Swadlincote Energy Recovery Facility (SERF)

Technical Description

on behalf of R&P Clean Power Limited

Application for Environmental Permit

May 2024

Prepared by Stantec

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1 Introduction

R&P Clean Power Limited (the 'Applicant') is developing the Swadlincote Energy Recovery Facility (SERF) (the 'Facility') to process up to 230,000 tonnes per annum of waste on land at Cadley Hill, Swadlincote, Derbyshire. The Facility will generate approximately 20.5 MW of electricity, of which ca. 18.5 MW will be exported to the public distribution network operated by National Grid Electricity Distribution.

This document forms part of the application for the Permit required for the operation of the SERF and is intended to provide a technical overview of the project and how it will operate.

As part of the Permit Application, the Environment Agency (EA) was contacted for pre-application advice. The reference for this pre-app advice correspondence is EPR/DP3925SK/P002.

1.1 The Applicant

R&P Clean Power Limited is registered in England (Company Number 12632942) and is the Applicant for the Permit. The Applicant's registered office address is Celixir House, Stratford Business and Technology Park, Innovation Way, Banbury Road, Stratford-Upon-Avon, CV37 7GZ.

1.2 The Site

The proposed Facility is located in South Derbyshire at Cadley Hill. Approximately 2 km west of Swadlincote, Derbyshire. The Facility is centred at National Grid Reference SK 268 190, with the nearest postcode at DE11 9EN. The surrounding area is characterised by a mix of rural land, residential properties and industrial estates. Immediately adjacent land uses include Willshee's Materials Recycling Facility (MRF), Stanton Sewage Works, the A444 (Burton Road), residential properties to the north and south, arable farmland to the west and south and the Appleby Glade and Cadley Hill Industrial Estate to the east. See Figure 1 for the Site location.

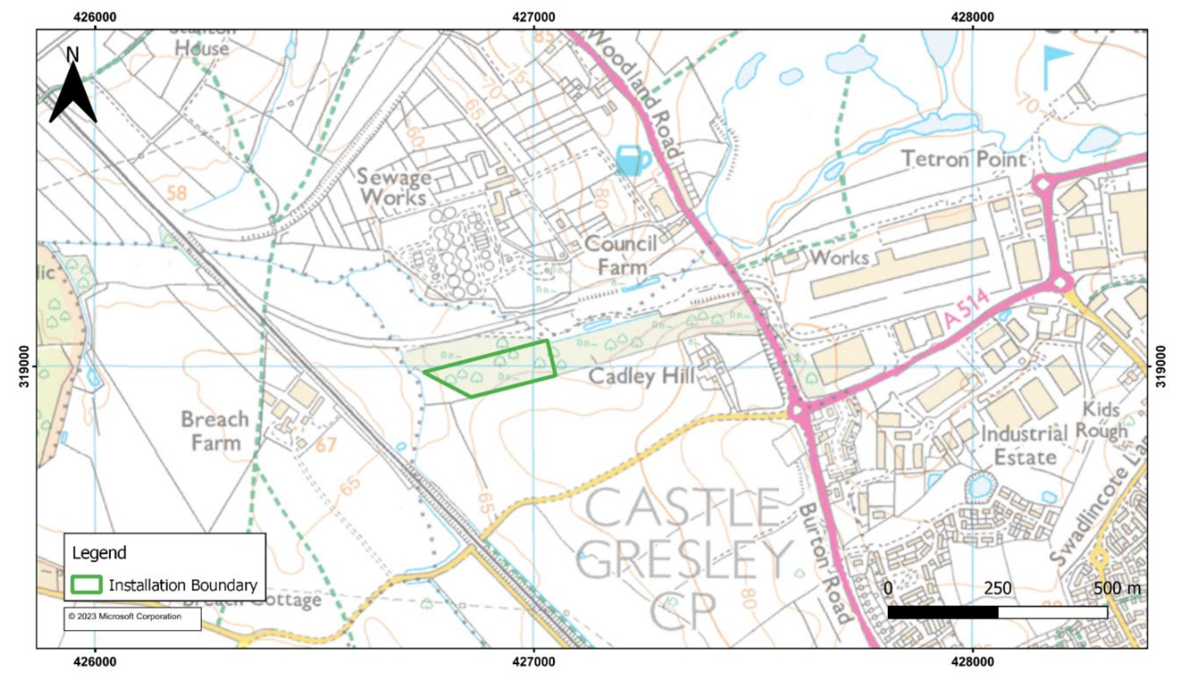

Figure 1: Site Location

1.3 Activities

The Facility will consist of a single Schedule 1 'Installation Activity', as defined within the relevant Environmental Permitting Regulations, and a number of 'Directly Associated Activities (DAA)'. These are summarised within Table 1 below.

Table 1: Activities

Type of Activity	Schedule 1 Reference	Description of Activity
Installation	5.1 Part A9(b)	The incineration of non-hazardous waste in a waste incineration plant
Waste Storage	DAA	Storage of fuel pending incineration and combustion residues prior to disposal
Process Effluent Treatment	DAA	Treatment of process effluents
Generation of Electricity	DAA	Operation of steam turbine

The Facility includes:

- Waste reception arrangements;
- Waste storage;

- Fuel oil and air supply systems;
- Furnace;
- Boiler;
- Steam turbine/generator set;
- Facilities for the treatment of exhaust gases;
- Storage of solid residues prior to disposal and/or recovery; and
- Devices and systems for controlling and monitoring operations and emissions.

2 Site Activities

The SERF is an energy from waste plant utilising pre-treated non-hazardous waste as fuel to produce electricity and heat. The accepted wastes are defined with European Waste Catalogue (EWC) waste codes from the List of Wastes (LoW), the wastes are listed below, hereafter referred to as the 'fuel':

- 19 12 10 - Combustible Waste (Refuse Derived Fuel)
- 19 12 12 - Other Wastes (Including Mixtures of Materials) from Mechanical Treatment of Wastes other than those mentioned in 19 12 11
- 20 03 01 - Mixed Municipal Waste
- Other wastes listed in Table 1b of Form B3

The fuel will be delivered to a reception hall by means of articulated vehicles equipped with walking floor, ejector or tipping trailers. The fuel will be deposited directly into an enclosed fuel storage bunker.

The Facility is equipped with:

- A Fuel reception area, divided into 4 bays, separated by walls;
- Fuel storage bunker;
    - The capacity of the fuel storage bunker is approx. 8,500m^3, equivalent to ca. 4 days of operation (assuming operation at Maximum Continuous Rate (MCR), fuel NCV of 10.5 MJ/kg and fuel density of 350 kg/m^3).
    - The fuel in the bunker is handled by an overhead crane that automatically spreads out the fuel, optimising the pit replenishment, and feeds a boiler hopper. From there, it passes to the feeding grate section in accordance with the demand of the boiler.

If sludge wastes are accepted at the Facility, a dedicated tank for the storage of sludges and a pumping system to transfer the sludges from the storage tank into the waste feeding hopper will be incorporated in the design.

The incineration grate will have the following functions:

- Transport of materials to be incinerated through the combustion chamber;
- Distribution of the materials to be incinerated; and
- Distribution of primary combustion.

The proposed Facility would have a gross electricity generating capacity of 20.5 MW. It would generate electricity by way of a steam turbine which would be driven through the controlled combustion of the residual waste materials. When operating at full load the Facility will export ca. 18.5 MW of electricity to the public distribution network operated by National Grid Electricity Distribution.

It is expected that the proposed ERF would accept and process in the region of 50,000 tpa of waste derived fuel from the adjacent MRF on the site, which in combination reduces the amount of waste being disposed to landfill, with the remaining 180,000 tpa coming from other sources. By locating the plant here, the ERF provides a solution that avoids the onward transportation of the fuel, produces locally distributed low carbon renewable energy, including the potential use of heat in neighbouring businesses.

2.1 *Process and Technology Description*

The fuel will be dosed by an integrated hydraulic pusher on the inclined mobile grate inside the combustion chamber, which will adjust the height and distribution of fuel on the grate and is cooled by air.

Electric air fans, equipped with variable frequency drives, provides the primary and secondary air in the various sections of the combustion grate and furnace.

The combustion chamber has been designed to achieve a good burnout of the combustion gases by ensuring that these are maintained at a minimum 850°C for a minimum residence time of 2 seconds at a minimum oxygen level of 6%. The correct design of the combustion chamber, combined with the control temperature and residence time, will be the primary technique for the control of dioxins and furans formation. This technique will also ensure the control of carbon monoxide formation.

For this reason, the secondary air injection in the combustion chamber will be carried out in order to supply a sufficient quantity of oxygen to complete the oxidation process of the fuel and to be sure to have oxygen in excess of 6%.

At start-up, auxiliary diesel-oil fed burners will be used to heat up the combustion chamber to at least 850°C before any waste is introduced. During operation, the burners will also be switched on automatically if the temperature approaches to fall below 850°C and, during shutdown, the burners are to be used to maintain this temperature until there is no more unburnt waste in the combustion chamber.

The primary technique to be used to limit the formation of thermal NOx will be the regulation of temperatures in the upper part of the combustion chamber after the oxidation zone by optimal dosing of primary and secondary air. Flue gas recirculation from the exhaust stack may also be used for this purpose if considered appropriate by the combustion system technology supplier.

Incinerator bottom ash developed in the combustion chamber will primarily be extracted from the bottom of the grate and quenched with water. A suitable transport system will then remove the quenched bottom ash, which will be temporarily stored within the building, before being collected for off-site disposal.

In order to further abate the NOx content in the exhaust, the Facility is equipped with a Selective Non-Catalytic Reduction (SNCR) process, which removes nitrogen oxides (a combination of nitrogen oxide and nitrogen dioxide) by injecting the reducing agent (urea) into the combustion chamber. The reactions occur at temperatures between 850°C and 1,050°C.

Acidic gases from the exhaust (typically HCl, SO_2 and HF) will be neutralised by adding alkaline reagent (hydrated lime) into the flue stream after the boiler.

Exiting the combustion chamber, gases will enter the boiler where they transfer the heat to the fluid which is evaporating water. After being superheated by means of an appropriate heat exchanger, the resultant steam is then sent to the steam turbine-generator.

During the passage of the exhaust fumes in the boiler, these are cooled by exchanging energy within the boiler tubes potentially to the temperature window of between 200°C and 400°C which could lead to the formation of dioxins and furans. Therefore, the boiler has been designed in such a way as to limit the residence time of the fumes within this temperature window.

The exhaust gases, upon exiting the boiler, will be treated to further remove the pollutants that may be present. Acidic gases will be treated by injecting hydrated lime into the flue ducts immediately before, or directly within, a reactor tower. At this point, the gases will also be dosed with activated carbon to reduce any heavy metals, dioxins, and furans present.

Following the reaction tower, exhaust gases are passed through a bag filter dust suppression system to retain the reacted products. The Air Pollution Control (APC) residues collected will be directed into a silo and sent to authorised facilities for proper disposal.

The super-heated steam coming from the boiler at a temperature in excess of 400°C and pressure of 50-60 bar(a) is delivered at the steam turbine for electrical power production. The steam turbine has one sliding pressure bleed feeding the deaerator and combustion air pre-heater. The exhaust steam is sent from the turbine to an air-cooled condenser for final condensation in order to optimise power production.

The process condensate is returned to the deaerator to be recycled to the steam boiler for a new cycle.

In the deaerator the process condensate is heated using a steam turbine bleed in order to strip the dissolved gases before the boiler feed. A demi-water production plant is also installed to make-up the small amount of water lost in the steam cycle.

A compressed air system is installed to supply instrument and service air to all the necessary equipment. The supervision and control system to operate the plant is a distributed control system (DCS) type and it assures the best flexibility.

2.2 *Delivery of Waste*

The ERF is designed for the incineration of refuse derived fuel produced from non-hazardous municipal solid waste (MSW) as well as commercial and industrial (C&I) wastes. Waste will be delivered to the Facility by bulk haulage vehicles, accessing the Facility via Keith Willshees Way.

Vehicles will enter and pass over the weighbridge. Following acceptance, they will travel to the Waste Reception Hall and will be directed to an area for tipping.

The process of vehicles accessing the Waste Reception Hall, to deliver their waste load, is one of the main potential sources of noise associated with operations. The delivery door will open only as the vehicle reverses into the Waste Reception Hall. Once the vehicle is fully within the Waste Reception Hall, the door will close immediately to minimise any escape of air from within the fully enclosed building. The reception hall is kept at negative pressure by the operation of the combustion process air fan, and therefore the closing of door is essential for maintaining the negative pressure, as well as acting to reduce noise emission from the Facility.

Once the vehicle has discharged its load and has been cleared to leave the Waste Reception Hall by the Mobile Plant Operator or Operations Technician, the driver will be directed by signage to exit via the weighbridge.

2.3 Storage

Incoming waste will be stored in a waste storage bunker. The bunker will facilitate the continuous operation of the plant, as it enables material delivered during the day to be stored and used on a 24-hour basis. The bunker will also provide sufficient storage to allow weekend and bank holiday operation when there are no waste deliveries, and for deliveries to continue during maintenance or plant shutdown.

The total storage of fuel on-site is therefore estimated to be 8,500m^3 at any one time and under normal operating conditions the duration of storage will be 4 days. The annual throughput of fuel to the plant is estimated to be up to 230,000 tonnes per year.

2.4 Fuel Loading

The fuel in the bunker will be handled by an overhead crane that automatically spreads out and mixes the fuel, improving its homogeneity and optimising the space for pit replenishment. The overhead crane is also used to load the boiler hopper. The operation of the overhead crane is fully automated via a PLC system, though it may be manually controlled if required.

From the hopper the fuel falls onto the feeder table and is pushed onto a reciprocating combustion grate by hydraulically driven rams. Fuel throughput at full capacity (100% MCR) will 23.2 tonnes per hour with fuel with an NCV of 10.5 MJ/kg.

2.5 Combustion Process

Once within the grate, waste is combusted in the combustion chamber with excess air, i.e. sufficient oxygen is supplied to the combustion process to allow full stochiometric combustion and realise complete combustion of the waste. Air is fed through the bottom of the grate into the fuel bed. This air serves as primary combustion air and to keep the grate bars cool to prevent undue heat damage. As the fuel moves down the length of the grate it goes through drying, volatilization, combustion and ash burn out before being discharged as bottom ash at the other end.

Secondary air is injected near the gas exit from the chamber to complete the combustion of combustible components in the gases. The gas temperature in the combustion chamber is maintained by the DCS by adjusting the flow of primary and secondary air; this aids the control of thermal NOx created by high temperatures in the chamber.

Oil-fired auxiliary burners are installed for start-up and shut down of the plant and to maintain the combustion space temperatures at 850°C as required for compliance with the Industrial Emissions Directive on the rare occasions when it becomes necessary to use auxiliary fuel to do so.

The hot gases from the combustion chamber pass through a boiler where the heat is transferred to the water circuit and where steam is raised.

The flue gases exiting the boiler are cleaned and discharged to atmosphere. Two systems are used to extract ash from the combustion chamber and boiler surfaces. Bottom ash (from the combustion grate) is collected within a wet quenched system from hoppers beneath the grate and conveyed to a dedicated storage area. Boiler ash (from radiant and conductive parts of the boiler) is dislodged by the boiler cleaning system, collected in hoppers at the bottom of the boiler passes and conveyed to the bottom ash handling system. In addition, the Facility is equipped with a SNCR system that can dose an aqueous solution of urea with a 40% concentration to reduce flue NOx.

2.6 *Power Generation*

The combustion gases will enter the boiler, where they will transfer the heat to the evaporating boiler. The steam is "superheated" via the exchanger in the boiler to a temperature in excess of 400°C, and the superheated steam is then delivered to the steam turbine for electrical power production.

Steam enters the turbine through a hydraulic emergency stop valve, and the rate of flow into the turbine is controlled via a hydraulic throttle valve. The gross electricity generation is 20.5 MWe, with a gross electrical efficiency is 30.3%. The net efficiency (taking into account the parasitic load of the plant, other auxiliary consumptions and electrical losses) is 18.5 MWe, an equivalent net electrical efficiency of 27.3%.

The electricity, produced at 33kV is connected to the electricity substation, as per the Connection Agreement with National Grid Electricity Distribution.

Steam from the steam turbine exhaust, flows into the main steam duct to the air-cooled condenser. The steam is condensed inside a heat exchanger using air as the cooling medium. The cooling air is forced through the heat exchanger by axial fans, driven by electric motors and speed reducing gearboxes. The condensate formed is collected by gravity into the condensate tank, from where it is pumped to a de-aerator to be recycled to the steam boiler for a new cycle.

A back-up diesel generator will provide power to shut-down the plant in safety operation mode in an emergency scenario.

2.7 *Exhaust Emissions*

Exhaust gases from the fuel combustion are mixed with lime and active carbon in the vertical reaction tower. Following this process, exhaust gases are sent to a dust separator system that consists of filter bags to ensure the emissions comply with the limits specified in the Best Available Techniques (BAT) Reference for Waste Incineration[1] and the Industrial Emission Directive (IED)[2].

Exhaust gases are discharged through a flue, with a height of 60m. A continuous Emission Monitoring System (CEMS) (with redundancy) is installed on the chimney to ensure compliance with the BAT Reference for Waste Incineration and the IED limits at the point of discharge.

2.8 *Water Treatment*

1 Best Available Techniques (BAT) Reference Document for Waste Incineration

2 Industrial Emissions Directive 2010/75/EU

A demineralised water production plant will be installed to make up the small amount of water lost in the steam cycle. The process requires a potable water supply of approx. 5 m^3 per hour on average, with a peak demand of 25 m^3 per hour (only during Start-up).

Raw water supply will be collected in a tank and transferred into the treatment plant, as required. The technology used in the water treatment plant will utilise either reverse osmosis, ion exchange technology or a combination of the two. Demineralised water will then be collected in a tank ready for use in the boiler.

2.9 Facility Control Systems

Process control at the Facility will be an important factor in combustion and emissions control. The Facility will be equipped with a DCS, which measures and records various process parameters that indicate whether the process is operating within design parameters. The Facility operator can control the process via the Human Machine Interface (HMI) which delivers a complete overview of the process components, reports system status and shows any alarms.

In addition, an emergency shutdown system is provided as a separate system that can be used to detect emergency situations and perform the required shutdowns.

2.10 End Products

As described above, the end products associated with these processes are flue gases, bottom ash and Air Pollution Control (APC) residues.

Exhaust gases from the combustion process are normal products of gas combustion and will be treated to ensure compliance with the IED emission limits.

The bottom ash is discharged via a conveyor system to an enclosed storage area and regularly transferred to the offtakers’ collection vehicles for off-site treatment. Once it has been treated it may be used as an aggregate replacement.

The APC residues are transported off-site for disposal under the relevant regulations, as they are considered to be a hazardous waste.

All waste products leaving the Facility will be subject to waste management regulations, to include waste characterisation and Duty of Care requirements.

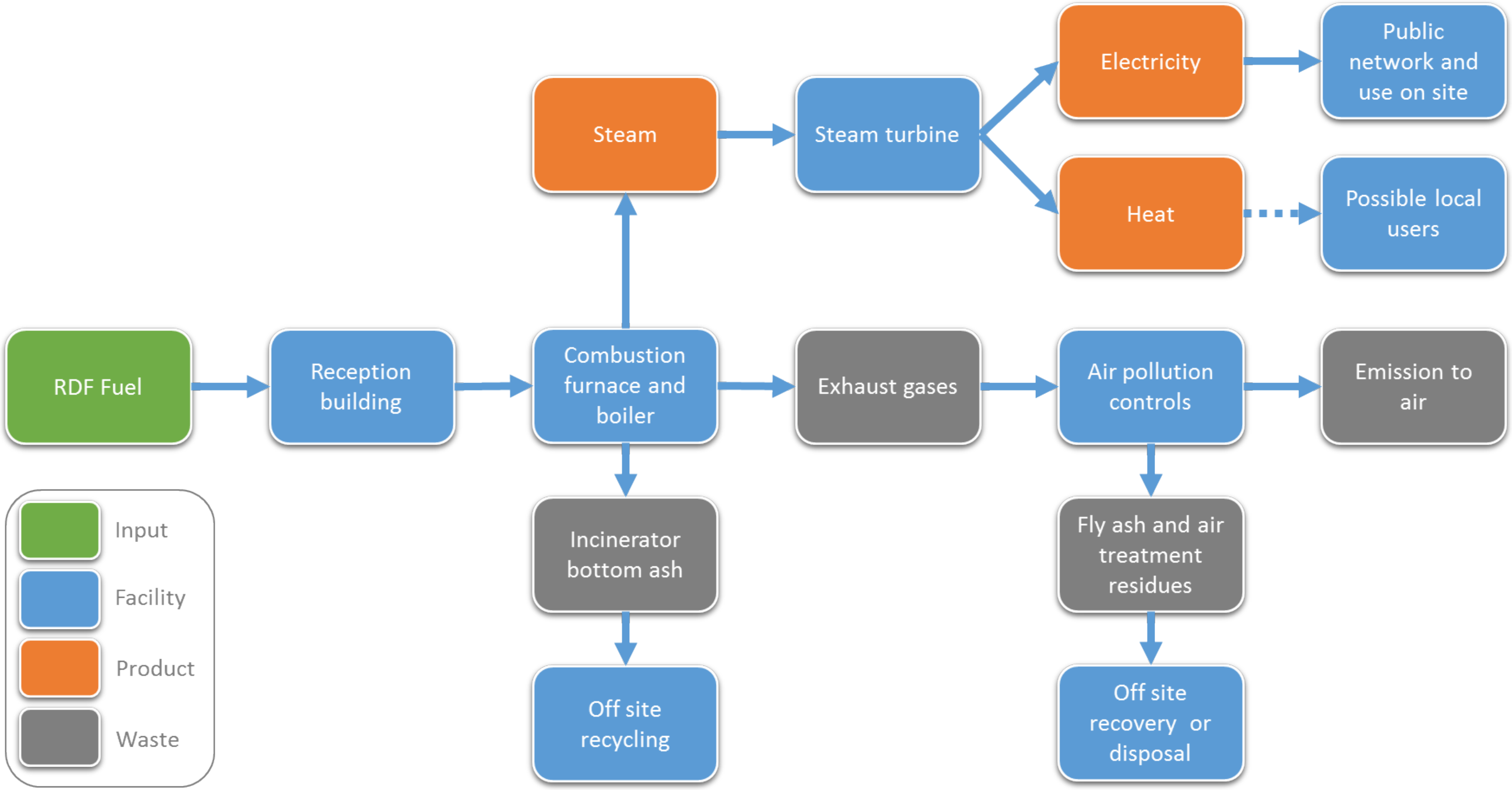

Figure 2: Process Flow Illustration

2.11 Emissions

2.11.1 Emissions to Air

The Facility includes a number of systems to ensure that releases to air are controlled below the limits specified within the current BREF and the IED which set out the standards that are expected to be achieved for facilities of this type.

The following techniques are used to reduce the emissions to atmosphere from the Facility:

1. Automated combustion control;
2. Selective Non-Catalytic Reduction (SNCR);
3. Flue Gas Recirculation (FGR) (subject to technology supplier's design);
4. Vertical reaction towers to enable lime and activated carbon reactions; and
5. Baghouse filter.

The combination of continuous monitoring and control systems with the treatment techniques enables a high level of flexibility in optimising the use of substances and processes to ensure emissions are within the prescribed limits. Detailed modelling of the dispersion of these emissions from the 60m stack installed at the Facility has been undertaken and are available as part of the application.

The potential for odour arising from the plant has been recognised, particularly during the delivery and offloading of fuel, and mitigation techniques have been included as detailed within the odour management and risk assessment which is included within the Odour Management Plan accompanying the application.

2.11.2 Emissions to Water

Process Water

There will be no emission of process effluent from the Facility under normal operation. Excess process waters arising from boiler blowdown, the demineralisation unit and the cleaning/draining of equipment and surfaces will be collected in the on-site wastewater pit and re-used in the Facility's bottom ash quenching system. Any excess process effluents will be tankered off site under a suitable waste collection contract. No process effluent will be discharged to surface water or sewer.

Surface Water

The Facility is to be served by a new stormwater network which includes use of Sustainable Drainage Systems (SuDS). Surface water runoff from the proposed buildings and infrastructure will be collected and transferred via private storm networks towards a series of attenuation features. Prior to release into any attenuation features, runoff will first drain through a series of pollution control measures (i.e., trapped gullies, manholes with catch pits etc). The attenuation features will include a combination of belowground tank storage, together with above-ground Sustainable Drainage Systems (SuDS), each sized to accommodate up to the 100-year return period storm, including 40% allowance for climate change.

Foul Water

Foul waters arising from domestic water use will drain to a new private package treatment plant. Treated flows will discharge to the proposed swale and wetland area which can provide further polishing ahead of outfall to the downstream watercourse. The final discharge of treated foul waters will be in accordance with the general binding rules for small sewage discharges with effect from 2 October 2023. This is shown as point S1 in Figure 3 Point Source Emissions to Air and Water, provided as part of the Environmental Permit application.

2.12 Residues

The main solid waste residue streams from the Facility are incinerator bottom ash (IBA) and air pollution control (APC) residues.

2.12.1 Incinerator Bottom Ash (IBA)

IBA is the inert or incombustible material from the combustion process. The bottom ash discharges from the grate and mixed with water, where wet ash is removed by a conveyor system. It is subsequently stored within an enclosed storage area and then loaded into vehicles for removal for recycling at an off-site treatment facility. Typically, this material is used as an alternative aggregate in the manufacture of construction products.

2.12.2 Air Pollution Control (APC) Residues

Fly ashes are particulates that are entrained within the combustion gases as these exit boiler. These are combined with substances injected into the furnace and collected along with the residues from the bag filter. Together these residues are termed Air Pollution Control (APC) residues and are collected within a sealed silo. The residues will be tested for their suitability for reprocessing at an appropriately licenced facility and their subsequent reuse. They are transported from the Facility within sealed bulk transport vehicles.

2.13 Energy Recovery

The Facility will generate electricity from the operation of the steam turbine and with a gross electrical efficiency of 30.3%. When operating at full load the Facility will export 18.5 MW of electricity to the public distribution network operated by National Grid Electricity Distribution. The plant has also been designed to be CHP ready – which means that it is capable of exporting heat to process or district heating loads that may be available in the vicinity of the Facility. A Heat Opportunity Report is included within the application, it has been concluded that currently potential heat loads that could be served are highly constrained by the presence of surrounding significant infrastructure. However, the Operators of the plant will review this assessment on a periodic basis.

2.14 Monitoring

The Facility design includes for the implementation of a continuous emissions monitoring system for the exhaust gases. The monitoring system will include monitoring of oxygen, carbon monoxide, hydrogen chloride, sulphur dioxide, oxides of nitrogen, volatile organic compounds, ammonia and particulates. Other pollutants will be recorded by spot measurements at regular intervals. All monitoring measurements will be recorded and are reported to the Environment Agency (EA).

In addition, the Facility will include modern process control technology utilising additional monitoring sensors and instruments to control operations, optimise the performance of the

Facility and respond to emergencies or abnormal operating conditions.