Short-term R&D Carbon Capture Plant Trial Proposal

CCUS Innovation 2.0

Key Knowledge Deliverable 1.1

January 2024

Acknowledgements

We would like to thank Bagley Biogas for collaborating with us on this R&D project and allowing the trial to take place at the Bagley site. We are also grateful to the EA for their guidance, ensuring safe systems of work are in place before operations begin. Lastly, we would like to acknowledge the contribution of all stakeholders towards the success of this project.

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Contents

Introduction

Across the globe, carbon capture is being thoroughly investigated throughout academia; however, very few methods have expanded to a commercial scale to date. CCm Technologies' fertiliser plant at Bagley Biogas is a successful industrial project that transforms dried anaerobic digestate (AD) cake into Low Carbon Fertiliser pellets. Multiple field trials with CCm's Low Carbon Fertiliser in farms around the UK have demonstrated above-average crop growth performance while promoting the circular economy by converting waste streams into stable, value-added materials.

To further explore the carbon capture potential at Bagley, CCm has partnered with Perlemax and Reepel to combine technologies to produce a high-volume carbon capture technology. This new project, which has received funding via a Department of Energy Security and Net Zero (DESNZ) grant, will use liquor from the Bagley AD plant to partially recover Ammonia and maximise algal growth for CO_2 capture and Phosphate, Potassium and trace nutrient recovery. Outputs from Perlemax and Reepel reactors can be integrated into the CCm sustainable Low Carbon Fertiliser process to provide a fertiliser pellet with a far lower carbon footprint than mineral and organo-mineral fertiliser alternatives.

It is proposed that the trial will be undertaken at the Bagley Biogas Anaerobic Digestion facility, Bagley, which is regulated under existing permit EPR/AB3008FJ/A001. Planning permission has been granted by Shropshire Council for processing of Digestates within this structure previously.

CCm has been awarded grants from Canada's Climate Change & Emissions Corporation (CCEMC), the UK's Department of Energy & Climate Change (DECC) and Department for Business, Energy and Industrial Strategy (BEIS) – which includes recent funding from the UK Research and Innovation agency (Innovate UK) – in recognition of CCm's potential contribution to sustainable industrial development. The awarded grant from DESNZ covers 70% of the project cost and the rest is match funded by the CCm, Perlemax and Reepel consortium to develop the R&D plant at Bagley Biogas' site in order to confirm the scalability of the process.

Competent and experienced staff employed by CCm, Perlemax and Reepel will operate, monitor and be responsible for the plant during the trialling period.

The Trial

Summary

The proposed R&D plant will be a skid-mounted package composed of an ammonia stripping reactor, a semi-continuous algal bioreactor, multiple flotation tanks (estimated footprint ca. three 20ft - 40ft containers) a downstream separator tank, reactive condenser, system pipework, pumps, air compressor and carbon dioxide cylinder(s). The trial facility will be situated between the Bagley AD plant and the slurry lagoon, inside the bunded area containing the biodigester, against the concrete wall so vehicle access is not obstructed. Maximum estimated height of flotation tanks is 3 – 4.5 metres placed inside the trench which is ca. 2.5 metres below levelled site surface. The resulting biomass from this plant will be transported to where the existing CCm Low Carbon Fertiliser plant is located at the top of site. Process equipment will be under the coverage area of existing CCTV surveillance and will only be accessible to CCm, Perlemax or Reepel personnel.

No waste materials will be brought onto site without prior written authorisation from the local EA officer.

Process Description

The feedstock used for the R&D trials (digestate liquor) is produced onsite and discharged into a lagoon. There are two options to feed the trial plant with the liquor: install a tee in the discharge pipework or pump the liquor from the lagoon. Once inside the first reactor, heated CO_2 microbubbles will recover ammonia from the liquor in the form of salts of ammonia and decolourising the liquor to maximise light penetration for the algae. System dilution with process water will further wash out the liquor. After transferring the lighter liquor to the algal bioreactor, the microalgae will take up some nutrients from the liquid digestate and CO_2 injection ensures production of starch for algal growth. Lights and flotation will be used to improve circulation and mixing of algal systems, which helps maintain exponential growth phase and semi-continuous biomass extraction. Remnant, nutrient-depleted liquor will be sampled and then pumped back into the slurry lagoon.

The goal is to capture 1 tonne per day of CO2.

The R&D plant products will then be transported to the CCm Low Carbon Fertiliser plant on site or to the CCm research facility in Swindon, and the carbon-rich biomass with some N-P-K components, which may require topping up with additives, will be used to produce bio-formulated Low Carbon Fertiliser via the CCm process.

The development of this project is required in order to ascertain technical viability at pilot-scale. If successful, the technology has the potential to lead to a wide range of environmental benefits.

The benefits include:

- Capture and utilisation of CO_2 (direct capture and CO_2 equivalent) which would otherwise be released to atmosphere;
- Algal CO_2 capture using liquid waste streams and partially recovers other plant nutrients such as phosphorous and potassium. These additional nutrients can also be integrated into the fertiliser process;
- Moving waste materials up the waste hierarchy;
- Production of fertiliser / soil improver, reducing dependence on finite resources;
- Low Carbon Fertiliser production enhances carbon capture outputs from microbubble and algal technologies to produce a commodity product that introduces a new revenue stream, significantly improving the business case for technology adoption.

Lab and bench-scale testing will take place off site at the Perlemax and Reepel sites. Site works at Bagley are expected to commence in January 2024 (e.g. procurement and delivery) and site installation is estimated to be completed by December 2024. Commissioning and operations will take place near the installation due date and be finished in February 2025. The R&D plant will be decommissioned and taken offsite following completion of the project.

Project operational activities must be complete by 28 February 2025.

Due to the low quantities of product produced there will be minimal effect on existing markets as they will be used on a trial basis.

Operating Hours

The operating hours for the import and export of materials to and from the fertiliser production operation will remain as approved for the AD facility under the existing Planning Permission.

Method Statement

Stage 1 Liquid digestate from AD plant fed to the trial unit (ca. 5-7 m^3) for ammonia stripping using compressed air and liquor dilution using process water.

Stage 2 Lighter liquor is pumped to the algal bioreactor with microalgae and CO_2 injection enables microalgal growth and some production of further ammoniacal salts. Reactor design and continuous flotation maximises yield. Biomass separation and extraction expected to occur nearly daily (goal of 1 tpd of captured CO_2).

Stage 3 C-rich biomass output collected in a container and transported to the existing CCm Low Carbon Fertiliser production facility to be incorporated and blended in the ribbon mixer. Some feedstock addition may be required depending on CCm's Low Carbon Fertiliser formulation.

Stage 4 Nutrient-depleted liquor pumped back into slurry lagoon.

Perlemax and Reepel have deployed analogous plants in other sites and are sufficiently competent to build and operate proposed R&D facility. CCm will also be present on site to assist project delivery. Relevant standard operating procedures, emergency plans, risk assessments, Material Safety Data Sheets (MSDS) and Control of Substances Hazardous to Health (COSHH) forms are available or will be developed where required and held on site. The trial plant will be situated within the Bagley Biogas compound, and will therefore comply with all policies and procedures associated with the permitted facility.

Stored materials will be in containers no greater than 1 m3 and will be stored in a designated area near the facility, including CO2 gas cylinders which will be secured in place.

Environmental Impacts

Risk to air

No emissions are anticipated from the processing units as the system operates as a sealed unit. There is a pressure relief valve on the tanks to vent CO_2 in the event of overpressure. Although the CO_2 will eventually re-enter the carbon cycle when the CCm Low Carbon Fertiliser is applied to fields, the carbon capture potential at Bagley by using both the solid and liquid fractions of the AD plant for fertiliser production has a significantly higher climate positive effect compared to traditional fertiliser production methods.

In the event of a leak or emergency, plant equipment can be switched off by multiple safety switches spread throughout the process and a local control panel until the reason can be determined and subsequently resolved.

The R&D plant will be sited away from DSEAR zones where risk of explosive atmosphere is very low.

Risk to Water, Soil, Plants & Animals

There is no emission to soil or watercourses from the process and the R&D plant is located in a sealed compound, therefore any risk to plants or animals is minimal. Secondary containment will be in place in the event of liquid spillages. Spills will be dealt with in line with the Site spills procedure.

The R&D plant will have minimal impact on the site’s containment capacity.

The proposed process recovers nutrients from liquid digestates that would otherwise be discharged into the slurry lagoon. Any undesired or waste materials (including general waste e.g. PPE) will be disposed of via an authorized facility, or recovered as appropriate.

The site Incident Risk Assessment & environment management system will be updated to include the R&D installation. CCm staff operating the R&D plant will be trained in site incident procedures and clear boundaries of responsibility will be laid out.

Noise, Vibration and Odour Nuisance

The system is essentially a sealed unit so external noise levels are expected to be minimal.

Material handling will be done using pumps and stored in sealed units, therefore any significant odour emissions from the process are not expected under normal operation.

Vibration from plant equipment is minimal; therefore, there are no sensitive receptors.

Energy consumption / heat generation

Energy is drawn from the production of electricity (and heat) by the AD plant biogas powering the onsite CHP engines.

The estimated peak power demand and daily electricity consumption will be determined following offsite lab and pilot-scale experiments. Main variables include production rate in bioreactors, air temperature required for ammonia stripping and feedstock composition (i.e. more nutritious feedstock requires less energy).

Risk to Human Health

There is no operator exposure to the process liquor, therefore the carbon capture process does not pose any significant risk to human health.

Reporting

The trial unit will be operated within the Bagley Biogas site permitted footprint. As such, in accordance with the existing site permit condition, notification to the Environment Agency will be carried out without delay following any malfunction, breakdown or failure of equipment or techniques, accident, or fugitive emission which has caused, is causing or may cause significant pollution. The probability of this type of event occurring during the R&D plant trial is considered very low due to the nature of the process.

Additionally, project stakeholders will be covered under the Bagley Biogas Environmental Management System (EMS). Compliance will be required with site procedures, risk assessments, H&S policy, training for incident management and any other Bagley Biogas regulations.

It is proposed that close liaison will be maintained between CCm, Bagley Biogas and the local Environment Agency officer for the duration of the project. For this purpose, the Project Manager will be Felipe Marques, Process Development & Project Engineer at CCm Technologies.

Decommissioning

Following completion of the trial, the plant will be made safe and decommissioned in line with the requirements of the EA and site owners.

Summary

The short-term R&D carbon capture plant trial project is considered to offer significant potential for future large scale carbon capture and has the potential to use existing waste streams, thus moving them up the waste hierarchy. The process will also produce saleable Low Carbon Fertilisers that are more environmentally friendly and beneficial to soil health than typical chemical fertilisers.

The skid-mounted package will have minimal effect on existing activities at the site. The plant will use liquid digestate from the Bagley anaerobic digestion plant that would otherwise be used less effectively by spraying onto fields than as CCm Low Carbon Fertiliser pellets. The result is a product with a much higher agricultural value.

The potential environmental impact is considered to be significantly positive overall given the CCUS potential of the Perlemax, Reepel and CCm processes. The plant will be operated within a secure facility which is secondary contained. There are not expected to be any significant releases from the plant.

No waste by-products are produced as all feedstock is utilised in the process or associated CCm Low Carbon Fertiliser production process with nutrient-depleted liquor circulated back into the lagoon.

It is considered that the trial should proceed for the required maximum 6-month operational period (plus circa 12 months including site build and commissioning) under the existing provisions of the Bagley Biogas Permit, with no requirement for Permit variation for R&D.

Project Team

Bagley Biogas

Oliver Kennerley,	Director,	Site Owner

CCm Technologies

Marcus Du Pree Thomas,	Delivery Director,	Project Director
Alexander Hammond,	Head of Partnerships,	Commercial Manager
Charles Markotter,	Plant Manager,	CCm Production Manager
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