

# Mersey Biochar Phase 2 final report

GGR Innovation Programme



© Crown copyright 2026

This publication is licensed under the terms of the Open Government Licence v3.0 except where otherwise stated. To view this licence, visit [nationalarchives.gov.uk/doc/open-government-licence/version/3](https://nationalarchives.gov.uk/doc/open-government-licence/version/3).

Where we have identified any third-party copyright information you will need to obtain permission from the copyright holders concerned.

---

# Contents

Executive Summary	6
Overview of the Project	7
Aims and Objectives	7
Technology Feasibility	7
Commercialisation	8
Dissemination	8
Partners	8
Site Description	9
Lingley Mere Business Park	9
Pyrolysis at Lingley Mere	10
Background	11
SWEA rationale for developing the project	11
SWEA experience in Biochar	12
Feasibility studies, calculations and models	13
Char Analysis	13
Business Model	14
Financial Modelling	15
Site selection	15
Technology Selection	16
Original planned technology	16
Final Technology Selection	16
The basic process of the Mersey Biochar Pyrolysis Plant	17
Administrative Work	20
Planning and permits	20
Lease	20
Legal support	21
NEC4 Contracts	21
Governance Structure and Risk Management	21
Governance	21
Risk Management	22

---

Staffing, resources and changes	23
Communications	24
Market Research	25
Technical Work	26
RIBA Stage 3 design	26
VRIBA Stage 4 design	26
Cost Plan	27
Budget setting	27
Site clearance	27
Foundations and setting out	28
CME works	29
Deliveries	30
Installation and assembly	31
Cold, hot commissioning, SAT	33
Life Cycle Assessment	33
Monitoring, Reporting and Verification	33
Major Variations	35
Descoping Cheesecake	35
Descoping heat exchangers	35
Stack and ductwork	35
SuDS	36
Gas booster and supply	36
Major Challenges	37
Personnel changes and available resources	37
Pyrocore in administration	37
Legal title, licensing and freedom to operate	38
Multiple contractors	38
Principal Contractor/Principal Designer	39
Budgets	39
Commercialisation	40
Offtakers for biochar	40
CO2 Removal Certificates (CORCs)	41
Lessons Learnt	43

---

Location, heat demand and space constraints	43
Partnerships, relationships and internal administration	44
Balance of power and scale of partners	44
Need for larger funding contingency	45
Securing offtakers, feedstock supply, CORC accreditation etc	45
Financial summary	46
CAPEX	46
OPEX (expected)	47
Environmental and social impacts	48
Carbon savings	48
Power and heat supply	48
Other social impacts	49
Positive Social Impacts	50
Negative Social Impacts	50
Mitigating Negative Impacts	51
Scaling and replication potential	52
Market potential	52
Barriers, risks and benefits of scaling and replication	52
IP and knowledge management	53
Future plans and commercial exploitation	54
Potential offtaker	54
Investors	54
Green Heat Network Fund	54
ORC	55
Alternative feedstocks	55
United Utilities sewage trials	55
Consultancy	56

# Executive Summary

The Mersey Biochar project was a £5 million project funded by the Department for Business Energy & Industrial Strategy (BEIS) under a Small Business Research Initiative (SBRI) contract. BEIS existed until 2023 when it was split and the project was then overseen by the Department for Energy Security and Net Zero (DESNZ)

The Mersey Biochar project aimed to establish one of the UK's first biochar production and carbon capture plants utilising advanced pyrolysis technology. Located at Lingley Mere Business Park, Warrington, the facility is designed to convert biomass feedstocks, primarily whole tree chip and forestry residues, into biochar and renewable heat and power, simultaneously contributing to the UK's net zero carbon targets. The project aimed to show technology feasibility and commercial viability, and to disseminate learning and knowledge.

This report details the activities completed during Phase 2 funding through the DESNZ Direct Air Capture and Greenhouse Gas Removal Innovation Programme. It details the design and development of the pilot system, key successes, lessons learned, remaining uncertainties and next steps.

# Overview of the Project

## Aims and Objectives

Mersey Biochar aimed to be one of the UK's first biochar production and carbon capture plants.

The plant at Lingley Mere Business Park in Warrington uses pyrolysis technology to produce biochar and heat from biomass feedstocks. The process is exothermic such that heat can be recovered and used to generate electricity and provide heat to a network equivalent. The overall aim is to capture carbon and sequester at a cost of £200/tonne or less. By making the plant commercially viable the concept will be scalable and offer an important contribution to meeting the UK's net zero targets.

The Mersey Biochar plant at Lingley Mere is designed to process 500kg/hr of whole tree chip and forestry residue feedstocks and operate for 8,000 hr/year. The 4,000 tonnes/yr of feedstock, in the form of whole tree chip, is pyrolysed at 700-850C, producing around 1,000 tonnes of biochar, 2,700 tonnes of sequestered carbon, and 8,000MWh of heat at 700C.

To be commercially viable and scalable the plant will have three principal income sources:

- Biochar sales - Biochar has a wide variety of uses in agriculture including soil amendment, nutrient and water retention, and enhancing crop yields. It is also used in the construction industry, for example in cement manufacture, as an additive to concrete and gypsum products, and road surfacing.
- Sequestered carbon - can be traded as carbon credits on carbon markets
- The high-grade heat produced by the process will be used to generate up to 2,800MWh of electricity and provide 4,600MWh of heat for offices on the site.

In addition, the plant is exploring the viability of a heat network using residual heat from the electricity generators to heat the United Utilities headquarters site.

The original application set out the aims and objectives of the Mersey Biochar project:

## Technology Feasibility

The Mersey Biochar project aims to demonstrate how biochar pyrolysis technology can remove carbon from the atmosphere, sequestered within biochar at forecast prices <£140/tonne (in 2025) and <£60/tonne (in 2030) when coupled with innovative energy technology that can deliver negative carbon flexible heat and power into the energy system.

The proposed solution is small-scale and modular, and the path to reaching 50,000 tonnes/year of sequestered carbon is through multiple deployments. This will be facilitated through flexibility, but also standardisation, both technical and commercial. The demonstrator

plant at Lingley Mere will be a single module site and will remove up to 2,700 tCO<sub>2</sub>e/year from the generated biochar.

The overall Phase 2 objective is to demonstrate that biochar and carbon sequestration can be generated at predicted rates, and that the beneficial utilisation of pyrolysis energy can be maximised. This will be assessed and confirmed within a Measurement and Verification protocol.

We will market the carbon removal credits into the voluntary carbon market and deploy the biochar in strictly controlled use-cases, such as soil amendment, water management and construction products, that ensure char durability. A robust method of Measurement and Verification will check and assure the carbon removal of the process.

## Commercialisation

Commercial viability is key to the success of any future carbon capturing and energy generating technology. Therefore, the aim of the project was to prove commercial viability.

A special purpose vehicle (SPV) company has been set up to own and operate the demonstrator. The SPV is wholly owned by SWEA. Mersey Biochar will be set up with the commercial aim to exploit the concept by raising investment to replicate and roll-out the business model across the UK.

## Dissemination

- Further Understanding and Build Consensus – disseminating to build understanding of removal in general and to build consensus around its robustness
- Build awareness and confidence (investors) – educate the investor community to the business model as an investment opportunity of the future
- Build awareness and confidence (sponsors) – educate potential sponsors (developer organisations) of the opportunity of this project type
- Encourage uptake of carbon removal
- Encourage site hosts – to succeed we will need to realise multiple deployments across suitable sites. This will enable us to reach the removal scales sought by DESNZ, but also to increase learning by doing and reduce development and deployment costs. To enable this we need owners and operators of suitable sites to approach us or to be amenable to discussion. Suitable sites include land located near existing or prospective feedstock sources and suitable heat demand.

## Partners

The Project Consortium for Phase 2 was formed of:

- Severn Wye Energy Agency Ltd (SWEA) – contracted partner with DESNZ (formerly BEIS) and Project Lead

- Cheesecake Energy
- Vital Energi – Principal Designer and Principal Contractor
- Pyrocore – pyrolysis technology provider
- Pure Leapfrog – administrative support and carbon trading and finance knowledge
- United Utilities – site owner and heat and power offtaker

## Site Description

### Lingley Mere Business Park

The Mersey Biochar plant has been developed at Lingley Mere Business Park which is the headquarters of United Utilities Group PLC (UU). The business park covers around 42 acres, of which nearly 32 acres are used by UU. There are 17 buildings on the site of which 10 are occupied and used by UU. Construction of the main buildings was completed in 1992, but further buildings have been added since then. The head office and administrative functions of the UU Group are based at Lingley Mere, along with two contact centres and a data centre. Some 4,500 staff work at the site, which is occupied 24/7, 365 days a year.

**Figure 1. Aerial view of the business park**



**Figure 2. United Utilities offices**



## Pyrolysis at Lingley Mere

The Mersey Biochar plant at Lingley Mere is designed to process woodchip feedstock. The wood chip is delivered to site by articulated vehicle and walking floor trailer in 20 tonne batches. The woodchip specification is whole tree chip and/or arboreal residue.

# Background

## SWEA rationale for developing the project

SWEA co-ordinated a Phase 1 project supported by BEIS through the Direct Air Capture and Greenhouse Gas Removal Programme, to explore the options for and feasibility of the Mersey Biochar project. The results, data and conclusions from the studies and reports from Phase 1 were used to prepare an application by SWEA to the Phase 2 competition, administered by BEIS. The application was successful and a contract for £4.994 million was awarded to SWEA to develop the Mersey Biochar project at Lingley Mere.

SWEA collaborated with several partners to develop Mersey Biochar, including:

- Vital Energi – Principal Designer and Principal Contractor
- Pyrocore – pyrolysis technology provider
- Cheesecake – compressed air energy storage (CAES) technology provider:
- Pure Leapfrog – administrative support and carbon trading and finance knowledge
- United Utilities – site owner and heat and power offtaker
- Esken Renewables – feedstock supplier

**Severn Wye Energy Agency Ltd (SWEA)** is a sustainability charity working to promote energy efficiency and low-carbon energy for the future.

**Vital Energi** provides low carbon energy generation, energy distribution and energy management solutions across sectors.

**Pyrocore** (no longer trading having entered administration in September 2024) was an engineering company specialising in the development of pyrolysis plant for a wide range of biomass and waste feedstocks.

**Cheesecake Energy Ltd** develops green energy storage technologies for medium to long-duration energy storage, and turning intermittent sources into reliable, on-demand power.

**Pure Leapfrog** is a registered charity specialising in carbon trading, sustainable finance, energy systems, and natural capital.

**United Utilities (UU)** provides water and wastewater services in the north-west of England. The headquarters are based at Lingley Mere Business Park.

**Seras** (formerly Esken Renewables) are the UK's market leading biomass fuel supplier.

## SWEA experience in Biochar

SWEA is an award-winning charity tackling fuel poverty and climate change across Wales and the West of England who operate across Wales and the English border counties. There are approximately 100 staff working on a range of programmes including domestic retrofit, business energy advice, fuel poverty alleviation programmes, and innovation including biochar programmes. The organisation brings 25 years of experience and learning into a unique approach to engaging and supporting communities to develop skills, increase awareness and champion a just transition to a greener future. SWEA's approach ensures individuals, organisations and decision makers can make real, tangible changes to tackle climate change at regional and local scales and directly benefit nearby communities with clean energy.

### **THREE-C Dŵr Cymru Welsh Water - Investigate Feasibility of Pyrolysis of Biosolids**

SWEA supported Dŵr Cymru Welsh Water in a series of Biochar trials using sewage sludge as a feedstock and worked with communities in the Welsh valleys to integrate biochar produced from forest residues as a soil enhancer to improve the biodiversity of the area.

Between 2019 – 2023, SWEA was a partner on the EU's Interreg NWE programme funded THREE C programme (THREE C - Creating and sustaining Charcoal value chains to promote a Circular Carbon economy in NWE Europe).

Within THREE-C, SWEA worked with Dŵr Cymru Welsh Water to evaluate the potential for pyrolysis and biochar adoption as a viable, environmental and economical process within wastewater treatment. The study evaluated technical viability, feedstock options, potential new revenues (or cost reductions), regulatory issues, carbon savings, and the overall business case for adoption.

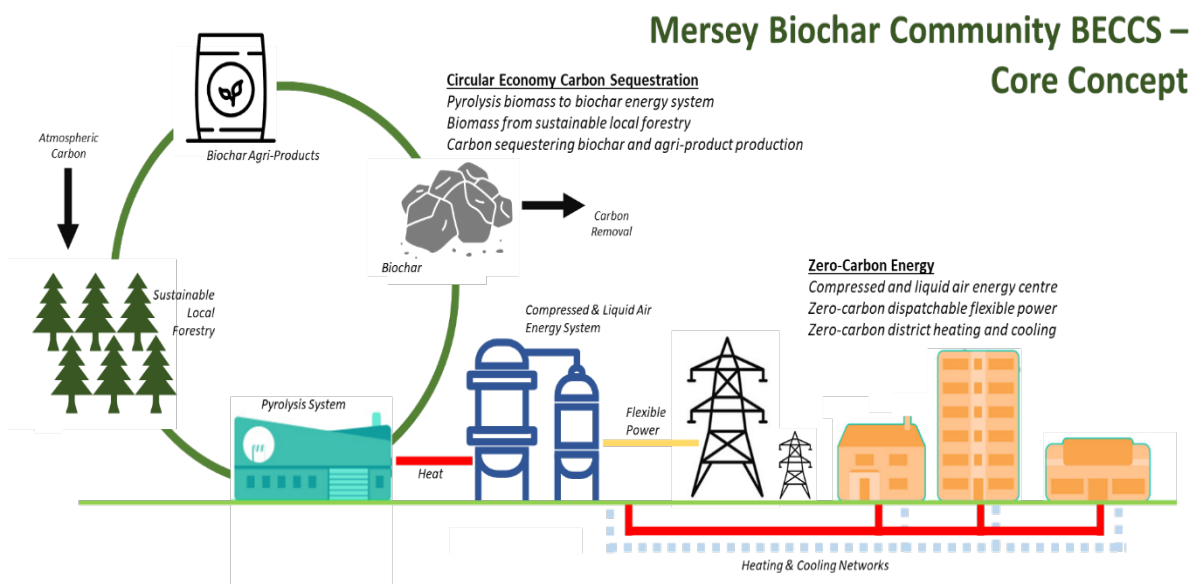
In the project's inception phase, the Dŵr Cymru Welsh Water team established the project steering group, finalized the project plan, and determined the required outputs and timescales. They identified and agreed upon a range of feedstocks to be tested at Aberystwyth University, including various forms of anaerobic digestion (AD) sludge, farm slurry, and blended biosolids with differing moisture contents. Laboratory trials were conducted, with samples transported for pyrolysis trials at the university. The resulting biochar was analysed, and findings were summarized in the first interim report. Phase 1 concluded with a review meeting to discuss the implications for Phase 2.

During Phase 2, practical plans for field trials were finalised, and a mobile pyrolysis plant was installed at the Eign treatment works. This plant processed locally generated feedstocks, producing pyrolysis products that represented the variations in feedstock characteristics typical at an operational treatment site. The plant was decommissioned and removed at the end of the trial period. The results from these trials were collected in a second interim report, and Phase 2 concluded with another review meeting. This phase ratified the findings from Phase 1, confirming the potential for carbonisation and biochar production for treating post-AD biosolids.

In Phase 3, the project focused on assessing the feasibility of scaling up pyrolysis processes. The detailed requirements for a feasibility study report were agreed upon, including which feedstocks and pyrolysis products to focus on. The technical data gathered, along with other relevant data from Dŵr Cymru Welsh Water, was used to explore the commercial viability at different scales. The findings were compiled into a business case, which included project costs, discounted cash flow analysis, and considerations for regulatory compliance and environmental benefits. The final study report was presented to the Dŵr Cymru Welsh Water team and other interested parties. Through extensive analysis, valuable knowledge was gained about regulatory compliance for pyrolysis and biochar production.

## Feasibility studies, calculations and models

**Figure 3. Original concept for bioenergy with carbon capture and storage (BECCS)**



### Char Analysis

During Phase 1, feedstock and char analysis was completed to maximise the benefit of the production.

Analysis was completed by an accredited laboratory of these biochars to the same levels required for European Biochar Certification, one of two existing keys standards recognised globally along with the International Biochar Initiative. In all cases the biochar produced met the highest level of compliance and therefore under guidance associated with the accreditations could be viable for use as, animal feed additives, organic agricultural application, standard agricultural application and material applications.

**Table 1: Level of compliance met**

Parameter	Regulation/Standard	Compliance
Emissions, inc. particulates and PFAS	DIRECTIVE 2010/75/EU	✓
Destruction of Pathogens	DIRECTIVE 86/278/EEC	✓
Heavy Metals: As, Cd & Hg	European Biochar Certification International Biochar Initiative Certification	✓ Class I-IV ✓
Heavy Metals: Cr, Cu, Pb, Ni & Zn	European Biochar Certification International Biochar Initiative Certification	✓ Class I-IV ✓
Organic Contaminants, inc. PCB and PFAS	European Biochar Certification International Biochar Initiative Certification	✓ Class I-IV ✓
Destruction of Micro/Nano plastics	No comprehensive law: DIRECTIVE 2010/75/EU REGULATION (EU) 2019/1009 – Fertilising Products Regulation	✓

## Business Model

At the end of Phase 1, the following were identified as the potential main revenue streams:

- Carbon Removal – biochar embodies carbon that was removed from atmosphere in pyrolysis. A given unit will produce around 700 tonnes per annum (tpa) of biochar and this equated to around 2400 tpa of carbon removal. We hope to achieve £100/tonne.
- Biochar – the char has value aside from its carbon content. It can be sold into different industries such as agriculture.
- Heat Sales – the sale of low grade (circa 90c) heat into buildings via distribution networks. We might produce enough heat to supply 200 homes or equivalent per unit. Green heat could be sold for £50-£100/MWh
- Electricity Related Revenues – our innovation will target higher value electricity outputs such as arbitrage of peak load generation rather than baseload.

These revenue streams would arise from the products and services that the technology would produce and would be needed to cover the costs of buying and operating the technology.

During Phase 2, due to the descoping of the Cheesecake technology and community energy, these revenue streams changed.

## Financial Modelling

During the Phase 1 feasibility studies, financial modelling was completed, performed on a representative future project at years 2025 and 2030. This was completed with a view to arriving at one of the key questions of the feasibility study, the cost of carbon removal, that is the price the project needs to sell carbon removal at to be economically viable and investible.

### Costs

The project would comprise three main capital elements:

- the core pyrolysis technology, the
- primary energy conversion equipment and
- the balance of plant and energy centre and then soft costs.

### Revenues

To achieve the lowest possible cost of carbon removal the project would have to maximise the value of saleable products, and minimise the cost of operation, relative to both biochar generation and capital cost (plant sizing). Revenues include:

- sale of char,
- sale of heat,
- sale of electrical power,
- arbitrage of power,
- sale of power related services (ancillary services) and
- sale of CO<sub>2</sub> derived products.

Through the financial modelling completed a Hurdle Rate of around 9-10% was adopted, and an estimate of the cost of removal at between £<140/tonne in the 2020s and around £50/tonne in the 2030s.

## Site selection

The proposed pilot site was the headquarters of United Utilities PLC (UU), the water utility company for the north west of the UK, located at Lingley Mere business park in Warrington.

The consortium had a relationship with UU during Phase 1 and UU are highly motivated to decarbonise their operations and agreed to provide land to develop the demonstrator and act as offtaker for the heat output and possibly offtake biochar and carbon credits as part of a long-

term agreement. At the point of application for Phase 2, we had developed a Heads of Terms agreement for a commercial partnership that covers land lease for demonstrator phase and longer-term commitment including offtake.

The team also had a well-established partnership with Warrington Council, the local planning authority, through collaboration on a wider borough decarbonisation project. Warrington is one of the leading UK councils for decarbonisation ambition, activity and progress.

## Technology Selection

Several engineered greenhouse gas removal (GGR) technologies were eligible for funding through the BEIS Greenhouse Gas Removal funding, of which we selected biochar-based technology.

During the development of this project, culminating in the Phase 2 Application, an initial technology combination was developed. This design was based on the findings from Phase 1, however during delivery of Phase 2, changes were made to the final designs and technologies.

Pyrolysis is an exothermic process and involves the thermal degradation of an organic material in the absence of oxygen. Unlike incineration, pyrolysis can produce three products: a solid char, a condensed liquid and a non-condensable gas.

### Original planned technology

The Mersey Biochar concept is a combination of core technologies to create a negative carbon community scale flexible power and heat process. The vision is that small scale biochar processing facilities would be connected onto communal and district heat networks, decarbonising heating and providing flexible dispatchable power into the local grid at dispersed sites across the UK. Therefore, the process concept not only removes carbon from atmosphere, but critically it also enables decarbonisation of the energy system. There are three main technology components to the concept:

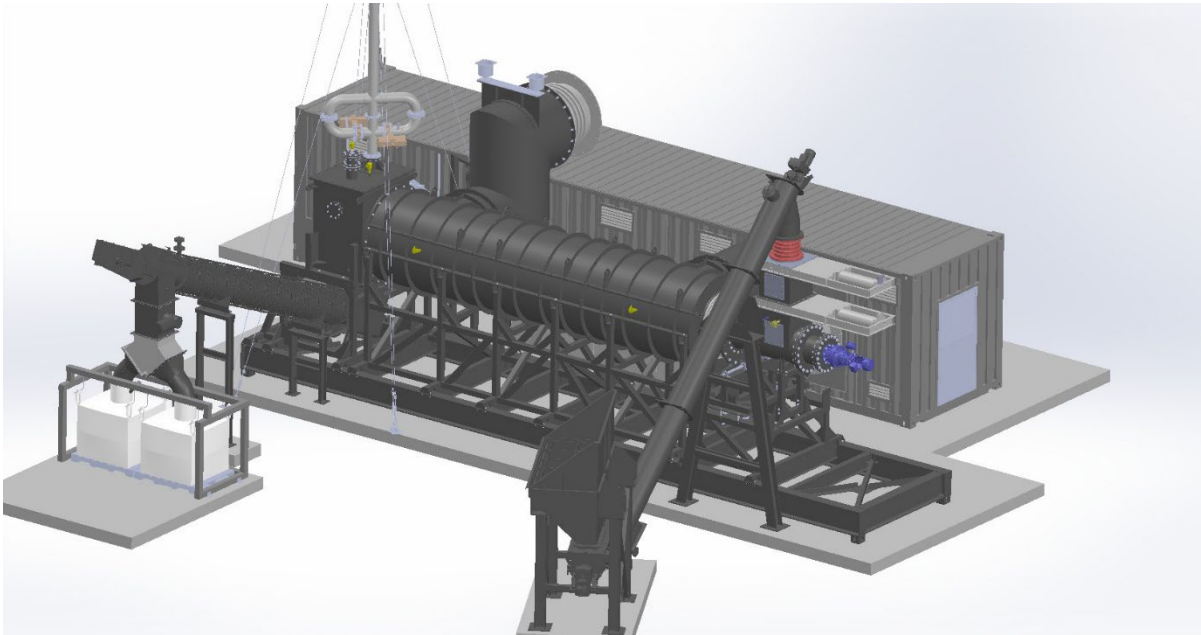
- Pyrolysis Engine - The biochar generation pyrolysis technology designed and supplied by Pyrocore.
- Energy Centre & Heat Network Infrastructure – the balance of plant and piping infrastructure that distributes the heat.
- Energy Capture/CAES Technology - The flexible energy and power storage CAES technology.

### Final Technology Selection

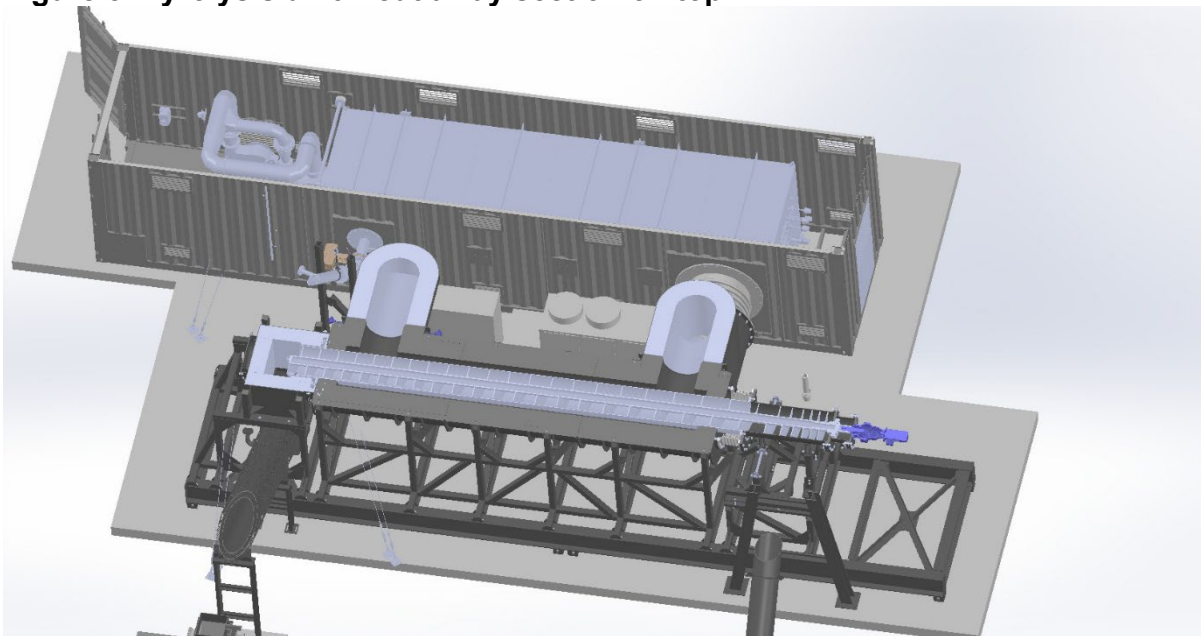
The final technology constructed on site, as part of Phase 2 consists of the Pyrocore Pyrolysis Unit. Further funding has been secured to complete feasibility, and based on the results of

these, capital funding for a Green Heat Network and an Organic Rankine Cycle (ORC) – further information on this is supplied later in this document.

**Figure 4. 3D image of the Pyrocore pyrolysis unit**



**Figure 5. Pyrolysis unit – cut away section on top**



### The basic process of the Mersey Biochar Pyrolysis Plant

Wood chip is the main feedstock used by the plant. It is delivered to site at a given specification (G30/G20/G10, 20% moisture content or lower). The main supplier is Seras Ltd (formerly Esken Renewables), based in Widnes.

The feedstock is delivered by articulated vehicle and discharged onto concrete floor, banded and checked for moisture content and bulk density.

Feedstock from the store is delivered to feedstock hopper by telehandler. The hopper holds sufficient woodchip to allow around 30 minutes of run time at 500kg/hr feed rate. It is replenished several times per hour.

The feedstock is fed from the hopper to the upper gate valve via two auger screws. The first screw is horizontal that drops feedstock on to the second screw which is inclined and then drops into the “open” upper gate valve and onto the “closed” lower gate valve, “charging” the intermediate hopper.

The feedstock passes through the gate valve and is held until the cycle is ready to accept the charge. A level sensor in the intermediate hopper is triggered when the feedstock reaches a predetermined level. At that point, the feed screws stop, the upper knife gate closes, and the lower gate opens to drop the feedstock into the pyro chamber. The lower gate then closes, the upper gate opens, and the feed screws start. This is called the “feed sequence”.

The pyro kiln is a 9m long, 600mm diameter tube made from material to cope with temperatures more than 1,200°C. An auger screw, the pyro screw, sits in the centre of the pyro kiln. The pyro screw is driven by a small 2.5kW motor and an 850:1 ratio reduction gearbox and rotates at a maximum speed of 2rpm to convey the feedstock along the kiln.

The residence time of the feedstock in the kiln is operationally defined, based on feedstock characteristics. A typical residence time for G30 woodchip at 16% moisture content is 18-20 minutes, at temperatures of 700-850C. The pyro kiln is heated by combusted syngas generated by the pyrolysis of the feedstock.

When the feedstock is fully pyrolysed, and has been converted to biochar, the char drops into the “char separator” onto an inclined auger screw. The screw and chute have chilled cooling water pumped around an external cooling jacket and through the auger screw shaft. The flow and return of the chilled water are controlled by a manifold to optimise cooling, achieving a discharge temperature of the biochar at around 65C.

Biochar is discharged from the inclined char screw and dropped onto a rotary valve. The rotary valve ensures an airtight seal whilst allowing char to pass into its receptacle.

When the biochar has been discharged from the rotary valve, there are two collection stations for bag filling. Only one bag is filled at a time, this is achieved by diverting the char into a specific bag. When the level sensor is triggered, the system will divert char into the empty “standby” bag and will proceed to fill it until that level sensor is triggered. In the meantime, the first bag is removed for storage and replaced.

Whilst discharging into the collection bags, the biochar is sparged to ensure there is no chance of ignition and to keep dust levels at a minimum. Sparging is system controlled, with water supplied from a rainwater harvesting tank (RWH) located outside the fuel store building. Water is pumped from the RWH tank into a valve train and flowmeter, and exits via ball valves linked

to whichever bag is being filled at the time. The char passes through two spray nozzles on opposing sides of the chute with a conical spray pattern.

The pyrolysis process breaks down the feedstock which in turn releases energy in the form of syngas, a hydrogen-rich gas. This gas is used to reheat the pyro chamber and maintain process temperatures in the kiln. As pyrolysis is an oxygen free process, the syngas cannot combust until it has been oxidised. The Induced Draft (ID) fan in the exhaust ductwork puts the plant into negative pressure of -5mbar, controlled at the char separator, and therefore pulls the syngas towards the exhaust stack via the thermal oxidiser.

The thermal oxidiser has two main functions:

- Use of a natural gas burner to bring the temperature in the pyro kiln up to processing temperature and to maintain it at the required temperature.
- Mix oxygen and syngas to create a self-sustaining flame without the burner.

On initial start-up (cold start) the burner is enabled, and will stay enabled, until a user defined temperature setpoint is achieved, usually 900°C. When this is achieved, the burner will modulate to maintain the setpoint and will eventually turn off when there is enough syngas to self-sustain the process. At this point, the burner is only required if there is a dip in temperature in the thermal oxidiser and remains on standby if required.

Syngas is drawn into the thermal oxidiser from the char separator by the ID fan. It is then mixed with ambient air supplied by a forced draft (FD) fan in the thermal oxidiser. The ambient air is metered into the thermal oxidiser via a combustion air valve which drives a damper plate in the air feed line into the oxidiser and will always try to maintain around 6-12% oxygen concentration to keep on the lean side of stoichiometry (for safety). When the syngas is fully combusted, a flame is created such that the flame is now heating the thermal oxidiser and therefore being drawn over the pyro kiln annulus. This creates a self-sustaining pyrolysis process.

After the combusted exhaust gas has passed over and heated the kiln, the gases are ducted away and cooled to protect the ID fan via two air dilution inlet dampers in the exhaust duct. The dampers are maintained at operationally defined temperature setpoint. The combusted gasses are dispersed to atmosphere at approximately 250-300°C.

The plan for the Mersey Biochar plant is to use the exhaust gas for electricity generation in an ORC, and supply heat via a district heating network. Around 1MWth of heat energy is available at 700C.

# Administrative Work

## Planning and permits

A planning application to Warrington Borough District Council was submitted 2 June 2023 and planning permission was awarded 24 August 2023.

Most of the conditions attached to planning were all expected and did not raise any major concerns. Two of the conditions however needed managing carefully by the project team to mitigate against risk of delay. These additional conditions were built into the delivery plan to ensure the project could be delivered as planned.

These were:

- Prior to the commencement of development, excluding demolition works and site enabling works, details of a sustainable surface water drainage scheme shall be submitted to and approved in writing by the Local Planning Authority.
- No development (except demolition and site clearance) shall take place until the works in Sections A and B below are undertaken and completed.

The Environment Agency issued a permit for the operation of the pyrolysis unit on 21 May 2024. The permit allows the use of the plant, based on the information submitted. The plant is defined as a Medium Combustion Plant (MCP) for regulatory purposes. Monitoring of emissions is subject to the requirements of the permit.

Key in providing assurance to host sites laboratories and in proving environmental compliance for MRV.

## Lease

Working with UU and legal firm Lux Nova, a draft lease was drawn up and agreed. We also took advice on the lease from specialist legal adviser, Michael Parkinson of Browne Jacobson. Concerns that had been raised by DESNZ regarding potential clauses that UU could add in, limiting the pilot operations, were mitigated.

The finalised lease, signed with United Utilities 21 November 2023 contains all the protections that allowed us to complete the pilot project whilst meeting the site-specific requirements of sensitive receptors such as United Utilities Laboratories.

## Legal support

Lux Nova were appointed to support with legal requirements, including preparation of NEC4 contracts, shareholders agreements, PCSAs etc. The letter of engagement with Lux Nova was signed on 28 November 2022.

## NEC4 Contracts

In January 2023 we established Pre-Construction Services Agreements (PCSA) with Vital Energi (signed 5 January 2023) and Pyrocore (signed 19 January 2023). These contracts covered the design works.

In January/February 2023 drafting and negotiation of the Pyrocore equipment procurement contract was completed. This was a 2-stage agreement, first by establishing an Early Works Agreement (EWA) with Pyrocore (signed 10 February 2023). This acted as the forerunner to the complete NEC4 Contract. The EWA contains the Heads of Terms for the NEC.

Where there were delays to full NEC4 contracts being signed, Letter Of Intents (LOI) were used to keep the project progressing.

The NEC4 contract with Pyrocore was signed 13 September 2023.

The NEC4 contract with Vital Energi was signed 23 February 2024.

A LOI was signed with Cheesecake Energy Ltd, 13 January 2023 for services around preliminary CAES configuration, modelling and budgeting.

## Governance Structure and Risk Management

### Governance

Mersey Biochar Limited was incorporated as a private limited company on 6 April 2023, Company Number 14785142.

The Project was overseen by the Mersey Biochar project board, initially consisting of Pure Leapfrog CEO, SWEA CEO, Pure Leapfrog Director of Operations and two SWEA trustees.

Membership of the board changed and as of March 2025, the Mersey Biochar board consisted of Sandy Ruthven (SWEA CEO), Chris Welby, Paul Smith Lomas and Jamie Abbott (SWEA trustees).

The Mersey Biochar project board oversaw delivery, managed and reviewed the project risk register and budget. The board met monthly and received and discussed a board summary report.

As part of the contract with DESNZ we delivered a monthly progress report along with a range of deliverable items that occurred within that month.

## Risk Management

The project team took a systematic approach to the task of identifying and assessing risks and planning and implementing risk responses which provided a disciplined environment for proactive decision making.

A risk register was created following the risk management procedure recommended under the PRINCE2 approach (a process-based method for project management), comprising five steps:

- Identify – the team regularly monitored and identified risks. The key risks were identified initially at the application stage and further explored and regularly updated throughout the lifetime of the project.
- Assess – the probability of the threats and opportunities were assessed and scored in terms of how likely they were to occur, the impact of each threat, and the proximity of when they might occur.
- Plan – together with the project board, the team identified and evaluated a range of options for responding to the threats and opportunities. This was done with value for money in mind – balancing the cost of implementing the responses against the probability and impact of allowing the risk to occur. The risks were then further assessed and scored after identifying actions that could be taken to resolve the risk.
- Implement – for each risk, a risk owner and risk actionee was clearly identified on the risk register.
- Communicate – the project team were responsible for maintaining the risk register which was regularly reviewed at the project team's weekly meetings. Risk was a standard agenda item at the monthly project board meetings where the project team presented updates on risks and opportunities. Risk register updates were also supplied at monthly meetings with our Monitoring Officer and DESNZ.

More than 50 risks were captured throughout the lifetime of the project. The main risks the project encountered can be summarised as budget, timetable, over-reliance on a single contractor and securing planning permission.

## Budget

The risk of budget over-run was an issue throughout the project and early on-cost savings had to be found where the Mersey Biochar project board (through the change request process to DESNZ) reduced the budget significantly for Cheesecake.

The costs quoted by Vital Energi increased enormously from that budgeted for and negotiations were escalated to arrive at a more practicable figure including descoping the energy centre from Vital's scope of works and finding an alternative supplier of a suitable building instead.

The cost of meeting the national standards for sustainable drainage systems (SuDS) was significantly higher than expected at £134k, gas booster (£49,935) and provision of a generator and water bowser (£23,446).

The most significant impact on the budget was when Pyrocore entered administration which left a £150,000 shortfall in budget.

### **Timetable**

We experienced a three-week delay to gaining planning permission (an issue where the planning authority had failed to consult all relevant parties).

Significant delays experienced as a result of Pyrocore entering administration, dealing with the administration process and subsequently contracting with multiple individual suppliers. This increased the lead time on components and introduced more complexity into the project management and administration of the project.

### **Over-reliance on one single contractor to deliver**

Contracts were put in place as soon as possible to secure prices and legal support was sought to draft NEC4 contracts with our two major contractors, Vital Energi and Pyrocore.

The most significant impact on the project was the unfortunate news of Pyrocore entering administration on 5 September 2024. This had a major impact on budget and timetable. We were extremely fortunate that West Pro Engineering Services were able to pick up the remaining installation and commissioning work.

### **Securing planning permission**

With the technology not well known or understood, there was a concern that the local community would oppose the project. We took great care to describe the project to ensure it wasn't mistaken for an industrial incineration plant. Expert planning agents were employed and a plan for community engagement was put in place to help with consultation. This included a website to describe the project and to pre-empt some of the questions that the public might have.

## **Staffing, resources and changes**

At the start of Phase 2, the consortium delivering the project was as follows:

- SWEA – Project Lead
- Vital Energi – Principal Designer and Principal Contractor
- Pyrocore – pyrolysis technology provider
- Pure Leapfrog – administrative support and carbon trading and finance knowledge
- United Utilities – site owner and heat and power offtaker

The project's original Project Manager was employed by Pure Leapfrog, and Project Management Support and Biochar Technology/Project Specialism was provided by SWEA.

In March 2023 staffing changes meant that a new project manager needed to be recruited and an employee of SWEA took on the role with external mentor support. At the end of April 2024 after further staffing changes, the project manager role was contracted to Moonbeam Consulting.

Project administration support was supplied by a Pure Leapfrog employee initially and from September 2024 with was contracted out by SWEA.

SWEA's CEO at time of application was Simone Lowthe-Thomas, Simone was in post until April 2022. Sandy Ruthven became SWEA's CEO in June 2022 coinciding with the start of Phase 2.

The project was 34 months long from June 2022 to March 2025. At project mobilisation, the project schedule was as follows:

- June 2022 Project funding starts
- June to December – design, budget/scope, planning application preparation
- November to January 2023 – Pyrolysis procurement contract drafted/executed
- March/April 2023 – planning decision returned / M&E and civil contract drafted/executed
- April 2023-April 2024 – construction
- April 2024-March 2025 – test and commission
- Spring 2025 – review with United Utilities, decision to proceed into commercial operation vs decommission
- March 2025 – end of funded period and report to BEIS.

## Communications

A communications strategy around planning was prepared with a [website and FAQ's](#) being delivered and contact with relevant local parties, MPs, community groups being conducted to try and avoid any misunderstanding as to the project's aims and alleviate any concerns.

The website offers information on the project, biochar/pyrolysis process and FAQs.

News and updates on the project were published on both the Mersey Biochar and SWEA websites. For example when [planning permission was granted](#) and [when work began](#) on site.

## Market Research

Through the Net Zero Innovation Portfolio (NZIP) Acceleration Support programme research was completed on our behalf evaluating the existing and potential markets for Biochar. This was completed by ERM, a multinational consultancy firm which focuses on sustainability and the environment.

The questions answered were:

- What VCM methodology would be most suitable for SW?
- Are there any issues that would impede sale of a carbon credit for the preferred methodology in either case?
- What is the current price that can be achieved in the VCM market, what is the price trend; what are the volumes, who are the key buyers and what are the motivations for these buyers?
- Does a higher quality MRV (beyond the spec norms) garner a higher carbon price?
- What physical markets exist for the sale of biochar in UK – price, volumes, specifications, names of potential buyers and rationale?
- What would be the preferred biochar market given the predicted volumes and quality of SW biochar?

21 potential biochar markets were assessed, ascertaining the technology readiness level (TRL) and whether there was evidence of a market to sell biochar. 12 markets were given further evaluation, with an in-detail evaluation completed for soil enhancement (gardening), soil enhancement (agriculture), livestock feed, livestock litter and bedding. A further 12 markets were evaluated at a high-level.

Seven global voluntary carbon credit schemes have active biochar methodologies of which six could be relevant as the methodologies are applicable to biochar projects developed in the UK. Puro.earth methodology was found to be the most applicable for SWEA, from feedstock and applications perspective as well as credit price and marketplace recognition.

# Technical Work

## RIBA Stage 3 design

The RIBA Stage 3 Technical Report was completed by Vital Energi on 15 June 2023. The design was developed under a pre-construction services agreement (PCSA).

### **The RIBA Stage 3 brief**

The proposed development is for an innovative biochar development which is being established to facilitate research into technological and commercial approaches to the removal of CO<sub>2</sub> and greenhouse gases from atmosphere at the lowest possible cost. The proposed development will involve the combustion of biowaste timber products, by way of pyrolysis, to produce biochar and hot combustion gases. There is intent to produce a variety of biochar products on site, via the pyrolysis process, which will be tested for different characteristics. There is also intent to recover heat available from the combustion gases. The recovered heat may then be used in an innovative compressed air energy storage system (CAES), heat network or other application. The site will therefore be an innovative testing site, developed under central government funding, opposed to a commercial/industrial biochar

The Stage 3 design developed under the PCSA yielded a cost plan which exceeded the project's funding. Therefore, a value engineered solution was developed to more closely align the Phase 1 design cost plan and project funding.

The alternative concept design was subsequently developed with the aim of removing high-cost elements that have been added during the design development. The main areas targeted for value engineering are the hard standing (civils), portal frame (fuel store) building and the 1.2MW air-to-air (CAES) heat exchanger.

The target cost savings associated with the recommended value engineering options were as follows:

- Re-use existing hard standing; target £230k saving
- Reduce size & specification of fuel store 'building'; target £620k saving
- Remove air/air heat exchanger & ducting; target £920k saving

## VRIBA Stage 4 design

The RIBA Stage 4A Technical Report was completed by Vital Energi on 20 September 2023. The design was developed under a pre-construction services agreement (PCSA).

The Stage 3 design report identified the design did not fit within the funding available and a value engineered solution presented which will more closely align the project funding. The Stage 4A design has developed the affordable design solution which has led to substantial design changes. The key changes were:

- designing out a high temperature air to air heat exchanger
- switching the fuel store to a modular building (removed from Vital Energi's scope)
- omission of a permanent accommodation block. Vital Energi shall hire site cabins for until system handover. It will then be the client's responsibility take over hire of the cabins.
- omission of a top loader feed system for a concrete push wall store (not in Vital Energi's scope but retaining existing hardstanding where possible)

## Cost Plan

Planning permission and completion of the RIBA Stage 4a Report allowed us to establish a fixed price cost schedule and NEC4 contract. It was felt a fixed price contract offered the best delivery route for the project to ensure delivery within the project budget due to the variable nature of construction costs and risks from external sources for price increases such as steel.

On receipt of planning at the end of August 2023 the construction programme was formally agreed along with the fixed cost fee. To ensure continuity of delivery an LOI was entered into initially in September which ran until 15 December 2023 when the full NEC4 contract was agreed.

## Budget setting

Inflation and market challenges led to significant cost increases during the delivery of the construction programme by Vital Energi. This was mitigated by securing a fixed cost contract and by adapting the design for delivery in the pilot phase. The decision to remove the heat exchanger element of the delivery which would connect to future CAES units was made and the appointment of a new building contractor were key to bringing the construction into a deliverable budget.

## Site clearance

Demolition was delayed by six weeks due to the submission of a statutory section 80 notice to the local authority. This was submitted on 20th October and signed off early December. The costs of demolition were subsequently offset against the previously agreed cost of the lease.

Demolishing existing site buildings and clearing services was completed 6 January 2024.

**Figure 6. Demolition and clearing of site**



**Figure 7. Demolition and clearing of site**



The ground contamination report required a series of bore holes across the site which were conducted in December 2023. The results of the analysis deemed the site as low risk with no notable contamination.

## Foundations and setting out

Severn Fabrications laid their foundations and started the building construction in late April.

**Figure 8. Foundations for chimney stack and pyrolysis kiln and thermal oxidiser**



**Figure 9. Foundations for chimney stack and pyrolysis kiln and thermal oxidiser**



Severn Fabrications submitted revised plans to Building Control to meet fire regulations. The additional work involved spraying intumescent paint to all steel work, concrete base panels along the bases of the two external boundaries of the building, and a concrete plinth underneath the panels to prevent fire egress.

Vital Energi completed the excavation of all major concrete pads – kiln and oxidiser, ID fan, chimney stack. These were approved by Building Control. DMC Construction, under contract to Vital Energi worked across approximately half the site to finish excavations and stoning up.

## CME works

Severn Fabrications were appointed to design and build fuel store agreed November 2023.

Severn Fabrications mobilised on site and laid foundations during March and April 2024. Severn Fabrications completed the building in June/July 2024.

In April 2024, Vital Energi started installing slabs for the Pyrocore unit and flue as well as other civil groundwork. By June 2024 the excavation of all major concrete pads (for kiln and oxidiser, ID fan and chimney stack). The kiln and thermal oxidiser were then craned into their final positions on their respective concrete pads.

During the CME works, underground cables were found, these were not picked up on original plans or investigations. This discovery caused several weeks of delay as mitigations were needed to be put in place.

DMC Construction stoned up the foundation pads of the steel columns, excavated and levelled the fuel store floor, and levelled and rolled with MOT. The concrete plinth along the top and end elevations were then poured. This was completed to meet fire regulation requirements.

Vital Energi started work on site drainage and the SuDS scheme in July 2024. SuDS work completed October/November 2024 with installation of rainwater harvesting tank.

Vital Energi demobilised from site at the end of November 2024.

Work to connect sewerage and foul water from the site office was completed in February 2025.

**Figure 10. Erection of the fuel store building**



## Deliveries

In January 2024 the key marque items for the plant's construction were delivered. These were:

- Kiln Fabrication
- Kiln Trap Plates
- Kiln Ducting and Supports
- Thermal Oxidiser
- Syngas line and Supports
- Emergency Syngas Vent
- Emergency Syngas Line
- Bagging System

Pyrocore entering administration in September 2024 caused a number of delays to deliveries of parts for the pyrolysis unit.

The char removal screw conveyor and gearbox from a supplier in Italy was delivered in December 2024.

100 tonnes of feedstock was procured for commissioning/SAT.

## Installation and assembly

On 17 October 2024, West Pro Engineering started the work to complete installation, integration and commissioning of the pyrolysis plant.

Additional power supplies were installed to meet the requirements of the compressed air and nitrogen supply systems.

The char removal system was installed in December 2024.

The control systems and panels were manufactured behind the original schedule because payment was delayed.

**Figure 11. Exhaust chimney**



**Figure 12. Nitrogen and compressed air system**



**Figure 13. Pyro kiln and thermal oxidiser**



**Figure 14 Feed hopper and feed screw/conveyor in place**



**Figure 15 Feed hopper and feed screw/conveyor in place**



## Cold, hot commissioning, SAT

Cold commissioning was started in February 2025 and hot commissioning and SAT (Site Acceptance Testing) completed by the end of March 2025.

A full technical construction file has been prepared comprising drawings, manuals, CE marking of component parts, specifications etc.

## Life Cycle Assessment

We have commissioned a study by University of Nottingham to complete a Life Cycle Assessment (LCA) of the Mersey Biochar facility. This will be completed after Phase 2, during the operational trial.

All life cycle activities from feedstock collection, feedstock transportation, biochar production, biochar transportation, heat and electricity generation by byproducts and soil application of biochar, will be included in the analyses.

Data will be collected across:

- Feedstock
- Pyrolysis Process
- Biochar
- Site

## Monitoring, Reporting and Verification

The contract with DESNZ requires SWEA to deliver data and information from a comprehensive and detailed monitoring, reporting, and verification (MRV) methodology for

carbon emissions associated with the operation of the pyrolysis plant at Lingley Mere. In relation to the Mersey Biochar plant, the data and information needs to demonstrate:

- the MRV methodology
- reliability, sufficient to allow the next stage of the commercialisation plan to be adopted
- operation with a range of feedstocks.

An interim Monitoring, Reporting and Verification (MRV) report was submitted alongside the 2nd Stage Gate Review with DESNZ. This highlighted our preferred MRV route as [Puro.Earth](#) and the rationale behind this choice.

Due to the fast-evolving marketplace, when considering MRV schemes, the final decision will be made when the plant is operating. The MRV will be completed once the site is operating commercially and producing biochar, after the end of Phase 2.

A consequence of Pyrocore entering administration, and its impact on project delivery and budgets, was our ability to carry out the planned 100-day trial and collect data for the Monitoring, Reporting and Verification (MRV) report. Following discussions with DESNZ in November 2024 it was agreed via a formal change request that after the funded period ends, we would be allowed to operate the plant on a commercial basis for up to three months, collect data and submit the MRV and final report at the end of June 2025.

At a meeting with DESNZ in January 2025, it was stressed that early MRV information is important to help inform policy decisions. It was agreed that desk-based data from an LCA should be supplied within the project period, and that the MRV would be reported as soon as feasibly practical using data and information from commercial operations. This was formally agreed as part of the change request process.

The plant has undergone 50 hours of trials but due to financial constraints it has not been possible to carry out 100 hours of trials. These should be completed in 2026.

# Major Variations

## Descoping Cheesecake

In the original application, approximately £1 million was against Cheesecake Energy Ltd. This was intended to be for two Compressed Air Energy Storage (CAES) systems and detailed design, test and commission of CAES integration.

On mobilisation of Phase 2, we engaged Cheesecake under an initial consultancy basis, with some demonstration activity.

By November 2022, after discussion with the project board, the budget for Cheesecake had reduced to £180k for consultancy and off-site demonstration. This was due to budget limitations, so the CAES technology had to be descoped, prioritising physical delivery of the pilot over the digital twin concept.

This was submitted to DESNZ in a change request, which was considered by a panel, and we received notification on the 29 September that our change request was approved.

Cheesecake were requested to review their proposal and develop a small consultancy offer to continue with design development and hosting DESNZ for an off-site demo of their new thermal store.

## Descoping heat exchangers

In the initial design, heat exchangers were included. These were not required for operating the plant and would only be needed if excess heat was being sold.

During development, as there was not an immediate offtaker for any excess heat, in agreement with Vital Energi, the heat exchangers were descoped. This reduced the budget by approximately £22.5k.

If the ORC and/or Heat Network are constructed in the future, these will include heat exchangers.

## Stack and ductwork

With the iterative nature of the design, and multiple changes through the process (descoping CAES and Heat Exchangers) there were modifications to designs of the ductwork, ID fan and stack of the pyrolysis plant.

## SuDS

Key activity led by Vital Energi on the site in this phase included early procurement of key materials, development of the planning conditions responses, the two of note being the requirement for a site Sustainable Urban Drainage System (SuDS) and a level two ground contamination report. Both of these required sign off by the relevant authority prior to site operation.

Pluviam, were appointed as SuDS consultants, and their initial report specified that the site would require 163m<sup>3</sup> of attenuation in the form of either a storage tank or crates. Both would have required substantial civils costing upwards of £150,000-£200,000 to deliver against an original budget of £43k. Through additional work, and discussions with UU and Pluviam, the final SuDS requirements were reduced to 43m<sup>3</sup>.

The SuDS design developed is split into an above ground rainwater capture and storage tank adjacent to the building covering the building development with a below ground grate and membrane tank system covering the developed hard standing areas.

The ground contamination report required a series of bore holes across the site which were conducted in December 2023. The results of the analysis deemed the site as low risk with no notable contamination.

The SuDS work was finalised during the latter part of 2024. The underground attenuation tank and associated pipework was installed. The surface over the tank was prepared and concreted at the same time as the other major pours in late September/early October. The above ground rainwater harvesting tank was installed in October such that the SuDS scheme was operational and compliant with necessary regulations by early October 2024.

## Gas booster and supply

One of the requirements for operating the pyrolysis plant, is a natural gas supply of a given pressure and volume. This is required to start up, and cool down, the system.

It was found during the project, that the existing gas supply on site was not of sufficient pressure to meet the requirements of the burner heads of the pyrolysis plant. To resolve this, a gas booster was required, this was not in the original design/project budget.

The original costs for gas pipework, were approximately £44k, with the additional gas booster the total spend was approximately £107k.

# Major Challenges

## Personnel changes and available resources

As detailed earlier in this report, there had been a number of personnel changes, especially relating to the role of project manager. This impacted project delivery through loss of relationships held by these individuals and the time taken for new staff to fully familiarise themselves with their new role and responsibilities.

## Pyrocore in administration

On 5th September 2024, one of our key contractors, Pyrocore went into administration. The company ceased trading, and all staff were made redundant without notice and with immediate effect. FRP Advisory Trading Limited were the appointed administrators of Pyrocore.

Pyrocore entering administration caused significant delays and financial costs to the project:

- Invoices paid without delivery of parts and services totalling £190k. This required re-engineering of the project at the last minute in order to stick within the budget.
- Securing pan-European supply chain parts and services to complete the build.
- SWEA had to take over as prime contractor managing multiple contracts, suppliers and ensuring site health and safety with the associated costs and time delays.
- 2-3 months of legal uncertainty relating to the ownership of the plant, IP, and warranties where construction was halted.

We instructed legal firms Lux Nova and Browne Jacobson to advise us of our position with regards to assignment of sub-contracts/orders, NEC4 contract termination, and titles to assets as set out in the NEC4 contract with Pyrocore.

We had several meetings with DESNZ to discuss the impact on the project

After Pyrocore went into administration, SWEA had a positive meeting with West Pro Engineering Services (established by two former employees of Pyrocore) to discuss whether they would be interested in working with SWEA to complete the Mersey Biochar project. West Pro Engineering Services were subsequently appointed to complete installation and commissioning of the pyrolysis unit.

SWEA had to negotiate with five of Pyrocore's principal subcontractors/vendors, securing new supply contracts. Many of these had been part paid by Pyrocore, with monies still outstanding.

This development impacted the project budget since several payments had been made to Pyrocore but not made from Pyrocore to their suppliers. These payments came to around £155k. A reprofiling of the project was completed, in agreement with DESNZ, under the

understanding that no additional budget would be provided. It was agreed that the 100-day trial could be descope from the Phase 2 project.

Ultimately, a serious risk to the project in the long term is now unavoidable. The unit has no warranty and thus any problems in the future will require capital payments. Additionally, all performance guarantees are null and void meaning all the risk sits with SWEA. With no technology provider able to maintain the unit, SWEA will be reliant on the two ex-Pyrocore employees (Now. Westpro engineering) to continue maintenance.

## Legal title, licensing and freedom to operate

Pyrocore's involvement in the project was delivered under an NEC4 contract. This meant all risk related to installation and commissioning rested with Pyrocore, and SWEA did not get legal title until the project was commissioned by Pyrocore.

As Pyrocore went into administration before completion, it was not clear who had legal title to kit and equipment at Warrington, some of which had only been part paid for. SWEA negotiated with vendors and Pyrocore's Administrator to gain legal title to all kit already delivered to site. This was a lengthy, involved process and delays were introduced by the Administrator as they followed their due process.

There was a risk to the project that the vendors could reclaim the equipment on site, as only partial payment had been made, and this would have had a catastrophic impact on project delivery.

One of the clauses from the NEC4 contract allowed us to have license rights to use kit in perpetuity. The NEC4 contract also allowed SWEA Freedom To Operate (FTO) using Pyrocore patents and IP.

## Multiple contractors

One of the risks identified by DESNZ was around the scale of project, and SWEA's experience in managing a congested multi contractor site against a tight deadline.

SWEA recognised that it does not have a history of managing a construction site of this nature and as such has worked from early in Phase 1 with Vital Energi, a very experienced biomass and bio-energy construction organisation with over 30 years' experience in project design and construction. Vital Energi was the principal contractor on the site and were responsible for ensuring the site, and all contractors on site comply with the construction and design management regulations (CDM) including managing risk and H&S on site.

The initial plan was for Vital Energi to fulfil the site manager role and be on site whenever activity was being undertaken. The site manager managed the key relationships with Pyrocore, United Utilities and EMCOR UK on site.

Contractual risks were managed by using the NEC4 construction contract suite of standard construction contracts. These include a full methodology on risk identification with early warning notices (EWA'S) raised should concerns of contractual risk such as delays or cost/scope changes. EWA review meetings were held bi-weekly and actions to mitigate are put in place.

## Principal Contractor/Principal Designer

Throughout delivery of the project, we have experienced difficulties with appointed Principal Contractor/Principal Designer (PC/PD). This has been due to changes in project scope during delivery.

Vital Energi were the initial PC/PD for the site, however when the construction of the fuel store was descoped from Vital Energi, and appointed Severn Fabrications, Vital Energi stood down as project PC/PD.

Through negotiation, Vital Energi agreed to return as PC/PD, but with no responsibility for work on the building. This led to the site being separated into two sites under Construction (Design and Management) Regulations (CDM), the building area and the rest of site (SuDS, Pyrolysis plant, ducting). Severn Fabrications acted as PC/PD for the building area, and Vital Energi for the rest of the site.

Concerns were raised with SWEA, relating to different working practices between contractors, and there were significant tensions between the two contractors. This had to be carefully managed by the SW Project Manager, and negotiations were made to ensure work was completed across the site.

After the building was completed and Severn Fabrications demobilised, Vital Energi resumed PC/PD for the entire site.

The shifting of PC/PD added significant management requirements.

## Budgets

The original project costings were put together in 2021 for submission for Phase 2 funding. Between 2021 and the project starting, emerging crises (Ukraine War, energy crisis, cost-of-living crisis, post-COVID cost increases) led to significant price inflation.

This meant that when the project board first met in November 2022, the budget needed for the project had increased to £5.2 million and immediate savings had to be found.

During design some additional requirements were identified, and the additional costs associated with these. These included the increase in SuDS requirements, the need for a Gas Booster and increase in values of NEC4 contracts which were both significantly higher than in the original Phase 2 proposal.

Further increases were due to be seen in the cost of the 100-day trial, as feedstock prices, originally budgeted at £75/tonne had increased to £150/tonne. This was a secondary reason for the 100-day trial being descope.

These cost increases led to SWEA descope both the CAES technology and the heat exchangers.

Even if SWEA had been able to secure additional investment to complete the items descope from the original design, the DESNZ funding process would not have allowed this.

## Commercialisation

The initial commercialisation calculations on project submission are outdated. The biochar industry and the market for biochar in the UK is in its infancy and is therefore by its very nature volatile and unpredictable. The same is true of carbon markets. As such the commercial plan for Mersey Biochar has evolved over the period of the project.

Feedstock homogeneity is very important for pyrolysis, a consistent, high-quality feedstock ensures the quality of the biochar produced.

For the pyrolysis plant we have built, we require feedstock with the following:

- Consistency - 20% moisture content, for every piece of woodchip, not an average moisture content across a batch
- Grading – G30 grade woodchip (max size of chip of 30mmx30mmx50mm)

These specifications increase the difficulty in sourcing suitable feedstock, and increase the price associated with it. A source has been secured, but the cost is significantly higher than the original budget, rising from £75/tonne to approximately £150/tonne.

## Offtakers for biochar

During Phase 1 development the consortium believed there would be an abundance of offtakers for biochar, as there are lots of potential uses for the char. Through Phase 2 our understanding of the market increased, and while there are a lot of small purchasers for biochar, who may buy a single tonne for £1,000, selling at scale is more difficult.

The biochar market is still in its infancy and there are currently few volume offtakers in the market. We have gained additional insight into the market. Volume offtakers will be buying char for a much lower price than the single tonne example above, our current estimation is £300-550/tonne for premium agri-grade biochars; £100-200/tonne for construction grade so the business model must reflect this.

Selling to small scale offtakers would likely also require additional processing of the char, e.g. packaging. There would not be space for these facilities at the Mersey Biochar site.

The Mersey Biochar plant is designed to run for 8,000 hours a year, processing 4,000 tonnes of woodchip and producing 1,000 tonnes of char. Unlike burning woodchip, where a small volume of ash would be produced, biochar produced through pyrolysis has a similar volume to the original woodchip. This means that a large amount of storage is required if a regular, significant offtaker is not already in production. In practice, we would be able to store approximately 3 days' worth of produced biochar at the Mersey Biochar site.

There is a small, existing market for biochar from other routes (e.g. Europe), however we have seen interest from 'blue chip' clients, who have an interest in the provenance of the char and would have a specification for UK produced biochar.

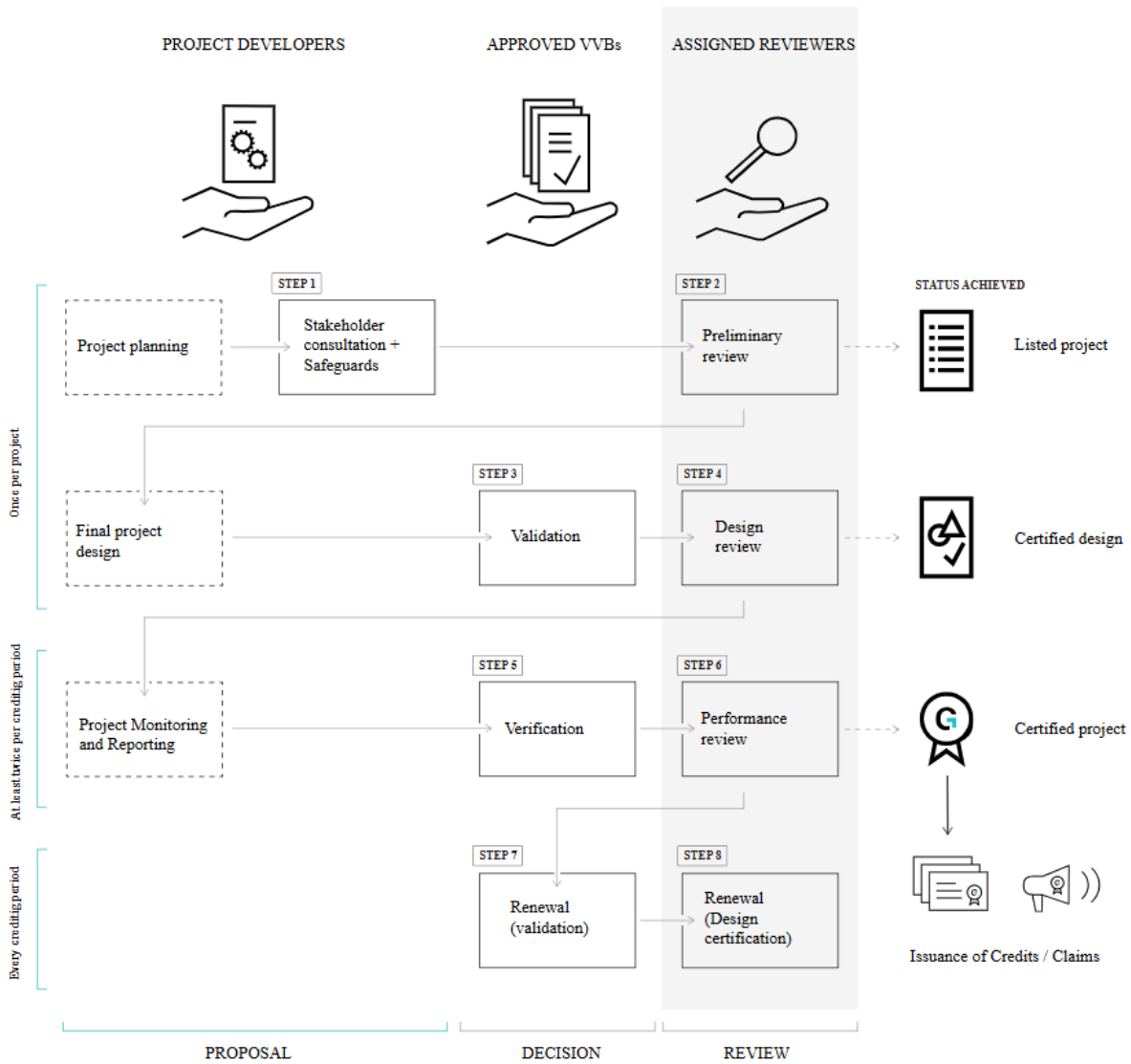
## CO2 Removal Certificates (CORCs)

A Carbon Removal Certificate (CORC) is required to verify that carbon has been removed from the atmosphere. The process to gain this accreditation is lengthy, working with an accreditation body (e.g. Puro.earth or Verra). It takes a minimum of 12 months to gain accreditation.

This means that for at least the first year of operation, we would be unable to sell certified carbon credits, removing one of the potential sources of revenue for the project.

One option considered is to 'forward sell' carbon credits at a reduced rate. This would mean any risk associated with not gaining accreditation would be passed to the buyer, but if accreditation is achieved the income per carbon credit would be significantly reduced.

**Figure 16. Example CORC accreditation process: Gold standard verification process**



# Lessons Learnt

## Location, heat demand and space constraints

The technology design integration has been a first of its kind and had offered considerable learning for the project team, particularly around technology scope and costs.

One significant area is around site selection. The Lingley Mere site was chosen as the location for the pilot project however, with hindsight we have identified several limitations:

### **Size**

The site provides sufficient space to run a pyrolysis plant, however there is no additional space available for feedstock processing or biochar storage on site. If more space were available, we would have an option to purchase a lower quality/cost feedstock and dry and chip ourselves. We also do not have space for additional storage for char produced, or for any char processing facilities.

### **Heat Demand**

While a district heating network has been proposed, it is not yet in place. And if the project progresses will likely not be in operation until March 2027 at the earliest. This means there is no market for the heat produced by the plant for at least two years.

### **Site Ownership**

As a tenant on the site, additional administrative and operational barriers have been faced by having to liaise with a landlord. If the site was under SWEA ownership, we would have had more control of the delivery process and reduced delays.

### **Site location**

Whilst heat offtake and a grid connection are potentially close by it is clear the site suffers being a significant distance from its feedstock. In addition, the site has limited space available on which feedstocks could be processed. For example, oversize compost from local authority operations could be a viable feedstock but space is required to receive, shred/chip, dry and store but no space is available at Lingley Mere. Most other biochar sites sit on or very close to their feedstock source – usually agriculture or woodland. There is an increase in feedstock costs as a result of the transport costs required to bring the feedstock to the machine.

In addition, the site has further constraints as an experimental unit. Large scale trials with other waste feedstocks including sewage sludge, AD waste or food waste are impossible on a site without waste processing permits.

## Partnerships, relationships and internal administration

This project brought together a number of partners and stakeholders, many of whom had not worked on a project of this type or scale previously.

The organisation contracted to DESNZ to deliver the project was Severn Wye with Pure Leapfrog initially leading the project, employing the project manager and being responsible for the economics of the project. A Joint Venture had been planned (between Severn Wye and Pure Leapfrog) to deliver the project but this was never progressed. Having a more formal arrangement in place from the start of the project would have clarified expectations and helped to minimise any friction experienced between the two organisations. Ultimately Severn Wye took on all management responsibilities for the project.

Also, in this project there were two main contractors, Vital Energi providing the civils, electricals etc. and Pyrocore providing the pyrolysis technology. This led to some issues when it came to designs and costings, with each contractor having their own preferences/suggestions, not always in line with each other.

These difficulties led to delays, and in order to recover as much of this time as possible a site coordination meeting was held on site on 11 January 2024 involving SWEA, Vital, Pyrocore and newly appointed building contractors, Severn Fabrications. This helped bring the partners/contractors together to support a more cohesive approach.

In future, we would set clearer, written expectations from the start, explicitly defining the rights, roles and responsibilities of each partner. These would be agreed through formal agreements.

Also, a single construction contract would be utilised, with sub-contractors below the PC/PD. This would reduce conflict of interests between subcontractors, leading to increased management requirements from the Project Management team.

## Balance of power and scale of partners

As a pilot project and recognising the lack of experience held by SWEA and Pure Leapfrog in delivering projects on this scale, working with one of the largest contractors in the country, Vital Energi, led to some differences in expectations and ways of working.

As a £333mil/year business, Vital Energi completes projects around energy operations on a very large scale. Mersey Biochar, and their £2mil contract within it, was an opportunity to explore the potential of pyrolysis. However, it was not their primary programme, unlike for SWEA's Innovation Team.

When issues arose, the difference in scale of the partners involved caused some tension, with differing processes and responses shown.

In future, we would look to work with a mid-size engineering company on a pilot project such as this.

## Need for larger funding contingency

Throughout delivery, the budget has been under real pressure. This has been a contributing factor to a lot of the tension between partners, due to descoping of elements, and reworking to find cost efficiencies/savings.

On multiple occasions the Mersey Biochar Board reiterated the need to have a contingency on a project of this size but recognised that DESNZ doesn't allow for a dedicated contingency cost line. To mitigate this risk, the original scope of the project, should have been less ambitious.

## Securing offtakers, feedstock supply, CORC accreditation etc

SW and its partners had no experience in securing Biochar sales, CoRC accreditation, PPA's or feedstock supply. In addition, the markets in these products are volatile and therefore unpredictable. Without clear commercialisation information the search for ongoing contracts has been delayed and unsystematic. It has taken considerably more time than predicted to search for and secure these contracts. However, at the time of writing Heads of Terms have been secured for char sales, CoRCs, feedstock and energy supply. This has been secured through the development of a high-quality investment plan by SW (after PL left the project). The SW CEO has secured these HOTS through networking and existing contacts along with significant investment in the business to ensure a minimum of two years of operation.

In addition, SW has secured further capital investment into electricity generation and the heat network.

# Financial summary

## CAPEX

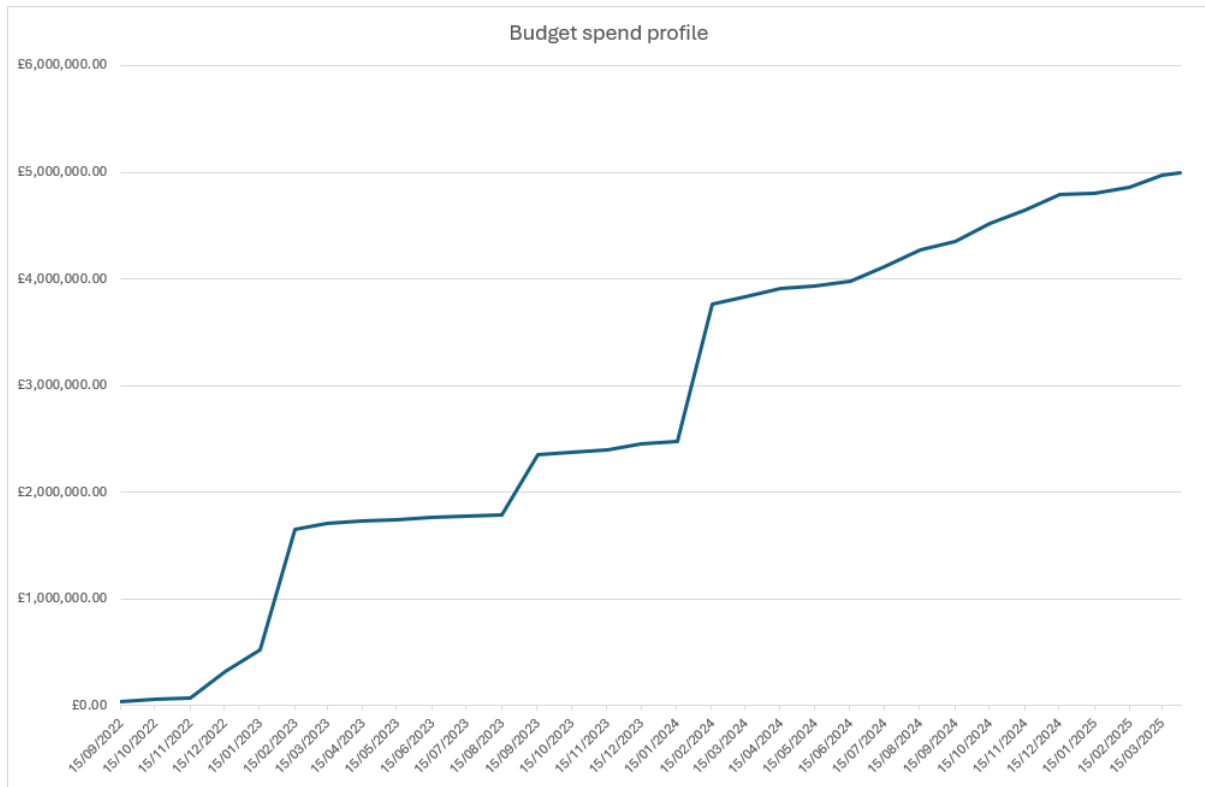
The initial budget for Phase 2, broadly broke down as follows:

**Table 2. Initial budget**

Pyrolysis Unit (including feedstock)	£1,750,000.00
Energy Conversion Process	£750,000.00
Plant Completion: Civil, M&E BOP	£992,000.00
Soft Costs	£386,823.57
Internal Labour	£468,548.71
Design Works	£563,240.00
Planning & Site Acquisition	£83,700.00
<b>Total</b>	<b>£4,994,312.28</b>

The majority of spend was due to be allocated across two NEC4 contracts with Vital Energi and Pyrocore.

**Figure 17. Cumulative Spend Profile Phase 2**



## OPEX (expected)

We have undertaken financial modelling to give us the Estimated Operating Costs (OPEX) and the cumulative profit and loss for the plant, for the first six years of operation. This information is commercially sensitive and has therefore not been included in this report.

# Environmental and social impacts

## Carbon savings

The pyrolysis plant at Lingley Mere, using whole tree chip as a feedstock has a number of environmental benefits. The plant will produce 1,000 tonnes of agri-grade biochar, a premium biochar. The biochar is a tradeable product. Associated with, but separate to, the biochar are carbon credits. The process is expected to sequester 2,700 tonnes/year of carbon.

## Power and heat supply

The plant also produces around 8,000MWh of excess, recoverable heat at 700C. This will be used to supply an innovative ORC system generating around 2,800MWh of carbon negative electricity, and supply around 4,600MWh of space and hot water heating for commercial and operations of United Utilities at Lingley Mere.

The use of a premium, homogenous feedstock has enabled the system to be designed and operated with minimal emissions abatement systems. The syngas generated by pyrolysis of the woodchip is combusted in the thermal oxidiser to provide the heat to sustain the process and to be recovered for other uses. At the same time, the exhaust gases contain mainly Carbon dioxide, steam, and very small amounts of particulates. The approach removes the need for costly filtration systems (such as bag filters, cyclones, candles). However, it also limits the feedstocks that can be used.

A pyrolysis plant can have significant environmental impacts, including air pollution from emissions such as carbon monoxide, nitrogen oxides, sulfur dioxide, and volatile organic compounds (VOCs), potential water pollution from wastewater discharge, and the risk of generating hazardous waste if not properly managed, requiring substantial investment in pollution control equipment to mitigate these issues; however, when designed and operated correctly, pyrolysis can be a more sustainable option for recycling certain waste materials compared to landfilling or incineration.

Key environmental concerns of a pyrolysis plant:

### **Air pollution**

- Emission of harmful gases like carbon monoxide, sulfur oxides, nitrogen oxides, and particulate matter, which can contribute to respiratory issues and smog if not properly controlled.
- Potential for release of volatile organic compounds (VOCs) depending on the feedstock and process conditions.

### **Water pollution**

- Wastewater discharge from cooling systems and cleaning processes can contain pollutants if not adequately treated.

### **Hazardous waste generation**

- Potential for producing unwanted byproducts like tars and heavy metals which require proper handling and disposal.

### **Energy consumption**

- High energy demand to operate the pyrolysis process, which can contribute to greenhouse gas emissions if the energy source is fossil fuel-based.

### **Potential for accidents**

- Risk of explosions if proper safety measures are not implemented due to the flammable nature of the gases produced.

### **Factors influencing environmental impact**

- Feedstock type: Different waste materials (plastics, biomass, tires) produce varying levels of pollutants.
- Process technology: Advanced pyrolysis techniques with efficient emission controls can significantly reduce environmental impact.
- Pollution control equipment: Proper filtration and scrubbing systems are crucial to minimize emissions.

### **Mitigating environmental impacts**

- Strict regulatory compliance: Adhering to established emission standards and monitoring systems.
- Advanced waste sorting: Separating different types of waste to optimize the pyrolysis process.
- Proper waste pretreatment: Cleaning and pre-processing feedstock to reduce contaminant levels.
- Heat recovery systems: Utilizing the heat generated during pyrolysis to improve energy efficiency.
- Treatment of byproducts: Properly managing and reusing or disposing of pyrolysis products like pyrolysis oil, char, and non-condensable gases.

## **Other social impacts**

A pyrolysis plant can have both positive and negative social impacts, in relation to improved waste management in a community, but also concerns about air pollution, potential health risks from emissions, and community engagement regarding plant siting and operation, especially if not properly managed or regulated.

## Positive Social Impacts

### **Economic development**

Pyrolysis plants can create jobs in construction, operation, and maintenance, contributing to local economies, particularly in areas with high unemployment rates. For example, at MB, the operations are likely to generate 11 FTE jobs, paying £30k-£45k/yr. The jobs will be for five semi-skilled and five skilled operators, and a manager. In addition, there are likely to be up to ten indirect jobs in the supply chain for biomass and biochar (tree surgeons, transport, drying), servicing and maintenance, administration, and in biochar applications in agriculture and land improvement.

### **Waste reduction**

By processing waste materials such as oversize compost, sewage sludge, food wastes, and waste streams difficult to recycle such as wind turbine blades, pyrolysis plants can significantly reduce the amount of waste going to landfills, improving overall waste management practices in a community.

### **Circular economy**

By converting waste into usable products such as biochar, and carbon negative heat and power, pyrolysis promotes a circular economy, reducing reliance on virgin materials.

### **Community empowerment**

Properly managed pyrolysis projects can empower communities by providing them with a solution to local waste problems and potential revenue streams from recycled materials.

## Negative Social Impacts

### **Air pollution**

If not adequately controlled, emissions from a pyrolysis plant can contain harmful pollutants like particulate matter, carbon monoxide, and volatile organic compounds, impacting air quality and potentially causing respiratory issues in nearby residents.

### **Odour concerns**

The pyrolysis process can produce unpleasant odours, leading to community complaints, especially if the plant is located in a densely populated area.

### **Community displacement**

Concerns about the potential negative impacts of a pyrolysis plant can lead to community opposition and resistance to its construction, especially if not properly addressed through community engagement.

### **Health risks**

Exposure to certain emissions from a pyrolysis plant, if not properly mitigated, could potentially lead to health problems, particularly for vulnerable populations like children and the elderly.

## Mitigating Negative Impacts

### **Strict regulations and monitoring**

Implementing robust environmental regulations and regular monitoring of emissions to ensure compliance with air quality standards.

### **Advanced technology**

Utilising advanced pyrolysis technologies with effective pollution control systems to minimise emissions.

### **Community engagement**

Engaging with local communities throughout the planning and construction process to address concerns and build trust.

### **Siting considerations**

Choosing a suitable location for the pyrolysis plant, taking into account factors like population density, wind patterns, and proximity to sensitive areas.

Overall, while pyrolysis technology has potential to address waste management challenges and provide social benefits, careful planning, implementation of proper mitigation measures, and strong community engagement are crucial to minimize negative social impacts and ensure a sustainable outcome.

# Scaling and replication potential

## Market potential

There are many reported uses of biochar across a wide range of sectors, notably in agriculture, horticulture, industrial production and construction. The characteristics of the biochar are key in determining the best use of the biochar. Very low contaminants such as heavy metals and polycyclic aromatic hydrocarbons (PAH) are required in biochars for use in agriculture and horticulture whilst key characteristics such as stability, specific surface area and cation exchange are key in biochars for use in construction and agricultural fertilisers.

A major challenge however to the scaling up of our model is the existing limits on application of biochar to agricultural land with a limit of up to 1 tonne of biochar per hectare over any 12-month period. The average farm in England is estimated to be 87 Hectares.

Likewise for animal feed additives only small quantities are required. If an average UK dairy herd of 143 cows consumed 500g per day of biochar additive this would equate to approximately 26 tonnes per annum assuming an all year-round diet.

With both these products there is potential for strong market demand in the future however when considering the requirement to scale the operation up to 2030 targets this would require, a significant increase in demand and continuing low uptake of production in the UK, neither of which can be guaranteed, with the latter expected to be highly unlikely.

The UK cement industry produces in the region of 9 million tonnes per annum. At an average application rate of 5% biochar this means the industry could potentially sequester in the region of 450,000 tonnes of biochar per annum.

## Barriers, risks and benefits of scaling and replication

A lack of awareness of biochar and its benefits by the most appropriate end-users i.e. the wider agricultural sector and commercial horticultural sectors, is generally seen as the first 'hurdle' to be overcome in attempting to stimulate market development.

As with all emerging and developing technologies the regulations around the production and use of biochar are currently limited and likely to change in the coming years as the practice is adopted more widely.

As it stands the key regulatory factor for consideration for the production of biochar is waste status. To determine the waste status of a product such as biochar we have to consider the feedstock status. If it is a waste, then the biochar would have to fit an exemption or go through an end of waste procedure to be considered a non-waste product. At this point there is not a specific end of waste protocol in the UK for this process although there are similar ones for biomass which could be adapted to facilitate this.

In the short term the voluntary carbon removal market could sustain a certain build-out of these projects, however this market is limited and not particularly stable. There is the potential to form partnerships with large corporates for long term removal credit procurements and this will be our approach for the 2nd project. Longer term, the successful commercialisation of the concept, as with all removal technologies will rest on policy and legislation. Without legislation to decarbonise heat we will not be able to compete against gas, which takes away our primary revenue stream. Of course, similar legislation would also be required to enforce removal credit procurement, the voluntary market will not sustain high value sales.

To gain accreditation for carbon credits is a lengthy process and would need to be completed for each site/process to ensure accredited credits.

The main barrier to financing will be funders perceptions around the stability of market process linked to the different revenue streams. However, the main revenue streams can be underwritten with long term offtake agreements for heat and support mechanisms such as DPA for arbitrage.

Scaling opportunities will also be tied to heat network (communal and district) roll out.

Potential for pyrolysis at a site will require:

- Proximity to Feedstock – all sites will require a consistent and reliable source of feedstock that is sustainably procured and is proximate to reduce carbon miles. We combined data sets on existing under-managed woodland with data on energy crop planting areas
- Heat Offtake Potential – all sites will need to sell the majority of the by-product heat produced in order to be economically viable and to operate as intended. Generally, this will be heat sales into buildings (domestic or non-domestic). We combined data on heat (gas) consumption, existing heat network infrastructure and off-gas grid locations.

With Pyrocore no longer trading, the future supplier of the pyrolysis units is unclear.

A benefit to replicating this approach will be improvements gained through the lessons learnt through Mersey Biochar. One potential area is around site location, if the pyrolysis unit was installed on a site already staffed for other operations (e.g. Household Recycling Centre) then there is a potential reduction in staffing needed for operation (for Mersey Biochar this will be 12 FTE). This saving could also be realised through multiple pyrolysis units on the same site.

## IP and knowledge management

The Mersey Biochar has not generated any new IP that can be protected. However, significant knowledge has been gained, and lessons learned from delivering the project. SWEA is looking at how to best disseminate these learnings.

# Future plans and commercial exploitation

Multiple scenarios and funding models have been explored, with specific situations mapped depending on the outcome of cold and hot commissioning. A number of the investments/agreements detailed below are dependent on successful commissioning.

## Potential offtaker

Significant work has been undertaken to identify potential offtakers for the char and carbon, that will be produced through pyrolysis at Mersey Biochar. One potential offtaker for the biochar is a well-established and cash rich company turning over £30m a year who enjoy a good reputation. They have been trading about 300 tonnes of Biochar a year (mainly sourced from the EU) for the past 2-3 years and see this as a market they want to get into and are looking to source 1000 tonnes + annually from the UK.

After a series of meetings and conversations, this company has indicated interest in buying most, or all of the char annually for a minimum of 2 years.

## Investors

As shown in the project OPEX budget, seeking investment is the only means of funding the operation of plant for the first two years.

While seeking potential investors, we have been careful to ensure any interest is legitimate and whose values align with SWEA's.

We have secured an in-principle offer, that would allow the plant to operate continuously after commissioning is complete.

## Green Heat Network Fund

Working with Vital Energi, SWEA has secured funding from the DESNZ Green Heat Network Fund for a potential district heating network using the waste heat from the Mersey Biochar pyrolysis plant. A commercialisation grant of £164k has been secured, and if the proposal proves commercial, a construction grant of £1.56m will be unlocked.

This project is prepared to deliver the technical solution for using waste heat in a district heating network from a pyrolysis system. The district heating network and energy centre will be delivering heat to four buildings in the Lingley Mere Business Park in Warrington. Based on the technical calculations we can get 1.050MW from the pyrolysis plant.

We plan to complete commercialisation period by the end of December 2025. Work would start on site in January 2026 and heat on date for the office buildings will be March 2027.

## ORC

SWEA has also secured funding, through the Energy Redress Innovation Scheme, to test the financial and operational sustainability of generating carbon-negative electricity and supplying it to Bromford Housing – our partner social housing providers - at below market rates, tackling both climate change and fuel poverty.

The project will purchase the capital equipment necessary to run the trial for a 3-month period to prove the concept. Optimising the running of the plant with reduced associated costs, exploring combined models of electricity output, carbon credits, and biochar sales.

Alongside this we will run a research study to design the legal structures for the distribution of the energy to fuel poor households. Exploring different community energy models including sleaving, energy local, direct power-purchase and community energy societies.

## Alternative feedstocks

We are talking to local estates in Cheshire and north-west England about possibilities of establishing short rotation coppice (SRC) plantations. This would bring multiple benefits to the estates (water management/quality, land use, biodiversity net gain), but they don't have a natural offtaker for SRC. Approximately 15 tonnes SRC is produced per acre per year. Mersey Biochar could offer to take 4 figure tonnage annually.

We are also exploring using oversize compost as a feedstock. This would add some additional challenges, as the consistency and quality of oversize compost varies hugely, depending on seasonality, moisture content and contamination. This means technology selection is more challenging and additional permitting and environmental controls would be required. Mersey Biochar has a pure feedstock going in, so can operate without emissions abatements technology (filters, cyclones etc.) which would have a significant additional cost.

## United Utilities sewage trials

The Water Industry is currently facing challenges related to sewage sludge going to land. Despite processing through anaerobic digestion, forever chemicals, pesticides, hormones and microplastics remain, and when spread on land could end up in the food chain. There is likely to be legislation introduced that will prevent this practice.

There are a number of tech alternatives being explored, including incineration, gasification and pyrolysis. All these processes can help with nutrient recovery and moving towards net zero.

SWEA has submitted a proposal to United Utilities to complete a feasibility study, exploring the viability of disposal of sewage sludge through pyrolysis, in order to meet the anticipated changes in regulation.

The overall aim of the trials would be to ascertain:

- Technical feasibility
- Environmental impact
- Regulatory compliance
- Commercial viability

## Consultancy

Building on the knowledge and skills gained through delivery of this project, SWEA is exploring opportunities to share this with other interested parties.

SWEA has recently secured a contract to complete a feasibility study for Cheshire West and Chester Council, exploring the feasibility of generating biochar from its managed waste. The main objective is to evaluate the potential of income generation from the Council's green waste if turned into biochar via pyrolysis. We will work with the council to evaluate the suitability of Council's green waste as primary feedstock for pyrolysis and identify pyrolysis technology requirements and compatibility. A delivery model and business case evaluation will then be completed.

We have also been approached to support development of a feasibility study for a community energy plant in Gloucestershire, generating energy from the pyrolysis of human waste and other local biomass.

---

This publication is available from: <https://www.gov.uk/government/publications/direct-air-capture-and-greenhouse-gas-removal-innovation-programme-selected-projects/direct-air-capture-and-greenhouse-gas-removal-innovation-programme-phase-2-projects>

If you need a version of this document in a more accessible format, please email [alt.formats@energysecurity.gov.uk](mailto:alt.formats@energysecurity.gov.uk). Please tell us what format you need. It will help us if you say what assistive technology you use.