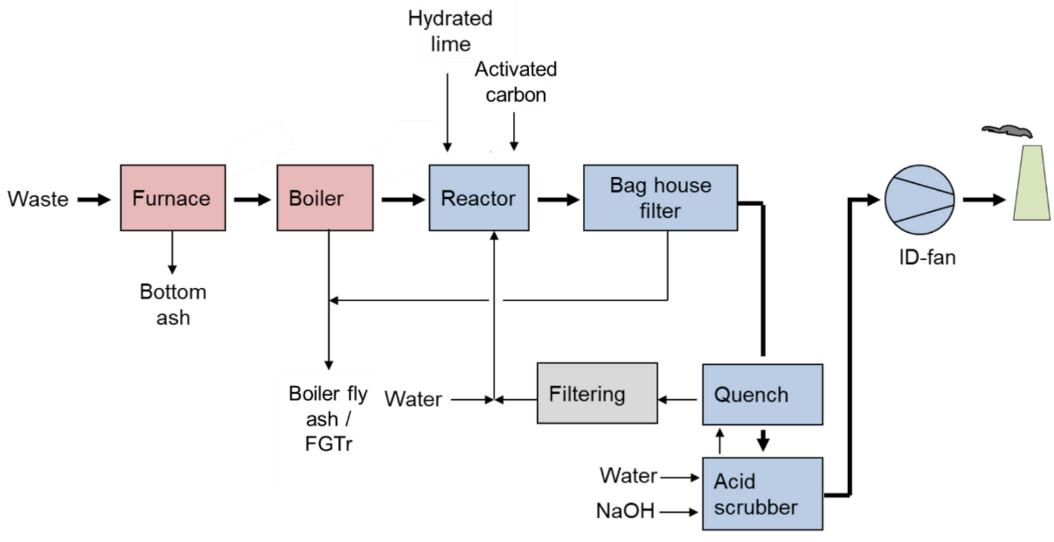

Figure 5: Combined dry wet process

The wet scrubber is located downstream of the bag house filter, therefore most components of the flue gas, including particulates, have already been removed. The wet scrubber will absorb residual acid gasses from the flue gas as well as some heavy metals, dust and ammonia. As the acid gasses are neutralized by addition of sodium lye, this process forms water soluble salts like sodium chloride (NaCl) and sodium sulphate (Na_2SO_4). Also, minor traces of dust from the former semi-dry FGT may be accumulated in the scrubber.

The scrubber itself, water pipes, flue gas ducts and pumps etc., will be made of FRP (fibre reinforced plastic), polyolefins or similar corrosion resistant material, hence no corrosion will occur. The output of the wet scrubber is a mixture of water, a small volume of dissolved solids and particulates. This is not the same as the sludge that would be formed in a fully wet process

All scrubber water including salts and particulates are recycled into the reactor FGT step to control the reaction temperature. This temperature control is called a quench, and water is sprayed directly into the hot flue gasses and cools the flue gas by evaporation. As the water evaporates any particulates and dissolved salts that were collected in the scrubber become dry are collected in the bag house filter. All residues from the wet scrubbing stage are therefore eventually disposed of as part of the FGTr.

No discharge of wastewater and/or sludge removal from the scrubber is generated and all liquid. output from the wet scrubber is reused in the FGT process, thus is a closed system.

Wet scrubbers in this configuration are used in both the Dublin and Filborna reference facilities.

3.2.2 Wet System

A wet scrubbing system utilises dust removal followed by a series of wet scrubbing stages to clean the flue gases.

Boiler fly ash from the incineration process need to be taken out of the flue gas before the flue gas enters the wet scrubbers. This is required to prevent blockage of the water scrubbing sections. This can be achieved using either an Electrostatic Precipitator (ESP) or a bag filter system. The majority of heavy metals are extracted from the flue gas together with the boiler fly ash except for mercury. After the ESP or bag filter system, the flue gas is direct to a quench stage where it is cooled by injection of quench liquid to the required scrubber temperature (manufacturer dependent) followed by an acid scrubber and an alkaline scrubber. The process is illustrated in Figure 6.

The water output from the system is hydrochloric acid taken from the quench and sulphate containing water taken from the SO2-scrubber. Waste water treatment and disposal is therefore required with a wet system.

The hydrochloric acid is neutralised as the first step of waste water treatment by lime, limestone or sodium chloride and various chemicals are added to the water for precipitation and flocculation of remaining heavy metals within the flue gases, thereby forming a heavy metal contaminated sludge. Sludge and gypsum may be separate streams or one combined product to be disposed. The treated wastewater is a calcium and/or sodium chloride solution with only trace of heavy metals. The treated wastewater is saline and needs to be discharged to a suitable industrial waste water treatment plant.

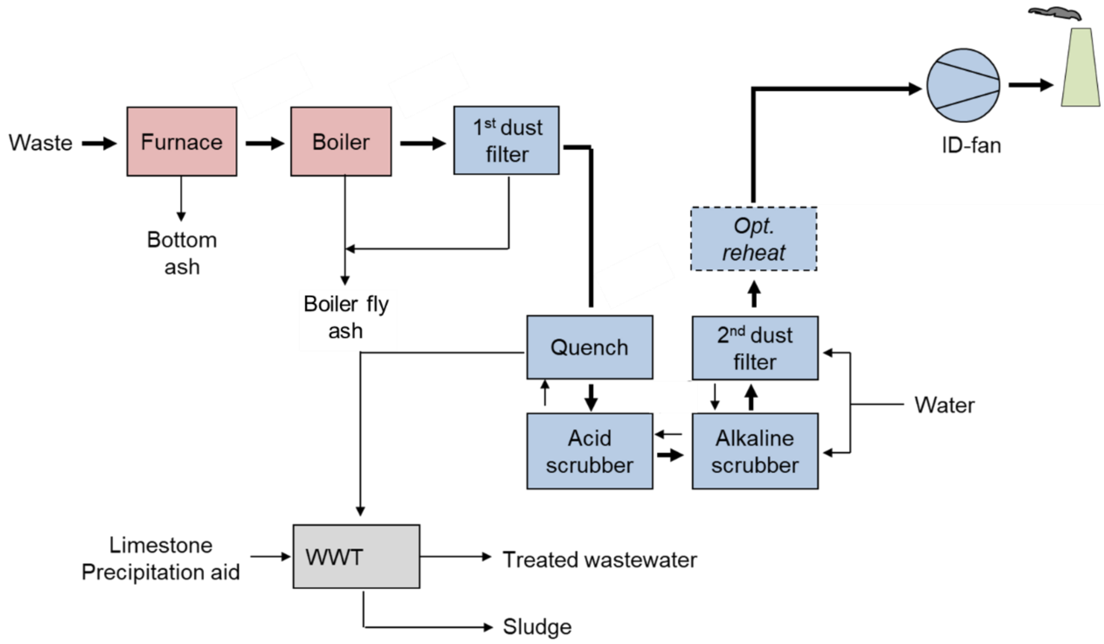

Figure 6: Wet flue gas treatment

3.2.3 Screening and Selection of Technology

All the systems above are described as different forms of Best Available Techniques (BAT) under the European Union Industrial Emissions Directive within the Waste Incineration (WI) BAT Reference Document (WI BREF). All systems can meet the emissions limit values, or where applicable emission limit ranges, set out in the WI BREF. Each treatment system type was analysed against a variety of criteria, the summary of which is provided in Table 3 below, to determine the preferred solution for the WSERRC.

Table 3: FGT comparison

Parameter	Base Semi-dry	Semi-dry with wet scrubber	Wet System
Suitable for proposed waste types	Yes	Yes	Yes
Proven technology	Yes	Yes	Yes
Operational Performance and Availability	Good	Good	Good
Flexibility to handle short term variation in waste characteristics	Possible difficulties with maintaining consistently low Sulphur Dioxide	Good – scrubber acts as an additional polishing stage	Good
Emissions Performance	Compliant with EU WI BREF upper limits	Compliant with EU WI BREF upper limits	Compliant with EU WI BREF upper limits
Future proofed against tighter emissions limits	No	Yes	Yes
Waste Water Stream Generated	No	No	Yes – waste water treatment required

After consideration of the different FGT technologies for WSERRC, a semi-dry system with additional wet scrubber was chosen:

- The base semi-dry system was discounted as there was concern that WI BREF emission limit values, particularly for sulphur dioxide, could be temporarily exceeded if there was a change in waste characteristic over a short period of time causing a change in the characteristics of the raw flue gases. In addition, the use of either a semi-dry system with a wet scrubber or a wet system provides an element of future proofing against potential tightening of emission limit values and provides lower emissions than a semi dry system.
- The fully wet system was discounted as it had similar characteristics to a semi-dry system, but with a wet scrubber it creates a wastewater stream and uses additional water. Given the potential for drought in the Sydney area, it was decided that a wet solution was not appropriate for the location. Additionally, there was no viable point of discharge for the industrial wastewater near the WSERRC site.

Therefore, the semi-dry solution with a wet scrubber was chosen. This solution has also been used at both reference facilities, Dublin and Filborna. Further information on the reference facilities can be found in **Chapter 5 EfW policy**.

3.3 Oxides of Nitrogen (NO_x) Reduction Technologies

The FGT options set out in Section 3.2 do not reduce NO_x within the flue gases therefore a NOx reduction stage needs to be considered. In this section, different NOx reduction technologies are discussed and the preferred technology to be used for WSERRC has been identified.

Waste thermal treatment in moving grate facility results in NOx concentrations within the raw flue gases of typically 300 mg/Nm3 to 400 mg/Nm3 (11 % O2, dry). The emission limit range for NOx identified in BREF, 2019 is described as a range between 120 mg/Nm^3 and 50 mg/Nm^3 (dry flue gas at 11 % O2) as a daily average value. Therefore, a treatment system to reduce NO_x concentration in line with international best practice is required.

The following two technologies are the most commonly applied methods used in waste incineration facilities globally for NO_x reduction;

- SNCR, Selective Non-Catalytic Reduction
- SCR, Selective Catalytic Reduction

They are both based on injection of ammonia in an aqueous solution. Urea can also be used but given the two consumables yield substantially similar results, ammonia was selected for WSERRC as it is more available. Both methods produce the same basic chemical reaction:

$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O,$$

This reaction results in reduction of NOx to free nitrogen and water, which are both harmless gases and abundant within the atmosphere.

Both technologies are described as Best Available Techniques, therefore either is acceptable based on international best practice as required under the NSW EfW Policy.

3.3.1 Selective Non-Catalytic Reduction (SNCR)

SNCR allows reduction of NO_x without the use of a catalyst. Ammonia water is injected in the afterburning chamber of the furnace where the temperature is sufficient such that ammonia reacts with NO and NO2. Some excess ammonia is needed to make sure contact between ammonia decomposition products and NO/NO2. The required volume of ammonia increases as the demand for NO_x reduction increases. For optimal results, the process requires careful control of ammonia injection points and flow rate together with combustion control. The process causes some unreacted ammonia to leave the boiler with the flue gas. This is not an issue for WSERRC, as the wet scrubber stage in the downstream FGT system will remove this excess ammonia.

SNCR technology can achieve NO_x levels of between 100 mg/Nm3 and 120 mg/Nm3. This is within the acceptable range set out in BREF, 2019.

3.3.2 SCR

In the SCR-process ammonia is injected upstream of a catalyst at a temperature of approximately 180 °C to 300 °C. The reaction between NO_x and ammonia then happens on the catalytic surface itself. There are a variety of different SCR configurations available. The two main options are;

- Tail End SCR - In a tail-end SCR, the catalyst is placed after the base FGT, and therefore reheating of the flue gas is necessary. This reheating process can reduce the thermal energy that can be recovered for electricity generation therefore can make the overall process less efficient.
- Front End SCR - In pulverized coal fired plants, the SCR-catalyst is usually placed as "high dust catalysts" at the point in the boiler system, where the temperature is optimal for the process. By locating the catalyst here reheating is not needed. In an EfW facility, a front-end SCR system requires dust removal using an electrostatic precipitator. The electrostatic precipitator uses electricity that would not be required in a SNCR system and is therefore less energy efficient. This system is rarely used in waste incineration plants due to the risk of catalyst deactivation, wear and clogging. Front end SCR would therefore not be suitable for WSERRC.

SCR technology is able to achieve NO_x levels of between 20 mg/Nm3 and 50 mg/Nm3. This is within the acceptable range set out in BREF, 2019.

3.3.3 Screening and Selection of Technology

Both SCR and SNCR technologies are described as "Best Available Techniques" (BAT) within the European Union Best Available Techniques Reference document for Waste Incineration and both are commonly used in Europe.

The WSERRC has chosen to utilise SNCR for the following reasons:

- SNCR achieves the upper WI BREF NO_x limit of 120mg/Nm^3
- SNCR is described as BAT in the WI BREF
- SNCR achieves significantly lower emission levels than the requirements for NO_x emission under New South Wales POEO legislation (500mg/Nm^3)
- SNCR is a simpler technology than SCR. SCR systems are complex to operate, require more intensive maintenance than SNCR systems and are more complex to maintain
- SNCR achieves a higher energy efficiency overall. A tail end SCR system requires reheating of the flue gases for proper operation of the catalyst, not required in SNCR technology, which uses energy that would otherwise be used for electricity generation. A front-end SCR system requires dust removal using an electrostatic precipitator to avoid blocking and clogging of the system. The electrostatic precipitator uses electricity that would not be required in a SNCR system and is therefore less energy efficient

- Modelling, as set out in Technical Report A: Air Quality and Odour Assessment Report, in line with achievable limits for SNCR technology has shown no adverse impact with respect to air quality.

The reference facilities for this proposal, Dublin Waste to Energy and Filborna Waste to Energy which are fully described in **Chapter 5 EfW policy** both use the SNCR technology.

4 Best Available Techniques (BAT) Assessment

This section of the assessment is provided to outline each of the BAT conclusions and how WSERRC complies with each of those conclusions. It demonstrates how WSERRC complies with the international best practice requirements under the NSW Energy from Waste policy. Note that where compliance with BAT conflicts with the requirements under local legislation such as the NSW Energy from Waste policy, the local requirements will take precedence as would be required in Australia.

The BREF document discusses the concept of "Existing Plants" and "New Plants". The requirements for "New Plants", which are defined as plants permitted post publication of the 2019 BREF, are more stringent that for Existing Plants. The facility has therefore been designed to comply with requirements set out for "New Plants".

4.1 Environmental

4.1.1 BAT 1

In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS).

An Environmental Management System (EMS) for WSERRC will be developed during the detailed design phase and will be refined between the construction contractor, the operational contractor and the owners of the project. The EMS will be set out as described in detail within the WI BREF and include all the required features. Features include but are not limited to:

- Management commitment, leadership and accountability for the implementation of an effective EMS
- Outline of possible environmental risks, identification of applicable legal requirements and management procedures of such risks
- Policy for continuous improvement
- Development of Key Performance Indicators (KPI's) to assess and facilitate continuous improvement
- Planning and implementing procedures and actions to achieve environmental objectives and avoid environmental risks
- Determination of structures, roles and responsibilities for the EMS
- Implementing training to staff around the EMS so that they are aware of the policy, procedures, responsibilities and risks
- Provide internal and external communication of the EMS
- Encourage and foster employee involvement in good environmental management practices through awareness, leadership and training

- Establishing and maintaining a management manual
- Establishing and implementing effective operational planning and process control
- Implementation of appropriate maintenance programmes
- Readiness for and management and operational procedures of potential environmental impacts in emergency situations
- Implementation of a monitoring and measurement programme in line with the IED and WI BREF
- Review of performance against benchmarks where available
- Recording and evaluation of any non-conformances with the policy and implementation of corrective action
- Periodic review and audit of the EMS and its continuing suitability, adequacy and effectiveness by senior management
- When redesigning a new installation (or a part of a new installation), consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning
- Periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether the EMS conforms to planned arrangements and has been properly implemented and maintained
- Following and taking into account the development of cleaner techniques which forms part of our continuous improvement.

4.2 Monitoring

4.2.1 BAT 2

BAT is to determine either the gross electrical efficiency, the gross energy efficiency, or the boiler efficiency of the incineration plant as a whole or of all the relevant parts of the incineration plant.

To determine energy efficiency of the plant, a performance test will be undertaken at the end of the commissioning phase. This will make sure that the electrical efficiency of the plant is in line with that selected during the design process. This will also make sure compliance with the requirement for a gross electrical efficiency of greater than 25% as required under the New South Wales Energy from Waste Policy Statement. The facility is targeting an electrical efficiency sufficiently greater than 25%. The current expected gross electrical efficiency of WSERRC is 30.5% with a net electrical efficiency (net of WSERRC parasitic self-consumption) of 27.8%. Note however that expected figures are dependent on finalisation during detailed design.

Additionally, annual review of gross electrical efficiency will be undertaken during the operational phase. This will be undertaken to monitor the overall performance of the plant to confirm that the facility is being operated as efficiently as is reasonable. This testing will be conducted using information gathered from the Site Control and Data Acquisition (SCADA) system and will be interrogated by the owners and operators of WSERRC. This exercise will also be carried out after any major overhaul or major revision to the plant. Although this is not required as part of the BAT conclusions, it a requirement of the NSW EfW policy statement to meet the thermal efficiency criteria, demonstrating that at least 25% of the energy generated from the thermal treatment of the material will be captured as electricity. This metric will be used to prove compliance with the NSW EfW policy statement.

4.2.2 BAT 3

BAT is to monitor key process parameters relevant for emissions to air and water including those given below.

Stream/Location	Parameter(s)	Monitoring
Flue-gas from the incineration of waste	Flow, oxygen content, temperature, pressure, water vapour content	Continuous measurement
Combustion chamber	Temperature	
Waste water from wet FGC	Flow, pH, temperature	
Waste water from bottom ash treatment plants	Flow, pH, conductivity	

WSERRC will measure all of the required flue gas parameters continuously using the Continuous Emissions Monitoring System (CEMS). Note that the facility will be compliant with the measurement requirements of the NSW EfW policy statement as well as the BAT conclusion requirements. The full list of monitoring can be found in the Project Description section of this EIS.

Combustion temperature will be measured using temperature sensors strategically placed in the boiler.

- The WSERRC will have no process waste water stream during normal operations from the plant as waste water will be recycled into the process.
- All waste water from the scrubbing process will be recycled into the process and therefore a waste water stream is not created.
- Whilst the IBA will include moisture due to the cooling process undertaken (wet ash quench) this moisture does not create a waste water stream, it is held within the IBA which will be transported offsite for treatment at a separate facility that does not form part of this application. Moisture in the IBA will naturally evaporate as part of the cooling process.

WSERRC has allowed for 300 m^3 of process waste water/cleaning water to be stored on-site to be reused in the process.

In the unlikely event where process waste water must be removed from site, it will be stored in a tanker and disposed of via a suitable, accredited waste water treatment facility following testing. Process wastewater should never have to be removed from site however this contingency plan is in place in the unlikely event removal is required. The only reasons for process wastewater removal from site would be;

- Full process wastewater tank that stores process water before it is re-used; or,
- The requirement to drain the boiler or other equipment due to maintenance activities and where that water could not be re-used after testing and where it cannot be stored in the process wastewater tank for re-use.

Both scenarios are highly unlikely, will never occur during normal operation and may never occur throughout the lifetime of the facility. The facility will utilise automatic monitoring and alarm systems so that tanks do not overflow and bunding will be installed which will mitigate the risk of uncontrolled water discharge. The facility will include an internal drainage system linked to the wastewater storage system so that any failure of process equipment does not lead to uncontrolled water discharge. All collected wastewater will be reused in the process.

Boiler water comprises of de-ionate (very clean water with no salts) and may include small particulates such as scale and rust. The scrubber water will contain some chlorides and sulphates and have a minor content of heavy metals.

The exact facility to be used for disposal would depend on the specification of the water which would have to be tested prior to disposal. WSERRC commits to testing any wastewater prior to disposal (if any) and selecting a suitable facility in compliance with legislation in New South Wales. In Europe, a municipal wastewater treatment plant would be sufficient to treat such water.

4.2.3 BAT 4

BAT is to monitor channelled emissions to air with at least the frequency given and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Note – the table referred to in BAT 4 has not been replicated here due to the size. Please refer to the WI BREF main document (link provided at the start of this document) for the relevant table (Section 5.1.2, Page 480).

WSERRC will comply with this conclusion;

- For continuous emissions measurement, the project will have a Continuous Emissions Monitoring System (CEMS). This will be integrated with the site Distributed Control System (DCS) and provide real-time feedback both to the operators and to the plant control system to control the injection of abatement chemicals. The CEMS will have suitable redundancy for continuous operation, even if there is a failure of one unit. There will be continuous measurement of NO_x, CO, particles (total), total organic compounds, HCI, HF if required, SO_2 and at least two measurements per year of heavy metals, polycyclic aromatic hydrocarbons and chlorinated dioxins and furans as required by the NSW EfW Policy.

- For periodic measurements (note that it is not technically possible to monitor all emissions continuously) a periodic monitoring and measurement regime will be set up. These procedures will be developed prior to operation of the project such that they are in place for the start of operations. Dedicated extractive measurement points will be provided to allow this in accordance with recognised industry standards for periodic measurement.

Emissions data will be made available to the EPA in real-time graphical publication and a weekly summary of monitoring data and compliance with emissions limits published on the internet as required under the NSW EfW Policy Statement.

Lag time between emissions abatement control and the CEMS system is negligible. The facility will operate sufficiently below the relevant emission limit value to allow feedback controls time to act before any emission limit value is breached.

4.2.4 BAT 5

BAT is to appropriately monitor channelled emissions to air from the incineration plant during OTNOC (Other Than Normal Operating Conditions).

WSERRC will monitor appropriate channelled emissions during OTNOC using the CEMS previously described. There will also be operational testing carried out during planned start-up/shutdown operations for those parameters that cannot be tested using the CEMS, periodically. The procedures for these tests will be finalised prior to operation of the facility.

4.2.5 BAT 6

BAT is to monitor emissions to water from FGC (Flue Gas Cleaning) and/or bottom ash treatment with at least the frequency given in the table and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Note – the table referred to in BAT 6 has not been replicated here due to the size. Please refer to the WI BREF main document (link provided at the start of this document) for the relevant table (Section 5.1.2, Page 482).

The WSERRC will have no process waste water stream during normal operations from the plant as waste water will be recycled into the process. Therefore BAT 6 is not applicable to the WSERRC.

4.2.6 BAT 7

BAT is to monitor the content of unburnt substances in slags and bottom ashes at the incineration plant with at least the frequency given below and in accordance with EN standards.

Parameter	Standard(s)	Minimum monitoring frequency	Monitoring associated with
Loss on ignition (1)	EN 14899 and either EN 15169 or EN 15935	Once every three months	BAT 14
Total organic carbon (1) (2)	EN 14899 and either EN 13137 or EN 15936		

(1) Either the loss on ignition or the total organic carbon is monitored.
(2) Elemental carbon (e.g. determined according to DIN 19539) may be subtracted from the measurement result.

WSERRC will comply with this conclusion by carrying out periodic monitoring and testing as required for each parameter in the table. Procedures for this monitoring and testing will be finalised prior to operation of the facility. Unless local standards are identified that are superior, European standard will be followed for monitoring and testing.

4.2.7 BAT 8

For the incineration of hazardous waste containing POPs (Persistent Organic Pollutants), BAT is to determine the POP content in the output streams (e.g. slags and bottom ashes, flue-gas, waste water) after the commissioning of the incineration plant and after each change that may significantly affect the POP content in the output streams.

This conclusion is not applicable to the WSERRC project as there will be no combustion of hazardous waste streams within the facility.

4.3 General environmental and combustion performance

4.3.1 BAT 9

In order to improve the overall environmental performance of the incineration plant by waste stream management (see BAT 1), BAT is to use all of the techniques (a) to (c) given below, and, where relevant, also techniques (d), (e) and (f).

1. **Determination of the types of waste that can be incinerated**
2. **Set-up and implementation of waste characterisation and pre-acceptance procedures**
3. **Set-up and implementation of waste acceptance procedures**
4. **Set-up and implementation of a waste tracking system and inventory**
5. **Waste segregation**

6. Verification of waste compatibility prior to the mixing or blending of hazardous wastes

The WSERRC will comply with this conclusion due to the following considerations:

1. The waste types incinerated will be suitable for the design of the plant. Our reference facilities have shown the capability of operating using Municipal Solid Waste and Commercial & Industrial Waste streams and it is proposed that like waste streams will be used at the WSERRC. Protocols will be put in place so that only wastes as described in this EIS are delivered to the facility. The project description of this EIS sets out the outline design parameters for the incineration of suitable waste streams including the firing diagram, ash content of the waste and size of waste. The reference facilities show operational characteristics materially like that proposed for WSERRC. Further information can be found in a variety of places in the main body of this EIS.
2. Suppliers of waste to the facility will be pre-registered and procedures will be in place to make sure that waste deliveries are in line with the requirements set out in this EIS.
3. Robust acceptance procedures will be in place at site. Each vehicle delivering waste will be registered within the plant control systems and number plate recognition systems will be in place. Documentation will set out the waste within the vehicle. If there is an issue with the documentation or a suspect vehicle enters site, there will be a designated inspection area. There will also be an area internal to the tipping hall that can be used for inspection of delivered waste. Any waste found not to be acceptable will be rejected and the supplier will retain responsibility for disposal offsite. Finally, there will be video monitoring of each tipping bay, linking the waste delivery truck (licence plate) with waste being tipped into the bunker (visual).
4. Waste tracking and inventory will be managed by the facility computer systems, the pre-registered information on waste delivery and the weighbridge systems. This will assist with retaining an accurate record of the waste types being delivered alongside the weight of each delivery. The system will also track the origin of the waste (i.e. the supplier).
5. All waste received on site will be stored in the bunker. There will be no other waste storage on site with the exception of a short-term waste quarantine area adjacent to the main bunker but inside the bunker hall envelope. The waste streams delivered on site (MSW and C&I) do not have to be kept separate and will be delivered to the same waste bunker. The waste in the bunker will be mixed using the crane systems prior to delivery to the chute for combustion. The facility will not accept hazardous waste streams, however, if a load of waste including hazardous material does arrive at site, the facility includes a quarantine area where such material can be quarantined before being disposed of at an appropriate, licensed facility.
6. Blending or mixing of hazardous wastes is not applicable to the project as no hazardous waste will be accepted on site.

4.3.2 BAT 10

In order to improve the overall environmental performance of the bottom ash treatment plant, BAT is to include output quality management features in the EMS (see BAT 1).

The WSERRC EMS system will include a section on quality management of environmental performance of the IBA treatment equipment. The proposal does not include a dedicated IBA treatment plant within the scope of this EIS. IBA will be exported off site for treatment and recycling (if possible in the regulatory and economic framework) or disposal.

Ferrous metal separation and bulk material removal will however take place on site as a recovery operation. Further metal removal will be undertaken offsite as part of the ash disposal/recycling route. Detailed procedures will be developed as part of the EMS.

4.3.3 BAT 11

In order to improve the overall environmental performance of the incineration plant, BAT is to monitor the waste deliveries as part of the waste acceptance procedures (see BAT 9 c) including, depending on the risk posed by the incoming waste, the elements given below.

Waste type	Waste delivery monitoring
Municipal solid waste and other non-hazardous waste	• Radioactivity detection • Weighing of the waste deliveries • Visual inspection • Periodic sampling of waste deliveries and analysis of key properties/substances (e.g. calorific value, content of halogens and metals/metalloids). For municipal solid waste, this involves separate unloading.
Sewage sludge	• Weighing of the waste deliveries (or measuring the flow if the sewage sludge is delivered via pipeline) • Visual inspection, as far as technically possible • Periodic sampling and analysis of key properties/substances (e.g. calorific value, content of water, ash and mercury)

Hazardous waste other than clinical waste	• Radioactivity detection
	• Weighing of the waste deliveries
	• Visual inspection, as far as technically possible
	• Control and comparison of individual waste deliveries with the declaration of the waste producer
	• Sampling of the content of:
	    ○ all bulk tankers and trailers
	    ○ packed waste (e.g. in drums, intermediate bulk containers (IBCs) or smaller packaging)
	and analysis of:
	    ○ combustion parameters (including calorific value and flashpoint)
	    ○ waste compatibility, to detect possible hazardous reactions upon blending or mixing wastes, prior to storage (BAT 9 f)
	    ○ key substances including POPs, halogens and sulphur, metals/metalloids

Clinical waste	• Radioactivity detection • Weighing of the waste deliveries • Visual inspection of the packaging integrity

The WSERRC will include the following waste delivery monitoring procedures:

- Periodic sampling and testing of key properties/substances
- Radioactivity detection via equipment installed at the facility
- Weighing of the waste deliveries via the weighbridges
- Video monitoring of the tipping bays and tipping hall
- The option for visual inspection in a dedicated bay within the tipping hall (as part of the quality control procedures) and visual inspection by the operator within the bunker itself (via a segregated viewing point used for waste crane operation).

The ability to remove mixed waste from the bunker using the waste crane if required via a backloading system into vehicles for removal from site.

Additional procedures outlined for sewage sludge, hazardous waste and clinical waste are not applicable to the WSERRC as these waste types will not be accepted at the facility.

4.3.4 BAT 12

In order to reduce the environmental risks associated with the reception, handling and storage of waste, BAT is to use both of the techniques given below.

1. Impermeable surfaces with an adequate drainage structure
2. Adequate waste storage capacity

WSERRC will comply with this conclusion as;

1. The Reception hall and waste bunker will be made of impermeable surface. Any liquid run off will be reabsorbed into the waste and go through the combustion process. Note that dedicated liquid waste loads will not be received at the facility. A suitable drainage system will be installed around the site for stormwater runoff.
2. The waste will be store in the waste bunker with a storage capacity of approximately 5 to 7 days. The quantity of stored waste is regularly monitored and estimated using a combination of weighbridge measurements to understand waste volume entering the facility and waste crane measurements to understand the throughput of waste for the combustion process.

4.3.5 BAT 13

In order to reduce the environmental risk associated with the storage and handling of clinical waste, BAT is to use a combination of the techniques given below.

1. Automated or semi-automated waste handling
2. Incineration of non-reusable sealed containers, if used

3. Cleaning and disinfection of reusable containers, if used

This conclusion is not applicable to the WSERRC, as clinical waste will not be accepted.

4.3.6 BAT 14

In order to improve the overall environmental performance of the incineration of waste, to reduce the content of unburnt substances in slags and bottom ashes, and to reduce emissions to air from the incineration of waste, BAT is to use an appropriate combination of the techniques given below.

1. Waste mixing and blending
2. Advanced system control
3. Optimisation of the incineration process

WSERRC will comply with this conclusion due to the following design features of the facility;

1. Incoming waste will be deposited in the waste bunker and the waste cranes within the facility will be used to mix this incoming waste within the bunker. Mixing of waste will be achieved using the waste cranes. This can be achieved in both automatic and manual mode 24 hours per day as required. Further information is provided in the **Chapter 3 Proposal Description** section of this EIS.
2. An advanced control system is integrated in the systems for combustion control and FGT. Combustion control and FGT control will be achieved using the Distributed Control System (DCS). Sensory and monitoring equipment around the plant will feedback in real time to the control system allowing combustion and treatment systems to be optimised.
3. The incineration process will be optimised using the advanced combustion control system integrated into the DCS to monitor and control airflow and fuel feed rate. Additionally, the combustion grate will be suitably designed so that unburnt substances in the IBA does not breach limits set out in the WI BREF, specifically Loss on Ignition and unburnt carbon in the IBA as per Table 5.1 of the WI BREF.

4.3.7 BAT 15

In order to improve the overall environmental performance of the incineration plant and to reduce emissions to air, BAT is to set up and implement procedures for the adjustment of the plant's settings, e.g. through the advanced control system (see description in Section 5.2.1), as and when needed and practicable, based on the characterisation and control of the waste (see BAT 11).

WSERRC will comply with this conclusion as follows;

- Emissions to air will be monitored using the CEMS which will be integrated with the DCS as an advanced control system. Real time feedback from the CEMS will control dosing rates to optimise environmental performance.
- Additionally, procedures for control and selection of set points will be fine-tuned over time through operational experience of the facility and dependent on the incoming waste streams to optimise performance.
- The facility will also include a raw gas analyser to monitor the raw flue gases pre FGT.

4.3.8 BAT 16

In order to improve the overall environmental performance of the incineration plant and to reduce emissions to air, BAT is to set up and implement operational procedures (e.g. organisation of the supply chain, continuous rather than batch operation) to limit as far as practicable shutdown and start-up operations.

WSERRC is compliant with this conclusion based on the following;

- Operation procedures will be developed in order to reduce emissions to air and to prevent or reduce risk of occasions with unplanned shutdown and start-up operations.
- The plant will be designed with a high level of redundancy (and includes two lines) to limit the risk of an unplanned shut down of the entire facility.
- The process is designed to be a continuous process. Procedures will be put in place, both with respect to operation and maintenance and scheduling of waste deliveries to minimise the risk of downtime. This will be done through standard operational requirements and procedures which are included in Waste Supply Agreements for the project such as waste delivery plans which coordinate the continuous delivery of waste against committed volumes around planned maintenance and scheduling of waste deliveries monthly, weekly and daily.

4.3.9 BAT 17

In order to reduce emissions to air and, where relevant, to water from the incineration plant, BAT is to ensure that the FGC system and the waste water treatment plant are appropriately designed (e.g. considering the maximum flow rate and pollutant concentrations), operated within their design range, and maintained so as to ensure optimal availability.

The emissions control systems for the WSERRC have been specified based on Best Available Techniques. Further work will be undertaken during detailed design to make sure the specified equipment (SNCR, bag filters, dry sorbent injection and wet scrubber) are sized appropriately for optimal operational conditions. Additionally, plant monitoring and control will occur so that the systems are operated in a suitable manner, with direct, real time feedback from the CEMS and the ability for the operators to adjust based on experience so that chemicals are not over dosed and so that the emissions from the plant remain within the limits set out by the EPA.

A comprehensive maintenance regime will also be put in place to make sure that all systems are maintained properly. This will form part of the overall operation and maintenance procedures for the plant, will be included within the EMS and will follow equipment manufacturers guidelines at a minimum.

The waste water treatment plant part of this conclusion is not applicable to the WSERRC as no process waste water is generated by the EfW process under normal operating conditions.

4.3.10 BAT 18

In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions to air and, where relevant, to water from the incineration plant during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the environmental management system (see BAT 1) that includes all of the following elements:

- identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences, and regular review and update of the list of identified OTNOC following the periodic assessment below;
- appropriate design of critical equipment (e.g. compartmentalisation of the bag filter, techniques to heat up the flue-gas and obviate the need to bypass the bag filter during start-up and shutdown, etc.);
- set-up and implementation of a preventive maintenance plan for critical equipment (see BAT 1 xii);
- monitoring and recording of emissions during OTNOC and associated circumstances (see BAT 5);
- periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary.

The EMS for WSERRC will include commentary and procedures on all of the elements set out in BAT conclusion 18. The detailed procedures, processes and equipment will be finalised during detailed design, however the following high level technique have been identified to date:

- OTNOC will be minimised by ensuring suitable design of the plant for continuous usage and by developing operational strategies to maintain downtime to as low a level as reasonably practicable.

4.4 Energy efficiency

4.4.1 BAT 19

In order to increase the resource efficiency of the incineration plant, BAT is to use a heat recovery boiler.

WSERRC is compliant with this conclusion as two heat recovery boilers are used, one per line which will generate steam for electricity production in a common turbine.

4.4.2 BAT 20

In order to increase the energy efficiency of the incineration plant, BAT is to use an appropriate combination of the techniques given below.

1. Drying of sewage sludge
2. Reduction of the flue-gas flow
3. Minimisation of heat losses
4. Optimisation of the boiler design
5. Low temperature flue-gas heat exchangers
6. High steam conditions
7. Cogeneration
8. Flue-gas condenser
9. Dry IBA handling

WSERRC complies with this conclusion as follows;

- Drying of sewage sludge is not applicable as the plant will not accept sewage sludge.
- Flue gas flow will be optimised by controlling primary and secondary air flow as part of the normal operation of the boiler. Advanced combustion control will be used to optimise airflow. Optimisation of airflow optimises the combustion conditions thus increases the overall efficiency of the facility.
- Heat losses are minimised by an integrated boiler/furnace system and suitably insulated equipment.
- Boiler design will be optimised by appropriate selection of flue gas velocities and distribution during detailed design. The facility will include convection bundles with water/steam circulation and on-line (mechanical rapping systems) and off-line (cleaning during annual planned maintenance) cleaning systems are included.
- The boiler package includes economiser sections to increase heat transferred from the exhaust gas path.

- High steam conditions will be utilised (greater than 45bar and greater than 400 degrees C) with suitable boiler protection.
- The facility will be designed to be capable of cogeneration if this is viable in the future. Although WSERRC will initially generate only, the project team is investigating the possibility of exporting heat to nearby customers in the future. For this reason, the plant will be designed to be Combined Heat and Power (CHP) ready.

The gross electrical efficiency of the plant will be greater than 25%. The current design gross electrical efficiency is 30.3% however this is subject to detailed design.

It should be noted that (h) flue gas condenser is not appropriate for this facility as there is no possible use of low-grade heat recovery, economisers are included within the design to allow for an efficient heat recovery process within the boilers themselves.

The wet IBA handling system (as opposed to (i) dry IBA handling) has been selected to avoid dust production during the handling and storage of the IBA. The facility design includes a pusher extractor that reduces the water content in the IBA to approximately 20%. This avoids any wastewater emissions form the ash handling process even though the technique is described as wet.

4.5 Emissions to air

4.5.1 BAT 21

In order to prevent or reduce diffuse emissions from the incineration plant, including odour emissions, BAT is to:

- store solid and bulk pasty wastes that are odorous and/or prone to releasing volatile substances in enclosed buildings under controlled subatmospheric pressure and use the extracted air as combustion air for incineration or send it to another suitable abatement system in the case of a risk of explosion;
- store liquid wastes in tanks under appropriate controlled pressure and duct the tank vents to the combustion air feed or to another suitable abatement system;
- control the risk of odour during complete shutdown periods when no incineration capacity is available, e.g. by:
    - sending the vented or extracted air to an alternative abatement system, e.g. a wet scrubber, a fixed adsorption bed;
    - minimising the amount of waste in storage, e.g. by interrupting, reducing or transferring waste deliveries, as a part of waste stream management (see BAT 9);
    - storing waste in properly sealed bales.

The WSERRC will include the following odour management features:

- All waste will be stored in the indoor bunker. Therefore, odour will only be released in the tipping hall and bunker hall. During operation, combustion air will be extracted from both the tipping hall and the bunker hall to maintain a sub atmospheric pressure environment to contain odour.

- When the plant is fully shut down, an activated carbon filter (or similar) odour abatement system will be used to mitigate odour release from the tipping hall and bunker hall. During planned shutdowns of one line, where possible the other boiler line will remain operational. During planned shutdown of the entire facility, as well as having a filter system, waste levels in the bunker will be managed to a low point to reduce the volume of waste available to release odour. This will form part of the management procedures for the site.

Liquid waste will not be accepted by the facility therefore storage of liquid wastes is not applicable.

4.5.2 BAT 22

In order to prevent diffuse emissions of volatile compounds from the handling of gaseous and liquid wastes that are odorous and/or prone to releasing volatile substances at incineration plants, BAT is to feed them to the furnace by direct feeding.

This conclusion is not applicable to WSERRC as the facility will not receive liquid or gaseous wastes.

4.5.3 BAT 23

In order to prevent or reduce diffuse dust emissions to air from the treatment of slags and bottom ashes, BAT is to include in the environmental management system (see BAT 1) the following diffuse dust emissions management features:

- identification of the most relevant diffuse dust emission sources (e.g. using EN 15445);
- definition and implementation of appropriate actions and techniques to prevent or reduce diffuse emissions over a given time frame.

The WSERRC will include detailed procedures in the EMS for handling of IBA and associated dust management. As above, the EMS will be developed during detailed design. The facility will have a fully enclosed ash handling system for IBA and no ash treatment or long term ash storage will be undertaken on site.

4.5.4 BAT 24

In order to prevent or reduce diffuse dust emissions to air from the treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given below.

1. Enclose and cover equipment
2. Limit height of discharge
3. Protect stockpiles against prevailing winds

4. Use water sprays
5. Optimise moisture content
6. Operate under sub atmospheric pressure

Note that no treatment of slags and IBA will be undertaken on site. However, IBA will be stored on site in the short term within an enclosed building and bunker before removal offsite for treatment.

The WSERRC will use the following techniques for IBA management at the facility:

- Handling will take place in enclosed areas. Handling equipment will be suitably covered to contain dust
- Discharge height will be limited using the conveying system and the ash crane. Using each, the height of the ash stored in the bunker will be controlled
- Ash will be stored in a bunker therefore will be protected from winds
- Moisture in the IBA post cooling (approximately 20% moisture content) will minimise the risk of dust, however the stream of ash won't become a flowing liquid.

The ash storage hall itself will be sufficiently ventilated with a fail-safe exhaust system which includes a dust filter to avoid dust emissions to the atmosphere.

4.5.5 BAT 25

In order to reduce channelled emissions to air of dust, metals and metalloids from the incineration of waste, BAT is to use one or a combination of the techniques given below.

1. Bag filter
2. Electrostatic precipitator
3. Dry sorbent injection
4. Wet scrubber
5. Fixed or moving-bed adsorption

The WSERRC will utilise the following techniques:

- Bag filter
- Dry Sorbent Injection
- Wet Scrubber (final polishing stage)

The combination of these systems (as used within the Dublin reference facility) will achieve optimal emissions control. The project has chosen to include a wet scrubbing stage to allow enhanced emission control and to future proof against possible future decreases in emissions limits.

Dry sorbent injection will involve the injection of activated carbon to reduce metals and metalloids, followed by the extraction of residues using the bag filter. The final wet scrubbing stage will reduce dust concentration further.

4.5.6 BAT 26

In order to reduce channelled dust emissions to air from the enclosed treatment of slags and bottom ashes with extraction of air (see BAT 24 f), BAT is to treat the extracted air with a bag filter (see Section 5.2.2).

At the WSERRC, extracted air will be treated with a bag filter. The system will be designed to fulfil the minimum requirement in table 5.4 of the WI BREF.

4.5.7 BAT 27

In order to reduce channelled emissions of HCl, HF and SO2 to air from the incineration of waste, BAT is to use one or a combination of the techniques given below.

1. Wet scrubber
2. Semi-wet absorber
3. Dry sorbent injection
4. Direct desulphurisation
5. Boiler sorbent injection

The WSERRC will utilise the following techniques:

- Semi-wet absorber;
- Dry Sorbent Injection; and,
- Wet Scrubber (final polishing stage).

The combination of these systems (as used within the Dublin reference facility) will achieve optimal emissions control. The project has chosen to include a wet scrubbing stage to allow enhanced emission control and to future proof against possible future decreases in emissions limits.

Dry sorbent injection (into a semi-wet absorber) will involve the injection of hydrated lime to reduce acid gases, followed by the extraction of residues using the bag filter. The final wet scrubbing stage will reduce acid gas concentration further. The process is described as semi-wet as a water spray will be utilised within the reactor.

4.5.8 BAT 28

In order to reduce channelled peak emissions of HCl, HF and SO2 to air from the incineration of waste while limiting the consumption of reagents and the amount of residues generated from dry sorbent injection and semi-

wet absorbers, BAT is to use technique (a) or both of the techniques given below.

1. Optimised and automated reagent dosage
2. Recirculation of reagents

The WSERRC will utilise both techniques listed in BAT Conclusion 28. Optimised and automated reagent dosage will be used. Automation will be achieved by linking the control systems for reagent dosing with the plant DCS and the CEMS. Real time feedback will be used to optimise the reagent dosage. The CEMS provides continuous measurement of HCl and SO2 to facilitate this. In addition, the facility will include recirculation of the reagents to reduce the volume of unreacted reagents in the residues thus optimising the dosing process.

4.5.9 BAT 29

In order to reduce channelled NOX emissions to air while limiting the emissions of CO and N2O from the incineration of waste and the emissions of NH3 from the use of SNCR and/or SCR, BAT is to use an appropriate combination of the techniques given below.

1. Optimisation of the incineration process
2. Flue-gas recirculation
3. Selective non-catalytic reduction (SNCR)
4. Selective catalytic reduction (SCR)
5. Catalytic filter bags
6. Optimisation of the SNCR/SCR design and operation
7. Wet scrubber

The WSERRC will utilise the following techniques to comply with the limiting range set out in Table 5.6 of the WI BREF:

- Optimisation of the incineration process - The incineration process will be optimised using the advanced combustion control system integrated into the DCS to monitor and control airflow and fuel feed rate
- Selective Non-Catalytic Reduction (SNCR) – The facility includes SNCR systems for the reduction of NOx. An ammonia solution will be used as the reagent
- SNCR systems will be optimised with automatic dosing control. Additionally, the boiler itself will be designed appropriately to allow suitable distribution and mixing of the reagent with the flue gases and operation within a defined temperature window
- Wet scrubber – the wet scrubbing stage will reduce ammonia slip (and therefore emissions of ammonia) within the flue gases. Ammonia slip is the term given to ammonia within the flue gases caused by using SNCR.

4.5.10 BAT 30

In order to reduce channelled emissions to air of organic compounds including PCDD/F and PCBs from the incineration of waste, BAT is to use techniques (a), (b), (c), (d), and one or a combination of techniques (e) to (i) given below.

1. Optimisation of the incineration process
2. Control of the waste feed
3. On-line and off-line boiler cleaning
4. Rapid flue-gas cooling
5. Dry sorbent injection
6. Fixed or moving-bed adsorption
7. SCR
8. Catalytic filter bags
9. Carbon sorbent in a wet scrubber

The WSERRC will utilise the following techniques to comply with the limiting range set out in Table 5.7 of the WI BREF:

- Optimisation of the incineration process – The design of the furnace/boiler and optimisation of combustion parameters will be undertaken using the advance combustion control system as discussed throughout this BAT assessment
- Use of residual MSW and C&I wastes as a feedstock, there will be no acceptance of hazardous waste streams
- Control of the waste feed – mixing of the waste will be achieved using the crane system to enable the waste feed to be as homogeneous as practical
- On-line and off-line boiler cleaning - on-line (mechanical rapping systems) and off-line (cleaning during annual planned maintenance) cleaning systems are included in the facility design
- Rapid flue-gas cooling – This will be achieved through a combination of boiler design and a flue gas conditioning water spray included within the design of the facility
- Dry sorbent injection - Dry sorbent injection will involve the injection of activated carbon to reduce organic compounds, followed by the extraction of residues using the bag filter.

4.5.11 BAT 31

In order to reduce channelled mercury emissions to air (including mercury emission peaks) from the incineration of waste, BAT is to use one or a combination of the techniques given below.

1. **Wet scrubber (low pH)**
2. **Dry sorbent injection**

3. Injection of special, highly reactive activated carbon

4. Bromine boiler addition

5. Fixed or moving-bed adsorption

The WSERRC will utilise dry sorbent injection through the injection of activated carbon for the reduction of mercury emissions within the flue gases. The bag filter will be used to remove residues. The facility will comply with the limiting range set out in Table 5.8 of the WI BREF

4.6 Emissions to water

4.6.1 BAT 32

In order to prevent the contamination of uncontaminated water, to reduce emissions to water, and to increase resource efficiency, BAT is to segregate waste water streams and to treat them separately, depending on their characteristics.

There is no process wastewater from the processes at the WSERRC during normal operation. All process waste water is collected separately and used in the process, there is no requirement for treatment of waste water streams.

Rainwater run-off from the EfW building roof will be collected and conveyed to rainwater harvesting tanks. When sufficient volume has been collected, this water will be re-used within the process reducing the volume of potable water used.

Site run-off from roads and other hardstanding will be collected by a conventional pit and pipe system. The stormwater quality treatment train for the site has been designed to comply with Blacktown City Council stormwater pollutant reduction targets. This includes gross pollutant traps and a bioretention basin with base filter area. Following treatment and detention, the stormwater will discharge to the overland channel.

Water from IBA treatment will be returned to the IBA silo and water collected from the waste reception, handling and storage areas is returned to the waste bunker (see BAT 12 (a)) on an impermeable surface in waste reception, handling and storage areas.

All water from the wet scrubbing stage will be recycled into the process.

Any sweepings from the waste bunker will be swept into the bunker. The waste itself is not wet and water will not be used for floor cleaning in the tipping hall. Leachate is not considered to be an issue during delivery as liquid/sludge waste is not accepted at the facility.

Cleaning water from the process hall (boiler/FGT hall) will be collected in drain trenches in the floor and used for cooling of the IBA.

Note that foul drainage from toilets and sinks in bathrooms and kitchen areas (non-process) is not subject to this assessment but will be dealt with by connecting to the local foul drainage sewer.

4.6.2 BAT 33

In order to reduce water usage and to prevent or reduce the generation of waste water from the incineration plant, BAT is to use one or a combination of the techniques given below.

1. **Waste water free FGC techniques**
2. **Injection of waste water from FGC**
3. **Water reuse-recycling**
4. **Dry bottom ash handling**

WSERRC uses the following techniques to comply with this conclusion;

- The FGT system for the WSERRC comprises of process wastewater free techniques, semi-dry FGT is used with an additional wet scrubber.
- Water from the scrubber system is reused to quench the flue gas in the semi-dry stage.
- In general water is reused/recycled e.g. blow down water from boiler is reused in cooling of IBA and reject from make-up water production is reused for IBA cooling and/or in the FGT.

The plant has been designed for optimal water usage and zero process waste water during normal operation. Some non-process waste water from toilets, bathrooms and kitchens etc. will be disposed of via a foul drainage network.

4.6.3 BAT 34

In order to reduce emissions to water from FGC and/or from the storage and treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given in the table, and to use secondary techniques as close as possible to the source in order to avoid dilution.

Note – the table referred to in BAT 34 has not been replicated here due to the size. Please refer to the WI BREF main document (link provided at the start of this document) for the relevant table (Section 5.1.6, Page 500).

This conclusion is not applicable to WSERRC as no external treatment of water takes place during normal operation.

4.7 Material efficiency

4.7.1 BAT 35

In order to increase resource efficiency, BAT is to handle and treat bottom ashes separately from FGC residues.

At the WSERRC, FGTr will not be mixed with the IBA. They will be collected, handled and disposed of separately.

The facility will recover and recycle metals. The project will also seek to treat IBA for re-use in construction materials or similar. See Chapter 22 Related Development of this EIS for further information.

4.7.2 BAT 36

In order to increase resource efficiency for the treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given below based on a risk assessment depending on the hazardous properties of the slags and bottom ashes.

1. Screening and sieving
2. Crushing
3. Aeraulic separation
4. Recovery of ferrous and non-ferrous metals
5. Ageing
6. Washing

IBA will be mostly treated offsite and therefore will be exported from the WSERRC. There will however be some resource recovery conducted on site.

At the WSERRC, a mechanical scalper system will be used to remove any bulky items just after the furnace. This reduces the risk of damage to the conveying systems as well as facilitating resource recovery. Secondly, ferrous metals will be removed and stored separately using a ferrous metal separator in line with the conveying equipment.

At an offsite facility, other steps will be taken to increase resource efficiency which will include at least the following;

- Screening and sieving using oscillating or vibrating screens.
- Further recovery of ferrous metals using magnetic separators and recovery of non-ferrous metals using eddy current separators.
- The IBA will undergo an ageing process that stabilises the mineral fraction of the IBA.

Note that the offsite facility does not form part of this application.

4.8 Noise

4.8.1 BAT 37

In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.

1. Appropriate location of equipment and buildings
2. Operational measures

3. Low-noise equipment
4. Noise attenuation
5. Noise-control equipment/infrastructure

At the WSERRC, Noisy equipment (turbine, ID Fan and pumps etc.) will be placed inside the building with suitable cladding to reach a reasonable external noise level. The plant will be operated by skilled and experienced staff and a proactive maintenance system will be implemented. Low noise equipment will be installed as required. Noise attenuation equipment will be installed as required. Suitable equipment will be specified during detailed design.

Further information on the noise assessment for the facility can be found in the noise section of this EIS.

5 Conclusion

The WSERRC has been designed such that it is compliant with the definition of Best Available Techniques used by the European Union and set out in the WI BREF, 2019. The facility therefore meets the requirements of the NSW Energy from Waste Policy Statement with respect to design in line with international best practice.