Logika GROUP

Report

Canford EfW CHP Facility Environmental Permit Application

Best Available Techniques Assessment

For MVV Environment

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Prepared By:	Anna McMahon
Reviewed By:	Adam Clegg

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Registered Office: 23 Coldharbour Road, Bristol BS6 7JT Tel: +44(0)117 974 1086

24 Greville Street, Farringdon, London, EC1N 8SS Tel: +44(0)20 3873 4780

First Floor, Patten House, Moulders Lane, Warrington WA1 2BA Tel: +44(0)1925 937 195

Avenue du Port, 86c Box 204, 1000 Bruxelles Tel: +44(0)20 3873 4784R

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1 Introduction

1.1 Background

MVV Environment Ltd (the Operator) is proposing to build and operate a new Energy from Waste (EfW) Combined Heat and Power (CHP) Facility (the EfW CHP Facility) to produce 28 MW_e of electricity (net) and up to 5 MW_{th} of usable heat in the form of low temperature hot water from non-hazardous residual household, industrial and commercial (HIC) waste.

In order to operate an EfW CHP Facility of this capacity, an Environmental Permit to operate a Part A(1) installation under the Environmental Permitting (England and Wales) Regulations 2016, as amended (EPR), is required. In order to obtain such a permit and comply with the requirements of the EPR, there is an obligation to demonstrate the application of Best Available Techniques (BAT). This report has been produced to satisfy those requirements.

The assessment does not replicate the detailed project description or impact assessment which can be found within the Supplementary Information Report (document No. J10/14990A/10-R02-F01).

1.2 Context

BAT is generally defined as "…*the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques … designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole*." (European Commission, 2010)

Best refers to those techniques most effective in achieving a high general level of protection of the environment as a whole.

Available means those techniques developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, as long as they are reasonably accessible to the operator.

Techniques includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

The BAT principle takes into account the environmental benefits associated with a particular technique and also the financial costs of implementing such a technique. The cost-effectiveness of a group of measures can be established to allow ranking and comparison to establish whether BAT for a range of options is clearly identifiable.

The European Commission has produced a detailed reference document and associated BAT Conclusions defining BAT for waste incineration (European Comission, 2019). The BAT Conclusions are to be used as the basis for setting conditions in the requisite permits to operate a regulated installation. They are introduced as Commission Implementing Decisions, giving the BAT Conclusions legal standing and making it much more difficult to deviate or secure a derogation from these Conclusions.

The Environment Agency's Incineration of Waste sector guidance note EPR 5.01 (Environment Agency, 2009) provides a technical reference document with industry specific examples of good industry practice (known as indicative BAT). Although not legally binding in the same way as BAT Conclusions, it does provide performance levels and measures for emissions to air, water, water consumption, waste, noise, and energy efficiency that are generally considered to be achievable at reasonable costs. Comparison of the EfW CHP Facility operations against the EPR 5.01 indicative BAT requirements are discussed in the Supplementary Information Report (document No. J10/14990A/10-R02-F01).

It is important to recognise that the definition of BAT refers to techniques and not technology, i.e., BAT does not just relate to the technology, but also the manner in which that technology is used and how the installation is managed by an operator.

BAT can generally be demonstrated by comparing the design and proposed operation of an installation against the indicative BAT requirements and/or BAT Conclusions. However, where there is a range of techniques available and referenced as BAT, it is necessary to perform an options appraisal to identify which technique, or combination of techniques, represents BAT for the specific site context and application. To that end, in addition to a comparison against the BAT Conclusions, options appraisals have been performed in the following four key areas:

- Selection of thermal treatment technology (Section 2);
- Options for control of emissions of oxides of nitrogen (NO_x) (Section 3);
- Options for acid gas management and reagent selection (Section 4); and
- Options for cooling water systems (Section 5).

Table 1-1 summarises the reference documents that have been consulted to appraise whether the design of the proposed EfW CHP Facility conforms with BAT.

Table 1-1 Reference Legislation and Guidance Consulted for the BAT Assessment

Document Source	Document Title	Date Published
European Commission	COMMISSION IMPLEMENTING DECISION (EU) 2019/2010 of 12 November 2019 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for waste incineration	November 2019
European Commission	Best Available Techniques (BAT) Reference Document for Waste Incineration	November 2019
European Commission	Reference Document on the Application of Best Available Techniques to Industrial Cooling Systems	December 2001
Environment Agency	How to Comply with your Environmental Permit Additional Guidance for: The Incineration of Waste (EPR 5.01)	February 2009
Environment Agency	UK Implementation Document for the 2019 Waste Incineration BAT Conclusions	September 2021

2 Options Appraisal for Thermal Treatment Technology

There are several available options for the mass treatment of waste material to produce energy. This review considers a number of the commonly used thermal treatment technologies. The technologies considered are conventional thermal treatment through combustion and alternative thermal treatment through gasification and pyrolysis, with further subcategories considered where appropriate.

The following sub-sections explain the operating principle of each technique and how it may affect the determination of BAT for treatment technology to be used for the EfW CHP Facility.

2.1 Conventional Thermal Treatment

Conventional thermal treatment technologies allow complete combustion (oxidation) of waste material in a furnace, with or without additional fuel, and are used to generate heat. This heat is then used to raise steam in a boiler and subsequently to generate electricity in a steam turbine.

Flue gas from the combustion of waste is exhausted through a chimney after passing through an air pollution control (APC) plant, with ash residue from the combustion chamber (incinerator bottom ash) collected and exported to off-site facilities for recovery as e.g., construction aggregates. Other forms of waste from the process include boiler ash and Air Pollution Control residues (APCr).

To comply with the Industrial Emissions Directive (IED), the incinerator's furnace is required to ensure that the gases generated from the combustion of non-hazardous waste are raised to a temperature of 850°C for at least two seconds under the most unfavourable operating conditions. This can be achieved using a variety of furnace types as discussed in the following sections.

Very simple conventional thermal treatment techniques that are unlikely to be able to meet modern standards of efficiency, such as a fixed hearth incinerators, or ones not suitable for combustion of municipal waste (liquid injection incinerators) or have very small capacities (pulsed hearth incinerators) have not been considered further.

2.1.1 Moving Grate Technology

One of the most common forms of mass waste combustion is the moving grate technique. This primarily handles municipal waste but can be adapted to accept sewage or clinical waste. Waste is introduced onto a grate via a chute/conveyor system from the waste bunker. The grate is normally inclined downwards, with the waste passing through drying, burning and burnout zones. It is common for the grate to comprise reciprocating bars or other means to ensure agitation of the waste; this ensures an efficient breakup of the waste as combustion takes place. The grate is either cooled using typically air or water increasing the longevity of the grate.

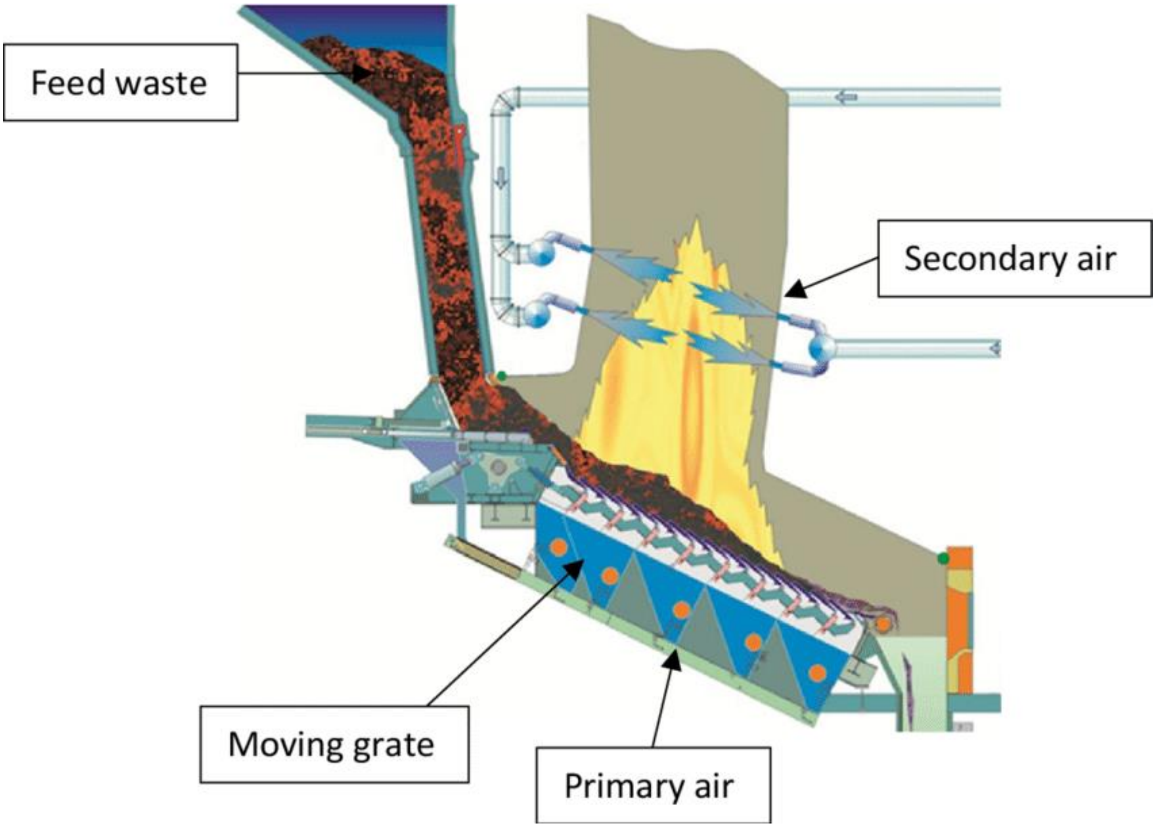
As the waste burns, ash (inert material and residue after complete combustion) falls off the end of the grate into a collection area, commonly filled with water to quench the bottom ash. The ash is then conveyed off-site to be treated and the excess water in the ash re-used in the quench.

The primary combustion air is delivered through the holes in the grate and is designed to achieve efficient combustion of waste. Secondary combustion air is delivered through nozzles above the grate, where an auxiliary burner(s) (fuelled using oil or natural gas and providing infrequent temperature support during normal operation) is also located. This arrangement serves the dual purpose of creating turbulent air within the combustion chamber and allowing greater control of furnace temperature and completion of the combustion reaction. The exact design of the grate, combustion chamber and combustion air delivery system will vary but are primarily designed to ensure efficient combustion of waste, reduce pollutant formation and allow sufficient residence time for the waste to achieve sufficient burnout.

This method of incineration allows for efficient and reliable combustion of large volumes of heterogeneous waste streams which require little pre-treatment.

A basic furnace design is provided in Figure 2-1.

Figure 2-1 Visualisation of a Typical Moving Grate Incinerator Combustion Chamber



2.1.2 Fluidised Bed

A fluidised bed waste incinerator operates by feeding waste material into the bottom of a combustion chamber where a bed of fluidised sand particles sits. Air is forced through these sand particles, causing movement and fluidising the bed. Fuel and waste are then added. Due to the fluidisation, it is easier to maintain more uniform temperature and oxygen parameters, with these types of incinerators operating at slightly lower temperatures. This makes it easier to control pollutants influenced by combustion conditions, particularly NOx formation.

However, due to the waste being combusted in a fluidised bed of sand, it requires small (<50mm) homogenous waste types and pre-processing is normally always required. Sewage sludge is well suited to being incinerated this way.

Similar to a moving grate incinerator, secondary air and burners (providing infrequent temperature support during normal operation) are used to increase mixing in the upper combustion chamber to allow for greater control of furnace temperatures. Depending on the technique incorporated, levels of bottom ash and fly ash can be higher.

2.1.3 Rotary Kiln

A rotary kiln incinerator operates by feeding waste material (and required fuel and air) into a rotating drum (kiln), which is usually fixed at an angle. The agitation of the waste allows for good combustion of the material and allows the operator to adjust the residence time of the waste. The drum is usually refractory-lined allowing for the burning of waste at higher temperatures, making it suitable for almost any type or composition of waste. A cooling system (water or air) is used to increase the service time of the refractory lining if being used at high temperatures. Exhaust gas and ash are gravity fed into a post-combustion chamber where bottom ash is collected; this chamber also commonly forms a secondary combustion chamber to ensure complete combustion.

2.2 Gasification and Pyrolysis

Gasification and pyrolysis are alternative techniques to the conventional thermal treatment options described in Section 2.1. The technologies require the heating of waste within carefully controlled conditions to avoid complete combustion. The main difference between the two technologies is that gasification occurs in the presence of a sub-stoichiometric level of oxygen; therefore, partial combustion is achieved, whilst pyrolysis occurs in the absence of oxygen (see Figure 2-2).

The heat produced is generally used to raise steam in a boiler, with the combustible gas (known as syngas) either burnt onsite (either in a secondary combustion chamber or gas engine) or captured, cleaned and transported offsite. With gasification, the composition of the air within the reactor is key to the quality of the syngas; pure oxygen results in less nitrogen within the syngas and a cleaner higher calorific fuel. In pyrolysis, heating within an inert environment generally produces a higher calorific value of gas.

While there are no direct emissions from the gasification/pyrolysis process itself, the resulting syngas would require clean-up or post combustion abatement to remove compounds similar to those produced by conventional thermal treatment.

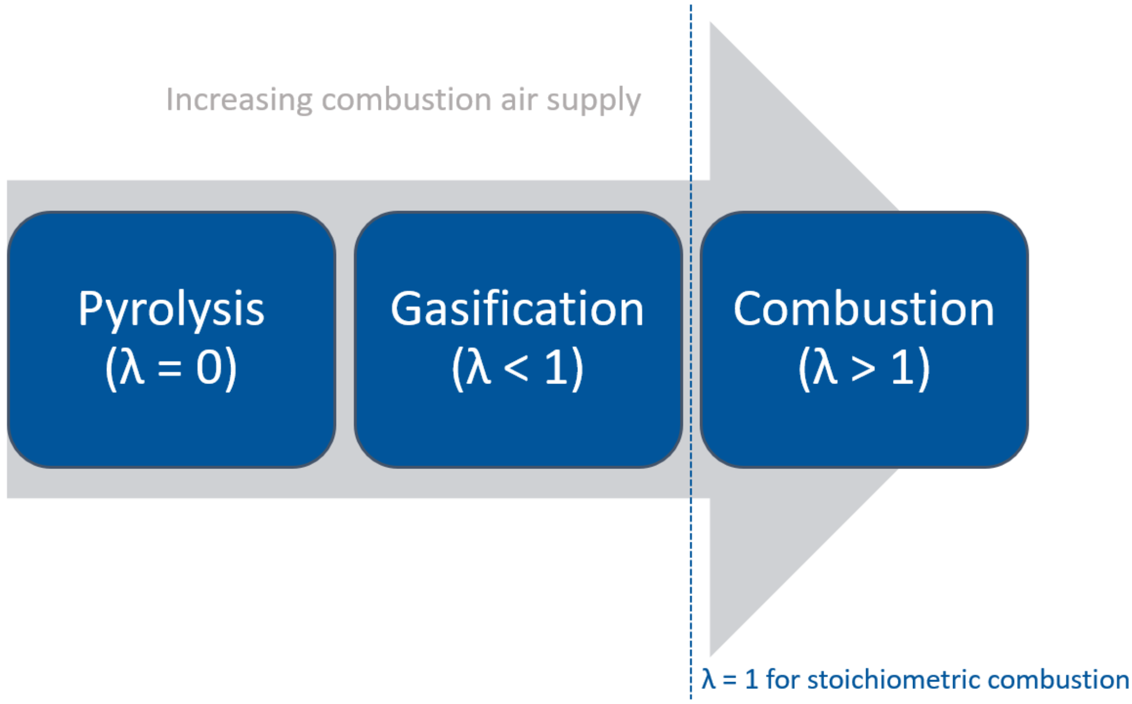
Further clean-up of the char produced during pyrolysis is normally required.

While both gasification and pyrolysis can theoretically accept a variety of waste types, both techniques are generally more efficient with pre-treated waste. Furthermore, current gasification sites generally cannot process more than 20t/h of waste, with pyrolysis having a typical operational limit of around 10t/h.

Additionally, there have also been well-documented construction and/or operational issues with many of these types of plant that have significantly affected availability and/or resulted in permits being revoked [1,2,3,4,5].

[1] https://www.endswasteandbioenergy.com/article/1712896/documents-reveals-vast-list-issues-waste-gasification-plant
[2] https://www.letsrecycle.com/news/gasification-plant-remains-closed-after-re-testing/
[3] https://waste-management-world.com/a/air-products-to-ditch-plasma-gasification-waste-to-energy-plants-in-teesside
[4] https://resource.co/article/Waste_Law/Scotgen_permit_revoked_after_series_breaches-3554
[5] https://resource.co/article/troubled-gasification-plant-stay-closed-until-2018-11585

Figure 2-2 Combustion Air Requirements for Thermal Treatment Technologies



2.3 Assessment of BAT Option

The EfW CHP Facility is required to produce both 28 MW_e (net) of electricity and up to 5 MW_{th} of usable heat. This will require the incineration of large quantities (up to 260,000t/y and up to 41 t/h) of mixed, residual non-hazardous waste. To assess which thermal treatment technology option represents BAT for the EfW CHP Facility, the options have been compared to various selection criteria, including:

- Capacity;
- Variety of waste and pre-sorting requirements;
- Reliability and capacity; and
- Operational experience;

Table 2-1 compares the above criteria for the main types of waste incineration technology.

Table 2-1 Thermal Treatment Technology Options Appraisal

	Moving Grate	Fluidised Bed	Rotary Kiln	Gasification	Pyrolysis
Capacity Range per Line [A]	Large	Medium	Small	Medium	Small
Variety of Waste Accepted	High	Medium	High	Medium	Medium
Pre-sorting Requirements	Low	High	Low	High	High
Proven Technology	High	Medium	High	Low [B]	Low

	Moving Grate	Fluidised Bed	Rotary Kiln	Gasification	Pyrolysis
Operational Experience	High	Medium	Medium	Low	Low

[A] Capacity range expressed as follows: small = < 10t/h; medium = 10 – 25t/h; large = > 25t/h

[B] There have been reported issues with gasification plants within the UK, resulting in significant shutdown periods or permits being revoked.

Based on the amount and type of waste (i.e., mixed residual non-hazardous waste) required to produce the energy requirements, moving grate technology is judged to be BAT for the EfW CHP Facility as it is considered to be the only proven technology to accept large volumes of unsorted, mixed residual household, industrial and commercial waste. As the EfW CHP Facility will not accept powdered or liquid wastes that may melt through the grate, there is no requirement to use a technique more favoured for these types of waste, such as fluidised beds.

3 Options for Appraisal for NOx Emission Control

3.1 Formation of NOx in Combustion Processes

There are three recognised mechanisms leading to the formation of NOx during combustion:

- **Fuel-NO_x** – formed from the oxidation of chemically bound nitrogen in the fuel;
- **Prompt-NO_x** – formed very quickly as a result of the interaction of nitrogen and oxygen with some of the active carbon species derived from the fuel in the flame; and
- **Thermal-NO_x** – formed from the disassociation of atmospheric oxygen and nitrogen at high temperature (> 1000°C).

Of the three mechanisms, fuel-NOx and thermal-NOx are of greater influence for most combustion applications.

The most important reactions for producing NO and NO_2 in flames are:

$$N_2 + O_2 \xleftrightarrow{k_1} 2NO \qquad (1)$$

$$NO + 0.5O_2 \xleftrightarrow{k_2} NO_2 \qquad (2)$$

Equilibrium reaction constants for the formation of NO and NO_2 by reactions (1) and (2) at varying temperatures are given in Table 3-1.

Table 3-1 Equilibrium Constants for the Formation of NO and NO_2 with Temperature

Temperature (K)	K_1 (dimensionless)	K_2 ($atm^{-1/2}$)
300	$7x10^{-31}$	$1.4x10^{6}$
500	$2.7x10^{-18}$	4.9
1,000	$7.5x10^{-9}$	0.11
1,500	$1.07x10^{-5}$	0.011
2,000	$4x10^{-4}$	$3.5x10^{-3}$
2,500	$3.5x10^{-3}$	$1.8x10^{-3}$

The subsequent equilibrium concentrations of NO and NO_2 can be obtained from:

$$[NO] = (k_1[N_2][O_2])^{0.5} \qquad (3)$$

$$[NO_2] = k_2[NO][O_2]^{0.5} \qquad (4)$$

Substituting the values of k_1 and k_2 from Table 3-1, and using equations (3) and (4), Table 3-2 provides the equilibrium concentrations of NO and NO_2 at varying temperatures and varying starting oxygen and nitrogen content.

Table 3-2 Equilibrium Concentration for the Formation of NO and NO_2 with Temperature and Oxygen Content

Temperature (K)	NO (ppm)		NO_2 (ppm)	
	78% N_2, 21% O_2	78% N_2, 4% O_2	78% N_2, 21% O_2	78% N_2, 4% O_2
300	3.4×10^{-10}	1.5×10^{-10}	2.2×10^{-4}	9.5×10^{-5}
500	6.7×10^{-4}	2.9×10^{-4}	1.5×10^{-3}	6.5×10^{-4}
1,000	35	15	2	1
1,500	1,324	578	7	3
2,000	8,094	3,533	13	6
2,500	23,944	10,450	20	9

Analysing Table 3-2, it becomes evident that:

- NO becomes the predominant component of NOx at temperatures greater than 500K;
- Concentrations of NOx increase exponentially with increasing combustion temperature; and
- For a given temperature, concentrations of NOx increase as a square root function of the oxygen content in the combustion atmosphere.

These observations are explained by the Zeldovich mechanism. This mechanism also dictates that NOx formation increases linearly with the residence time at high temperature. Thus, NOx formation is increased with:

- Temperature;
- Residence time at high temperature; and
- Oxygen content at high temperature.

Therefore, as is the case with traditional combustion processes, EfW furnace manufacturers will seek to reduce each of the above to reduce NOx formation. Additional complexity for EfW plants is brought about by the composition of the waste, which, assuming it is not high in nitrogen containing compounds, will not materially affect the formation of NOx itself; however, different waste compositions will affect the stability of the furnace's temperature and oxygen context. As such, it is common for EfW facilities to be equipped with advanced combustion control systems that continuously monitor key process parameters and alter aspects such as primary and combustion air flows, grate speed etc., to ensure stable combustion conditions.

3.2 Options for Reducing NOx Emissions

The options for reducing NOx emissions from the proposed EfW CHP Facility have been informed by the measures highlighted in the waste incineration BREF and BAT Conclusions. They include the following primary and secondary control measures:

- Primary Measures:
  - Optimisation of the combustion process; and
  - Flue gas recirculation.
- Secondary Measures:

- Selective catalytic reduction (SCR); and
- Selective non-catalytic reduction (SNCR).

3.2.1 Optimisation of the combustion process

Optimisation of the combustion process is the control of conditions within the combustion chamber to limit overly high temperatures and excess/insufficient oxygen levels, which are the main drivers in NOx formation during the combustion of waste. This also involves ensuring a uniform supply of homogenised waste to avoid 'spikes' in combustion conditions.

Optimisation of the combustion process is primarily achieved by the design of the combustion chamber itself, as well as controlling the speed at which the waste is fed into the furnace and the supply and injection locations of both primary and secondary combustion air. These parameters can be monitored and controlled by an advanced control system, which monitors e.g., flow rates, temperature, oxygen context, waste depth, grate speed etc., then adjusts accordingly to achieve the optimum conditions.

While there is a financial cost in implementing an advanced control system, the benefits of such a system extend beyond control of NOx emissions, allowing efficient combustion of waste, reduced ash formation, control of reagent input and minimisation of raw materials, and reduction in the formation of other pollutants, such as carbon monoxide and organic compounds.

3.2.2 Flue Gas Circulation

Flue Gas Circulation (FGR) involves replacing between 10 – 20% of the secondary combustion air with recirculated flue-gases. The concentration of oxygen in the flue gas is lower than the secondary combustion air and FGR reduces thermal NOx by both cooling temperatures within the immediate area where the flue gas is introduced and replacing the fuel-air mixture with relatively inert gases such as carbon dioxide (CO_2) and nitrogen (N_2) in preference to oxygen (O_2).

While FGR can reduce NOx formation by between 10% - 20%, it will also increase the cost of the system, as it requires additional duct work and fans to reroute the flue gas back to the combustion chamber. Importantly, it also increases the parasitic energy demand and can increase levels of corrosion and therefore, maintenance costs.

3.2.3 Selective Catalytic Reduction

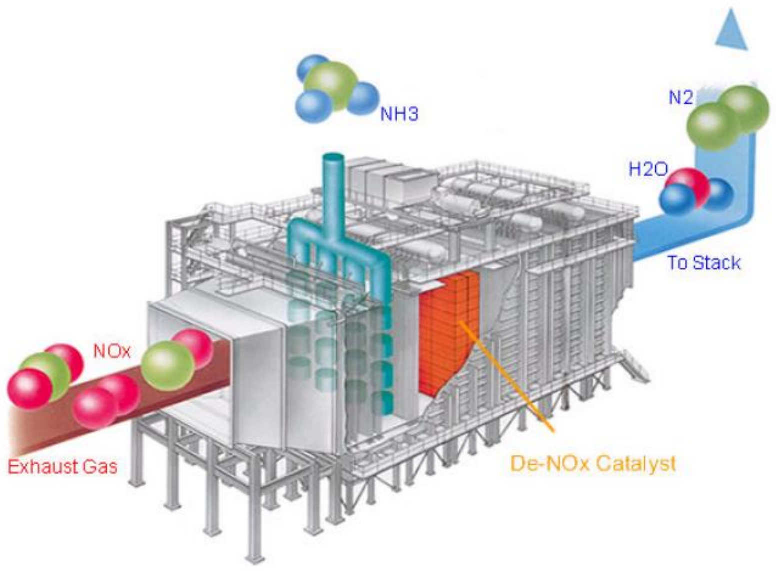
Selective Catalytic Reduction (SCR) is a process by which NOx is removed from the exhaust gases following combustion. SCR operates by injecting ammonia (NH_3), or high purity urea, into the exhaust gas stream. The NH_3 is adsorbed on to the surface of a catalyst (typically containing copper or titanium compounds) and reactions on the catalyst surface reduce NOx to molecular nitrogen (N_2):

$$4NO + 4NH_3 + O_2 \longrightarrow 4N_2 + 6H_2O \qquad (5)$$

$$2NO_2 + 4NH_3 + O_2 \longrightarrow 3N_2 + 6H_2O \qquad (6)$$

An example SCR process schematic is provided in Figure 3-1. SCR can typically achieve NOx reductions of 80-90% and emission concentrations less than 50 mg/Nm^3 (@ 11% oxygen).

Figure 3-1 Example SCR Process Schematic



The SCR catalyst operates in an ideal temperature band and its location within the overall process is, therefore, of crucial importance. This often results in the requirement to re-heat flue gases to attain the ideal operating temperature which can manifest as a fuel penalty (e.g., if gas is supplementary fired to provide the additional heat) or efficiency penalty (if steam is used). The catalyst is also very sensitive to sulphur concentrations within the flue gas; the sulphur can react directly with the catalyst reducing its NO_x reduction efficiency and ammonia and sulphurous compounds can react to produce ammonium sulphate particles, which can build up on the surface of the catalyst and result in catalyst deactivation.

Not all NH_3 is used in the reduction process; some passes through the catalyst and is emitted directly to atmosphere. This process is known as ammonia slip and may result in environmental impacts if feedback mechanisms are not in place to prevent the overdosing of NH_3.

The installation and operation of an SCR plant can be at significant economic cost. Additional capital costs compared to other control techniques in the form of the catalyst and reactor, reheat systems and civil works, and additional operational costs associated with catalyst cleaning/replacement and efficiency/power generation losses from reheat requirements may prove prohibitive in certain situations.

Catalyst lifetime can range from 3 – 5 years dependent on the waste type, capacity, plant operation, inlet NO_x concentration, required outlet concentration and the allowable ammonia slip.

SCR units are less efficient when a combustion unit is in start-up mode as the required temperatures in the catalyst bed are not yet reached. This can cause higher concentrations of NO_x and increased NH_3 slippage at start-up. The SCR unit's ability to control emissions at start-up, and during significant load changes, depends both on the control system and the design of the catalyst itself. Older systems have a greater tendency to emit higher levels of NO_x and NH_3 at start-up and during significant load changes. However, more modern designs, with low thermal mass catalysts, allow the unit to reach optimum operating temperature generally within 10 minutes.

In addition to ammonia slip, other cross media effects associated with the use of SCR relate to the periodic requirement to dispose of additional waste streams (spent catalyst) and potential safety issues relating to ammonia storage.

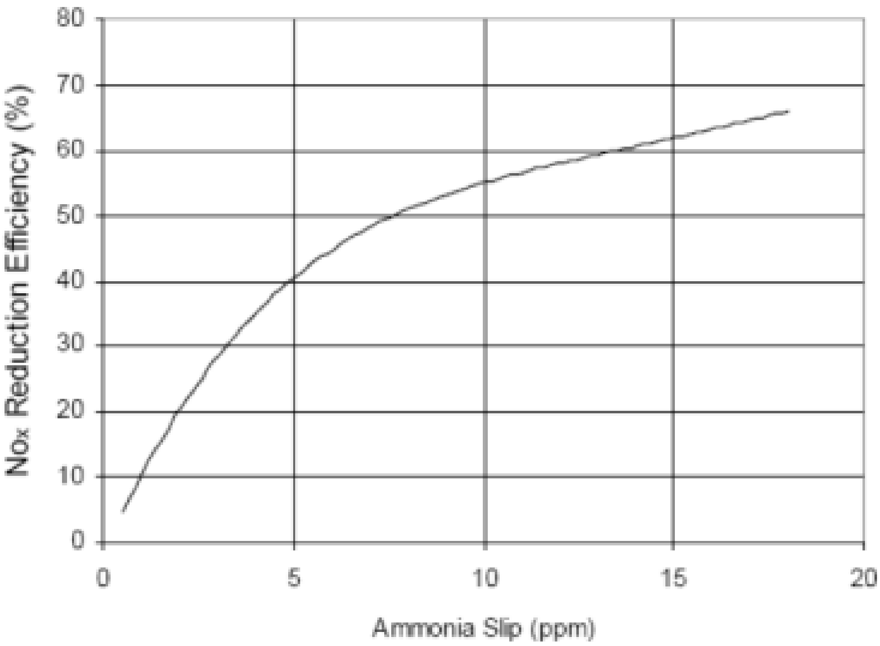
3.2.4 Selective non-Catalytic Reduction

Selective non-catalytic reduction (SNCR) is the process by which NOx is removed from the exhaust gases within the combustion chamber itself. This follows a similar process to SCR (equations 5 and 6); with either a form of ammonia or urea reacting with NO_X in the presence of oxygen to form nitrogen and water. The exact chemistry will depend on the reagent used, but if urea is used, greater amounts of nitrous oxide (N_2O) will be formed due to the isocyanic acid produced when urea is broken down to ammonia.

SNCR operates within a much higher, specific temperature band of 750 - 1000°C and, therefore, is suitable for the combustion chamber of most EfW furnaces. This effective temperature range is reduced to between 850 - 950°C if ammonia is used as a reagent. As with SCR, any unreacted ammonia will slip through into the exhaust gas. It is therefore important to employ SNCR with techniques to optimise the combustion process and control the amount of reagent used, to avoid excess ammonia slip (see Figure 3-2).

SNCR has advantages over SCR in terms of energy efficiency, cost and material use (no catalyst is required); however, SCR can achieve higher levels of NOx reduction and lower levels of N_2O emissions.

Figure 3-2 Relationship between NOx Reduction Efficiency and Ammonia Slip



3.3 Assessment of the BAT option

An initial screening exercise has been performed to identify whether any of the potential NO_X emission reduction options in Section 3.2 are unlikely to be viable for the specific site location. This screening is summarised in Table 3-3.

As an example of best practice which offers a multitude of benefits and operational control beyond just reducing NO_x emissions, an advanced control system is already featured in the base design case for the proposed EfW CHP Facility and, consequently, has not been subject to further comparative assessment in the options appraisal.

Table 3-3 Initial Screening of Options for NOx Emissions Control

Option	Feasible	Justification for exclusion if not considered feasible
Optimisation of Combustion Process	Yes	Considered as part of the base case design and not subject to further comparative assessment
Flue Gas Recirculation	Yes	-
SCR	Yes	-
SNCR	Yes	-

To determine the BAT option for the EfW CHP Facility, it is necessary to estimate the costs of the different techniques, the emission reductions achievable, potential cross media effects and whether each option is capable of meeting the BAT Associated Emission Levels (BAT-AEL) and IED Emission Limit Values (ELVs).

Costs can be broadly categorised in to two elements:

- Capital expenditure (CAPEX) – the initial capital investment to acquire and install an emission control technology.
- Operating expenditure (OPEX) – the ongoing costs that are required to operate and maintain the emission control technology. OPEX can be further sub-categorised in to variable OPEX, i.e., costs that are dependent on the level of activity, e.g., utility costs, costs for waste disposal etc., and fixed OPEX, i.e., costs that are independent on the level of activity, e.g., labour, insurance etc.

The accuracy of any cost estimate depends on the stage of engineering development at which that estimate is made. The more detailed the design, the more accurate the cost estimate. Since detailed design development requires considerable effort, and can be both time consuming and expensive, it is important to establish what accuracy of estimate is required.

At one end of the development scale is a feasibility study estimate, which can be used for ranking and elimination of clearly uneconomic options. Such estimates require less time and effort and typically have an uncertainty rating of ± 30-50% as quoted by AACE International Recommended Practice 18R-97 '*Cost Estimate Classification System as Applied in Engineering, Procurement and Construction for the Process Industries*'.

At the other end of the scale is a high-definition estimate which requires detailed descriptions of each individual piece of equipment and, therefore, requires substantial effort. Such estimates typically result from detailed design studies and are used for making investment decisions and budgeting. These estimates typically have an accuracy of ±10%. However, the amount of effort (and cost) to develop this level of definition is significant. In many cases, detailed engineering design can account for between 10 – 15% of the overall CAPEX. Hence, for a single emission control technique on one site which may have a CAPEX of £30M, the detailed engineering design itself, i.e., the process by which a ±10% cost estimate could be obtained, could quite conceivably cost between £3M – 4.5M.

For environmental strategy and options appraisals, a feasibility type estimate will generally be sufficient and is the basis upon which the cost estimates in this assessment have been made. Although this analysis is less detailed than that resulting from a detailed design study, this does not mean that the cost estimate is meaningless, simply that the level of uncertainty associated with the cost estimates must be understood and appreciated before making decisions based on these estimates.

Estimated capital and operating costs for the techniques have been developed based on data contained within the European Commission's waste incineration BREF or previous project experience. These are not detailed cost estimates and represent an uncertainty level associated with a feasibility-type estimate. However, this basis is suitable for ranking the different options by their potential cost.

Where capital costs are provided for a stated level of capacity, the formula below has been used to scale costs to the specific capacity of the EfW CHP Facility as adopted by Concawe (2011)[6].

$$C = C_{ref}\left(\frac{A}{A_{ref}}\right)^{0.6}$$

Where:

C = cost for a specific capacity of plant

C_{ref} = cost for a reference plant

A = capacity or activity level of the specific plant

A_{ref} = capacity or activity level of the reference plant

The capital costs can be annualised and combined with operating costs to derive an equivalent annual cost (EAC) by applying an annuity factor to the capital cost. The annuity factor is calculated from the lifetime of the investment, n, (in this case the anticipated lifetime of the emissions reduction technique) and a discount rate, r:

$$A = \frac{r}{1-(1+r)^{-n}}$$

The discount rate is the interest rate used to determine the present value of future cash flows. For the purposes of this study, a discount rate of 3.5% has been used which is consistent with approaches for policy assessment in the UK e.g., HM Treasury Green Book. The lifetime of each technique has been assumed as 20 years[7].

By combining the EAC with the annual mass of pollutant avoided, it is possible to calculate the cost-effectiveness of each technique, expressed as a £/tonne figure. For the purposes of assessing the mass of NOx abated, it has been assumed the NOx emission level with just the advanced combustion control system would be 375 mg/Nm^3 (@ 11% oxygen) based on design data.

Table 3-4 provides relevant emission reduction and cost data for the NOx emissions control techniques.

Table 3-4 NOx Emission Reduction and Cost-Effectiveness Data

	SCR	SNCR	SNCR + FGR
Daily average NO_x emission concentration without technique (mg/Nm^3) [A]	375	375	375
Annual NO_x emission without technique (t/y) [B]	657	657	657
Daily average NO_x emission concentration with technique (mg/Nm^3)	50	120	108 [C]
Annual NO_x emission with technique (t/y)	88	210	189

[6] Concawe (2011) 'Cost effectiveness of emissions abatement options in European refineries' Report no. 6/11
[7] The design lifetime of the EfW CHP Facility overall is 40 years.

	SCR	SNCR	SNCR + FGR
NO_x emissions reduction (t/y)	569	447	468
Annual mean NO_2 process contribution as percentage of air quality standard	0.3%	0.8%	0.7%
Annualised capital cost (£/y) [D]	497,099	124,275	226,443
Operating costs (£/y) [E]	747,114	273,211	309,470
Equivalent annualised costs (£/y)	1,244,213	397,486	535,913
Cost-effectiveness (£/tonne)	2,187	889	1,145

[A] Emission concentration expressed at reference conditions of 273K, 101.3 kPa, 11% O_2, dry gas

[B] The plant is anticipated to operate up to 7,830 hours in a year and therefore all calculations are based on the upper value of 7,830 hours / year.

[C] Assumes a further 10% reduction in emissions compared to SNCR alone.

[D] Capital costs have been taken from the European Commission's waste incineration BREF and uplifted from a 2002 base year to 2024 base year using a 2002 – 2024 GDP GBP inflator of 1.76 and EUR to GBP exchange rate of 1 EUR = 0.857 GBP.

[E] Operating costs have been established from experience of other facilities (using 2022 data) with linear interpolation between the different capacities. Operating costs include e.g., maintenance costs, reagent costs, monetary valuation of the reduction in exported power due to a higher parasitic demand etc. The 2022 operating costs have been uplifted to 2024 using a 2022 – 2024 GDP GBP inflator of 1.08.

BAT has been established by comparing the cost-effectiveness of the techniques and wider aspects including cross-media effects, whether the technique is capable of achieving the BAT-AEL and whether the technique prevents an exceedance of relevant environmental benchmarks. This summary comparison is presented in Table 3-5.

Table 3-5 Summary of NOx Emission Control Options

	SCR	SNCR	SNCR + FGR
Emission reduction achieved (t/y)	569	447	468
Annual mean NO_2 process contribution as percentage of air quality standard	0.3%	0.8%	0.7%
Cost-effectiveness (£/tonne)	2,187	889	1,145
Typical N_2O emissions with technique (mg/Nm^3)	10 - 15	25 - 35	25 - 35
Typical NH_3 emissions with technique (mg/Nm^3)	< 3	1 - 6	1 - 6
Waste production/raw material requirement [A, B]	3	1	1
Photochemical ozone creation potential [A, C]	3	1	2

	SCR	SNCR	SNCR + FGR
Global warming potential [A, D]	3	1	2
Meets BAT-AEL?	Yes	Yes	Yes
Exceedances of environmental assessment level for ambient air?	No	No	No

[A] Ranked based on performance. A lower score indicates the better performing technique.

[B] SCR requires a catalyst that needs to be periodically replaced and disposed of.

[C] NO acts as a sink for ozone in the troposphere, i.e., it has a negative POCP value (-42.7), and this absolute value is greater than that of NO_2 which has a positive POCP value (2.8). Hence, as more than 90% of NO_x emissions will be in the form of NO, techniques which reduce NO_x emissions the most have a negative impact on photochemical ozone creation potential (i.e., result in less ozone destruction compared to other techniques).

[D] Whilst N_2O emissions are higher for SNCR/SNCR+FGR than SCR, SCR introduces an additional pressure drop resulting in an increase in power consumption by the ID fan, whilst the requirement to re-heat flue gases to the optimum temperature of the catalyst reduces power generated by the turbine. Both factors reduce the net electrical export and decrease the energy efficiency. FGR requires additional fans to recirculate the flue gas, which increases the parasitic demand of the EfW CHP Facility compared to SNCR alone.

Whilst SCR performs better from a NO_x emissions release perspective, the overall environmental performance of the SNCR option is considered to be more optimal as it has fewer cross media effects than SCR (or SNCR in combination with FGR) and, on its own, will meet the required BAT-AELs and prevent an exceedance of respective environmental benchmarks. As a result, it is considered to represent the BAT option for the proposed EfW CHP Facility.

4 Options for Acid Gas Emissions Control

During the combustion of municipal waste, acid gases such as SO_2, HCl and HF are formed within the combustion chamber in high concentrations. For example, plastics may contain large amounts of chlorinated or fluorinated compounds which, when combusted, convert to HCl and HF. Sulphur compounds can also be present in large amounts of household waste items and when combusted will oxidise to SO_2 within the furnace. As emissions of these components are exclusively determined by their content in the incoming waste, controlling the combustion conditions will have less of an effect on the formation of acid gases which must be removed using secondary measures. The various techniques that could constitute BAT are discussed below.

4.1 Options for Reducing Acid Gas Emissions

For all acid gases, BAT is to remove the compounds by passing them through a scrubber. Several different types of scrubbers can remove acid gases and constitute BAT. These include:

- Wet scrubbers;
- Semi-dry scrubbers; and
- Dry scrubbers.

4.1.1 Dry Scrubbing

Dry scrubbing is the process of removing acid gases by passing the flue gas through a reaction chamber and injecting a powdered sorbent. This powdered sorbent commonly takes the form of a calcium or sodium-based compound, such as hydrated lime or sodium bicarbonate. The acid gases react with the sorbent, forming solid calcium or sodium containing compounds and water; using hydrated lime as an example ($Ca(OH)_2$) the relevant chemical reactions are given below:

$$Ca(OH)_2 + SO_2 + 0.5O_2 \longrightarrow CaSO_4 + H_2O \quad (7)$$

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O \quad (8)$$

$$Ca(OH)_2 + 2HF \longrightarrow CaF_2 + 2H_2O \quad (9)$$

The flue gas containing the newly formed solid calcium or sodium containing compounds exits the reaction chamber and passes through a particulate removal stage (such as a fabric filter) to remove the solid reaction products. Temperature, humidity and the relationship between SO_2/HF/HCl concentrations have an impact on the efficiency of the acid gas removal. The removal efficiency can therefore be controlled by lowering the flue gas temperature prior to abatement and/or increasing the relative humidity, and using an automated dosing control system (therefore maintaining an optimum acid gas equilibrium). To reduce reagent consumption and increase efficiency, it is common practice to re-inject portions of the particulate matter deposited in the fabric filter to minimise the amount of unreacted sorbent.

4.1.2 Semi-dry Scrubbing

With semi-dry scrubbing, the powdered sorbent agent is mixed with water to form a slurry and injected into the reaction chamber. Similar reactions in equations 7, 8 and 9 occur within the slurry and, when the water is evaporated by the heat of the flue gas, leaves behind an alkali solid. As with dry scrubbing, a post particulate removal stage is required to remove the solid reaction products. Semi-dry scrubbing has the disadvantage of increasing water and power consumption, as well as resulting in a slightly higher quantity of waste residue to dispose of..

4.1.3 Wet Scrubbing

Wet scrubbers control acid gases by passing the flue gas through water or liquid alkaline solution, such as an aqueous lime or sodium hydroxide solution. The solution reacts with the acid gases to form salts, which are then collected as a sludge, dewatered, and landfilled. Wet scrubbers used to treat acid gases from waste incineration are normally two or three stages, being a mixture of venturi and tower scrubbers. Wet scrubbing is also capable of reducing particulate matter emissions, although cannot meet the same level of reduction as a fabric filter. Wet scrubbing can have a high removal efficiency that is superior to dry/semi-dry scrubbing due to the high contact time with the liquid reagent; however, it has significantly higher cross media effects in the form of water consumption, energy requirements and waste disposal requirements.

4.2 Assessment of the BAT option

An initial screening exercise has been performed to identify whether any of the potential acid gas emission reduction options in Section 4.1 are unlikely to be viable for the specific site location. This screening is summarised in Table 4-1.

Table 4-1 Initial Screening of Options for Acid Gas Emissions Control

Option	Feasible	Justification for exclusion if not considered feasible
Dry scrubbing	Yes	-
Semi-dry scrubbing	Yes	-
Wet scrubbing	No	Wet scrubbing requires significant volumes of water and produces a hazardous waste liquid effluent that requires treatment before being discharged from site. There is insufficient space within the plot area to accommodate the capacity and type of effluent treatment required. Whilst wet scrubbing is considered a candidate BAT option in the BAT Conclusions, it is mainly used for facilities treating hazardous liquid and chemical waste with high chlorinated and fluorinated content that would require the additional removal efficiency achieved by wet scrubbing. The EfW CHP Facility will not accept such wastes, and precedent established by the Environment Agency on other municipal waste incinerators suggest this option would not be considered BAT due to the potentially significant cross media effects. Furthermore, wet scrubbing could not meet the IED ELVs and BAT-AEL in isolation.

To determine the BAT option for the EfW CHP Facility, it is necessary to estimate the costs of the different techniques, the emission reductions achievable, potential cross media effects and whether each option is capable of meeting the BAT-AEL and IED ELVs.

Costs have been developed on a similar basis as that described for NOx in Section 3. For the purposes of assessing the cost-effectiveness, emissions of HCl have been used as a proxy pollutant based on the guidance in EPR 5.01. The design estimate of the HCl concentration of the flue gas leaving the boiler is 1,200 mg/Nm^3 (@ 11% oxygen). Table 4-2 provides relevant emission reduction and cost data for the acid gas emissions control techniques.

Table 4-2 Acid Gas Emission Reduction and Cost-Effectiveness Data

	Semi-dry scrubbing	Dry scrubbing
HCl emission concentration without technique (mg/Nm^3) [A]	1,200	1,200
Annual HCl emission without technique (t/y) [B]	2,104	2,104
Daily average HCl emission concentration with technique (mg/Nm^3)	6	6
Annual HCl emission with technique (t/y)	11	11
Hourly mean HCl process contribution as a percentage of Environmental Assessment Level	0.2%	0.2%
HCl emissions reduction (t/y)	2,093	2,093
Annualised capital cost (£/y) [C]	186,412	178,024
Operating costs (£/y) [D]	4,046,073	3,710,815
Equivalent annualised costs (£/y)	4,232,485	3,888,838
Cost-effectiveness (£/tonne)	2,022	1,858

[A] At reference conditions of 273K, 101.3 kPa, 11% O_2, dry gas

[B] The plant is anticipated to operate up to 7,830 hours in a year and therefore all calculations are based on the upper value of 7,830 hours / year.

[C] Capital costs have been taken from the European Commission's waste incineration BREF and uplifted from a 2002 base year to 2024 base year using a 2002 – 2024 GDP GBP inflator of 1.76 and EUR to USD exchange rate of 1 EUR = 0.857 GBP. The estimate excludes costs for the fabric filter as it is assumed this forms part of the BAT base design basis for control of particulate matter emissions.

[D] Operating costs have been established from experience of other facilities (using 2022 data) with linear interpolation between the different capacities. Operating costs include e.g., maintenance costs, reagent costs, monetary valuation of the reduction in exported power due to a higher parasitic demand etc. The 2022 operating costs have been uplifted to 2024 using a 2022 – 2024 GDP GBP inflator of 1.08.

BAT has been established by comparing the cost-effectiveness of the techniques and wider aspects including cross-media effects, whether the technique is capable of achieving the BAT-AEL and whether the technique prevents an exceedance of relevant environmental assessment levels for ambient air. This summary comparison is presented in Table 4-3.

Table 4-3 Summary of Acid Gas Emission Control Options

	Semi-dry scrubbing	Dry scrubbing
Emission reduction achieved (t/y)	2,093	2,093
Hourly mean HCl process contribution as a percentage of Environmental Assessment Level	0.2%	0.2%
Cost-effectiveness (£/tonne HCl)	2,022	1,858

	Semi-dry scrubbing	Dry scrubbing
Typical HCl emissions with technique (mg/Nm^3)	6	6
Water consumption (l/tonne waste)	300	45[A]
Reagent use (kg/tonne waste)	7 – 10	10 – 20
Energy requirement (kWh/tonne waste)	6 – 13	< 5
Meets BAT-AEL?	Yes	Yes
Exceedances of environmental assessment levels for ambient air?	No	No

[A] Although water will not be used to form a lime slurry, water will be used for humidification purposes in the reactor to increase the abatement efficiency.

On the basis of the evidence in Table 4-3, dry scrubbing has been selected as the BAT option for the EfW CHP Facility. The justification is summarised as:

- Dry scrubbing achieves a similar level of emissions performance as semi-dry scrubbing and is a more cost-effective technique;
- Dry scrubbing reduces the consumption of water;
- Whilst semi-dry scrubbing has a slightly lower reagent requirement, it has a larger energy requirement than dry scrubbing. Hence, coupled with the reduced consumption of water, there are fewer cross-media effects with dry scrubbing; and
- Dry scrubbing can meet the BAT-AEL and prevents exceedances of relevant environmental benchmarks.

4.3 Options for Acid Gas Removal Reagent Selection

In addition to establishing the BAT option for acid gas management technology, it is also relevant to identify the BAT option for reagent selection, since different reagents are available. As wet and semi-dry scrubbing have been eliminated as suitable techniques for the EfW CHP Facility, only reagents used for the dry system (hydrated lime or sodium bicarbonate) have been considered.

The following sections detail how the two reagents may affect the different factors that influence the BAT decision making process.

4.3.1 Acid Gas Removal Efficiency

Neither hydrated lime nor sodium bicarbonate will materially affect the emission reduction estimated in Table 4-2. They both would provide the same level of acid gas removal.

4.3.2 Photochemical Ozone Creation Potential (POCP)

As hydrated lime and sodium bicarbonate provide the same level of acid gas abatement, they would consequently have the same POCP.

4.3.3 Global Warming Potential (GWP)

Sodium bicarbonate has a higher optimum reaction temperature range than hydrated lime which means less heat can be captured in the boiler (unless used in a boiler sorbent injection configuration where the reagent injection occurs within the boiler itself) and the optimum reaction temperature is generally at the upper end for particulate matter control using bag filters. Furthermore, the reaction of acid gases with sodium bicarbonate results in emissions of CO_2, whereas the reaction with hydrated lime does not. Hydrated lime therefore has a GWP advantage compared to sodium bicarbonate.

4.3.4 Raw Material Consumption and Waste Residues

The reagents are generally injected in excess quantities than required to promote the acid gas reduction reactions. On a molar basis, more hydrated lime is required to be added to ensure an efficient reaction takes place than sodium bicarbonate and the stoichiometric ratio (the ratio between the quantity of reagent supplied and the minimum requirement for the reaction) is also higher.

The mass of waste residues produced is similar for each option due to differences in the relative molecular weight and number of moles reacting. However, hydrated lime produces a low leaching solid residue, whilst residues from sodium bicarbonate are more leachable. Additionally, certain emerging techniques e.g., Carbon8 Accelerated Carbonation Technology, can recycle lime-based residues but cannot do so for bicarbonate residues.

4.3.5 Costs

The purchase price for sodium bicarbonate is higher than that of lime, as is the disposal cost, as sodium based residues are more difficult to stabilise than calcium. Consequently, operating costs with sodium bicarbonate can be more than 50% greater than those with lime.

4.3.6 Conclusion

Hydrated lime has been selected as the BAT option for reagent choice on the basis of:

- No material difference in the acid gas emissions or POCP of either reagent;
- Lower GWP;
- Residues which are less prone to leaching;
- Future potential for recycling lime based residues; and
- Lower operational costs.

5 Options for Cooling Systems

EfW facilities generally operate under the Rankine cycle whereby heat energy is supplied to a boiler and a working fluid (water) is converted to high pressure steam to drive a steam turbine. After the turbine, the fluid is condensed back to a liquid state, rejecting waste heat, before the cycle begins again. The condenser and the cooling system are, therefore, key parts of the EfW CHP Facility and can have significant impacts on its efficiency and availability.

Cooling systems are required in all EfW facilities to remove the condensation energy from the steam, or the unusable energy of the process, and allow the release of non-recoverable heat to the environment. Cooling systems can be categorised by their design and by the main cooling principle, which typically involves using water or air, or a combination of water and air, as coolants.

The cooling systems options for the EfW CHP Facility have been informed by the measures highlighted in both the European Commission Industrial Cooling Systems and Waste Incineration BREF. These options include:

- Once-through cooling systems;
- Closed circuit wet evaporative cooling systems; and
- Closed circuit dry cooling system.

5.1 Once-through cooling systems

In direct once-through cooling (OTC) systems, water is pumped from a source, such as a river, lake or the sea using large water inlet channels directly to the process. After passing heat exchangers or condensers the heated water is discharged directly back to the surface water source. The heat is transferred from the process to the coolant through a partition wall in the form of tubes in a shell and tube heat exchanger or in a plate in a frame heat exchanger.

Indirect OTC systems are also available where there is no direct transfer from the process fluid/vapour to the coolant that is discharged. Heat is transferred from the process to a coolant that circulates in a closed circuit. The coolant in this secondary cooling circuit transfers its heat via heat exchangers to the coolant (e.g., surface water) that flows through the heat exchangers only once. This primary cooling water is directly discharged into the surface water, whereas the secondary coolant remains in the closed circuit. This avoids, or reduces, the risk of discharges of leaked process fluids to surface water.

OTC systems have the best performance of any cooling system and have the lowest impact on plant efficiency. However, OTC systems consume substantial quantities of water which needs to be returned to the receiving water body at elevated temperature. This increased thermal load can deplete dissolved oxygen levels and have associated ecological impacts. Aquatic organisms can also be drawn into cooling water intakes and become impinged on the intake structure, or entrained in the cooling water system itself.

5.2 Closed circuit wet evaporative cooling systems

In these systems, cooling water that is passed through the heat exchangers is cooled in a cooling tower where the majority of the heat is discharged to the environment. In the cooling tower, the heated water is distributed over the cooling tower fill and is cooled by contact with air and collected in a reservoir, after which it is pumped back to be reused as a coolant.

The air movement is created by natural draught or by means of fans that push or pull the air through the tower. Cooling of the water is a result of evaporation of a small part of the cooling water and of sensible heat loss by the direct cooling of water by air. Cooling towers can be either natural draught wet cooling towers, or mechanical draught cooling towers, where fans assist in providing the necessary airflow, allowing a lower profile cooling tower to be used.

Most of the water that is cooled in the cooling tower is recirculated and can be used as cooling water again. However, not all of the water is recovered and the main causes of water loss from the closed-circuit system include:

- Evaporation;
- Drift and windage; and
- Purge i.e., intentional blowdown

Portions of the recirculating cooling water system need to be periodically purged to avoid thickening of the cooling water and to reduce the concentration of any contaminants. To compensate for the blowdown and evaporation, water is added to the system, also referred to as make-up water. Generally, the make-up water flow used by a recirculating system is only a fraction (1 – 3%) of that required by an OTC system for the same cooling capacity. However, whilst the make-up water consumption is substantially less than that of an OTC system, the system still requires sufficient quantities of water available all year round.

Other benefits of this system compared to an OTC system is a reduction in the heat load to the receiving water body by transfer of heat from the water to air. However, this does create a saturated, visible plume which may condense on surfaces causing corrosion or may lead to icing in low ambient temperatures.

To control the growth of bacteria and fungi in the recirculating cooling water system, e.g., to control the development of Legionella, it is typical to add biocides. These biocides will be contained within the purge water discharged back to the surface water. Consequently, the purge water typically needs further on-site treatment before it can be discharged back to the receiving water body. Bacteria and fungi can also be carried over in the spray/drift from cooling towers (also known as bioaerosols) with associated health implications.

5.3 Closed circuit dry cooling systems

Dry cooling systems typically involve the use of an air-cooled condenser (ACC). In this arrangement, the exhaust steam from the steam turbine is ducted to the ACC where the steam is distributed through a large number of finned tubes. Cooling air is forced over these tube bundles by fans. The steam rejects heat directly to the atmosphere via the finned tubes, condenses and flows by gravity into a condensate tank.

The ACC concept is technically feasible over a wide range of power plant unit sizes although, due to space and costs, dry cooling systems are generally not used for very large capacities and are typically restricted to plant with a capacity less than 900 MW_{th}.

Compared to wet cooling systems, the ACC's efficiency of heat transfer to the atmosphere is relatively low with the returned water temperature largely being determined by the dry bulb air temperature. Consequently, performance suffers with increasing ambient temperatures. However, dry cooling with an ACC avoids the need for large cooling towers, removes the requirement for chemical dosing and associated monitoring, eliminates the vapour plume and avoids the requirement to extract and discharge large quantities of water.

As ACCs use a number of large fans, the parasitic demand is generally increased compared to wet cooling methods, reducing the power plant's net electrical efficiency. ACCs also increase the noise profile of the plant.

5.4 Assessment of the BAT Option

An initial screening exercise has been performed to identify whether any of the potential cooling system options are unlikely to be viable for the specific site location. This screening is summarised in Table 5-1.

Table 5-1 Initial Screening of Options for Cooling Systems

Option	Feasible	Justification for exclusion if not considered feasible
Once through cooling (OTC) systems	No	There is no suitable local water resource to provide the relevant cooling requirement.
Closed circuit wet evaporative system	Yes	-
Air cooled condensers (ACC)	Yes	-

To assess which cooling system option represents BAT for the EfW CHP Facility, the two options which have passed the screening stage have been compared to various selection criteria, including:

- Water resource requirement;
- Capital expenditure;
- Operating expenditure;
- Effects on plant electrical efficiency; and
- Cross media effects.

Table 5-2 presents this comparison in matrix form.

Table 5-2 Cooling systems options appraisal

Criterion	Closed circuit wet evaporative system	ACC system
Water resource requirement	Low	None
Typical capital expenditure (£k/MW_{th}) [A]	150 – 447	176 – 484
Typical operating expenditure (£k/y/MW_{th}) [A]	50 – 128	29 – 79
Effect on net electrical efficiency (relative to closed circuit wet evaporative)	0	- 0.6%
Cross media effects	Visible plume, carry-over of biocides in purge water to surface water bodies, bioaerosol emissions, noise	Noise

[A] Prices estimated for a 2024 base year. Estimates developed from the Industrial Cooling Systems BREF and forecast from a 1995 base year to 2024 base year using a 1995 – 2022 GDP GBP inflator of 1.96 and EUR to GBP exchange rate of 1 EUR = 0.857 GBP.

Based on the data in Table 5-2, an AAC (closed-circuit dry cooling) system is considered BAT for this location despite having a greater impact on energy efficiency due to the following factors:

- The closed circuit wet evaporative system, whilst significantly reducing the water requirement compared to an OTC system, still requires a year-round water supply and will increase water consumption by the EfW CHP Facility. An ACC will minimise water consumption compared to the other systems;

- The closed circuit wet evaporative cooling system has a requirement to treat significant amounts of water before being discharged to a receiving water course; and
- Dry cooling systems have fewer cross media effects than a closed circuit wet evaporative system. They do not produce a visible plume, do not result in effluent discharges containing biocides, and do not result in the emission to air of bioaerosols.

6 Comparison against sectoral BAT Conclusions

Table 6-1 compares the design of the proposed EfW CHP Facility against the indicative BAT requirements in the European Commission's BAT Conclusions for Waste Incineration.

Table 6-1 Comparison against BAT Conclusions for Waste Incineration

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
BAT 1	In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates a list of features as identified in the waste incineration BAT Conclusions document.	MVV has an existing Integrated Management System (IMS) in place certified to ISO 14001:2015. The scope of the IMS includes MVV's operations at other EfW facilities and waste wood biomass plants in the UK and Germany. The scope of the IMS will be extended to cover operations at the proposed EfW CHP Facility and the Operator proposes to achieve certification of the extended IMS within the first 18 months of its operation. The extended IMS will reflect the specific requirements for environmental management systems in the Environment Agency's guidance and BAT 1. This will ensure that compliance with the permit and the required standards of environmental protection are achieved. The key elements of the IMS will include: • Leadership Hierarchy; • Site Risk Assessment; • MVV Environmental Policy; • Maintenance philosophy, policy and strategy; • H&S Training Procedure; • Complaints Procedures; • Internal Audit Procedure; • Other than normal operating conditions (OTNOC) management plan; • Odour management plan; • Accident Management Plan; • Site Emergency Response Plan; • Site Closure Plan; and • Fire Prevention Plan.	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
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.	The gross electrical efficiency will be determined by carrying out a performance test at full load during the commissioning stage. Furthermore, MVV operates an IMS accredited to the requirements of ISO 50001:2018, and this existing accreditation will be extended to the Operator to cover operations at the proposed EfW CHP Facility. As part of the operational procedures in this system and the associated IMS, energy use and electrical efficiency will be monitored throughout the operational lifetime of the EfW CHP Facility.	Yes
BAT 3	BAT is to monitor key process parameters relevant for emissions to air and water including those given below: Flue-gas from the incineration of waste (flow, oxygen content, temperature, pressure, water vapour content) Combustion chamber (temperature) Waste water from wet flue-gas cleaning (FGC) (flow, pH, temperature) Waste water from bottom ash treatment plants (flow, pH, conductivity)	As detailed further in section 5.9 of the Supplementary Technical Information Report, continuous measurement of the flue gas flow, oxygen content, temperature, pressure and water vapour content, as well as temperature of the combustion chamber will be performed. As wet flue gas treatment will not be used, nor will the treatment of bottom ash take place onsite, these specific components of BAT 3 are not relevant.	Yes
BAT 4	BAT is to monitor channelled emissions to air with at least the frequency given in the waste incineration BAT Conclusions document 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.	Section 5.9 of the supplementary technical information document sets out the pollutants to be monitored and their monitoring method and frequencies. These are fully compliant with the requirements of BAT 4. As permitted by the BAT Conclusions, the following monitoring frequencies will be varied: • Six monthly HF monitoring will be undertaken if HCl emissions are proven to be stable; • PBDD/F will not be monitored as there will be no incineration of brominated flame retardants or use of continuous injection of bromine to reduce emissions of mercury; • Long term sampling of PCDD/F and Dioxin-like PCBs will not be undertaken if extractive sampling using the Environment Agency's PCDD/F Monitoring Protocol proves emissions to be stable; and • In accordance with footnote 5 in BAT 4. continuous monitoring of Hg is not proposed as contractual	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
		specifications with waste providers will ensure a low and stable content of mercury in the incoming waste. This will be demonstrated from an emissions performance perspective using the Environment Agency's Mercury Monitoring Protocol.	
BAT 5	BAT is to appropriately monitor channelled emissions to air from the incineration plant during OTNOC.	Monitoring during OTNOC will be carried out by direct emission measurements for relevant pollutants using CEMS as described in Section 5.9 of the Supplementary Information Document. Emissions during start-up and shutdown of pollutants monitored discontinuously, while no waste is being incinerated, including emissions of PCDD/F, will be estimated based on measurement campaigns carried out every 3 years during planned start-up/shutdown operations. The Operator will develop a formal OTNOC plan as part of the extension to scope of MVV's existing IMS.	Yes
BAT 6	BAT is to monitor emissions to water from FGC and/or bottom ash treatment with at least the frequency given in the waste incineration BAT Conclusions document 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.	BAT 6 is not applicable, as there will be no wet flue gas treatment, nor treatment of bottom ash on-site.	N/A
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 in the waste incineration BAT Conclusions document and in accordance with EN standards.	Incinerator bottom ash will be tested for total organic carbon or loss of ignition every 3 months using EN standards as described in Section 5.9 of the Supplementary Technical Information document.	Yes
BAT 8	For the incineration of hazardous waste containing POPs, 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.	BAT 8 is not applicable, as hazardous waste will not be accepted at the EfW CHP Facility.	N/A

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
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) in the waste incineration BAT Conclusions document, and, where relevant, also techniques (d), (e) and (f): a) Determination of the types of waste that can be incinerated b) Set-up and implementation of waste characterisation and pre-acceptance measures c) Set-up and implementation of waste acceptance procedures d) Set-up and implementation of a waste tracking system and inventory e) Waste segregation f) Verification of waste compatibility prior to the mixing or blending of hazardous wastes	Non-hazardous waste in the form of household, industrial and commercial (HIC) waste will be the only waste delivered to the EfW CHP Facility from pre-approved suppliers with contracts specifying the type of waste to be delivered. The types of waste (EWC codes) approved for use within the EfW CHP Facility are contained in Table 4-1 within the Supplementary Technical Information document. Regular audits of companies supplying waste to the EfW CHP Facility will be undertaken to ensure these contractual requirements are being met. Waste pre-acceptance and acceptance procedures are described in more detail in Section 4.2.1 of the Supplementary Technical Information document and will be incorporated into the IMS (BAT 9a, 9b, 9c). Weighing cells and Automatic Number Plate Recognition (ANPR) cameras will be available to provide input information to an automated tracking system to monitor waste consignments from individual vehicles and the associated mass of waste deposited (BAT 9d). BAT 9e and 9f are not considered applicable as the only waste type accepted at the EfW CHP Facility will be HIC waste and no hazardous waste will be accepted onsite.	Yes
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).	BAT 10 is not applicable as there will be no bottom ash treatment plant onsite.	N/A

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
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 for the elements given below for Municipal Solid Waste (MSW) and other non-hazardous waste: Radioactivity detection Weighing of waste deliveries Visual inspection Periodic sampling of waste deliveries and analysis of key properties/substances	It is not proposed to undertake radioactivity detection tests as no radioactive waste will be received and this will be enforced through contracts established under the waste pre-acceptance procedures. Weighing of the waste deliveries will be undertaken on their entry and exit from site. It will not be practical to perform a visual check on every waste delivery vehicle prior to the unloading of waste. Consequently, the waste will be observed by an operative as it is tipped into the tipping bunker. Potential non-conforming waste can be removed from the bunker by the crane operator by changing the operating state of the cranes to manual mode to allow further inspection in a dedicated quarantine area within the enclosed building, prior to transfer off-site to an appropriately licensed waste disposal or recovery facility. Periodic sampling of waste deliveries will be undertaken with a frequency defined by the final waste acceptance procedures developed as part of the existing IMS extension for the EfW CHP Facility. These will be shared with the Environment Agency prior to commissioning.	Yes
BAT 12	In order to reduce the environmental risks associated with the reception, handling and storage of waste, BAT is to use both impermeable surfaces with an adequate drainage infrastructure and adequate waste storage capacity.	The surface of the tipping hall will be impermeable and equipped with suitable drainage that diverts run-off from these areas to the main bunker through appropriate design of kerbing, floor falls and drains. The integrity of the surface in these areas will be checked regularly under procedures established under the IMS. The tipping and main bunker will be watertight concrete constructions designed to achieve a minimum tightness class 2 in accordance with the requirements of BS EN 1992-3 *Eurocode 2: Design of concrete structures. Liquid retaining and containment structures*. The main waste bunker has a capacity of ~17,000m^3 with an equivalent waste storage capacity of approximately 8	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
		days. Once the bunker is at capacity, waste will no longer be accepted by the EfW CHP Facility, and an alternative recovery/disposal route will be arranged. For a planned shutdown, the waste levels in the bunker will be reduced prior to shutdown to allow longer periods before the bunker reaches its capacity. This provides suitable contingency in the event of shutdown of the whole EfW CHP Facility. The quantity of waste stored will be regularly monitored against the maximum allowed storage capacity using the automated waste tracking system.	
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 waste incineration BAT Conclusions document.	BAT 13 is not applicable, as the site will not handle clinical waste.	N/A
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: • Waste blending and mixing • Advanced control system • Optimisation of the incineration process • The BAT Associated Environmental Performance (AEPL) is for a TOC content in slags and bottom ashes of 1-3% dry wt and loss on ignition of 1-5% dry wt.	Waste will be mixed and moved by means of a large grab mounted on the travelling cranes. Bunker management procedures will be developed to ensure mixing of the different incoming waste sources to improve the homogeneity of the feed to the furnaces. These management procedures will include mixing and turning of incoming wastes using trenching and stacking by the waste bunker cranes to blend the incoming waste (BAT 14a). An advanced control system will also be used to control operating parameters such as the rate at which waste is fed into the furnace, the grate speed, supply and injection of both primary and secondary combustion air etc. Control of these operating parameters will optimise the combustion conditions and reduce the content of unburnt substances in the bottom ash (BAT 14b and c). The EfW CHP Facility is designed to achieve the BAT-AEPLs and this will be confirmed by periodic monitoring of the bottom ash as described in Section 5.9.3 of the Supplementary Technical Information document.	Yes
BAT 15	In order to improve the overall environmental performance of the incineration plant and to reduce	An advanced control system will be used to control the combustion process and the air pollution control system. This	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
	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 of the BREF for Waste Incineration), as and when needed and practicable, based on the characterisation and control of the waste (see BAT 11).	will monitor and control key operational parameters such as the rate at which waste is fed into the furnace, the grate speed, and the supply of both primary and secondary combustion air to optimise combustion conditions and reduce emissions. Dosing of urea and hydrated lime will be monitored and varied by the automated control system based on the monitored NO_x and HCl/SO_2 measurements from the CEMS. Activated carbon will be dosed based on the flue gas volume flow using MVV's operational experience at other facilities.	
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.	The plant has been designed and will be operated to ensure that start-up and shutdown operations, including emergency shutdown scenarios, are minimised and, where they do occur, are carried out safely and without significant environmental impact. The EfW CHP Facility would be capable of handling approximately 260,000 tonnes of residual (non-recyclable) waste per annum at an LCV of 10.9MJ/kg and an availability of 7,830 hours/year. It is intended that the EfW CHP Facility would be able to export up to 28 MWe (net) and potentially up to 5 MWth of low temperature hot water. Procedures for start-up and shutdown will be included in the IMS.	Yes
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 air pollution control system will be appropriately designed, operated and maintained in order to reduce emissions to air. The EPC Contractor will identify the optimum configuration and design of the air pollution control system during the detailed design phase based on the waste and process specifications provided by the Operator. Waste acceptance and bunker management will assist with controlling the homogeneity of waste feed to the furnaces. The advanced control system will regulate the combustion conditions	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
		within the design range, which seeks to minimise pollutant formation. The air pollution control system will also be monitored and controlled by the distributed control system to ensure it is operated within the design range specified by the manufacturer and that it is regularly maintained to ensure optimal availability. Maintenance procedures and frequencies will be established in the IMS. No wet flue gas cleaning plant is proposed; therefore, associated wastewater treatment is not carried out.	
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 elements within the waste incineration BAT Conclusions document.	An OTNOC management plan will be included within the IMS that will be extended to cover operations at the EfW CHP Facility (BAT 1). This will cover the elements set out in BAT 18. Periodic assessment of emissions during OTNOC will be established in the IMS. The management plan will consider aspects such as: • Identification of potential OTNOC scenarios and potential consequences, including regular review and assessment; • Ensuring appropriate design of critical equipment; • Implementation of preventative maintenance programmes for critical equipment; • Monitoring of emissions during OTNOC; and • Periodic assessment of emissions during OTNOC and implementation of corrective actions if necessary.	Yes
BAT 19	In order to increase the resource efficiency of the incineration plant, BAT is to use a heat recovery boiler.	Heat generated during the combustion of the waste will be recovered in a boiler in the form of steam which is subsequently used to generate electricity in a steam turbine generator and allow export of heat to nearby industrial consumers (subject to commercial arrangements being established).	Yes
BAT 20	In order to increase the energy efficiency of the incineration plant, BAT	The design of the EfW CHP Facility has been optimised to recover heat and minimise parasitic demand to increase	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
	is to use an appropriate combination of the techniques given below: a) Drying of sewage sludge b) Reduction of flue-gas flow c) Minimisation of heat losses d) Optimisation of the boiler design e) Low-temperature flue-gas heat exchangers f) High steam conditions g) Cogeneration h) Flue-gas condenser i) Dry bottom ash handling The BAT Associated Energy Efficiency Level (AEEL) for gross electrical efficiency for new plant combusting MSW is 25 – 35%	its energy efficiency. The design gross electrical efficiency of 30.2% meets the BAT-AEEL requirement. Measures to optimise the energy efficiency of the EfW CHP Facility are described in detail in Section 3.3 of the Supplementary Technical Information document. Flue gas flow will be reduced by improving the distribution of primary and secondary air and will be automatically controlled by the advanced control system. Injection points will be optimised using Computational Fluid Dynamics (CFD) modelling (BAT 20b). The main combustion chambers in the furnace will be insulated to retain energy. The boiler generated high pressure steam will be transported within well insulated steam mains to the steam turbine generator (STG). All condensate pipes will be insulated to minimise heat loss during the transfer of boiler feed water back to the boiler drum, ensuring heat losses are minimised (BAT 20c). The boiler design has been optimised to allow high levels of efficiency and will be equipped with an economiser and superheaters to maximise efficiency with flue-gas velocity and distribution throughout the boiler optimised using CFD modelling. Boiler heat exchange surfaces will be cleaned on a regular basis using online and offline methods to minimise fouling and maximise efficient heat recovery (BAT20d). The EfW CHP Facility is designed to generate high temperature, high pressure steam at 380°C and 45 barg (potentially up to 420°C and 60 barg dependent on EPC Contractor selection) (BAT 30f) and is designed to be CHP-ready at the outset (BAT 30g). Low temperature flue-gas heat exchangers at the boiler exit (BAT 20e) have not been proposed due to: • Increased risk of corrosion. The design boiler exit temperature is 145-150°C and the BREF references that there is an increased risk of	

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
		corrosion in low-temperature heat exchangers when temperatures are below 180°C; and • Inefficiencies in the air pollution control system. The dry scrubbing process requires a minimum temperature of approx. 130-140°C. As the flue gas temperature at the boiler exit is already at 145-150°C, further extraction of heat from the flue gases could compromise the removal efficiency in the APC plant and result in sticky residue and blockages. Use of a flue gas condenser (BAT 30h) has not been proposed as this will increase the frequency of visible plumes and will reduce buoyancy-driven plume rise that will increase air quality impacts. Whilst it is acknowledged that dry bottom ash handling (BAT 30i) can further improve energy efficiency, this increases the risk of fugitive dust emissions. Higher temperature air from the incinerator bottom ash (IBA) storage building, extracted from the roof level of the boiler house to prevent fogging, will, however, be used as part of the secondary air requirement to improve energy efficiency.	
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	Measures for control of diffuse emissions of odour are described in the Odour Management Plan contained within Appendix A14 of the supplementary technical information report. Both the tipping hall and waste bunker will be kept under slight negative pressure, with the air from the buildings extracted and used as primary combustion air. The tipping hall will be fitted with a fast acting door to minimise fugitive odour emissions. During periods of complete plant shutdown, the negative pressure through the waste bunker and tipping hall will be maintained by operating the shutdown fan; this passes air through a dust and activated carbon filter system to remove odorous compounds, prior to being emitted to atmosphere. Prior to	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
	vented or extracted air to an alternative abatement system, e.g., a wet scrubber or fixed adsorption bed, minimising the amount of waste in storage and storing waste in properly sealed bales.	the planned shutdown waste inputs will be reduced to lower the level of waste stored within the bunker to a minimum and waste will continue to be received at a reduced capacity for the duration of the outage.	
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 introduce them into the furnace by direct feeding.	BAT 22 is not applicable, as the site does not handle gaseous and liquid wastes.	N/A
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.	BAT 23 is not applicable, as the site will not treat slags and bottom ashes.	N/A
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 presented within the waste incineration BAT Conclusions document.	BAT 24 is not applicable, as the site will not treat slags and bottom ashes.	N/A
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: a) Bag filter b) Electrostatic precipitator c) Dry sorbent injection d) Wet scrubber e) Fixed or moving bed adsorption. The BAT AELs are as follows: • Dust <2 – 5 mg/Nm^3 • Cd + Tl 0.005 – 0.02 mg/Nm^3 • Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V 0.01 – 0.3 mg/Nm^3	A fabric filter (BAT 25a) and dry injection of activated carbon (BAT 25c) will be used at the EfW CHP Facility to reduce emissions of dust and metals. The fabric filter is the primary technique for controlling these emissions and is considered BAT in EPR 5.01. As a combination of the above is considered to be sufficient to reduce the pollutants to their required BAT-AELs, BAT 25b, d and e are not proposed to be used as the increased cost of these systems would be disproportionate to their benefits and will introduce additional cross media effects.	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
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.	BAT 26 is not applicable, as the site will not treat slags and bottom ashes.	N/A
BAT 27	In order to reduce channelled emissions of HCl, HF and SO_2 to air from the incineration of waste, BAT is to use one or a combination of the techniques given below: a) Wet scrubber b) Semi-wet scrubber c) Dry sorbent injection d) Direct desulphurisation e) Boiler sorbent injection	Dry sorbent injection using hydrated lime (BAT 27c) will be used to remove HCl, HF and SO_2. As detailed within section 4 of this BAT assessment, neither a wet scrubber (BAT 27a) nor a semi-wet scrubber (BAT 27b) is considered BAT for the EfW CHP Facility. Direct desulphurisation (BAT 27d) would also not be suitable at the EfW CHP Facility as it does not utilise fluidised bed technology. Boiler sorbent injection (BAT 27e) is not proposed. Whilst this may provide a higher level of abatement than dry scrubbing alone, it will increase raw material consumption and costs. As the BAT-AELs can be met with a dry scrubbing solution in isolation, and as process contributions of acid gases are screened as insignificant based on the dispersion modelling results, it would not be proportionate to implement boiler sorbent injection.	Yes
BAT 28	In order to reduce channelled peak emissions of HCl, HF and SO_2 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 techniques given below: a) Optimised and automated reagent dosage b) Recirculation of reagents BAT-AELs are as follows for new plant: • HCl <2 – 6 • HF < 1 • SO_2 5 -30	The hydrated lime will be injected into a reactor upstream of a fabric filter using an automated dosing control system that optimises the dosing rate based on the HCl and SO_2 readings from the CEMS to prevent unnecessary use of raw materials whilst ensuring compliance with emission limits. Furthermore, portions of the APCr from the fabric filter will be recycled back into the reactor to minimise the quantity of unreacted reagents.	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
BAT 29	In order to reduce channelled NO_X emissions to air while limiting the emissions of CO and N_2O from the incineration of waste and the emissions of NH_3 from the use of SNCR and/or SCR, BAT is to use an appropriate combination of the techniques given below: a) Optimisation of the incineration process b) Flue gas recirculation c) SNCR d) SCR e) Catalytic filter bags f) Optimisation of the SNCR/SCR design and operation g) Wet scrubber BAT-AELs for new plant are as follows: • NOx 50 – 120 • CO 10 – 50 • NH_3 2 - 10	A combination of an optimised incineration process (BAT 29a), SNCR (BAT 29c) and the optimisation of the SNCR design and operation (BAT 29f) will control emissions of NOx, CO, N_2O and NH_3 and allow the BAT-AELs to be met. Measurement of NOx will also be monitored continuously to optimise the dosing rate of urea and reduce ammonia slip and N_2O formation. Urea injection points will be optimised using CFD (BAT 29f). As described in Section 3, SNCR is considered BAT for this installation so flue gas recirculation (BAT 29b) and SCR (BAT 29d) are not proposed. However, further consideration for the use of SNCR + FGR will be given during detailed design. Catalytic bag filters (BAT 29e) are not considered feasible for the EfW CHP Facility as the BREF states that the temperature of the flue gas entering the filter bags should be between 180 - 210°C for effective destruction of NO_x. As the temperature of flue gases leaving the boiler will be between 145 - 150°C, the flue gas temperature will be lower than that required for effective destruction using catalytic filter bags. As described in this BAT assessment, wet scrubbers are only considered BAT for use on hazardous liquid/chemical waste incinerators (BAT 29g).	Yes
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) provided below: a) Optimisation of the incineration process b) Control of the waste feed c) On-line and off-line boiler cleaning d) Rapid flue-gas cooling e) Dry sorbent injection f) Fixed- or moving-bed adsorption g) SCR h) Catalytic filter bags i) Carbon sorbent in a wet scrubber	As described in the Supplementary Technical Information document, a combination of an optimised incineration process (BAT 30a), control of the waste feed (BAT 30b), on-line and off-line boiler cleaning (BAT 30c), rapid cooling of the flue-gas (BAT 30d) and powdered activated carbon (BAT 30e) will be used to control emissions of PCDD/F and PCBs. As the EfW CHP Facility is able to comply with the BAT-AELs, and as impacts of these emissions are assessed as insignificant, techniques BAT 30 f, g, h or i are not proposed as the increased cost of these systems would be disproportionate to their benefits.	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
	BAT-AELs are as follows: • TVOC <3 – 10 mg/Nm^3 • PCDD/F <0.01 – 0.04 ng I-TEQ/Nm^3 • PCDD/F + dioxin-like PCBs <0.01 – 0.06 ng WHO-TEQ/Nm^3	Additionally, as described above, although the optimum temperature range for removal of PCDD/Fs using catalytic filter bags is lower than NO_x (170-190°C), the temperature of the flue gas is still too low after exiting the boiler for this technique to be effective.	
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 presented within the waste incineration BAT Conclusions document. The BAT-AEL for new plant is < 5 – 20 µg/Nm^3 (daily average or average over sampling period) or 1 – 10 µg/Nm^3 for a long-term sampling period.	In accordance with the BREF and EPR 5.01, injection of activated carbon will be used to control mercury emissions as it "*gives reliable and effective mercury reductions*" and allows the BAT-AEL to be achieved. Boiler bromine addition has not been proposed as it requires a downstream wet scrubber which has previously been identified as not representing BAT for the EfW CHP Facility.	Yes
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 will be separate systems for uncontaminated surface run-off, run-off from waste and bottom ash storage areas and other process waters, and cooling water. Run-off from the EfW CHP Facility's waste reception, handling and storage areas will be diverted to the main bunker, while drainage from other process areas will be collected in the process water system and re-used within the IBA quench. In normal operation, there will be no process effluents discharged to sewer other than discharges to foul sewer from amenity areas. During online maintenance of the water treatment plant, effluent from regeneration of the resins will be preferentially discharged to the process water system (subject to capacity) or to sewer after neutralisation. Uncontaminated run-off from roofs, roads and other hardstanding areas of the site that does not involve the storage of waste or potentially polluting substances will be collected in a dedicated surface water drainage system which contains a number of interceptors to contain oil and sediments prior to discharge.	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
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: a) Waste-water-free FGC techniques b) Injection of waste water from FGC c) Water re-use/recycling d) Dry bottom ash handling	Water consumption will be minimised using a dry scrubbing technique to remove acid gases which does not produce waste water (BAT 33a). As such, BAT 33b is not relevant. Excess water from the bottom ash quenching will be redirected back to the quench, whilst run-off from e.g., washdown operations, and boiler blowdown will be captured in the process water system and recycled in the IBA quench. (BAT 33c). Dry bottom ash handling (BAT 33d) has not been incorporated due to the increased risk of fugitive emissions of dust.	
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 presented within the waste incineration BAT Conclusions document, and to use secondary techniques as close as possible to the source in order to avoid dilution.	BAT 34 is not applicable, as wet flue gas treatment will not be used and no treatment of bottom ash will take place. Run-off from areas storing bottom ash will be routed to the process water tank and re-used in the IBA quench.	N/A
BAT 35	In order to increase resource efficiency, BAT is to handle and treat bottom ashes separately from FGC residues.	FGC residues and bottom ash will be handled and stored separately.	Yes
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 presented within the waste incineration BAT Conclusions document depending on the hazardous properties of the slags and bottom ashes.	BAT 36 is not applicable, as the EfW CHP Facility will not treat slags and bottom ashes.	N/A
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: a) Appropriate location of equipment and buildings b) Operational measures c) Low-noise equipment d) Noise attenuation e) Noise-control equipment/infrastructure	The layout of the EfW CHP Facility has been optimised such that the main noise generating equipment is oriented away from the nearest receptors. Although the EfW CHP Facility will operate 24 hours a day, waste deliveries will only take place between the hours of 07.00 – 20.00, thus avoiding the most sensitive night time period (BAT 37a). Other operational measures (BAT 37b) will include:	Yes

BATC Reference Number	Requirement	Design proposals	Compliant with BAT Conclusion?
		• Implementation of a pro-active inspection and maintenance plan through the IMS; • Equipment operated by suitably qualified and experienced staff; and • Closing windows and doors of enclosed areas where possible. If identified as a requirement during detailed design to meet the BS 4142 adverse impact descriptors as summarised in the Environment Agency's *Noise and vibration management: environmental* permits guidance, the EPC Contractor will include provision for low-noise compressors, pumps and fans as part of its design (BAT 37c) Where possible, noise generating equipment will be installed within a building or, where that is not possible, will be housed in suitable enclosures (e.g., fan enclosures) to provide additional attenuation (BAT 37d and e).	

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