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Permit Application Supporting Information

Land at Coder Road, Ludlow Shropshire.

19 March 2025

Report Reference: 354/Shropshire(Pyrolysis)

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1.0	19.03.25	Report issue	Tony Higgins BSc (Hons), MSc, PGDip, MIOA, CMCIEH. Director Enviroconsult

Executive Summary

Enviroconsult Limited has been instructed by Biodynamic Carbon Limited (the operator) to prepare environmental permit application for their proposed pyrolysis site in Ludlow.

Consultation with the EHO at Shropshire Council (SC) noted that the type of permit application would depend on the materials combusted at the facility. Following discussion, it was agreed that a Chapter IV Schedule 13A SWIP permit application was appropriate.

Pyrolysis is the thermal decomposition of organic matter that releases combustible gases leaving behind a solid biochar. Charcoal is the term given to char substances from pyrolysis which are burned, whilst biochar is the term given to substances from pyrolysis where there the substance is not combusted but has other uses (in essence they are the same). Biochar is a very versatile commodity and can be used for agriculture, industrials or commercial applications dependent on the composition.

The volatile gases released from the organic matter are combusted to produce heat (for the drying and thermal decomposition) and energy by conversion to electricity.

Pyrolyzing waste requires a permit from the Local Authority.

The Biodynamic Carbon Limited process at Coder Road, Ludlow intends to process principally virgin wood, logs, green waste arisings from arboriculture, and compost oversize (materials that are screened out of compost as too big to process or those that have not degraded in the composting process).

The process is proposed to have a single pyrolysis reactor capable of processing ~6000 tonnes of waste/wood per year and produce around 1.4 MW of power as heat most of which is used onsite as primary heat, and the remainder is converted to electrical energy around 0.3 MW being used on site and exported to the grid. The reactor is estimated to generate up to 2000 tonnes per year of biochar (the main desired product).

The process is controlled by a computerised system to ensure materials are pyrolyzed at the correct rate, to ensure that full pyrolysis occurs so that biochar production is optimised, and that combustion is always maintained within regulatory limits.

The process is continuously monitored to ensure that emissions to air are compliant with best available techniques as described in UK law and referencing EU Directives and guidance.

This document and associated submissions provide the technical basis for the grant of an environmental permit to operate the process.

1 Introduction

1.1 Instruction

Enviroconsult Limited has been instructed by Biodynamic Carbon Limited (the operator) to prepare environmental permit application for their site in Ludlow.

Consultation with the EHO at Shropshire Council (SC) noted that the type of permit application would depend on the materials pyrolyzed at the facility. Following discussion, it was agreed that a Chapter IV Schedule 13A SWIP permit application was appropriate. It was also agreed that an application to the Environment Agency was not required but that they would be consulted as part of the permit application process.

Further it was noted that the Environment Agency had been approached as the primary waste regulator and that the designation of inputs and outputs from the process in respect of waste are separate to this application. This application and the site would be regulated on the basis of European Waste Code (EWC designations) and the appropriate verification of those wastes managed by the operator.

Enviroconsult has reviewed the site paperwork and inspected the trial plant (located in Powys, Wales) and has reviewed typical fuel source data, and confirms that the site requires a formal application in line with Environmental Permitting (England and Wales) Regulations 2016 (as amended) Schedule 13A as noted in section 1.3 below Basis for permitting below.

This document should be considered in conjunction with the application form.

The following work was identified:

- Review the waste inputs for the process
- Review the plant construction, design and operation commenting on suitability for intended use in the area.
- Review of primary legislation applicable to the installation (based on above).
- Identify BAT provisions for the installation for emissions to:
    - Air
    - Land
    - Water
    - Noise
    - Energy
    - Waste outputs
- Prepare and summarise the above in an appropriate format for a formal application to Shropshire Council.

1.2 Background

1.2.1 Site Description

Biodynamic Carbon is proposing to operate a pyrolysis process at the Former Biodigester Plant site, located at Coder Road, Ludlow, Shropshire.

The Site is located to the east of Ludlow on the Coder Road Industrial Estate, and directly adjacent to the A49 Main Road. The site is a former waste treatment facility incorporating hardstanding and a small, grassed area. It is completely screened from the road by mature trees and visible only from within the industrial estate.

The site is approximately 0.31 hectares of land and comprises a single large industrial building approximately 40m long x 15m wide x 8m high (to the roof ridge). The site also has 4 large silos to the rear (which may be retained for use for the pyrolysis process).

There are potential sensitive receptors to the west (approximately 160m), and to the north (approximately 260m) and south (340m), from the site. There are open fields to the east of the site.

The only other receptors are industrial buildings on the Coder Road Industrial Estate all within ~ 150m to the west. The surrounding landscape is comprised of agricultural and horticultural fields, and small copse and woodlands (see Appendix 7 for identified sensitive sites) and the river Teme (approximately 800m southwest of the site).

The site itself currently has hardstanding on approximately 90% of the land area, incorporating the site access, hard standing areas and a large tank installation comprising at least 4 large tanks.

The proposal is to erect a modern pyrolysis plant within the existing site building with ancillary waste handling to the rear (eastern side) adjacent to the road.

1.2.2 The Pyrolysis Process

Pyrolysis refers to the thermal decomposition of an organic feedstock in conditions of low (or no) oxygen (i.e. anaerobic conditions). The process can be a batch or a continuous process using energy electrical, direct fired gas or oil, biomass (which is the subject of this application), or even microwaves to provide the required thermal decomposition of the raw organic material, but in most cases the volatile syngas released from the process are combusted as the primary fuel. The types of input raw material in terms of nature, volatility, particle size, composition etc. dictate the most appropriate method of providing primary heat.

In all cases the thermal decomposition heats the raw material to a point where volatile components are driven from the solid mass in the form of gases and vapours. As the volatiles are removed, this leaves behind the inert carbon (Char).

The vapours comprise a mixture of organic hydrocarbons from low molecular mass hydrocarbons similar to natural gas, or alcohols, to heavier longer chain hydrocarbons similar to diesel, petrol or other oils.

The actual type of vapours and gases produced is dependent on the feedstock raw materials (composition, size, available surface area) and the process conditions, (time, temperature and pressure) to which the feedstock is exposed.

The low molecular weight gases and vapours are higher volatility (syngas) and are normally burned to produce the primary heat for the process, the high molecular weight gases and vapours can be condensed into a range of oils (pyro oil) or retained with the gases for combustion, leaving behind the solid inert char.

The proportion of syngas, oil, and char is determined by the raw material feedstock and the conditions of treatment. The conditions of treatment are normally deliberately fixed to optimise the production of one or more of the products and this can be assisted by the additional of a catalyst that may be required and, in some cases, can be used to accelerate or optimise the pyrolysis process.

Any organic material can be pyrolyzed. Pyrolyzing waste is inherently very similar to pyrolyzing virgin raw materials but may also include a range of undesired contaminants within the emitted products such as chlorine, sulphur, heavy metals and other contaminants dependent on the feedstock. Pyrolyzing waste therefore requires a greater level of control, and additional plant/equipment to control those contaminants to ensure that the products produced by the pyrolysis process meet the required standards to avoid being considered waste in their own right.

The most important driver behind the commercialisation of pyrolysis is the potentially significant environmental and economic benefits that can be achieved through the re-use of the gas, and solid products produced by the process and the avoidance costs associated with avoiding creating waste streams. Whilst high calorific value raw materials such as tyres and plastics are highly attractive feedstock materials for the pyrolysis process, the nature of the materials and the fact that these are wastes can make control difficult, particularly on a small scale. Processing waste in any form is subject to enhanced regulation that creates some operational and regulatory barriers for handling and processing of the raw materials, but also ensuring generated products are not waste.

Conversely, processing virgin raw material has fewer constraints. The image below shows the C1000 pyrolysis device (Figure 1.2.2).

Fig.1.2.2 C1000 Pyrolysis device

Pyrolysis of wood, (either virgin materials or arboricultural wastes or waste wood) and compost oversize is the proposed feedstock for a pyrolysis plant supplied by WoodTek Engineering Limited [link]. Future use of the plant may include other waste materials subject to verification of performance and compliance with permit conditions.

2 Compliance requirements (‘BAT’)

Drawn from the requirements of Schedule 13A EPR, the following sections provide the details of the required compliance standard and material evidencing how the Biodynamic Carbon facility is to comply.

2.1 Basis for Permitting

Operation of the Biomass pyrolysis process requires an environmental permit to control polluting emissions under the Environmental Permitting (England and Wales) Regulations 2016 (as amended) (EPR) [link].

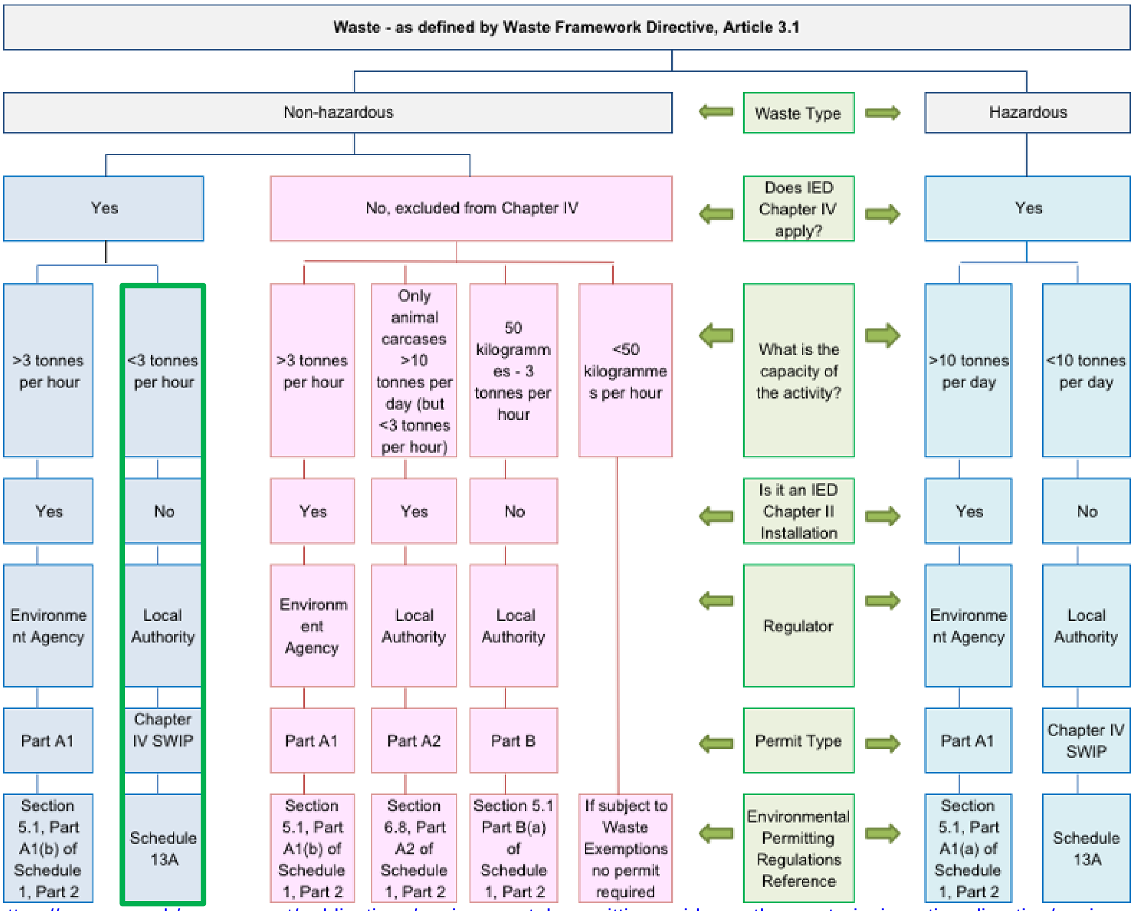
An environmental permit is required where;

(a) An A1 permit application under Schedule 1 section 1.2(f) for Gasification (*without combustion*) of carbonaceous material and the subsequent condensation and distillation to recover fuel. This is regulated by the Environment Agency and would apply *where no combustion of waste* takes place,
There is an absolute exemption in Part A(1), that states: :

> “*Carbonaceous material” includes such materials as charcoal, coke, peat, rubber and wood, but does not include wood which has not been chemically treated or sewage.*” [*emphasis added*]

(b) A permit application (see summary table Fig 2.1 below) for the incineration of *waste* (typically syngas) arising from the process dependent on the size and quantity of waste materials consumed.

Fig 2.1 Summary of the regulatory position for waste



https://www.gov.uk/government/publications/environmental-permitting-guidance-the-waste-incineration-directive/environmental-permitting-guidance-waste-incineration

To determine the permitting status, the following key questions have been used to determine the need for and type of environmental permit as follows:

1. Is the material pyrolyzed a waste?
    a. If material is waste a permit may be required under section 5.1 Schedule 1 EPR, or Schedule 13A EPR dependent on whether the waste is designated as hazardous or non-hazardous and subject to point 2 below.

       The materials to be pyrolyzed are listed in Section 3.1 below and the waste codes provided.

    b. If the material is not waste, then no permit will normally be required, however any combustion activity under section 1.1 Part B Schedule 1 EPR may apply where the net rated thermal input >20 MW), equally a requirement for a Medium Combustion Plant permit may be required where net rated thermal input exceeds 1 MW [link].

       The site will process non waste virgin biomass, clean woodchip or other biomass fuels that are non-waste. The controls applied for the permitted activity, will meet the requirements listed above.

    c. A Schedule 13A SWIP permit would supersede the need for a Medium Combustion Plant permit.

2. Where materials are subject to a Schedule 13A SWIP the following waste exemptions may apply if:
    a. the waste or the process exempt from permitting legislation (see Schedules 2 and 3 EPR)
    b. the waste or process below the minimum thresholds (see Schedule 1 EPR).

3. Is the material combusted subject to section 5.1 Schedule 1 EPR?
    a. Schedule 5.1 lists the following activities in Part B:
        i. *vegetable waste from agriculture or forestry*.
        ii. vegetable waste from the food processing industry, if the heat generated is recovered.
        iii. fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and the heat generated is recovered.
        iv. cork waste.
        v. *wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coatings.*
        vi. animal carcasses.

    The intention is to process not only (i) and (v) from the above list, but also to process compost oversize that are not stated in the section.

This application is therefore based on a need for a Schedule 13A SWIP for incineration of non-hazardous material no more than 3 tonnes/hour.

Note:
This is a pyrolysis process; the waste itself is not consumed by the combustion and only the evolved volatile gases are combusted. This represents a small fraction of the overall waste, and the combusted gases are significantly cleaner than for comparable incineration of waste. However, the gas itself, irrespective of the composition and clean nature is still designated as a waste. The materials processed are designated as wastes and therefore waste law still applies (see below).

2.1.1 Waste Permitting

The installation will not need a separate waste permit. Chapter IV waste incineration permits include the storage and pretreatment of wastes associated with the incineration.

Schedule 13(4)(e) references Article 42(1) of the Industrial Emissions Directive which states:

> *"For the purposes of this Chapter, waste incineration plants and waste co-incineration plants shall include all incineration lines or co-incineration lines, waste reception, storage, on site pretreatment facilities, waste-, fuel- and air-supply systems, boilers, facilities for the treatment of waste gases, on-site facilities for treatment or storage of residues and waste water, stacks, devices and systems for controlling incineration or co-incineration operations, recording and monitoring incineration or co-incineration conditions."*

Where a facility is permitted under Schedule 13A of the EPR, all waste storage and pretreatment is regulated by the Local Authority permit.

There is not normally a requirement for a separate waste permit.

2.1.2 End of Waste (EoW)

It is normal that waste derived products would have to demonstrate and meet 'end of waste' criteria laid down in law or match a currently existing Quality Protocol (QP). Quality Protocols are very specific.

A list of the current QP is found here.

There are currently no QP related specifically to the products of wood pyrolysis.

It is likely that any pyrolysis waste derived product will be viewed as a waste recovery operation and will need to consider EoW criteria to ensure that products (in particular the biochar) can be sold as a non-waste.

The EoW process requires that the products demonstrate the requirements of Article 6 (1) Waste Framework Directive which sets out the end of waste test. There are 4 key conditions that a recovered material must meet to achieve end of waste status. These are:

- Condition (a) – the substance or object is to be used for specific purposes.
- Condition (b) – a market or demand exists for such a substance or object.
- Condition (c) – the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products.
- Condition (d) – the use of the substance or object will not lead to overall adverse environmental or human health impacts.

The first three elements of the EoW process are normally fulfilled because of obvious customer demand and rigorous testing to ensure the recovered product meets the technical and operational requirements for use.

Biochar having potential value in many sectors, agriculture, construction materials, minerals processing, industrial applications etc. will be able to easily identify specific uses, market demands and technical/operational evidence.

The principal intention is to use the recovered Biochar as a soil improver and as an additive in low carbon construction materials (concrete, asphalt etc.).

The Environment Agency produced the product comparators for materials applied to land: non-waste biochar [link] in 2015. The document contains a series of tests on virgin raw material biochar's for use as soil improvers. It also contains the testing associated with the research.

The status of the products arising from the proposed pyrolysis process is as follows:

Syngas	Gas arising from the heating of waste and then combusted as part of the pyrolysis permit.
Condensate	Condensate arising from the drying process is condensed as far as practicable and discharged to storage tanks for reuse within the process. *There will be no condensate from the process as all water is recycled.*

Biochar — Biochar is the primary product of the pyrolysis process. The char chemical and physical properties determine end use. End of Waste is a matter for the Environment Agency.

Note: The sale and use of Biochar to third parties will be as a waste with declared physical and chemical parameters. The end user will determine the requirements for reuse, and the need or otherwise, for environmental permits or exemptions to handle and use the biochar.

2.2 Best Available Techniques

There is no specific section 65 EPR Guidance on pyrolysis. Determination of appropriate compliance is therefore based on the requirements of primary legislation, plus any associated relevant guidance and as follows:

- Schedule 13A EPR
- BAT Conclusion Waste Incineration 2019 (BATC WI) [link]
- BREF Note Waste Incineration (BREF) [link]
- Environmental Permitting Guidance: Waste incineration (online) [link]
- PG13/1(21) Reference document for the operation of small waste incineration plants (SWIPs) [link]

2.2.1 Schedule 13A requirements

Schedule 13A outlines the specific requirements for a Small Waste Incineration Plant (which includes Pyrolysis plants). An annotated version of the schedule marked for emphasis (underlined) is reproduced in full below with additional comments in *italic* text:

Application

1. This Schedule applies in relation to—

(a) every small waste incineration plant, and

(b) every waste incineration plant or waste co-incineration plant, to which Chapter IV of the Industrial Emissions Directive applies, except those which are operated as a domestic activity in connection with a private dwelling.

Interpretation

2. When interpreting Chapter IV of the Industrial Emissions Directive for the purposes of this Schedule—

(a) an expression that is defined in Part 1 of these Regulations has the meaning given in that Part;

(b) the competent authority is the regulator;

(c) "permit" means environmental permit;

(d) "general binding rule" means a standard rule published under regulation 26.

Applications for the grant of an environmental permit

3. The regulator must ensure that every application for the grant of an environmental permit includes the information specified in Article 44 of the Industrial Emissions Directive.

Article 44

An application for a permit for a waste incineration plant or waste co-incineration plant shall include a description of the measures which are envisaged to guarantee that the following requirements are met:

(a) the plant is designed, equipped and will be maintained and operated in such a manner that the requirements of this Chapter are met taking into account the categories of waste to be incinerated or co-incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable through the generation of heat, steam or power;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Union law.

Exercise of relevant functions

4.—

(1) The regulator must exercise its relevant functions so as to ensure compliance with the following provisions of the Industrial Emissions Directive—

(a)	Article 5(1) and (3);	(Grant of a permit)
(b)	Article 7;	*(Incidents and Accidents)*
(c)	Article 8(2);	*(Noncompliance breach of conditions)*
(d)	Article 9;	*(Emission of Greenhouse gases)*
(e)	Article 42(1)	*(Scope for Waste Incineration)*
(f)	Article 43;	(Definition of residue)
(g)	Article 45(1), (2) and (4);	*(Mandatory Permit Conditions)*
(h)	Article 46;	*(Control of emissions)*
(i)	Article 47;	*(Breakdown)*
(j)	Article 48(1) to (4);	*(Monitoring)*
(k)	Article 49;	(*Emission limit values)*
(l)	Article 50;	*(Operating conditions)*
(m)	Article 51(1) to (3);	*(Changing operating conditions)*
(n)	Article 52;	*(Delivery and reception of waste)*
(o)	Article 53;	*(Residues)*
(p)	Article 54;	(Substantial Change)
(q)	Article 55;	(Reporting & Public Information)
(r)	*Article 82(5) and (6).*	(Transitional Provisions – Not Applicable)

(2) But when interpreting the Industrial Emissions Directive for the purposes of this Schedule—

(a) in Article 51(1) ignore the words “Member states may lay down rules governing these authorisations”;

(b) paragraph 2.1(c) of Part 6 of Annex VI is to be read as if the words “and dioxin-like polychlorinated biphenyls and polycyclic aromatic hydrocarbons” appeared after the word “furans”, but only in the case of particular plants where the regulator can demonstrate that emissions of those additional substances are, or are likely to be, significant.

The remainder of this supporting statement will reference the requirements in *italics* and provide supporting information on demonstration of compliance having regard to specific guidance on the BAT WI conclusions (see section 2.3 below) and other guidance noted above as they apply to pyrolysis.

Schedule 13A Small Waste Incineration Processes (SWIP) must meet some of requirement listed in the Industrial Emissions Directive (noted above). It is *not identified as an installation* and as such it is a different class of regulated facility covered by Schedule 13A of the Environmental Permitting (England and Wales) Regulations 2016 (EPR). BAT does not apply to these SWIPs in England. BAT only applies to SWIPs in England if they are directly associated with a Part A or Part B installation activity. However, demonstration of compliance with ‘specified’ standards in Schedule 13A also references the BAT Conclusions on Waste Incineration. For simplicity, this document will use the compliance metric of BAT as a simplification of the ‘Non-BAT Schedule 13A compliance requirements”.

The compliance metric is therefore limited to those aspects identified in the IED above identified as the relevant functions in paragraph 4(1). It follows that the BAT Conclusion on Waste Incineration BATC Waste Incineration 2019 (BATC WI) provisions applicable to a SWIP are limited to those issues identified in the Schedule 13A requirements. The applicable BATC WI requirements *specifically related to management and operational control, emissions, and monitoring* outlined in BATC WI are included as required in the demonstrate of ‘BAT’ for each required element.

2.3 BAT Conclusion Waste Incineration

Pyrolysis subject to Schedule 13A permitting is not an installation as defined in the Environmental permitting regulations. The plant is required to comply with only Chapter IV and Annex VI requirements of the IED and the elements of Secretary of States' Guidance note PG13/1(21). However, in complying with the requirements of Schedule 13A, this references Article 44, and the other articles as requirements for compliance without defining particular standards. **The requirements of the BAT WI do not apply to Schedule 13A as the facility is not an installation as defined but compliance with the requirements is indicative of good compliance with permitting law**.

The BATC WI document therefore provides additional guidance that will help demonstrate compliance and has been included as a baseline. The relevant and helpful BAT conclusions are reproduced below.

2.3.1 BAT 1 EMS

In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the 28 itemised features for organisation management, operational control, planning for operation outside normal conditions, emergencies, meeting current emissions standards, demonstration of compliance through monitoring and continuous monitoring etc.

The applicant has an outline EMS that will be developed on commissioning of the plant to the requirements for BAT 1. The basis of the EMS will be to comply with the specific requirement of Schedule 13A. Elements of the EMS are already available for review if required.

2.3.2 BAT 2 Energy

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 applicant has supplied some basic energy data projections for the plant, but verification of energy produced will be provided only after construction and commissioning. The data provided identifies expected syngas composition, flow rates and projected energy production based on net rated thermal input and expected energy conversion efficiency to heat.

Additional data on the recovery of heat for beneficial reuse is provided from drying of raw materials, conversion to electrical energy and low temperature recovery.

Full details will be verified on commissioning. The current data is available at section 3.6 of this document.

2.3.3 BAT 3 Monitoring

BAT is to monitor key process parameters relevant for emissions to air and water including those given in the table below and those identified in section 2.3.4.

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

The process plant has continuous monitoring for all operational parameters (see section 4.1 below).

2.3.4 BAT 4 Emission Limit Values

BAT is to monitor channelled emissions to air with at least the frequency given below 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.

The emission limit values, monitoring frequency and standards and continuous monitoring relevant to the proposed Biodynamic Carbon facility in compliance with BAT 4 & 5 are:

Parameter	**Daily Average (mg/m^3)**	**Half Hour Average 97% (mg/m^3)**	**Daily Average 100% (mg/m^3)**	**Average 30 Mins - 8 Hours (mg/m^3)**	**Average 6 - 8 Hours (mg/m^3)**	**Continuous Monitoring requirements (CEM)**	**Periodic Monitoring frequency**	**Periodic Monitoring standard or method[1]**
No visible emissions (other than steam or water vapour)	-	-	-	-	-	No	At least 1/day	Observation
Oxides of Nitrogen (NO and NO_2 expressed as NO_2)	200	200	400	-	-	Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year	BS EN 14792
Oxides of Sulphur (expressed as SO_2)	50	50	200			Yes EN 14181 daily average	Within 3 months of commissioning then minimum of once per year	EN 14791
Carbon monoxide	50	-	100	-	-	Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year	BS EN 15058
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	10	10	20			Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year	EN 12619. BS EN
Hydrogen Chloride (SCl)	10	10	60			Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year	EN 1911 or EN 16429.
Hydrogen Fluoride (HF)	1	2	4			No	Within 3 months of commissioning then minimum of once per year	CEN TS 17340

Parameter	Daily Average (mg/m^3)	Half Hour Average 97% (mg/m^3)	Daily Average 100% (mg/m^3)	Average 30 Mins - 8 Hours (mg/m^3)	Average 6 - 8 Hours (mg/m^3)	Continuous Monitoring requirements (CEM)	Periodic Monitoring frequency	Periodic Monitoring standard or method[1]
Total Dust	10	10	30	-	-	Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year	EN 13284-1
Metals								
Mercury (and its compounds) (Hg)	-	-	-	0.05	-	No	Every 3month for 1st year Then Biannually	EN 13211
Grp 1 Metals Cadmium, Thallium and their compounds (total)) (Cd)(Th)	-	-	-	0.05	-	No	Every 3month for 1st year Then Biannually	EN 14385 and MID for EN 14385
Group 3 Metals Antimony, Arsenic, Lead, Chromium, Cobalt, Copper, Manganese, Nickel, Vanadium)	-	-	-	0.5	-	No	Every 3month for 1st year Then Biannually	EN 14385 and MID for EN 14385
Polychlorinated dibenzo-dioxins and polychlorinated dibenzo furans (Dioxins and furans)	-	-	-	-	0.1 ng/m^3	No	Every 3month for 1st year Then Biannually	EN 1948-4

Note 1: Monitoring techniques shall be carried out in accordance with MCERTs. Monitoring standards shall be carried out in accordance with the latest standard of the Monitoring stack emissions: techniques and standards for periodic monitoring [link] currently 17.11.22.

Note 2: In accordance with Article 46(6) of the IED no emissions shall continue to process waste where the emission limit is exceeded for more than 4 hours.

Note 3: In accordance with Article 46(6) of the IED non-compliant emissions shall not cumulatively exceed 60 hours in any 12-month period.

Note 4: Certification to the MCERTS performance standards indicates compliance with BS EN 15267-3

Compliance monitoring will be conducted within 3 months of commissioning.

2.3.5 BAT 5, 18 Other Than Normal Operating Conditions (OTNOC)/Breakdown

BAT 5 is to appropriately monitor channelled emissions to air from the incineration plant during OTNOC.

BAT 18 requires:

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

The process controls are designed to avoid the facility running where there are deviations from the required operational parameters, particularly those associated with combustion of syngas (see section 3.3 and section 4.2 below). These are based on the process control systems derived from HAZard OPerability studies (HAZOP) and identified critical control points. The proposed continuous monitoring (CEMS) identified in Section 4.1 will be installed and will always function recording compliance. Emergency procedures are identified and controlled using the SCADA system (see Appendix 4).

Maintenance plans will be produced once commissioning is completed.

2.3.6 BAT 6, 32 Emissions to water

BAT 6 is to monitor emissions to water from FGC and/or bottom ash treatment with at least the frequency given below 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.

There are no process emissions to water (other than surface water) from the proposed facility.

Surface water from process building is captured and recycled into the process as far as practicable to reduce the need for mains supply.

BAT 32 is required to prevent the contamination of uncontaminated water, to reduce emissions to water, and to increase resource efficiency, BAT is to segregate wastewater streams and to treat them separately, depending on their characteristics.

The aim is to ensure compliance with the emissions associated with BAT 6. As noted above, the Biodynamic Carbon plant recirculates and uses water, with no process releases related to the operation. Roof water is also captured and used within the process to offset mains water use. The mass balance of water notes that most water loss is via absorption into the biochar for cooling, evaporation or losses during drying and combustion. (See section 3.5.1 below)

2.3.7 BAT 1 for Residues

Residues within the meaning of the BATC are defined as "Slags and/or bottom ashes Solid residues removed from the furnace once wastes have been incinerated".

BAT 1 (xxiii) states:

> *a residues management plan including measures aiming to:*
> *(a) <u>minimise the generation of residues</u>;*
> *(b) <u>optimise the reuse</u>, regeneration, recycling of, and/or energy recovery from the residues;*
> *(c) <u>ensure the proper disposal of residues</u>; [emphasis added]*

The BAT conclusions assume that the residue is an undesired by product of combustion. Pyrolysis is a thermal decomposition process of organic materials where the residue (the biochar) is the desired product of the process. The entire purpose of the pyrolysis process is to produce a residue that has value whilst ensuring that its production is managed sustainably and without environmental impact.

The focus of residues in the context of pyrolysis is therefore to maximise the production of biochar, the exact opposite of the requirements noted above.

Clearly, where the biochar is produced using waste, the char remains waste until it is used either subject to an exemption or has been declared end of waste (see section 2.1.2 above).

Residues produced by combustion are recycled into the biochar product as part of the quench system. All residues (within the meaning of BAT 1) are reused within the process.

2.3.8 BAT 12 storage and handling of waste

BAT 12 requires that, in order to reduce the environmental risks associated with the reception, handling and storage of waste, BAT is to use both of the techniques given below:

	Technique	Description
(a)	Impermeable surfaces with an adequate drainage infrastructure	Depending on the risks posed by the waste in terms of soil or water contamination, the surface of the waste reception, handling and storage areas is made impermeable to the liquids concerned and fitted with an adequate drainage infrastructure (see BAT 32). The integrity of this surface is periodically verified, as far as technically possible.
(b)	Adequate waste storage capacity	Measures are taken to avoid accumulation of waste, such as: — the maximum waste storage capacity is clearly established and not exceeded, taking into account the characteristics of the wastes (e.g. regarding the risk of fire) and the treatment capacity; — the quantity of waste stored is regularly monitored against the maximum allowed storage capacity; — for wastes that are not mixed during storage (e.g. clinical waste, packed waste), the maximum residence time is clearly established.

BAT 32 states that in order to prevent the contamination of uncontaminated water, to reduce emissions to water, and to increase resource efficiency, BAT is to segregate wastewater streams and to treat them separately, depending on their characteristics.

Biodynamic Carbon plans provide for a fully concreted impervious surfaces for all operational areas. Designated waste deposition areas and a storage area for produced biochar are bunded to prevent waste escaping designated areas and any effluent leachate is captured and recycled back into the process. Wastewater does not leave the site.

All other wastes (other than non-conforming waste to be returned to suppliers) is processed by the pyrolysis plant and emissions minimised.

The surface water drainage for the site is processed connected to the main surface water sewer. Overflow from rainwater capture from extreme weather events is directed to the sewer, except where prevented by use of Penstock valves (Section 3.5.1 below).

3 Installation description

Biodynamic Carbon's pyrolysis operation receives waste from a number of sources. The waste is received in accordance with strict waste acceptance criteria (WAC), (see Appendix 2). Waste is stockpiled prior to further treatment and use. The wastes to be treated at the installation are outlined in section 3.1 below. The Biodynamic Carbon pyrolysis process is described in more detail in section 3.2 below

3.1 Wastes to be processed (C1)

3.1.1 Waste inputs

The proposed plant is to pyrolyze a mixture of waste only non-waste wood consisting of virgin timber, green waste, and compost oversize. Depending on the EWC waste classification, the following waste codes are considered necessary:

EWC Code	Description
02 01 03	plant-tissue waste
02 01 07	wastes from forestry
03 03 01	waste bark and wood
17 02 01	Wood
19 05 03	Off specification compost

All the wastes considered are designated as Absolute Non-Hazardous (AN) with the exception of Wood waste which is defined as Mirror Non-Hazardous (MN). The mirror designation recognises that some wood can contain hazardous materials, Biodynamic Carbon confirms that all wood will conform to 17 02 01 waste and will be verified as non-hazardous. Treated wood will not be processed. Designations and technical descriptions for the above can be sources from Guidance on the classification and assessment of waste (1st Edition v1.2.GB) Technical Guidance WM3 [link]

Processing virgin wood (products) will not require a permit. Processing (even part processing) a waste of any description will require a Part B or Schedule 13A permit and would require a Chapter IV SWIP permit subject to tighter environmental controls.

No hazardous wastes are to be processed.

3.1.2 Outputs

The product outputs from the pyrolysis process are combusted pyrolysis gases carrying heat (approx. 1.3 MW), and biochar ~ 1,000 – 2,000 tonnes/annum.

Where only virgin wood feedstock is processed (i.e. wood with no European Waste Code code) then the products are non-waste and are likely to be sold without waste regulation controls being applied, for example, wood logs arising from agricultural operations may not be waste, whilst wood chippings of brash arising from the same process may be. The following criteria are normally applied to determination of waste in respect of products.

- The material is waste and it has been discarded.
- The material was never waste – it meets the 'by-product' test or the 'reuse' requirements.
- The material has stopped being waste – it meets the 'end of waste' test.

It is likely that 'woody' wastes will be classified as 02 01 03, 17 02 01 or 19 05 03. In most cases these non-hazardous wastes are likely to be fairly consistent materials in respect of pyrolysis.

Biodynamic Carbon will not process hazardous waste.

The greatest concern for pyrolysis plants is water content of waste as this detrimentally impacts pyrolysis processes. In all cases the Biodynamic Carbon plant has pre-process drying to ensure consistent moisture content.

Wastes will be blended within the installation and the pyrolysis plant controls will adapt to the input materials using process controls (see section 3.5 below).

Where a feedstock material has a waste code, and if *any of the material* contains waste, then the products of any process or recovery operation remain designated as waste.

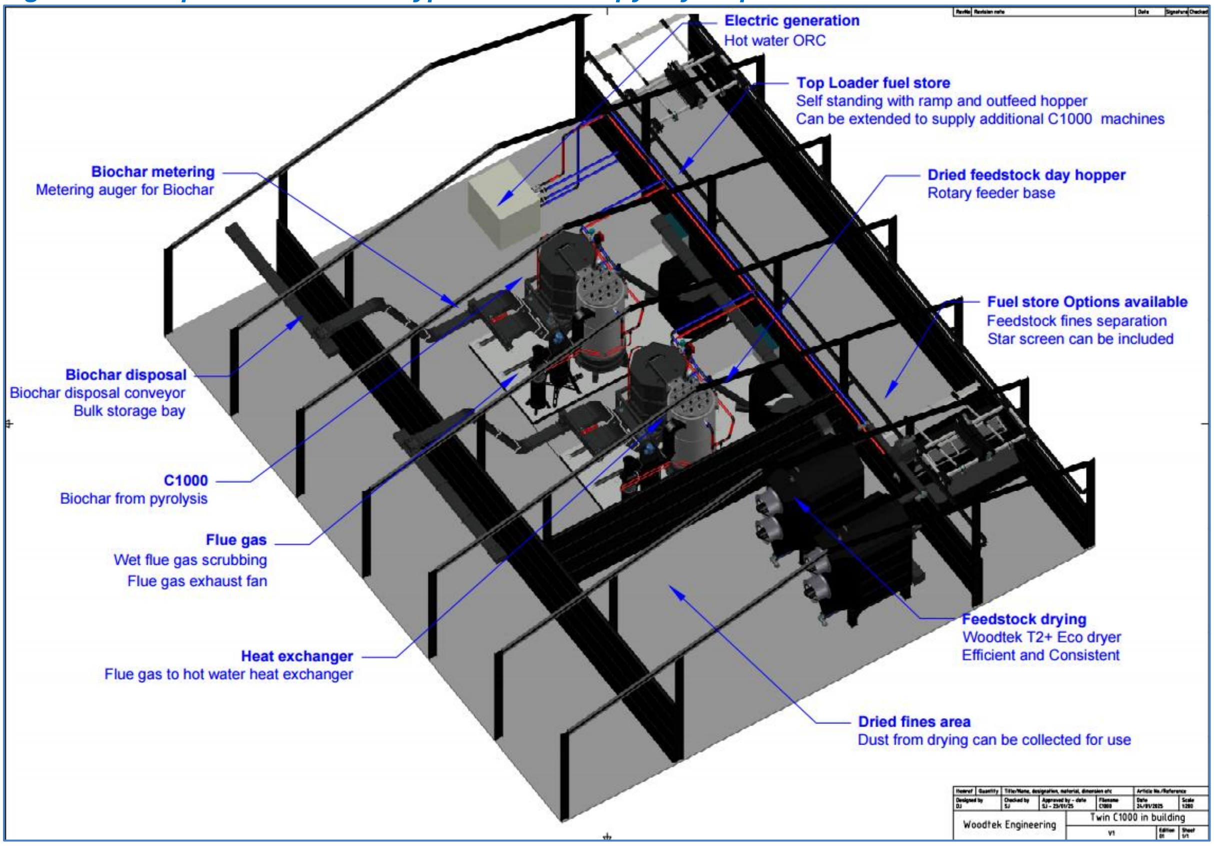
This is important because such materials cannot legally be sold as products without have a designated end of waste assessment (normally demonstrated by certification to a Quality Protocol or formal End of Waste Assessment).

This permit application does not deal with the End of Waste aspects as these are regulated by the Environment Agency. The issue is important as, if output products are still designated as wastes, then control of the product storage (Biochar) and management in accordance with the permit is still required (see section 2.1.2 above).

3.2 The Biodynamic Carbon process (D1)

The proposed key elements for the proposed plant provided in the diagram Fig.1.2.2 and text below:

Fig.1.2.2 3D representation of a typical Woodtek pyrolysis plant



The elements of the Woodtek plant are described below.

1. Biomass & Chipping

Biomass material in the form of logs, chipped wood and compost oversize material will be delivered to the site and stored in controlled conditions to prevent additional moisture gain.

The material is then chipped if required, (noting the majority of material is likely to be received at 50mm or smaller) and is then taken by loading shovel to the large top loader storage for continuous supply to the drier. Where material does not need chipping, the material will be placed directly inside the top loader avoiding unnecessary loader movements.

2. The feed auger

The feed auger takes material from the hopper and screw feeds it to the drier at a fixed predetermined rate to avoid blockage.

3. T4+ dryer

The T4+ drier is a vertical woodchip drier with a maximum output rate aligned to a single C1000s (rate of 581 kg/hr at 15% moisture content). The drier provides a high level of precision control to utilise only the power required to delivery wood of a specified moisture content to the pyrolysis reactor. Energy requirements are met by a parasitic load on the combustion of syngas. There will be one drier in the plant, providing dry feedstock for the C1000.

4. C- 1000 pyrolysis thermal combustion plant

The C-1000 pyrolysis reactor is rated to produce over 2 tonnes of Biochar per day. The pyrolysis reaction generates gases which are combusted ahead of flowing through a Flue-gas-to-water heat exchanger to provide thermal energy for Organic Rankine Cycle (ORC) for electrical generation. The 999kW hot water heat exchangers are connected to an ElectaTherm power unit.

5. Gas scrubbing

The exhaust gas having had most of the heat from it recovered in the heat exchangers is directed to a wet gas scrubber. Exhaust gases pass through cascading water in the form of droplets, and the gas/liquid interface removes physically removes solid particles and chemically removes soluble gases such as Hydrogen Chloride. The gas is further cooled with water being condensed and reused, reducing external water demands.

6. Flue Vent

The Flue Vent (chimney) has an internal diameter of 450mm, and a height of 10m. Exhaust gases are vented at least 15m/s to achieve good dispersion and meet appropriate air quality guidelines.

The flue vent terminates 2m above the roof ridge so as to avoid aerodynamic downwash and is fitted with an accelerator cone to reduce the diameter at the final point of exit to 400mm (increasing efflux velocity to >15m/s).

7. Discharge conveyors

The chain drag conveyors, remove the biochar from the process after quenching and deposit the biochar in a concrete bunker outside the processing building.

The quench water is recycled into the process and is part of an enclosed system for gas scrubbing.

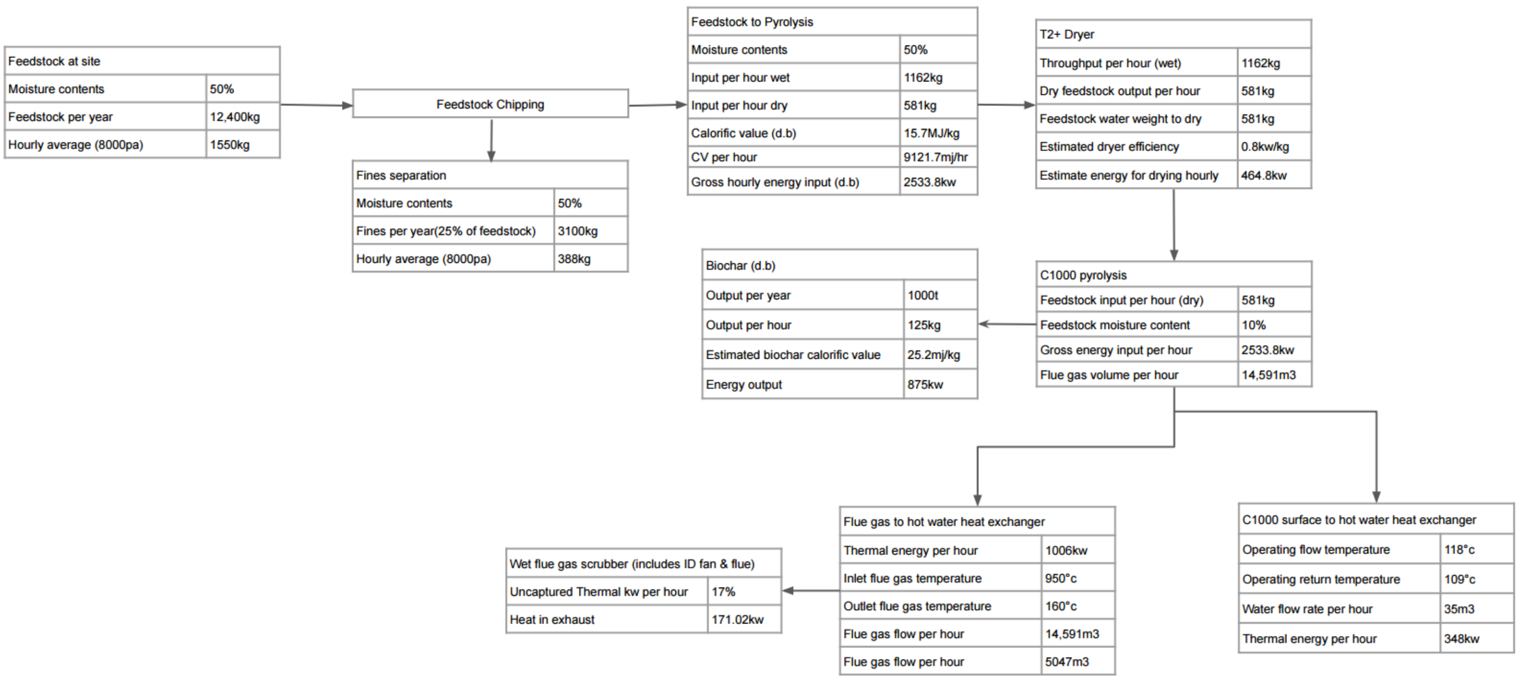
Energy Generation

The ORC system is specifically designed for capture of maximum energy from low temperature systems and optimises energy generation potential.

Initially, ElectraTherms ORCs will be used, the integration of a semi-hermetic, twin-screw expander gives ElectraTherm's ORC systems an advantage over competitive technologies and opens market opportunities where waste heat recovery has previously been either impossible or unpractical and includes an ability to manage multiple different thermal loads in varying wet and dry conditions.

The ElectaTherm 75 power unit is capable of generating 75 kWe of energy. The system is designed to be operated 24 hours per day, 365 days per year and can be monitored and operated remotely, ensuring that operational efficiency is optimised.

3.3 Process Overview (D1)



The above block diagram shows a typical simple mass energy balance for the C1000.

Raw materials are delivered to the site and normally delivered directly to the main process building. Additional wastes are stored in the covered bunker areas located to the north of the site.

Input materials are auger fed in for each process plant at maximum rate of 750kg/hr ~6,000 tonnes/year/reactor. The feed rate will vary as the moisture content of the feedstock varies through the seasons. There is only one reactor at the Ludlow site.

The feedstock is dried to ~10-15% moisture content and is then subject to pyrolysis in the C1000 pyrolysis plant.

The feedstock is heated in a low oxygen environment and releases the remaining moisture and volatile compounds that are subsequently extracted and combusted to provide the primary heat. The volatile gases contain trace pollutants that are destroyed during the combustion process.

Emissions from the combustion process are driven through the heat exchanger to the wet scrubber, where excess moisture, soluble pollutants and particulate matter is removed.

The process plant final emissions to atmosphere are monitored continuously to demonstrate compliance and emitted to atmosphere through a 10m high emission stack.

The evaporated water which condenses in the scrubber is sent to the water bath for quenching biochar before being recirculated back to the scrubber. Hot water from the heat exchanger enters the Orcan ORC plant and generates energy in a closed loop system.

The residues (biochar) are removed from the reactor and are quenched prior to being moved by conveyor to Biochar Storage.

3.3.1 Process controls

The proposed pyrolysis plant is a new development project. Four other such plants currently operate in Sweden, BioDynamic Carbon in Powys (Wales), Brodie Bioamss in Surrey and BIOCCUS in West Sussex but process only materials controlled by a Part B SWIP. The process control systems therefore need development to ensure compliance with a Chapter IV plant.

The controls are summarised as follows:

- At source controls (feedstock control)
- Process (engineering and operational) controls
- Dispersion

At source controls are based on control of feedstock to ensure that the waste processed conforms to:

- Waste codes permitted to be processed
- Size and shape of materials to be introduced into the process (optimum size is <30mm)
- Composition of materials to be introduced conforming to expected parameters (received waste from known sources and suppliers)
- Materials testing where required to ensure appropriate calorific value, moisture content and (where necessary) sampling of contaminants.

Process and engineering operational controls rely on the SCADA/PLC systems. The full process control system is subject to commercial sensitivity and will need to be developed on a site specific basis, however the key elements are provided in Appendix 4.

Dispersion of residual pollutants is the final control measure. A D1 chimney height calculation has been conducted which informed the dispersion model carried out for dispersion of residual emissions.

The dispersion model deals with pyrolysis of virgin wood, and compost oversize (see Redmore Environmental Report ref 8820r2)

3.3.2 Controls and Residence Time

Once in the main pyrolysis reactor building the waste is screw fed into the Woodtek C1000 plant. The screw feed is regulated to a set rate, the rate of feed dictates the amount of waste fuel introduced into the unit and therefore the power output. It also prevents overloading of the pyrolysis chamber. Current monitoring on the screw feed detects blockages and ensure consistent feed rate. Additionally, there is burn back protection to prevent the main combustion chamber igniting waste in the screw feed, this is principally accomplished by:

- ensuring that there are no air flowing in with the waste feed through use of a rotary feed valve.
- Having feedstock breaks (sections of empty auger) in the auger so the distance any burn back could occur is minimal

The fuel then enters the reaction chamber and is subject to thermal decomposition in a low oxygen atmosphere. The temperature of the chamber is optimised for the feedstock type (including moisture content, particle size and composition) and is likely to be at around 700ºC. The waste fuel is subjected to a complete pyrolysis cycle with pyrolysis gases providing the primary heat source via combustion of the gases in a chamber with a temperature above 850ºC and a residence time > 2 seconds (confirmation report to be provided on commissioning).

The carbon residue (now biochar) is quenched in a water bath at the base of the unit before being removed with chain conveyor and directed into an exterior storage bunker.

The combustion gases have a residence time in the primary combustion chamber of approximately 2 seconds. They then pass through a heat exchanger and the useful heat is recovered for reuse, the gases are then pass through a multi-cyclone wet scrubber to remove particulate matter and harmful emissions. Finally, the gases emit to air through a 10m 450mm emission stack with a 300mm cone. This stack height is ~1.5m above all buildings within the immediate area (see dispersion above), the silos are not considered to interfere with dispersion.

The calculations for the residence time for combustion of the syngas are being completed by KIWA Gastec Limited. Provisional data completed for a similar plant report that 4.07m^3 of combustion space is required, based on this and the thermal rating of a C1000 is 1,426 kW and with the combustion area there are no concerns the calculations will show a residence time of over 2 seconds.

3.3.3 Cleaning and Maintenance

Routine cleaning and maintenance mainly consist of cleaning of the heat exchanger tubes as well as greasing bearings and visually inspecting key components for wear. All cleaning and maintenance is carried out in accordance with the Woodtek instruction manufacturer instructions.

The key cleaning and maintenance is carried out by individuals certified and trained to operate, clean and maintain the plant and records of compliance are retained (see Appendix 6 forms).

The SCADA system highlights upcoming maintenance requirements for selected aspects including auger wear. The SCADA system also has an alarms log which will be used to optimise the maintenance routines. Plant failures are managed by the Biodynamic Carbon operators and where required independent engineering contractors. All maintenance and repairs are logged, analysed with lessons learned being taken to prevent future stoppages.

3.4 Receipt of waste (C2)

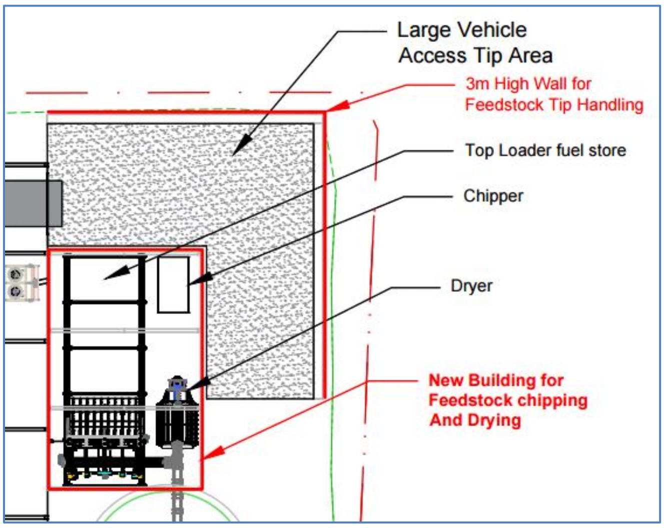
Most wood and compost oversize materials are delivered to site ready to process. Any materials screened to <50mm can be processed, however, to optimise throughput and efficiencies <30mm is preferred. Bulk green waste (and other wood or compost oversize) not delivered prepared, will be deposited in the main yard area at the rear of the process building and then manually loaded into the chipper. The manual loading also allows blending of wastes if necessary. The chipped material is discharged by ejector spout into the top loader if required. The waste is deposited directly into the top loaders, should a load need pre-processing or blending ahead of being delivered into the top loaders, it will be deposited into the main waste reception area introduced alternately to the chipper so that waste is spread across the length of the top loader (see fig.2.4.1 below). The top loader moves the waste automatically into transfer screw feed (see schematic plan fig.2.4.2 below). The top loader, chipper and drier are located within the extended building and are completely enclosed protecting the material from the weather and keeping in odours.

Waste is then automatically screw-fed from the drier to the main silo storage.

Moisture content of waste must be minimised to ensure efficiency of processing as it affects the calorific value of waste fuels. The calorific value of waste can vary, so where significantly different materials are being process, they will be combined to ensure homogenous mix to ensure consistent moisture content and calorific value and avoid any consistency variations.

Figure 2.4.1 example top loader

Fig.2.4.2 schematic of waste processing



Receipt of waste is managed in accordance with the waste acceptance criteria (see Appendix 3). These are the primary control mechanisms to ensure good combustion and relies on effective waste management and control.

All waste storage areas are located in areas with concrete hard standing.

All waste storage areas are connected to sealed drainage systems.

All waste storage areas are located in buildings to prevent possible emissions to air of dust or odour.

3.5 Storage of waste

Waste storage is managed for:

- Waste delivered to the installation
- Products (specifically biochar) generated by the installation that are not designated as End of Waste (see section 2.1.3 above).

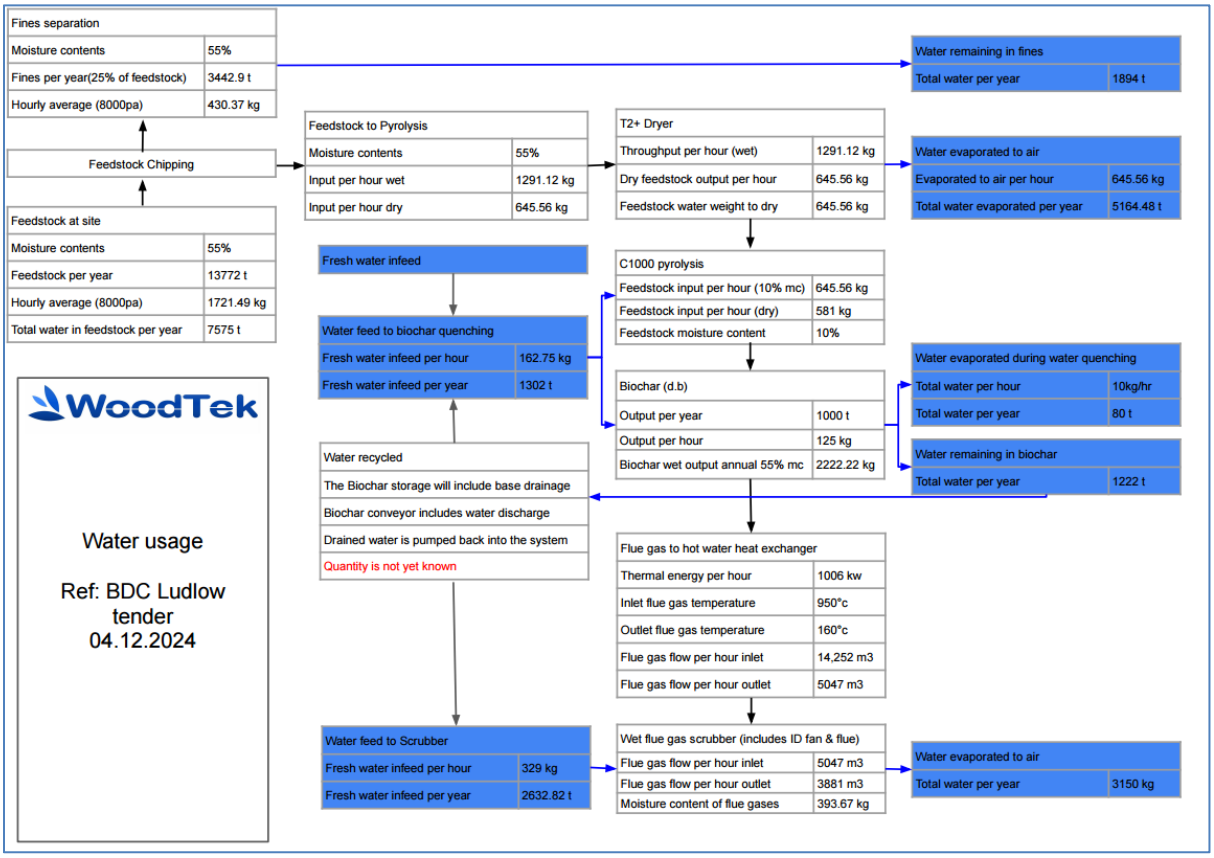
Raw material wastes are sourced from customers with robust environmental management systems. The wastes conform specifically to the waste inputs identified in section 3.1 above and are handled with due care to ensure potential dust and odour generation are minimised.

All wastes are stored in designated areas with concrete hard standing and fully contained within buildings or bunded areas. All waste areas are covered to prevent additional water ingress. Water (leachate) is not emitted from stored waste and is typically stored for <3 days and there is no potential for in situ composting. The majority of waste storage is in the top loader inside the main building.

All waste is retained onsite as short a time as possible to avoid composting or the degradation of the waste properties. Surface water from primary building is collected into tanks prior to reuse within the process.

There are no other waste arisings from the process.

3.5.1 Waste Waters



There are no process wastewater discharges from the installation.

Surface waters from the primary buildings are collected and recycled into the process as quench water. Process condensate from the driers and the pyrolysis process is used in the scrubbers. *There is no discharge of water from the installation.*

Through the efficient use and recycling of water it is expected that the facility will require around 160 litres/hour of additional top up water from mains supply.

The predicted water use is identified in the process flow above.

Firewater

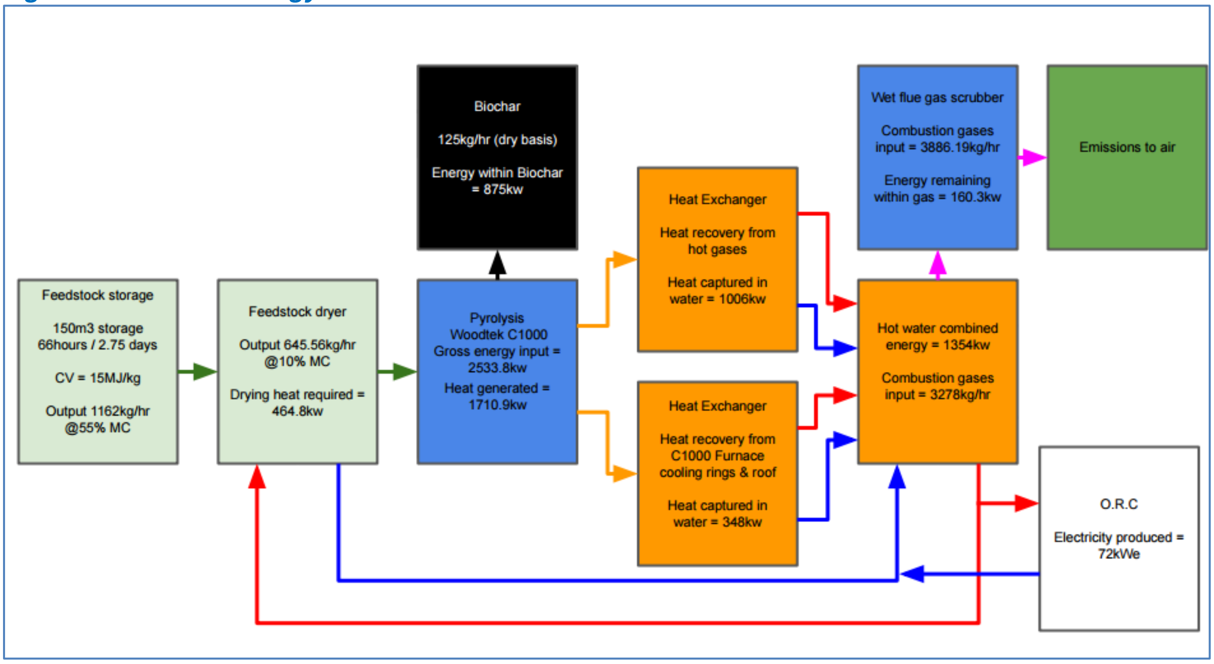
A firewater tank (likely to be a e rainwater storage tank) will be provided based on the size required by a firewater risk assessment.

The capacity of the system is the subject of the firewater management plan to be prepared prior to completion of commissioning.

3.6 Use of Energy (D4)

Energy generation within the installation comprises two aspects, heat and electricity generation are summarised in the diagram Fig.2.7 below. The diagram shows mass flow of feedstock and associated energy balance. Further details are provided in sections 3.6.1 and 3.6.2 below, however the data may be revised on commissioning to reflect actual operational levels.

Fig.3.6. Predicted Energy and mass flow



3.6.1 Heat

The heat generated from the combusted syngas is utilised for making the pyrolysis process self-sufficient. The hot flue gases are then passed through the Heat Exchangers, which capture this heat in the form of hot water. Even after making the system self-sufficient, the exhaust gases carry excess energy which can utilised for drying the feedstock. This excess heat can be either utilised as it is (for dying or space heating purposes or converted into electricity. Biodynamic Carbon employs the Organic Rankine Cycle (ORC) method for this purpose.

3.6.2 Electricity

An Organic Rankine Cycle (ORC) generator uses an organic working fluid to convert heat into mechanical work, which is then used to drive a generator to produce electricity. Biodynamic Carbon will export around ~50 kW of net electricity export after satisfying the parasitic load of the system.

A simple energy flow diagram for a single C1000 can be found in the mass energy balance diagram in Fig.3.6 above.

This electricity is carbon neutral and can be either utilised on-site or sold back to the grid depending on the requirements.

3.6.3 Energy generation

The pyrolysis gas is combusted to produce hot flue gases. The energy content of these gases is calculated by dividing the pyrolysis gas energy generation rate (MJ/hr) by the pyrolysis gas flow rate (kg/hr). For system 1 processing compost oversize and arb waste blended, the CV of the pyrolysis gas is calculated as 15-19 MJ/kg, for system 2 processing arb waste, the CV of the pyrolysis gas is calculated as ~16 MJ/kg and for wood ~19MJ/Kg.

The pyrolysis gases are all combusted within the C1000 (there is no piping of the gas and no condensation of tars or wood vinegars). The hot flue gases (post combusted pyrolysis gases) carrying the heat from the combusted pyrolysis gases are passed through Heat Exchangers to capture the heat in the form of hot water at the required temperature for the ORCs. This translates to roughly 1,050 kWh/hr of energy, which can be utilised directly for heating applications or passed through an ORC machine to convert it into electricity. Using cutting edge technology that will allow recovery of heat from low temperature water energy, the ORC machine will produce ~72 kWe of electricity. Considering the parasitic load of the entire system, the net electricity available for export or usage will be around 50 kWe.

Parameter	Value
Energy collected by water in HE	1,000 kW
Electricity produced by ORC	72 kWe
Parasitic load	25 kWe
Electricity available for export	50 kWe

3.6.4 CO2 Removal Certificates (CORC) (D1 & Article 9)

A CO2 Removal Certificate (CORC) is a carbon removal credit specifically from Puro Earth for 1 metric tonne of CO2. Puro Earth is the world's largest carbon removal registry. CORCs are created from activities that remove carbon dioxide from the atmosphere. They are the first credits for engineered carbon removal from biochar production. CORCs demonstrate that biochar is a net-negative product and process, meaning they remove more CO2 from the atmosphere than is produced during the production of the biochar.

To qualify for CORCs, a supplier's emissions are calculated based on a lifecycle analysis. These emissions are deducted from the CO2 removed by the company's products. Only the remaining net-negative emissions can be turned into CORCs, with each CORC representing one tonne of carbon dioxide removal. The emissions reductions are independently verified by an accredited auditor, and CORCs are issued in the Puro Registry where they are publicly visible.

Biodynamic Carbon has partnered with Puro to calculate and obtain CORCs for the carbon removal Biodynamic Carbon will achieve. Based on calculations, the project is predicted to generate around 2000 CORCs annually, which is equivalent to net carbon removal of approximately 2000 tCO2e every year. The exact figure will be calculated with a full life cycle assessment after operations commence.

Article 9 of the Industrial Emissions Directive (IED) requires that greenhouse gas emissions are managed, and emission limits set if applicable to the installation. While Article 9 specifically addresses the emission of carbon dioxide from installations, it excludes those specified in Annex I of the 2003/87/EC Greenhouse Gas Emissions Trading Directive and specifically installations with a net rated thermal input of less than 20 MW.

The Biodynamic Carbon facility has a net CO2 benefit where emissions are considered subject to ensuring appropriate operational control to ensure good combustion (see section 2.3 above).

4 Emissions Limits and Combustion Controls

The Biodynamic Carbon pyrolysis plant combusts waste generated syngas that requires a permit to be issued under the provisions of the Environmental Permitting (England and Wales) Regulations 2016 (as amended) in line with the requirements as noted above.

4.1 Emission limits and monitoring (D5)

The primary guidance for incineration of waste for Chapter IV incineration processes is the BAT WI. Guidance notes PG1/12(18) and PG5/1(21) may also contribute to processes burning wood and waste wood requires compliance monitoring of emitted pollutants, as part of demonstrating compliance. In each case the tightest emission limit has been selected that is applicable to the plant.

Careful selection of feedstock, and optimising combustion are the principal control mechanisms for ensuring low levels of pollutant emissions. For that reason, the installed plant automatically monitors temperature and oxygen conditions within the combustion chambers and automatically adjusts fuel feed rate or influent air to ensure that combustion is maintained in optimum conditions (see combustion controls section 4.2 below).

Annually the plant should be sampled for pollutant emissions to formally demonstrate compliance with the standard outlined in the BATC paragraph 4 and continuously monitor some of the key parameters (see section 2.3.4). The following monitoring is proposed for the facility.

Parameter	**Daily Average (mg/m^3)**	**Half Hour Average 97% (mg/m^3)**	**Daily Average 100% (mg/m^3)**	**Average 30 Mins - 8 Hours (mg/m^3)**	**Average 6 - 8 Hours (mg/m^3)**	**Continuous Monitoring requirements (CEM)**	**Periodic Monitoring frequency**
No visible emissions (other than steam or water vapour)	-	-	-	-	-	No	At least 1/day
Oxides of Nitrogen (NO and NO_2 expressed as NO_2)	200	200	400	-	-	Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year
Oxides of Sulphur (expressed as SO_2)	50	50	200			Yes EN 14181 daily average	Within 3 months of commissioning then minimum of once per year
Carbon monoxide	50	-	100	-	-	Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	10	10	20			Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year

Parameter	Daily Average (mg/m^3)	Half Hour Average 97% (mg/m^3)	Daily Average 100% (mg/m^3)	Average 30 Mins - 8 Hours (mg/m^3)	Average 6 - 8 Hours (mg/m^3)	Continuous Monitoring requirements (CEM)	Periodic Monitoring frequency
Hydrogen Chloride (SCl)	10	10	60			Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year
Hydrogen Fluoride (HF)	1	2	4			No	Within 3 months of commissioning then minimum of once per year
Total Dust	10	10	30	-	-	Yes EN 14181 30min and daily average	Within 3 months of commissioning then minimum of once per year
Mercury (and its compounds) (Hg)	-	-	-	0.05	-	No	Every 3month for 1st year Then Biannually
Grp 1 Metals Cadmium, Thallium and their compounds (total)) (Cd)(Th)	-	-	-	0.05	-	No	Every 3month for 1st year Then Biannually
Group 3 Metals Antimony, Arsenic, Lead, Chromium, Cobalt, Copper, Manganese, Nickel, Vanadium)	-	-	-	0.5	-	No	Every 3month for 1st year Then Biannually
Polychlorinated dibenzo-dioxins and polychlorinated dibenzo furans (Dioxins and furans)	-	-	-	-	0.1 ng/m^3	No	Every 3month for 1st year Then Biannually

Note 1: Monitoring techniques shall be carried out in accordance with MCERTs. Monitoring standards shall be carried out in accordance with the latest standard of the Monitoring stack emissions: techniques and standards for periodic monitoring [link] currently 17.11.22.

Note 2: In accordance with Article 46(6) of the IED no emissions shall continue to process waste where the emission limit is exceeded for more than 4 hours.

Note 3: In accordance with Article 46(6) of the IED non-compliant emissions shall not cumulatively exceed 60 hours in any 12-month period.

Note 4: Certification to the MCERTS performance standards indicates compliance with BS EN 15267-3

Note 5: Continuous emission of HCL and TOC will only be required once fully commissioned and Compost oversize is processed as part of the phased introduction.

Formal compliance monitoring of stack emissions results for the facility will be provided within 3 months commissioning.

Neither the IED nor the BATC WI provides a definition for 'normal' operations. It is usually accepted that normal operations are determined to be typical continuous combustion using feedstock for which the facility is permitted and within process design specifications. Non-normal conditions must therefore be where the process is not continuously combusting or where plant operation is outside of normal process controls (see process control Appendix 4).

During startup clean virgin biomass (woodchip) is fully combusted, but the feed rate is substantively reduced to ensure uniform temperature increase of the plant. The purpose of the startup procedure is to raise the chamber temperatures up to operational levels. During this period ash will be produced, this ash will discharge from the unit with the biochar when the switch from startup to full operational mode is made. Startups are envisaged every three months following routine maintenance and take approximately 6 hours. Excess emissions are not envisaged during startup.

The Dark Smoke (Permitted Periods) Regulations, 1958 provided exemptions for dark smoke emissions in relation some loading/unloading activities. The principle here is identical. It follows that some emission periodically may be acceptable providing appropriate BAT controls are in place. The acceptability of such emissions would be dependent on the combustion controls.

4.2 Combustion Controls (D1)

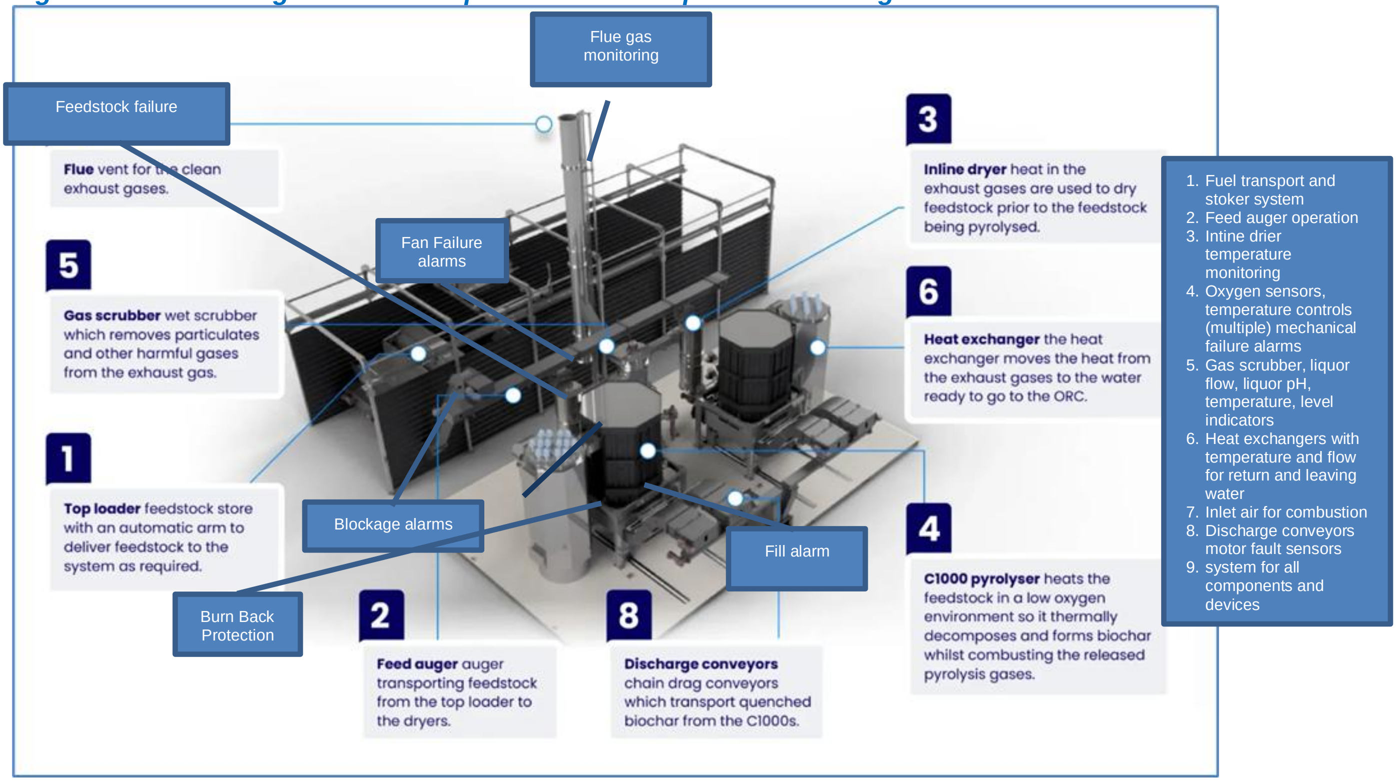
Pollutant emissions from the boilers are controlled by ensuring complete combustion. The technical specification for the C1000 (see SCADA Manual Extract) described the process controls in detail. In summary they are:

- Use of Lambda probe (O2 sensor) to ensure fuel/air mixture is optimised during operation to control combustion related pollutants; and,
- Use of continuous temperature and pressure monitoring in the combustion chamber to control combustion temperatures and ensure complete combustion of fuel
- Feed rate adjustment to control fuel delivery.
- Current sensors on fuel input screws to notify of blockages (if a blockage is detected, augers will reverse for a few seconds before resuming to attempt to self-clear the blockages)
- Rotary feed valves to prevent O2 ingress into the unti preventing back burn.
- Wet scrubbing cyclone to control emissions of particulate matter and emissions;
- Motor alarms to notify or a fan, pump or motor failure.
- Use of compressed air mechanism which is controlled via control unit to clean the heat exchanger, ensuring optimal efficiency.
- Quarterly cleaning and servicing in accordance with manufacturer specification/instruction;
- Automatic shutdown should a set temperature/pressure /O2 value be exceeded or a failure in a motor.

The diagram Fig.4.2 below provides an indicative schematic of the plant.

The full process controls for the plant are implemented by the SCADA system. A summary of the system controls for emergencies is provided in Appendix 4. General operational controls are provided in the SCADA Manual Extract.

Fig.4.2 Indicative diagram of C1000 plant and critical point monitoring



The company also have enhanced controls operating at the site.

All plant telemetry, oxygen sensor data, side air controls, fuel flow rates, alarms, etc. is linked to onsite alarms, and to mobile phone alarm systems held by key individuals,

(1) The main plant operator
(2) The QSHE manager

Both individuals are notified if the boiler plant deviates from any of the pre-set programmed controls, for example, if Oxygen concentrations drop below 6% the alarm sounds and both mobile phones register the alarm status. Either phone may then be used to correct the fault via remote operation if this becomes necessary. Similarly, any failure alarm will shut down the process into standby mode, for example, fuel feed blockages.

The plant has automatic controls with capability to vary key parameters based on programmed scenarios. The plant therefore requires very little day to day manual operational control providing the fuel source is kept consistent. Significant time is spent ensuring WAC are complied with, that ensures fuel sources are constant.

Moreover, the control panel is programmed to automatically stop the process if the device parameters significantly vary from the normal settings. The key values will be set during commissioning and based on the feedstock properties.

This is considered comply with the requirements of BATC WI. The only remaining potential concern for visible emissions from the installation would be dispersion or residual pollutants. It should be noted that some water vapour loss may be noticeable dependent on ambient temperature and weather conditions.

4.3 Dispersion (D2)

The emissions stack provides a method of dispersion of the residual pollutants following combustion. The height is one of the main factors dictating how effectively the residual pollutants are diluted and dispersed into the environment. There is a minimum emission height for all chimneys that must be calculated before installation. A basic calculation has been undertaken as the basis for emission modelling.

A dispersion model was conducted by Redmore Environmental to determine the impact of emissions from the proposed plant at chimney height of 10m. The modelled was conducted as per the Environment Agency Guidance, and the results compared to the ambient air quality for the area. The potential additional impact of combustion determined, and the process contributions calculated for key pollutants. A summary of the results of the modelling are provided in Appendix 5, the full report is attached to the application as a supplementary document.

The results show that, based on a conservative approach a chimney height of 10m is the optimum height to disperse residual pollutants and avoid potential human receptor concerns as well as minimise impacts on ecological receptors.

4.3.1 Odour

The potential for offsite odour is considered low.

The main source would be unprocessed material stored within covered bunker storage bays or within the main building. The materials to be processed, wood, green arboricultural waste, and compost oversize are not typically odorous.

Good combustion eliminates odorous chemicals and reduces them to harmless by products normally CO2 and water. Any such incident would be short duration, as the combustion plant is either turned off, or run to completion in prior to rectifying the feed stock or fault causing the incomplete combustion.

Most odour events would be a minimal impact due to the distance of separation from source to sensitive receptors. It is also noted that wind directions would need to be easterly to impact the closest receptors.

In context, and given that offensive odour should not occur, process emissions should be minimised by the proposed 10m chimney height, which provides enhanced dispersion is considered suitable and deliverable within reasonable cost and should be considered in association with the simple odour management plan noted in paragraph 3.4.2 below.

4.3.2 Odour Management Plan

Scope

The following *simple* plan should be implemented in the event that incomplete combustion is occurring either as a result of the sounding of alarms, visible emissions of smoke, reported emissions of smoke or odours off site. Odour receptors are noted to be as follows (table derived from Table 2 IAQM odour guidance July 2018):

Distance	Sensitivity	Severity
<150 m Industrial and commercial locations surrounding the plant to the north, west and south	**LOW sensitivity** Surrounding land where: • the enjoyment of amenity would not reasonably be expected; or • there is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Examples may include industrial use, farms, footpaths and roads.	**Moderate odour impact,** potential for a occasionally noticeable from occasional burning wood smell from startup or shutdown in the immediate area. However, this is unlikely unless easterly winds occur.
>150m Residential locations to the west	**High Sensitivity** Surrounding land where: • users can reasonably expect enjoyment of a high level of amenity; and • people would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Examples may include residential dwellings, hospitals, schools/education and tourist/cultural.	**LOW odour impact**, potential for a slight detectable wood burning wood smell in a small urban residential area. However, this is very unlikely unless easterly winds occur.

It is noted that the most likely to be affected by any odorous emission are local industrial sources. The likelihood of an odour event is LOW. Where an event occurs, and compromised combustion creates offensive odour the potential for odour impact is moderate. It is unlikely that industrial receptors will be significantly adversely affected. The duration of such events is likely of the short, and the controls in place should reduce frequency to a negligible level.

A more significant impact would be an odour event that is noticeable at residential receptors. These receptors are HIGH sensitivity but unlikely to experience a noticeable odour as the concentration of odour at the extended separation distance is LOW. Whilst the sensitivity may be high, wind direction, odour strength and duration of incident all need to coincide to create a potential adverse event. Again, the duration of events is short, and the frequency should be negligible.

This can be summarised in the matrix below (Table 3 IAQM Odour Guidance), the blue and green boxes summarise the potential impacts associated with an odour event:

Relative Odour Exposure (Impact)	Receptor Sensitivity: Low	Receptor Sensitivity: Medium	Receptor Sensitivity: High
Very Large	Moderate adverse	Substantial adverse	Substantial adverse
Large	Slight adverse	Moderate adverse	Substantial adverse
Medium	Negligible	Slight adverse	Moderate adverse
Small	Negligible	Negligible	Slight adverse
Negligible	Negligible	Negligible	Negligible

Applicable to odours at the "most offensive" end of the relative-unpleasantness spectrum

Potential for odour creation is dependent on issues arising with the installation.

Odour issues

Emissions of odour from the combustion plant are likely to be due to one or more of the following:

- Plant failure,
- Improper combustion conditions, low oxygen, low temperature, etc.
- Improper fuel source selection (see waste acceptance criteria),
- Externally stored wet or contaminated materials.
- Improper raw material storage

If any of the above issues are noted then the operator shall implement any/all of the following control measures,

Controls

Control the combustion by ensuring that the cause of the emission is addressed, and the ongoing issue mitigated as far as practicable.

1. Check plant for alarm failures
2. Check primary combustion temperature is within specified operating range
3. Check combustion O_2 is above specified minimum%
4. Check feedstock is dry (visual inspection)
5. Check feedstock is not excessively contaminated (visual inspection)
6. Check atmosphere conditions for abnormal weather events e.g. inversions.

Where controls 1 – 6 are checked and corrected as necessary to conform to normal parameters, if odour persists, the plant should be brought to a controlled stop and cleaned and maintained as necessary. If during a restart, odour issues persist, an appropriately qualified engineer should be contacted, and the plant should remain stopped until the cause of the fault is determined, and repairs have been completed.

Recording
The time, date and duration or all adverse odour events should be recorded, along with the details of corrective action taken to resolve the problem. This incident report should be formally recorded, and the correct operation of the combustion plant verified pending continued operation.

Where an event has the potential for offsite adverse impacts, the regulator should be notified and provided with the incident report as soon as practicable.

Complaints
Any complaints of odour shall be investigated immediately, control measures should be verified as working, and an assessment of the potential impact carried out. An incident report should be produced to formally record the outcome of the investigation. The regulator should be notified of the complaint, and the actions taken to investigate. The complainant should be contacted and advised as to the outcome of the investigation and any corrective action taken.

5 Competency

BAT 1 of the BATC WI states:

> *"BAT 1. In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:*
>
> *(vii) ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training);"*

Within the UK competency for management and handling of waste is demonstrated by compliance with one of the following schemes:

- the scheme run jointly by the Chartered Institution of Wastes Management (CIWM) and Waste Management Industry Training and Advisory Board (WAMITAB)
- the Energy & Utility sector Skills Council (EU Skills) - a scheme run jointly by EU Skills and the Environmental Services Association (ESA)

Biodynamic Carbon confirms that prior to operation staff will be suitably competent to manage and operate the facility once commissioning has completed. During commissioning suitably qualified individuals will be available to authorise commissioning in accordance with the provisional controls identified in this document and in line with best practice.

Woodtek Limited (the plant supplier) currently have 4 operational plants in the UK and abroad, successfully processing the materials noted in this application.

Full guidance on operator competency is provide on the following government website [link]

6 Conclusion

Enviroconsult is satisfied that the pyrolysis plant has been properly identified as a Chapter IV SWIP and that a Schedule 13A application is appropriate to secure both the current and intended immediate future use of the site.

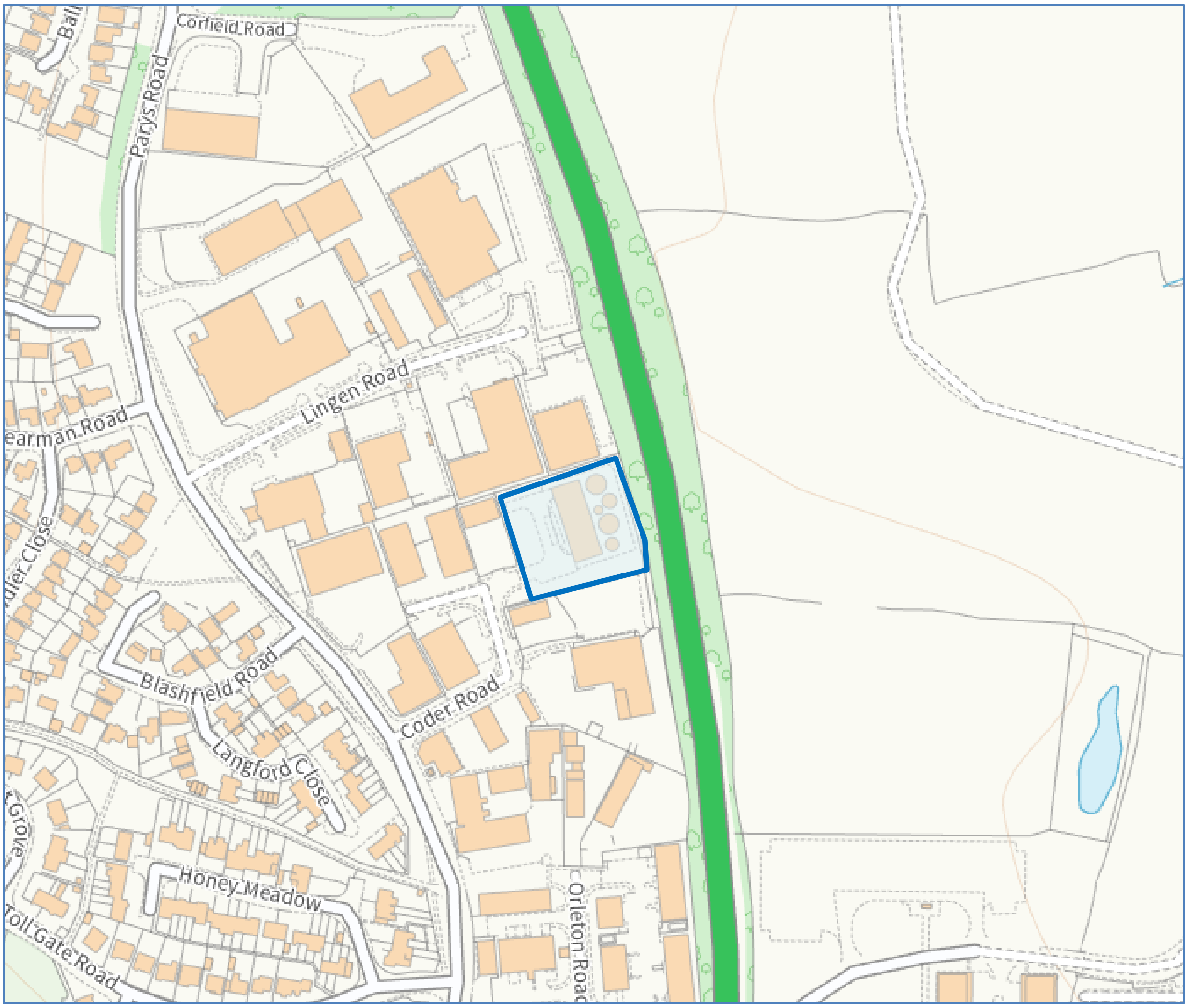
Enviroconsult is satisfied that the environmental permit template issued by the LAU is suitable and is fit for purpose and contains the expected controls and emission limit values applicable to this installation.

Enviroconsult has reviewed the waste acceptance criteria, the documented systems for control of waste, the plant operation, the control mechanisms, and the paperwork systems demonstrating that those systems are in place and/or will be developed on commissioning. Enviroconsult is satisfied that plant is suitable for the intended use, and that the control measures in place represent appropriate criteria for compliance (read BAT). Enviroconsult is satisfied that these controls can be implemented on site by suitably qualified individuals.

Enviroconsult is satisfied that maintenance and cleaning procedures are in place in line with manufacturer's instructions.

Appendix 1 – Plans (B)

Location Plan



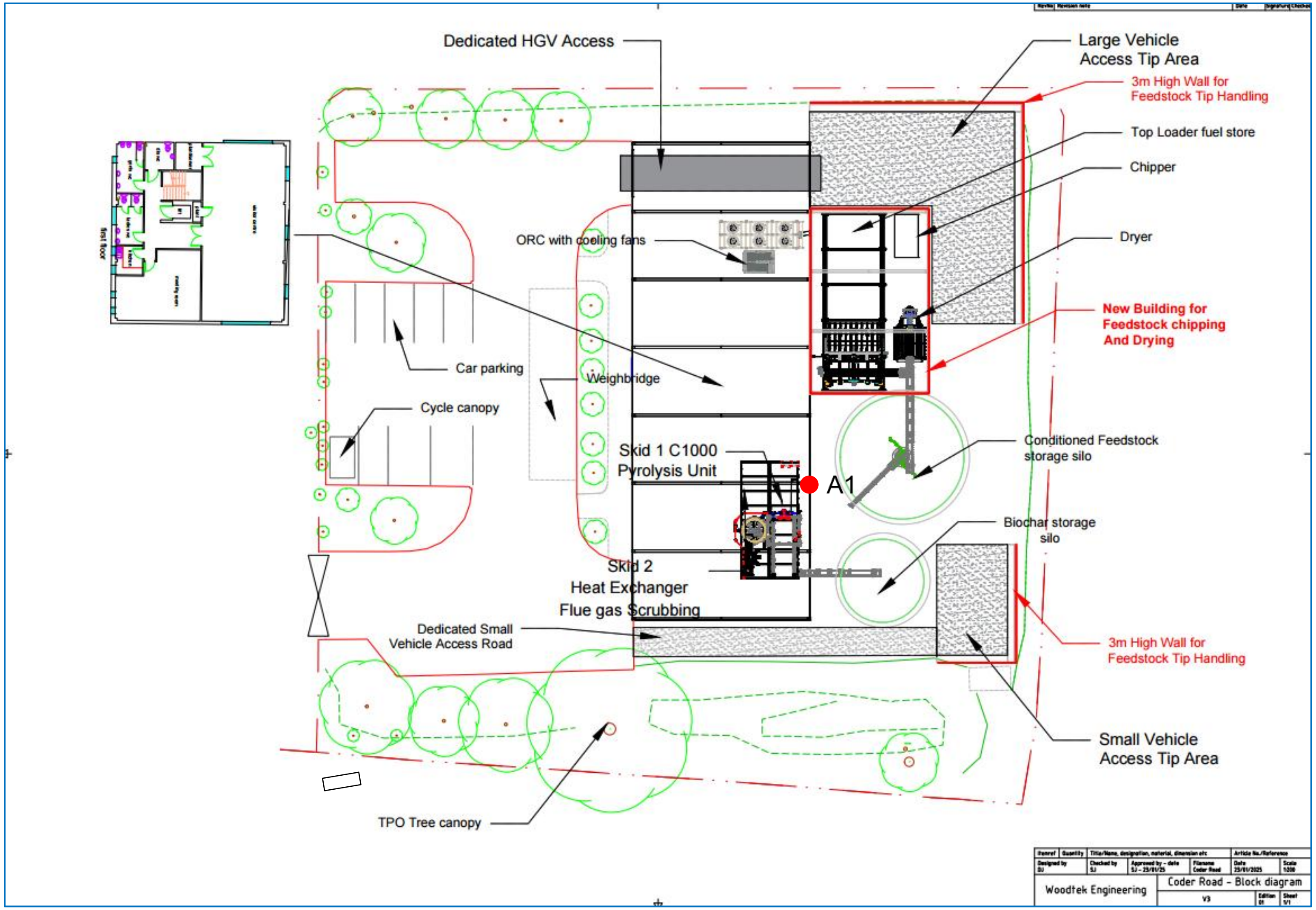
Site location

Mapping coordinates:

Easting 352714

Northing 274708

Site Layout Plan



Site Boundary

Installation Boundary

Emission stack

Site Drainage Plan

(brown dashed line)	Foul sewers
(blue dashed line)	Surface water system

Surface water discharges from site are limited to rainwater goods downpipe discharges and internal tarmac road drainage (including weighbridge).

Note: drains inside the process building are NOT connected to the surface water system.

Appendix 2 – Waste Reception Process

Wastes are delivered for processing in accordance with the permitted waste codes as follows:

EWC Code	Description
02 01 03	plant-tissue waste
02 01 07	wastes from forestry
03 03 01	waste bark and wood
17 02 01	Wood
19 05 03	Off specification compost

All wastes are delivered by selected trusted companies that have been audited by Biodynamic Carbon. The wastes are delivered in bulk carriers, skips or trailers as agreed with the waste supplier.

The reception process utilises the waste acceptance criteria (see Appendix 3 below) before being accepted as feedstock.

Feedstock Checks

Once the feedstock arrives at the site, it will be regularly assessed before feeding it into the system. First, the feedstocks will be weighed in on a weigh bridge. In order to ensure that the feedstock is in accordance with the profile agreed with the supplier, a site operator will undertake spot checks of the feedstock at unloading.

Feedstock storage

Since the properties of woodchip (whole tree and arb waste) and compost oversize are different, it is necessary to segregate where there is a requirement to blend the wastes. Where segregation occurs the materials are stored in separate areas on the main yard.

Dried woodchip delivered as chip will be delivered within the process building and directly into the process hopper.

Arboricultural waste will be delivered on the main storage pad and then moved processed immediately through the chipper that then discharges the material into the top loaders. The top loader is located within the extension to the main building and is fully enclosed to prevent the dust and particles emissions from the loading process, and to protect the woodchip from inclement weather.

Compost Oversize: The CO will be delivered into main yard area. All compost oversize materials will be chipped and processed on delivery. The top loader is enclosed, protecting the oversize from the weather and minimising potential for odour.

Green waste: The green waste is delivered to the site and stored in the same manner as arboricultural waste.

Since the woodchip particle size is pre-determined by the chipping configuration, there is no requirement of sieving it before blending and drying. However, if the size is found to be not suitable, a sieving stage will be added before the woodchip is processed or mixed with the compost oversize and sent further for drying.

Blending and drying

The blending of the Compost Oversize and woodchip will take place initially in the toploader by use of swing shute. While the partly blended material is transported from the top loader, it becomes fully blended with the woodchip in the auger. The auger then delivers the blended feedstock to the T2+ drier. This dryer will utilise the heat from the pyrolysis units to dry the feedstock to around 10-15% moisture content. Another auger will then transport the dried feedstock to a loading hopper inside the main process building.

Biodynamic Carbon is committed to work with the supplier companies and help establish supply chains to ensure duty of care responsibilities are managed. Additionally, Biodynamic Carbon will ensure that the biochar produced at the site is sustainably produced and will (as far as possible) be transported to the feedstock sourcing sites as part of a circular economy. The biochar will ideally be used on the land where the feedstock was initially sourced, closing the circular loop and promoting regenerative agricultural practices.

Appendix 3 – Waste Acceptance Criteria (C3)

This provisional waste acceptance criteria for materials but may be subject to change upon commissioning or where legislation or statutory guidance is updated at which point it will be revised in line with required changes.

Prior to commissioning, Biodynamic Carbon will implement acceptance procedures so that controls on the composition of the waste feedstock are known before it arrives at site and that materials are sourced from trusted sources in accordance with due diligence and duty of care requirements under waste law.

The site will receive source segregated waste wood from external sources, green waste from specified sources and compost oversize from regulated waste composting sites limited to the following waste codes:

EWC Code	Description
02 01 03	plant-tissue waste
02 01 07	wastes from forestry
03 03 01	waste bark and wood
17 02 01	Wood
19 05 03	Off specification compost

The acceptance criteria for waste and the operational procedures that will be in a place to inspect waste delivered to site as summarised as follows:

1. Waste is delivered to site *by audited preferred suppliers* normally in bulk containers, but may also be transported in skips, or trailers. The loads are weighed using the weighbridge facility.
2. A visual inspection is conducted to confirm that received waste conformed to the codes accepted at the site.
3. Paperwork is checked to ensure waste is of the correct waste codes and the driver is instructed where to unload the waste at the prescribed location and, once unloaded, a further visual inspection of the load is undertaken to ensure that the waste conforms to that expected. Only waste codes noted above will be accepted at the installation and only following a quality check to ensure the waste is visibly identifiable as that code using the criteria in Table below. No other waste wood is pyrolyzed.
4. If the waste has been delivered by a third party, the driver is required to wait on-site until the visual inspection has been completed. Once the load has been verified as acceptable, the driver is permitted to leave the site.
5. The unloaded waste may then be loaded directly into the process plant or stored in the waste storage areas for further processing and mixing as required. The resulting waste material is then transferred to either the main building for immediate processing or storage areas as shown on the site layout plan.

Waste classification	Other
Virgin Timber	Virgin timber from arboricultural, forestry and other activities.
Green waste	Grass clippings, Leaves, Hedge trimmings, Branches, Plants, Flowers, Fruit and vegetable scraps, Landscape pruning, Brush, and Logs
Forestry Wastes Waste bark and wood	Residues from logging, such as branches, stumps, treetops, bark, and sawdust
Wood Grade A “Clean” Recycled Wood	Solid softwood and hardwood, packaging waste, scrap pallets, packing cases and cable drums. Process off-cuts from joinery/manufacturing. Nails and metal fixings (removed before processing). Minor amounts of paint, and surface coatings Waste wood that has been classified as hazardous waste or has come from construction and demolition works (e.g. grades B, C & D), will not be used as a feedstock
Off specification compost	Over size material arising from screening of compost, may contain soil, humus, some plastic, paper, stones etc.

The proposed plant is to provisionally to pyrolyze a mixture of waste only non-waste wood consisting of virgin timber, green waste, and compost oversize.

Non-conforming waste

Where non-conforming waste is identified at the site entrance, the load will not be accepted and will be returned to the supplier.

Where non-conforming waste is identified after it has been unloaded, the load will be kept in a designated quarantine area, away from other wastes and ignition sources, until a suitably licensed waste handler collects it for disposal or treatment at another licensed site.

The designated quarantine area will be separate from all other storage areas, clearly marked as a quarantine area and always kept free of obstruction, unless in use.

The quarantine area, like other waste areas will be located on a concrete surface within a bunded area to avoid the risks of contaminated runoff and/or fugitive emissions.

The quarantine area will normally be one of the wood chip storage bays that are cleared and repurposed for the duration of the storage of the non-conforming waste. Where the waste is particularly odorous, it will be removed as soon as practicable.

In all cases the supplier or waste producer will be contacted, and the nature of non-conformance discussed.

A record of the non-conformance, reasons for accepting the waste and actions taken will be recorded and retained on site for review.

The procedure set out in the Environment Agency rejected loads guidance will be followed [link].

Training

All staff responsible for acceptance of waste will be trained. Staff will be provided with guidance and training on waste acceptance, duty of care, waste loading and unloading procedures to be followed, and procedures managing non-conforming waste to enable quarantine and removal.

Appendix 4 – Process controls (SCADA)

SCADA is an anacronym for **S**upervisory **C**ontrol **a**nd **D**ata **A**cquisition. SCADA systems are used for controlling, monitoring, and analysing industrial devices and processes. Most systems comprise hardware monitoring systems, temperature and pressure sensors, flow meters, pH meters, etc. as well as software to enable remote and on-site gathering of data from the industrial equipment.

SCADA normally is an extension of Programable Logic Controllers (PLCs) or Remote Terminal Units (RTUs) that are small, computerised devices used to monitor and control equipment. The PLC's provide automated controls and are normally used in conjunction with Human Machine Interfaces (HMI), which provide users with a graphical user interface (see examples below).

Both SCADA and PLC's can be enabled to raise non-conformance alerts in the event that the process they monitor deviates from preselected process control parameters. For example, the primary combustion chamber temperature might be set to 750ºC, an alert may occur if the temperature drops or raises by ± 20ºC, similarly devices such as flow meters or pressure sensors may activate on high or low flow or pressure or no or excess flow as required.

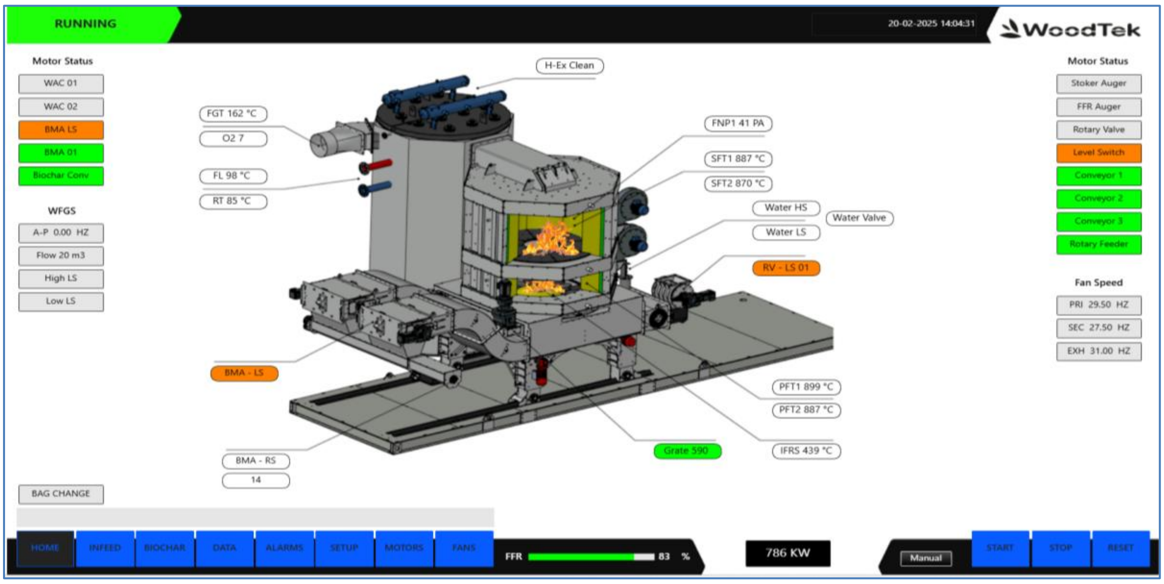
By definition, a SCADA (or similar) is a bespoke control system for the process and is normally finalised on commissioning of the plant.

Biodynamic Carbon intend to create a control system based on the Hazard Operability Study, the process requirements for the Ludlow site and the existing SCADA controls.

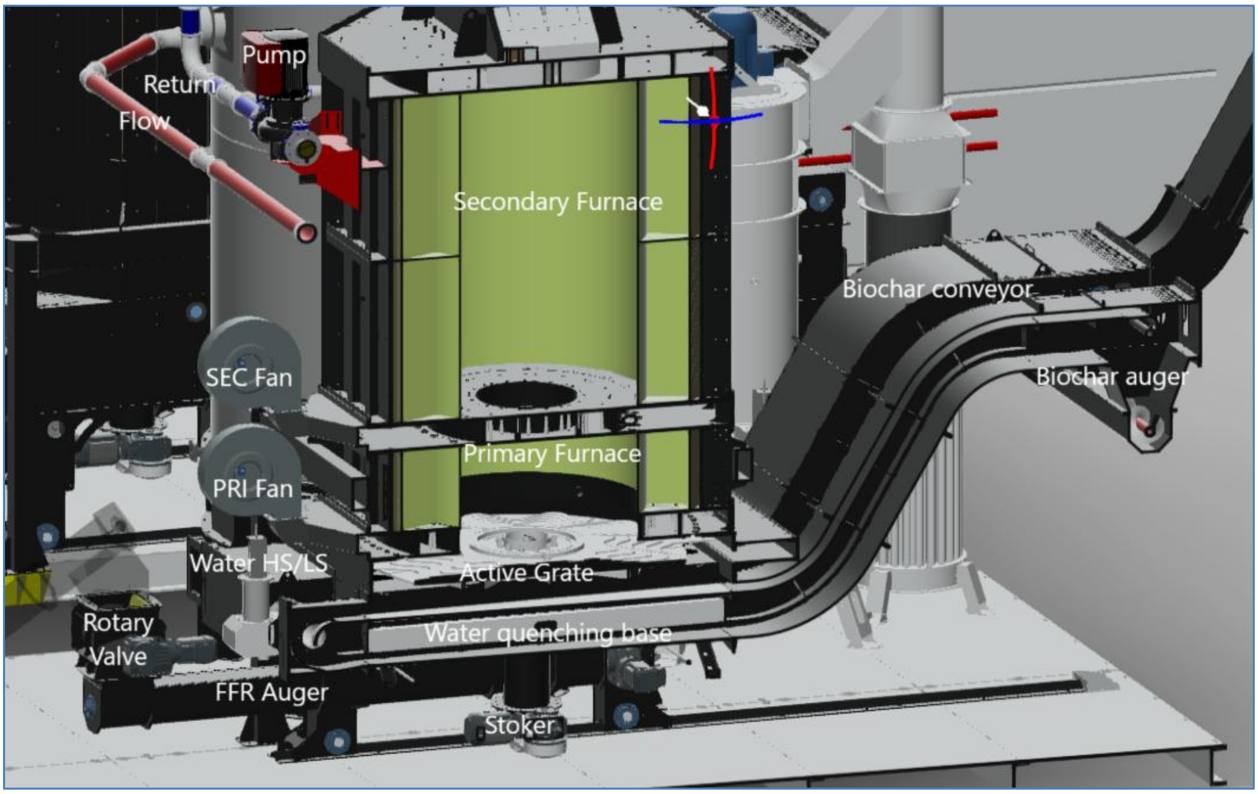
The existing SCADA controls are:

- Feed auger sensor (mass flow) Rotary feeder
- Primary temperature sensors (reactor) (6 locations) and flue gas
- Oxygen sensor (combustion optimisation)
- Pressure sensors (gas)
- Flow sensors (water) high/low and flow (multiple)
- Temperature sensors (water) heat exchangers.
- Valve activation detection
- Conveyor operation sensors (motors fault)
- Fan speed monitors (various).
- Flue gas monitoring (emission gases) (various sensors)

The following text summarises the SCADA Manual. The full operational control system is provided in the SCADA Manual Extract (section 3).



C1000 Reference diagram



SCADA Parameter Table - HMI visible

Parameter	Description	Normal Range	Alarm Limit	Interlock Applied?	Action on Deviation
FFR Fuel Feed Rate auger	The speed of the FFR auger is the main power control	20-100%	NA	Reduction of FFR is the automated control in the event of over and under temperature	Other alarm(s) should be present and show the cause of low FFR
FGT Flue Gas Temperature	Measures flue gas exhaust temperature after Pyrolysis process and heat exchange process	130–190°C	> 220°C	Visual warning alarm only	Potential partial blocking of heat exchanger. An early service may be required
O2 Oxygen	Oxygen level inside the combustion chamber	5–10%	<5% or >12%	Yes, controlled shutdown	-Inspect plant seals -Sensor calibration
FL Heating fluid Flow temperature	Temperature of hot water/flow from the heat exchanger	80–120°C	<76°C or >124°C	Yes, controlled shutdown	-Inspect thermal load
RT Heating fluid Return temperature	Temperature of cold water/return to the heat exchanger	80–110°C	<76°C or >114°C	Yes, controlled shutdown	-Inspect thermal load
IFRS Infra red temperature sensor	Measures the temperature of the biochar in pyrolysis	450-550°c	<400°C or >600°C	Visual warning alarm if intermittent Controlled shutdown if consistent	Inspect combustion, fuel, negative pressure, furnace seals
PFT1 & PFT2 Primary Furnace temperature 1 & 2	Temperature of Primary Furnace	450–950°C	>249°C >650°C >700°C	(On start up) Ignition ends Enables Biochar conveyor Enables active grate	Inspect fuel feed for interruption. Ensure all combustion

				If the minimum temperature is not achieved, controlled shutdown	controls are working (FFR, PRI, SEC Grate)
SFT1 & SFT2 Secondary Furnace temperature 1 & 2	Temperature of Secondary Furnace	550–1050°C	No alarm	For information/combustion feedback only	Expect SFT1&2 to follow the trend with PFT1&2. If not then inspect sensors.
FNP1 Furnace Negative Pressure	Works on a PID for the EXH fan to maintain a target negative pressure	30–70 PA	<20 or >80 PA	Yes, controlled shutdown if FNP1 reads 0 for a set period	Potential partial blocking of heat exchanger. An early service may be required
Water HS Water quenching water level - High set	High water levels	Within range	Out of range	Visual warning alarm if intermittent Controlled shutdown if consistent	Check water valve is closing when activated
Water LS Water quenching water level - Low set	Low water levels	Within range	Out of range	Yes, controlled shutdown	Check water supply Check water valve is opening when activated
Grate Active Grate position	Moving grate position sensor	200-900 position	<200 or >900	Yes, controlled shutdown	Inspect motor, Inspect grate for blockage, Inspect position sensor
Fan Speed PRI Primary air fan speed	Primary fan	16–28 Hz	No Alarm	PRI fan speed is PID set 550°c of **IFRS**	NA
Fan Speed SEC Secondary air fan speed	Secondary fan	15–50 Hz	No Alarm	SEC fan speed is PID set 7% of **O2**	NA
Fan Speed EXH Exhaust fan speed	Exhaust/ID fan	10–38 Hz	No Alarm	EXH fan speed is PID set 50PA of **FNP1**	NA

The existing system is proven to control and operate the existing plants and ensure compliance with the existing permits issued and can be modified to include other controls where necessary.

Full details of the process controls in respect of SCADA are provided in the SCADA Manual Extract document.

An example the controls for emissions related environmental shutdown are reproduced below:

4 SCADA Environmental Emissions Overview

The SCADA Environmental Emissions Monitoring System is responsible for detecting, analysing, and mitigating emissions-related risks in the C1000 pyrolysis process. It ensures that **particulate matter (PM) and nitrogen oxides (NOx) emissions remain within regulatory limits** under both normal operation and failure conditions.

SCADA & PLC Integration

The SCADA system interfaces with Programmable Logic Controllers (PLCs) to continuously monitor emission-critical parameters, including:

- Flue Gas Scrubber Performance (flow rates, nozzle efficiency, circulation pump operation)
- Combustion Airflow and Gas Flow Rates (negative pressure, fan speeds)
- Process Temperature and Fuel Feed Rate (to prevent excessive combustion fluctuations)

When a deviation from acceptable emission levels occurs, the SCADA system responds automatically, adjusting combustion settings or initiating a controlled shutdown to minimize environmental impact.

Emission Control and Regulatory Compliance

The SCADA system ensures compliance with regulatory emission standards for NOx and PM emissions by:

- Real-time monitoring of scrubber efficiency and water flow
- Automated failure detection with alarm-triggered shutdowns
- Emission mitigation measures that reduce combustion power when faults occur

Failure Response and Environmental Impact Prevention

SCADA is programmed to respond to environmental risks proactively:

- Scrubber failure: Triggers a shutdown before PM levels exceed limits
- Exhaust fan failure: Ensures emissions remain stable by reducing overall combustion
- Circulation pump trip: Prevents PM emissions by limiting pyrolysis power

This system ensures continuous monitoring and protection, safeguarding both environmental compliance and system efficiency

4.1 SCADA Environmental Emissions - Wet Flue Gas Scrubber Failure

4.1.1 Failure Scenario: Wet Flue Gas Scrubber Circulation Pump/Nozzle Blockage

In the event of a circulation pump blockage or a nozzle blockage, the system would experience a gradual increase in blockage, leading to reduced scrubbing efficiency. Without intervention, this could result in increased particulate matter (PM) emissions due to ineffective gas scrubbing.

SCADA Detection & Response

The SCADA system continuously monitors the scrubber circuit using a flow meter positioned between the main scrubber circulation pump and the scrubber nozzles.

- Low Flow Alarm: If the flow meter detects reduced circulation flow, an alarm is triggered, leading to a controlled shutdown before emissions exceed environmental limits.
- Hydro Cyclone Operation: Particulates and sludge are pumped from the scrubber base to a hydro cyclone, where they are removed and transferred into the water quenching base. The filtered water then flows back to the scrubber nozzles for continuous operation.

4.1.2 Failure Scenario: Scrubber Circulation Pump Failure

In the event of a mechanical or electrical failure of the scrubber circulation pump, the motor will trip, leading to a controlled shutdown to prevent further system damage and excessive emissions.

- Environmental Risk: The failure of the scrubber pump may cause a temporary increase in particulate emissions. However, due to the controlled shutdown sequence, combustion power will gradually decrease, reducing PM output.
- Feedstock Pyrolysis Limitation: The feedstock on the active grate undergoes pyrolysis for a maximum of 15 minutes. After this period, all combustion is completed, ensuring no further emissions occur post-shutdown.

4.1.3 Environmental Impact

If the scrubber circulation flow is reduced, the system's ability to capture particulate matter (PM) decreases, potentially leading to increased emissions. However, SCADA monitoring ensures that a low flow alarm is triggered before emissions exceed regulatory limits.

In routine operation, if the scrubber flow is low but not low enough to trigger an alarm, it is inspected during planned preventative maintenance (PPM) to prevent further deterioration

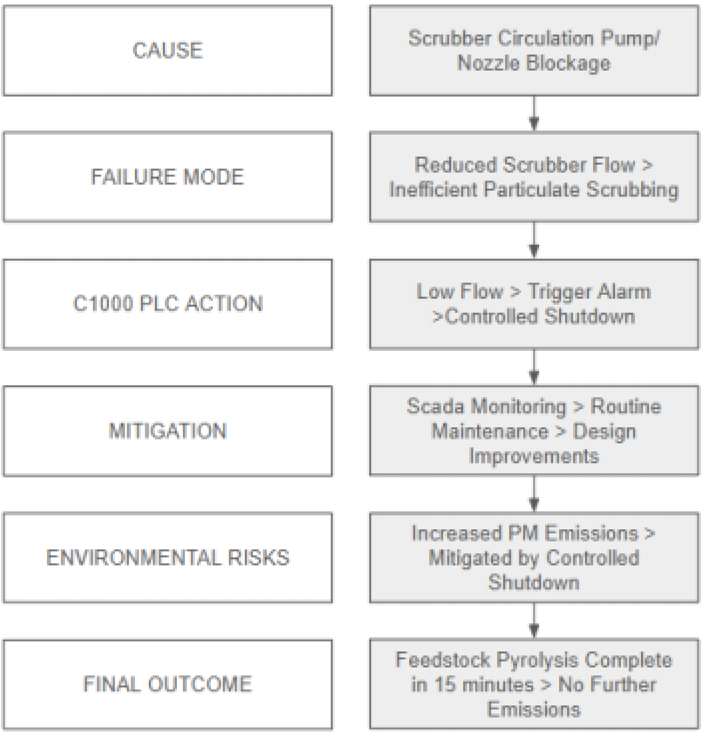
4.1.4 Mitigation Measures

To prevent long-term environmental impact, the following mitigation measures are in place:

- SCADA monitoring detects gradual reductions in scrubber circulation flow before total failure.
- A low flow alarm triggers a controlled shutdown before emissions exceed limits.
- Routine servicing includes inspection and cleaning of scrubber nozzles, circulation pumps, and the hydro cyclone.
- If scrubber flow is slightly reduced but not alarming, it is scheduled for review in planned preventative maintenance (PPM).
- Potential design improvements include alternative nozzle layouts and backup pumps for redundancy.
- Feedstock pyrolysis is limited to 15 minutes, ensuring no sustained emissions post-shutdown.

4.1.5 Block Diagram - Scrubber Failure Flowchart

The diagram below represents the failure sequence, PLC action, mitigation strategies, and environmental impact for a scrubber circulation pump/nozzle blockage failure scenario.



Similar processes are provided for:

Exhaust fan failure
Primary air fan failure
Secondary air fan failure
Oil/lubricant leaks
Low water in Scrubber
Low water in Water Quench
High Water Pressure & PRV failure
Liquid Seal Failure
Gas seal failure

Each of the above considered to be critical controls for prevention of emissions.

Appendix 5 Dispersion Model

Introduction

Combustion emissions from the proposed plant have the potential to cause air quality impacts during normal operation.

Redmore Environmental were commissioned to provide Air Quality Impact Assessments for the operation of the proposed plant.

The Air Quality Assessment was undertaken in order to determine baseline conditions and consider potential effects.

Dispersion modelling was undertaken in accordance with Environment Agency guidelines [link] for determination of the impact of industrial sites for environmental permitting purposes.

The modelling process requires the use of a recognised dispersion model, and an approved method to predict pollutant concentrations at sensitive locations as a result of emissions from the facility. The results indicated that impacts on pollutant concentrations were not predicted to be significant at any human receptor location in the vicinity of the site.

Model outputs for permitting purposes are typically described as predicted environmental concentrations (PEC) of pollutants at receptor locations, and as a %age of contribution from the process under assessment (PC) compared to existing typical background levels or set standards.

Redmore Environmental report reference 8820r2 has produced a dispersion model as part of the assessment. The model is based on the processing of 100% compost oversize (a worst case). The second

Dispersion Model

Dispersion modelling was undertaken using ADMS-6 (v6.0.2.0), which is developed by Cambridge Environmental Research Consultants (CERC) Ltd. ADMS-6 is a short-range dispersion modelling software package that simulates a wide range of buoyant and passive releases to atmosphere. It is a new generation model utilising boundary layer height and Monin-Obukhov length to describe the atmospheric boundary layer and a skewed Gaussian concentration distribution to calculate dispersion under convective conditions.

The model utilises hourly meteorological data to define conditions for plume rise, transport and diffusion. It estimates the concentration for each source and receptor combination for each hour of input meteorology and calculates user-selected long-term and short-term averages.

The model requires input data that details the following parameters:

- Stack emission data (height, diameter, efflux velocity flow rate)
- Source pollutant release rate (g/s)
- Spatial co-ordinates of emission points;
- Building heights and dimensions
- topography
- Meteorological data;
- Roughness length (z_0); and,
- Monin-Obukhov length.
- Receptor locations

The modelling considers both sensitive human receptors and sensitive ecological receptors. The standards for each are considered within the detailed reports. There are 4 stages of assessment used with the impacts being screened out for pollutants of concern where thresholds are not met. The final impact assessment outcome is considered acceptable if the pollutant concentrations are screened out. Where a pollutant cannot be screened out a detailed assessment of adverse impact is required.

Pollutant concentrations

Modelling of the pollutant concentrations in the exhaust gas streams (input data) utilised a worst case where emissions were considered to be the maximum permitted by the industrial Emissions Directive. This provides a worst case scenario.

A summary of the pollutant concentrations is provided in Table 18 of the report (reproduced below).

Table 18 Pollutant Emission Concentrations

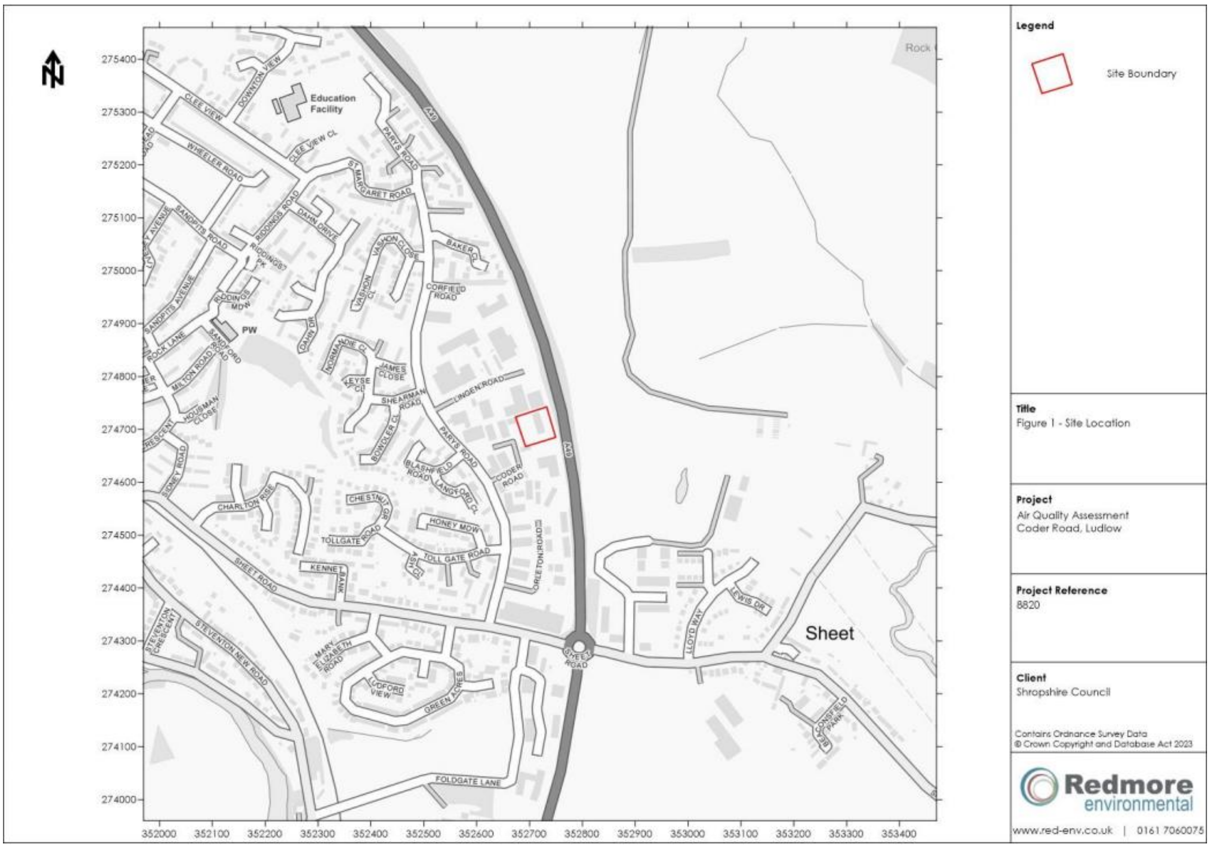
Pollutant	Pollutant Concentration (mg/m^3)[a]	
NO_x	400[b]	
Particulate matter (PM)	10	
C_6H_6	20 (half-hour mean)	10 (24-hour mean)
SO_2	200 (half-hour mean)	50 (24-hour mean)
CO	100	
HCl	60 (half-hour mean)	10 (24-hour mean)
HF	4 (half-hour mean)	1 (24-hour mean)
Cd and thallium (Tl)	0.05	
Hg	0.05	
Metals (total Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V and their compounds)	0.5	
PCDD/Fs	0.0000001	

Note: (a) Stated at 11% oxygen, dry gas, 273K.
(b) 100% compliance required at all times. An ELV of 200mg/m³ over a 24-hour period is to be achieved for a minimum of 97% of the time.

Assessment Area

The assessment area was defined based on the facility location, anticipated pollutant dispersion patterns and the positioning of sensitive receptors. Ambient concentrations were predicted over NGR: 351970, 273960 to 353470, 275460. One Cartesian grid with a resolution of 10m was used within the model to produce data suitable for contour plotting using the Surfer software package.

Receptor locations (both human health and ecological receptors were identified and the predicted concentration of pollutants assessed at each key location.


Legend
Site Boundary
Title
Figure 1 - Site Location
Project
Air Quality Assessment
Coder Road, Ludlow
Project Reference
8820
Client
Shropshire Council
Contains Ordnance Survey Data
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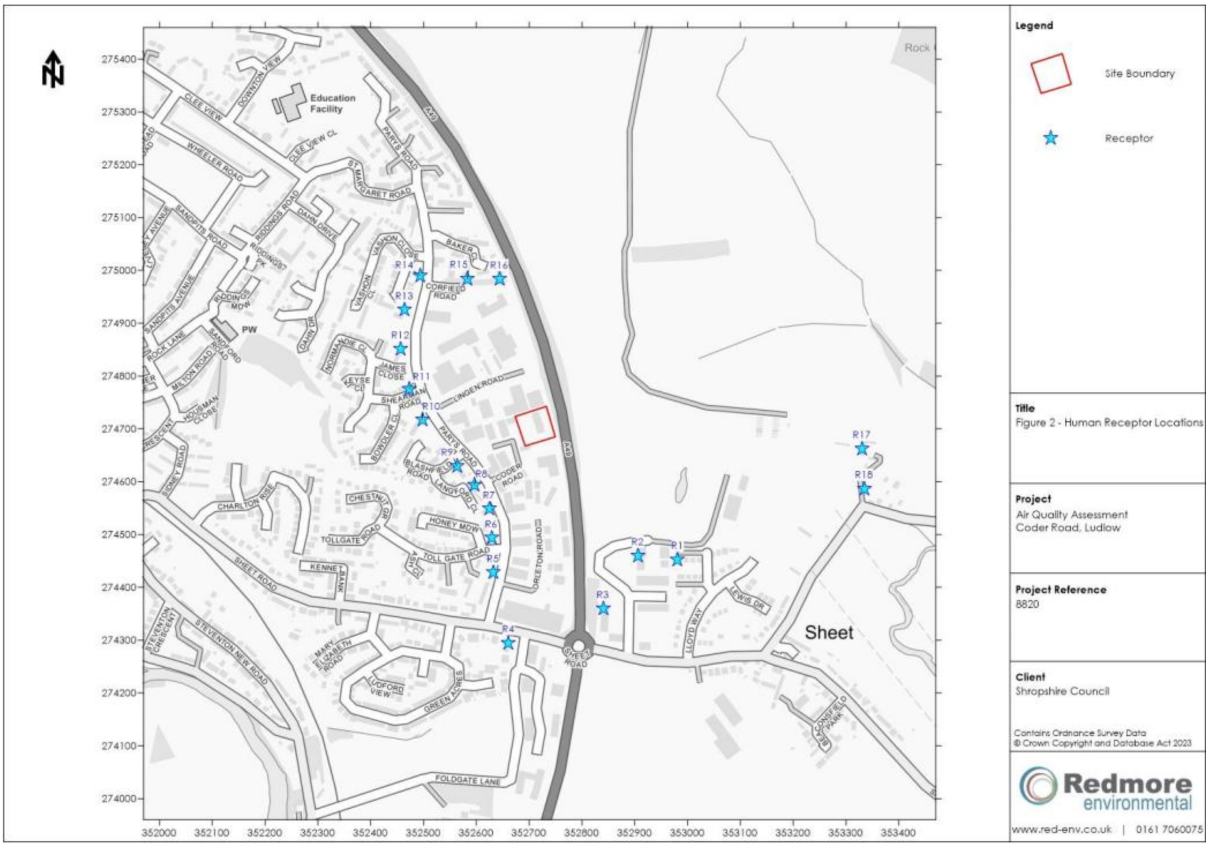
Legend
Site Boundary
Receptor
Title
Figure 2 - Human Receptor Locations
Project
Air Quality Assessment
Coder Road, Ludlow
Project Reference
8820
Client
Shropshire Council
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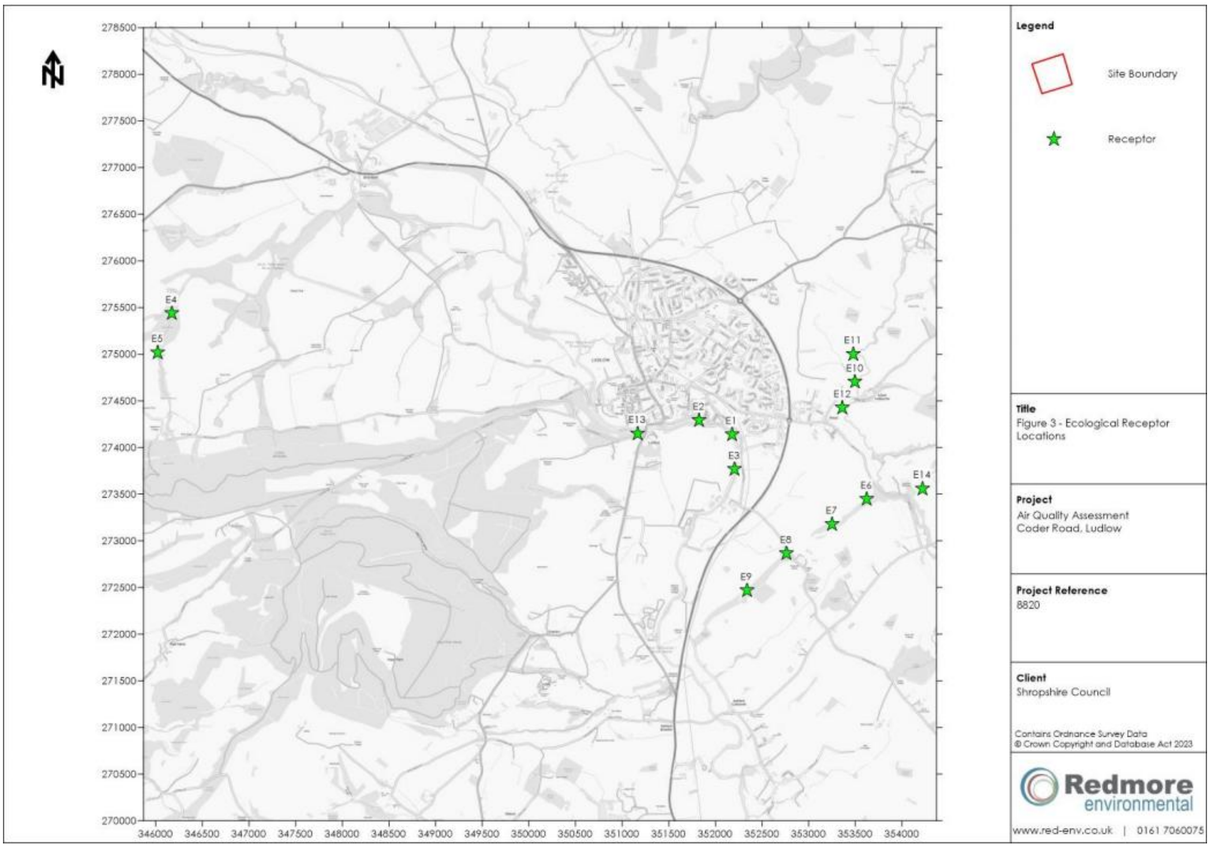

Assessment conclusions

Assessments have been conducted for:

Human receptors

- Nitrogen Dioxide
- Particulate Matter
- Hydrogen Chloride
- Hydrogen Fluoride
- Carbon Monoxide
- Cadmium
- Mercury
- Dioxins and Furans

Ecological Receptors

- Nitrogen Oxides
- Hydrogen Fluoride
- Nitrogen deposition
- Acid deposition

Maximum pollutant concentrations for key pollutants for Reports 1 is presented below:

Table 24 Maximum Predicted Pollutant Concentrations

Pollutant	Averaging Period	Units	EQS	PC	PC Proportion of EQS (%)	PEC	PEC Proportion of EQS (%)
NO_2	Annual	µg/m³	40	18.11	45.3	22.42	56.1
	99.8th %ile 1-hour	µg/m³	200	79.91	40.0	88.52	44.3
PM_{10}	Annual	µg/m³	40	1.26	3.2	11.34	28.3
	90.4th %ile 24-hour	µg/m³	50	1.85	3.7	22.00	44.0
$PM_{2.5}$	Annual	µg/m³	10	1.26	12.6	6.89	68.9
C_6H_6	Annual	µg/m³	5	1.37	27.3	1.52	30.5
	24-hour	µg/m³	30	6.20	20.7	6.51	21.7
SO_2	99.2nd %ile 24-hour	µg/m³	125	13.08	10.5	17.78	14.2
	99.7th %ile 1-hour	µg/m³	350	105.00	30.0	109.70	31.3
	99.9th %ile 15-minute	µg/m³	266	131.35	49.4	136.05	51.1
HCl	1-hour	µg/m³	750	44.33	5.9	44.85	6.0
HF	Monthly	µg/m³	16	0.13	0.8	2.48	15.5
	1-hour	µg/m³	160	2.99	1.9	7.69	4.8
CO	Rolling 8-hour	µg/m³	10,000	43.19	0.4	455.19	4.6
Cd	Annual	ng/m³	5	2.83	56.5	3.26	65.2
	24-hour	ng/m³	30	6.45	21.5	6.89	23.0
Hg	24-hour	ng/m³	60	14.57	24.3	16.22	27.0
	1-hour	ng/m³	600	33.25	5.5	36.56	6.1
PCDD/Fs	Annual	fg/m³	n/a	12.57	-	24.97	-
	1-hour	fg/m³	n/a	73.92	-	98.72	-

As shown in Table 24, there were no predicted exceedances of any EQS at any location for any pollutant or averaging period of interest. The process contribution (PC) being less than 70% in all cases.

Note: The modelling is based on maximum emission rates. Also, in respect of metals, neither Cadmium nor Mercury are expected in biomass, waste wood or compost oversize, and in any event are not present at any sensitive receptor locations for the point of maximum exposure as identified in LAQM TG(22). They are therefore not considered locations for relevant exposure.

Deposition

The impact of deposition on sensitive receptors is considered in Section 5.5 of the Redmore Report for the ecological receptors.

Assessments for deposition of Nitrogen Oxides, Hydrogen Fluoride, and Acid Deposition have been conducted, and all are well below the potential to adversely impact the ecological receptors and in all cases are noted to be not significant.

Conclusion

The report concludes that:

> *6.1.4 The results indicated that impacts on pollutant concentrations were **not predicted to be significant** at any human or ecological receptor location in the vicinity of the site.*

.

The full report is submitted with this application.

Appendix 6 Maintenance & Cleaning

Basic maintenance and cleaning requirements to be verified by manufacturer following commissioning. An example of expected maintenance and cleaning is provided below but actual schedules will depend on site size and configuration and would be prepared following commissioning:

Maintenance

Frequency	Check required	Compliance
daily	• Check combustion chamber and flame appearance • Check temperatures of leaving and return water Circuit from boiler • Check flue gas temperature (170 - 220°C) • Check for unusual noise • Check for fly ash container level • Check for fuel level	
weekly	• Control of burnout zone; if necessary, push the ashes to the rear or remove. • Inspect the condition of the pyrolysis chamber • Drain condensate with air compressor	
1-2 months	• Check oil level in hydraulic devices • check and lubrication of ball bearings according to lubrication plan or instructions during implementation • check sealing of sluice	
Annually	• Full process checks of critical plant • Full process checks of critical control devices • Checks on process alarms	

Cleaning

Frequency	Cleaning required	
Every 2-4 weeks	Depending on fuel quality (contamination) and heat output • Cleaning of heat exchanger tubes **1** with brush or by rotating the turbulators with cleaning machine. Not necessary with automatic cleaning. To make this work properly, switch on the flue gas ventilator (manual mode flue gas ventilator).	
Every 4-6 weeks	• Cleaning of combustion chamber and pyrolysis zone with a shovel or with a special ash vacuum cleaner. Before making this work, the installation should be operated for 20 - 30 minutes in the “ventilation“ mode (manual mode ventilators)	
Every 6 months	• Heat exchanger tubes (not necessary with automatic cleaning) • Flue gas ventilator incl. Impeller • Cyclone entry • Flue gas tubing and chimney • Cleaning of combustion chamber and zone beyond the grate 2 and also the burnout section • Check grate and if necessary clean/disassembling	

Appendix 7 Receptors

Receptors identified from Redmore Environmental Report reference 8820r2 21st January 2025

Human Receptors

Receptor		NGR (m)	
		X	Y
R1	Residential - Eco Park Road	352981.3	274453.0
R2	Education Facility - Eco Park Road	352906.1	274460.1
R3	Medical Facility - Eco Park Road	352840.1	274360.3
R4	Residential - Sheet Road	352661.1	274295.2
R5	Residential - Parys Road	352632.0	274428.3
R6	Residential - Honey Meadow	352628.8	274493.9
R7	Residential - Langford Close	352624.6	274548.5
R8	Residential - Langford Close	352595.9	274593.7
R9	Residential - Blashfield Road	352563.7	274629.7
R10	Residential - Blashfield Road	352497.8	274717.6
R11	Residential - Shearman Road	352472.3	274776.1
R12	Residential - James Close	352456.7	274851.5
R13	Residential - Ballard Close	352464.3	274925.5
R14	Residential - Ballard Close	352493.7	274990.2
R15	Residential - Baker Close	352583.2	274983.6
R16	Residential - Baker Close	352644.1	274983.9
R17	Residential - Squirrel Lane	353330.7	274662.9
R18	Residential - Squirrel Lane	353334.7	274587.1

Ecological Receptors

Receptor		NGR (m)	
		X	Y
E1	River Teme SSSI	352175.1	274139.9
E2	River Teme SSSI	351822.6	274293.0
E3	River Teme SSSI	352203.9	273767.1
E4	Downton Gorge SAC	346169.9	275438.3
E5	Downton Gorge SAC	346020.0	275019.6
E6	Ploughnhill Wood AW	353621.6	273448.0
E7	Ploughnhill Wood AW	353248.3	273178.3
E8	Tinkershill Wood AW	352759.5	272863.7
E9	Tinkershill Wood AW	352335.5	272467.9
E10	Ledwyche Brook LWS	353498.3	274702.9
E11	Ledwyche Brook LWS	353478.2	275004.3
E12	Ledwyche Brook LWS	353363.1	274426.5
E13	Whitcliffe Common Reserve LWS	351163.1	274150.3
E14	Meadows below Caynham Camp LWS	354218.7	273561.7

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