FICHTNER
Consulting Engineers Limited


Protos ERF EP Variation

Encyclis

Supporting Information

ENGINEERING CONSULTING

Document approval

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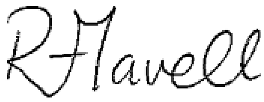
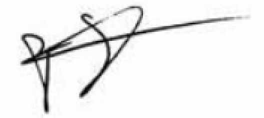
Prepared by:	Rosalind Flavell		Senior Environmental Consultant	23/11/2023
Checked by:	James Sturman		Lead Environmental Consultant	23/11/2023

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Non-technical Summary

An Environmental Permit (EP) (Ref: EPR/LP3132FX) was granted by the Environment Agency (EA) for the Protos Energy Recovery Facility (ERF) (herein referred to as the Facility) on 16 September 2011. This EP replaced the EP for the Facility (Ref: TP3135LS) originally granted by the EA on 21 December 2006 to Peel Environmental Ince Limited.

The EP (EPR/LP3132FX) has been varied 8 times. The latest variation to the EP was granted by the EA to Encyclis Limited (Encyclis) on 02 May 2023 to incorporate the requirements of the Waste Incineration BREF review process. Within this application, Encyclis is applying for a variation to the EP to incorporate the proposed carbon capture (CC) facility to capture the carbon dioxide (CO_2) produced by the ERF for sequestration.

In October 2021, the Department for Business, Energy and Industrial Strategy (BEIS) announced funding for two regional carbon capture hubs, HyNet in the North West of England and the East Coast Cluster in the North East. The ERF comprises two incineration lines. Encyclis is proposing to install a CC facility incorporating two carbon capture lines; one to extract the CO_2 from the emissions produced by each line of the ERF. The proposed CC facility will form part of the North West of England Cluster project. The proposed CC facility is projected to capture approximately 410,000 tonnes of CO_2 from the flue gases for transmission and storage off-shore in the Liverpool bay sub-sea depleted oil and gas reservoirs.

To incorporate the proposed CC facility, Encyclis is applying for the following changes to the EP:

1. Inclusion of an additional Schedule 1 regulated activity (Section 6.10), incorporating two carbon capture lines, and its directly associated activities:
    a. Treatment of wastewaters for re-use within the Facility with a capacity of <50 tonnes per day; and
    b. Compression of captured CO2.
2. The addition of a discharge point of water (W3) for surface water run-off from the CC facility.
3. Extending the Installation Boundary to include an additional area of land where the proposed CC facility will be located.
4. Update the Site Layout to incorporate the layout changes associated with the CC facility.
5. Update the provisions for emissions monitoring associated with the installation of the CC facility.

Air quality assessments are included with the application, and have concluded that the proposed changes will not result in any significant impacts on human health and the environment.

Process effluents generated by the CC facility will be treated and re-used within the installation. Therefore, it will continue to be zero-discharge installation.

Encyclis understands that this application will be classified as a Substantial Variation due to the inclusion of an additional regulated activity.

Contents

1 Introduction

1.1 Background

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1.2 Summary of proposed changes

Within this Variation application, Encyclis is applying for the following changes to the EP:

6. Inclusion of an additional Schedule 1 regulated activity (Section 6.10), incorporating two carbon capture lines, and its directly associated activities:
    a. Treatment of wastewaters for re-use within the Facility with a capacity of <50 tonnes per day; and
    b. Compression of captured CO2.
7. The addition of a discharge of water (W3) for surface water run-off from the CC facility.
8. Extending the Installation Boundary to include an additional area of land where the proposed CC facility will be located.
9. Update the Site Layout to incorporate the layout changes associated with the CC facility.
10. Update the provisions for emissions monitoring associated with the installation of the CC facility.

The proposed changes are required to incorporate the proposed CC facility within the EP.

1.3 Type of variation

The EA guidance on Charging Schemes states that there are four types of variations – administrative, minor technical, normal and substantial.

Encyclis acknowledges that the proposed changes will not constitute either an administrative or minor technical variation.

The EA has published guidance (Regulatory Guidance Note 8 – Substantial Change) which defines a substantial change (it is acknowledged that the guidance has been withdrawn). The guidance defined a substantial change as:

'… a change in operation of installations or mining waste facilities, which in our opinion may have significant negative effects on human beings or the environment. Certain changes are automatically regarded as substantial, namely:

a. a change in operation of a Part A installation which in itself meets the thresholds, if any, set out in Part 2 of Schedule 1 EPRs; or

b. a change in operation of an incineration or co-incineration plant for non-hazardous waste which would involve the incineration or co-incineration of hazardous waste.'

As demonstrated within section 3, the addition of the CC facility will require the inclusion of an additional Regulated Activity, 6.10, as defined within Part 2 of Schedule 1 of the Environmental Permitting Regulations (EPRs). Therefore, Encyclis understands that the application will constitute a 'Substantial Change' to the EP and should be determined as a Substantial Variation. This has been confirmed by the EA during pre-application discussions.

2 Carbon Capture and Storage Technologies

2.1 Background

In a CC process, CO_2 is extracted from a mixture of gases to create a CO_2 rich stream. The CO_2 captured can then be injected into underground formations (storage), used in the manufacture of a wide range of products, or used as a plant growth enhancer in agriculture. Overall, the process is referred to as carbon capture and storage (CCS). Where the CO_2 can be used as a resource in another process, the process is referred to as carbon capture, usage and storage (CCUS). CCUS can be applied to large scale point sources of carbon including energy intensive industries, power generation, heat production, transport and maritime sectors. The process can be divided into three main steps which are:

1. separation of CO_2 from the gas stream;
2. compression and transportation of the CO_2 (via pipeline or shipping); and
3. use of the captured CO_2 as a resource for other industries or storage within suitable geological formations (saline aquifers, depleted oil and gas reservoirs).

In the UK and in Europe, residual Municipal Solid Waste (MSW) and Refuse Derived Fuel (RDF) are combusted for power generation, such as at the ERF. These feedstocks contain a mixture of plant and fossil fuel derived materials which are of biogenic and non-biogenic origin respectively. Consequently, coupling of EfW plants with CCS allows for the capture of CO_2 produced from the combustion of both the biogenic and non-biogenic fractions of the waste. This means that EfW plants can become net-negative emission plants. Furthermore, for EfW plants in the UK which operate on waste with a low biogenic content, CCS is considered as the sole route for decarbonisation of these systems.

To date, although CCS systems have been integrated with several large coal plants, only three demonstration scale CCS systems have been operated on flue gases from EfW plants. Of these plants the largest has a nominal capture capacity of 10 tCO_2/day.

2.2 CCS technologies

The technologies developed for carbon capture can be divided into four main categories:

1. pre-combustion;
2. post-combustion;
3. oxyfuel combustion; and
4. direct air capture (DAC).

Pre, post and oxyfuel combustion technologies all require a point source of CO_2, such as combustion of fossil fuels or biomass. A point source of combustion is not required for direct air capture systems. Post-combustion capture is considered to be the most commercially viable process for capture of CO_2 from power generation processes, such as the ERF, as it provides a means for near-term capture from existing power generation and other industrial sources. It is currently the technology most widely developed and is the process which is discussed in this report for the capture of CO_2.

3 The Carbon Capture Facility

At the Protos ERF the full flue gas flow will be extracted from each line of the ERF using dampers. The dampers will isolate the flue gas from the existing ERF stacks. A duct will be used to send the flue gases from each line of the ERF to the CC facility. Exhaust gases from each line of the ERF will be treated as separate lines in the CC facility. A process schematic for the CC facility is provided in Appendix A.

The CC facility will utilise heat from the waste incineration processes for CO_2 stripping, amine regeneration and flue gas re-heating. Steam produced from the ERF will be extracted for use in the CC facility, expanded to the correct pressure using a back pressure turbine, which will generate sufficient power for the CC facility and export the balance back to the ERF.

A CHP report setting out the arrangements for the export of heat and power from the ERF to the CC facility is provided in Appendix B.

The CC facility is designed so that the flue gases from the ERF can either be treated within the CC facility or released to atmosphere through the existing stack without treatment, i.e. via a by-pass. Flue gas cleaning of emissions from the ERF will be carried out before the emissions are extracted for treatment in the CC facility to ensure compliance with the ELVs in the existing EP and the Waste Incineration BREF.

Carbon capture and storage is listed as a regulated activity within section 6.10 of Part 2 of Schedule 1 of the EPRs as per the following definition:

> *(a) Capture of carbon dioxide streams from an installation for the purposes of geological storage pursuant to Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide.*

During pre-application discussions with the EA, it was confirmed that the CC facility would require an additional activity to be incorporated within the EP, refer to section 1.2.

The CC facility will be located outside of the existing Installation Boundary. Therefore, within this application it has been proposed that the Installation Boundary is extended to include this additional land, refer to section 5.1.

3.1 Flue gas cooling

Flue gas will be cooled across the direct contact cooler (DCC) by spraying water into the flue gas stream. Initially, this water will be vapourised and the flue gas cooled by losing the heat required for vaporisation. Eventually the flue gas reaches saturation and cannot hold any more water. The point at which the flue gas becomes saturated is a strong function of the temperature of the gas and the saturation point decreases as the gas is cooled. After the gas has reached this point, it is cooled further by increasing the temperature of the liquid water it passes through. As the gas is cooled and the saturation point reduces, water condenses from the flue gas (referred to as DCC condensate). As such, there is a net increase in the water pumped from the bottom of the DCC compared to that sprayed into the unit.

The quantity of DCC condensate depends on the initial moisture content of the flue gas and the exit temperature of the flue gas. For the proposed CC system, monoethanolamine (MEA), a primary amine will be used for capture of the CO_2 in the flue gas. To minimise thermal degradation of the MEA, the exit temperature is required to be around 40°C.

The DCC also functions as a polishing scrubber. As the flue gas condenses, acidic gases within the gas will also condense. The DCC cooling water will be cooled by the CC facility cooling system, refer to section 3.8. The pH of the cooling water circulating in the DCC will be monitored, with sodium hydroxide dosed to maintain a slightly alkaline pH and neutralise any acids condensed from the gas.

3.2 Booster fan

The booster fan increases the pressure of the flue gas to overcome the pressure drop experienced across the CC facility. The booster fan will work in tandem with the ID fan to ensure there is no under-pressure in the ducting between the ID fan and booster fan. The booster fan will be equipped with a variable speed drive to ensure that turndown can be achieved without significant loss of efficiency.

3.3 CO_2 absorption

Cooled flue gas will enter the base of the absorber and flow counter current to the lean amine solution. As the flue gas passes through the absorber and the amine solution, the CO_2 reacts with the lean amine. This reaction is exothermic, and as such the temperature of the will flue gas increase as it passes through the absorber. To maintain a constant temperature of amine within the absorber, heat is removed by intercooling the amine solution and flue gas within the column. The flue gas will pass through sections of packing within the column, which increases the internal area of the column and increase the rate of reaction.

Following the packing section, the flue gas enters the water wash section of the column, which injects water to the flue gas stream via a series of spray nozzles. Water will be sprayed in this section for the abatement of emissions of amines, nitrosamines, and nitramines. Nitrosamines and nitramines are formed by degradation of all amines used in the capture process[1]. These chemicals are soluble in water and as such the water wash removes these chemicals from the gas.

At the outlet of the water wash, the flue gas will pass through an acid wash. This acid wash will remove ammonia which is generated by degradation of the amine solution within the column. As Ammonia is an alkali it will be neutralised using the acid wash, and therefore, removed from the flue gas.

The CC facility control system will measure the CO_2 content at the inlet and outlet of the CC facility as well as the inlet and outlet flowrate, allowing for calculation of the mass flowrate of CO_2. The system will then adjust the flow rate of lean amine solution into the absorber based on the CO_2 content of the flue gas.

Since the flow of lean amine from the stripper may not match the demand of the absorber, a lean amine tank will be included in the process to provide a control buffer. If more amine is demanded by the system to absorb more CO_2, then the level in the lean amine tank will drop. If the level drops below a defined value, additional amine will be demanded from the make-up amine tank.

A reservoir of rich amine solution will be provided in the base of the absorber tower. The level of holdup in the absorber will be controlled to a constant level by a control valve on the exit line from the base of the absorber, and as such the flow rate into the stripper will vary.

The rich amine pumps will be located at the base of the absorber. This will provide a pressure increase in the rich amine tank to overcome the pressure drop in the interlinking pipework, heat

[1] Although nitrosamines can be formed during the degradation of any amines, the potential for formation is highest with secondary amines followed by tertiary amines. Primary amines exhibit the lowest risk for formation of nitrosamines.

exchangers, the hydrostatic pressure to reach the top of the stripper and to match the higher pressure within the stripper.

As flue gas passes across the water wash and acid wash, its temperature decreases, causing water to condense from the flue gas. Water condensed from the water and acid washes will be managed by measuring the level of holdup in the wash, and bleeding water from the cooling water tank back into the absorber, with a percentage blown down to control the build-up of pollutants within the water.

Outgoing flue gas will be reheated using hot condensate from the reboiler to aid dispersion of the flue gas. The outgoing flue gases will be released from a stack on top of the absorber tower.

3.4 Amine regeneration

To regenerate the amine solution and release the CO_2 absorbed, the temperature of the rich amine solution will be increased. This is first done by recovering heat from the hot, lean amine solution exiting the stripper via a plate heat exchanger. This also reduces the cooling duty required for the lean amine solution. To ensure this amine is at the optimum temperature for capture in the absorber, it will be cooled further by the lean trim cooler.

The heated rich amine enters the stripper at the top of the column. The liquid is distributed across the column cross section and falls through a packed section within column, flowing counter to the high temperature vapour generated in the reboiler. This increases the temperature of the rich amine and liberates the captured CO_2 from the solution.

The CO_2 and amine vapour which reaches the top of the tower will be cooled by an overhead condenser, fed from the cooling water circuit. The cooled vapour/CO_2 mixture then passes to a reflux drum, where the gas and liquid fractions are separated. The gas fraction will be passed to the CO_2 compression system. The liquid portion will be returned to the top of the stripper.

The reboiler boils the amine solution by condensing low pressure (3.5 bar) steam. The reboiler takes the amine which has collected in the base of the stripper. The reboiler is positioned vertically such that the amine level in the reboiler matches the level in the stripper through hydraulics. The amine will be heated by the incoming steam, which condenses in the tubes within the reboiler. This causes the CO_2 to outgas, and a portion of the amine solution will boil, and escape through the top of the reboiler as a vapour whereupon it is readmitted to the stripper column below the level of rich amine addition. The lean amine vapour will mix with the incoming rich amine liquid, giving up its heat to release CO_2 from the rich amine liquid and causing the lean vapour to condense, whereupon it will fall back down the column to the reservoir at the bottom.

A weir in the reboiler will maintain a liquid level which, in combination with baffles, will ensure sufficient residence time in the reboiler for sufficient CO_2 to be removed. As amine solution falls to the bottom of the stripper column causing the level to rise, an equivalent quantity of amine solution in the reboiler will flow over the weir to be pumped back to the absorber.

The quantity of heat admitted to the reboiler is self-controlled by the vacuum drawn by steam condensing in the reboiler. If less rich amine flows into the stripper, the rate of solution flowing over the weir in the reboiler will drop, which means less heat will be absorbed in the reboiler, which means less steam will condense and therefore less steam will flow to the reboiler.

As the amine solution is recycled, the solvent degrades due to the presence of other gaseous species in the flue gas, such as sulphur dioxide and nitrous oxides. These species react with the amines, and form degradation products, which can be heat stable salts, non-volatile organic compounds, or suspended solids. These products are corrosive and reduce the effectiveness of the solvent for capturing CO_2. Therefore, reclaiming is required to remove these products and restore the effectiveness of the amine solution.

The reclaimer for the CC facility has been designed based on thermal reclamation. In this process, a slip stream of the amine is dosed with sodium hydroxide to remove acids. The amine is then admitted to a reboiler, which heats the amine until the liquid has 'boiled-off'. The remainder is a residual sludge which is consists of water, amine, thermal degradation products and heat stable salts.

3.5 CO_2 compression

Compression of captured CO_2 is necessary to meet the requirements of the HyNet CO_2 cluster. CO_2 compression will be carried out using an electrically driven compressor.

To increase the efficiency of compression, several stages of compression, with intercooling between stages will be used. Intercooling will reduce the temperature of the pressurised gas to the temperature of the inlet gas to the previous compression stage. This cooling reduces the specific volume of the gas, therefore aiding further compression. Additionally, cooling the gas reduces its ability to hold moisture, and therefore condenses moisture from the gas, reducing the duty on the gas dryer.

A cooler located after the compressor is also required to control the outlet temperature of the CO_2 to match the requirements of the HyNet cluster, and will also reduce the duty on the gas dryer.

3.6 CO_2 drying

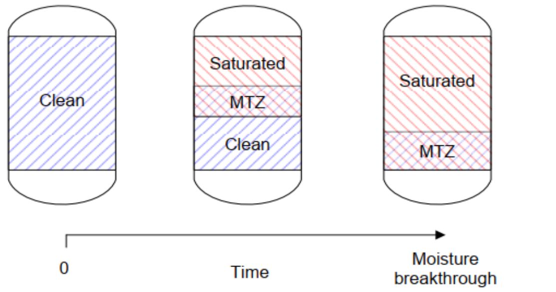
To meet the HyNet moisture requirements of <50 ppm mol of water the compressed CO_2 needs to be dried. This will be done to minimise the effects of corrosion on the transport pipelines, which could occur at a higher rate if water is present in the stream. Water can react with CO_2 and form weak acid – carbonic acid, which has corrosion rates in carbon steel in the range of mm/year. The second reason for dehydration of the CO_2 is to minimise the formation of hydrates that can block the transmission lines.

The drying system at the CC facility will be a desiccant dryer, as glycol systems have been prohibited on the HyNet network. Two desiccant drums will be used in this system, with one in operation and one being regenerated.

The mechanism of adsorption is as follows.

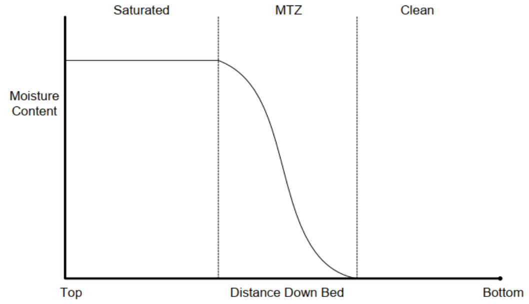
1. In the volume closest to where the gas is injected into the vessel an equilibrium zone forms. In this zone water in the inlet CO_2 gas is in equilibrium with the water adsorbed into the desiccant. This equilibrium point will be controlled by the pressure and temperature of the vessel.
2. In the volume further from the injection point, the mass transfer zone (MTZ) exists. This is where the transfer of water from the CO_2 gas into the adsorbent occurs. The size of this zone is determined by the kinetics of the adsorption reaction on the surface of the desiccant, heat and mass flow limitations (which in turn are a function of temperature and pressure of the vessel) and the velocity of gas flow. When this zone reaches the outlet of the dehydration vessel, the dehydration process should be stopped, and the vessel should be regenerated. This is illustrated in Figure 2 and Figure 2.
3. The fresh adsorbent zone shrinks as water is adsorbed in the vessel.

Figure 1: Adsorption zones within the dehydration bed



Source: Evaluation and Analysis of the Performance of Dehydration Units for CO_2 Capture, IEAGHG, 2014

Figure 2: Moisture content in a bed during the dehydration



Source: Evaluation and Analysis of the Performance of Dehydration Units for CO_2 Capture, IEAGHG, 2014

Once the bed is saturated, it will be regenerated by thermal swing, in which the bed is heated to a temperature of around 200 – 320°C (temperature depends on type of the desiccant used and operating philosophy) and then flashed with the heated dry product gas. At the end of this phase the vessel will be cooled down with unheated dry gas. Variations of this method involve the use of the wet (untreated CO_2) gas or the hot CO_2 gas from the compressor to replace the dry product gas as the flashing medium in the regeneration phase.

3.7 Rejected CO_2

The CC facility is designed to compress and treat the CO_2 for injection into the HyNet CO_2 pipeline. If the quality of the CO_2 does not meet pipeline specifications, it cannot be exported and must be vented to atmosphere.

Venting can occur in two locations in the process:

1. Upstream of the compressor – in the case that the compressor is not in operation or there is a stop in production of CO_2.
2. Downstream of the CO_2 analyser – in the case that the CO_2 quality does not meet the specification.

By building in redundancy and reliability into the CC process, periods of venting can be reduced to a minimum. In both instances the gases would be released via the CO_2 vent stack.

The CC facility can only be brought into operation once the ERF is operating normally at steady-state specifically when sufficient high-pressure steam is available and the quality of the flue gas at the ERF is within the emission limits and the CC facility operational envelope.

Whenever the quality of the flue gas from the ERF deviates from the operational envelope, this is considered abnormal operation and the flue gas will be released from the ERF stack without CO_2 removal. If flue gas is diverted from the CC facility for a prolonged period, CO_2 compression and export will be interrupted.

During the following scenarios venting cannot be avoided:

1. CC facility start-up;
2. CC facility shut-down;
3. Emergency CC facility shutdown;
4. Protection stop on the CO_2 compressor;
5. Abnormal operation; and

6. Safety valve opening.

These scenarios are detailed in the following sections. In all these scenarios the gas will be vented to the CO_2 vent stack prior to release to atmosphere.

3.7.1 CC facility start-up

During start-up of the CC facility, some gas will begin exiting the stripper once the reboiler is put in operation, thus starting the production of steam flow to the stripper. At this point the compressor does not have the minimum flow rate that results in minimum inlet pressure conditions to start the compressor, and the upstream vent must be opened. A control valve in the vent line will be used to establish the stripper operating pressure as the gas flow increases. This occurs after the flue gas damper from the ERF is opened and the CO_2-loading of amine solution entering the stripper increases. The vented gas will initially be small amounts of air and water at near atmospheric conditions. The temperature and pressure exiting the stripper will then increase to the required conditions. Once the pressure in the stripper is stable, the compressor can be started, and the vent upstream of the compressor is closed. However, the gas stream cannot immediately be exported to the pipeline. First, air in the system must be purged and then the required quality of CO2 must be achieved. During this time, the vent downstream of the CO_2 analyser is opened.

The CO_2 analyser will continuously monitor to assess the quality of the CO_2. Once the pipeline specifications are met, the shut-off damper to HyNet's above ground installation (AGI) is opened, and the export control valve can gradually be opened as the vent valve is closed. CO_2 venting for the CC facility start up is then complete.

3.7.2 Shutdown of the CC facility

During shutdown of the CC facility the compressor will be stopped when CO_2 flow from the stripper drops such that the minimum suction pressure can no longer be maintained. The upstream vent will be opened to release the remaining gas flow until shut-down of the CC facility is complete. The downstream pressure will drop until no more CO_2 can be exported, then the shut-off damper to the AGI will be closed.

3.7.3 Emergency shut-down of the CC facility

In case of an emergency shutdown of either the ERF or the CC facility where no steam or grid connection is available, most equipment including the compressor will shut down and both vent locations as well as the flue gas damper to the ERF stack will open (safety position open). This will result in a sharp peak in flow rate through the CO_2 vent stack which will quickly subside because no more flue gas is fed to the CC facility and amine circulation stops.

3.7.4 Protection stop on the CO_2 compressor

Even with a robust process design, it remains possible that during operation a malfunction will occur which affects the quality of the CO_2 entering the compressor from the stripper. In case of conditions harmful to the compressor, e.g. high temperature pressure, a protection stop of the compressor will be triggered and the vent upstream will open. This event will result in a CO_2 peak released to atmosphere, including ongoing CO_2 flow from the stripper and backflow of pressurised CO_2 from downstream of the compressor. If the problem cannot be corrected in a short time, the whole CC facility will have to shut down, and the venting will continue according to the shutdown procedure for a short period during shutdown.

3.7.5 Abnormal operations

The process design allows for the possibility of the CO_2 quality (temperature, pressure, or composition) not meeting pipeline specifications on a temporary basis during operation. If this occurs, the deviation will be detected by the CO_2 measurement, triggering the downstream vent to open and the export valve to the HyNet AGI to close until the quality is acceptable again, or the CC facility begins the shutdown procedure.

3.7.6 Safety valve opening

In case of high CO_2 flow from the stripper the upstream vent will maintain the suction pressure of the compressor below its trip value by venting CO_2. In addition, a safety valve will be installed between the stripper outlet and the compressor and will open to the vent in case of high overpressure, which will also trigger a protection stop of the compressor.

3.8 Cooling water

Cooling water will be required to cool the incoming flue gas, the lean amine, the water wash flow water and product CO_2. Wet or hybrid coolers will be used in conjunction with dry cooling, providing better thermodynamic performance. In addition, the use of both cooling technologies allows for re-use of the condensate from the DCC within the cooling towers.

A tank has been allowed for in the design, to ensure that the level of water in the circuit is maintained.

Periodically, blowdown from the cooling towers will be transferred to the water treatment plant to maintain the water quality parameters within the cooling towers.

3.9 Process effluent treatment plant

The design of the on-site effluent treatment plant is subject to detailed design. However, at this stage it is anticipated that it will include the following treatment steps:

1. Pre-treatment - carbon filtration.
2. Final Treatment/polishing - Reverse osmosis plant to maximise re-use of water in the CC facility.

In addition to treating the process effluent after the carbon filtration stage, the reverse osmosis plant will also process the boiler blowdown stream from the ERF. The clean water from the water treatment plant will be returned to the Absorber tower, to be re-used as feedwater for the CC facility.

The reject water from the carbon filtration and the reverse osmosis plant will be pumped to the ERF to be re-used in the bottom ash quench system. On this basis, there will be zero-discharges of process effluent from the CC facility with all effluents being re-used within the installation.

Overall, the implementation of the CC facility will reduce the mains water consumption of the ERF.

The process effluent treatment plant, including pre-treatment, will have a capacity of <50 tonnes per day.

3.10 Drainage and domestic effluent treatment

Uncontaminated surface water run-off from building roofs and roadways will be discharged to the Protos drainage network via an on-site drainage system (W3). Surface water run-off from roadways will pass through an interceptor prior to discharge. The surface water drainage systems will be fitted with a penstock valve to isolate the drainage systems in the event of an environmental incident/chemical spill.

A cesspit will be provided for the treatment of domestic effluent. This would be applied for under a separate permit.

4 Additional Information

An environmental risk assessment identifying the potential environmental impacts, and associated measures which have been incorporated into the design to mitigate the risks is presented in Appendix C.

4.1 Raw materials and reagents

The installation of the CC facility will not change the types or quantities of chemicals and raw materials which are currently consumed at the Facility. However, the CC facility will require the following additional consumables:

1. Amine solvent, used to top up the circuit.
2. Sodium hydroxide, used for acid abatement and in the reclaimer to reduce the concentration of heat stable salts.
3. Mains water, to replace that lost in drying of the product CO_2.

The CC facility will also need heat as steam, and electrical power, but these are assessed separately in section 4.2. The estimated quantity of each consumable required is stated in Table 1.

Table 1: Reagent consumption

Substance	Unit	Value
Amine solvent	kg/h	71.6
Sodium hydroxide	kg/h	24.0
Mains water	t/h	1.1

Reagents and chemicals will be delivered to the Facility by road via HGVs in drums and intermediate bulk containers (IBCs).

All chemicals will be stored in an appropriate storage facilities incorporating the use of suitable secondary (incorporating acid and alkali resistant coatings where appropriate) and tertiary containment measures.

Facilities for the handling and storage of chemicals will be designed in accordance with EA Pollution Prevention Guidance titled '*Pollution prevention for businesses*'.

Deliveries of all chemicals will be unloaded and transferred to suitable storage facilities. Areas and facilities for the storage of chemicals and liquid hazardous materials will be situated within secondary containment.

Secondary containment facilities will have capacity to contain whichever is the greater of 110% of the tank capacity or 25% of the total volume of materials being stored, in case of failure of the storage systems. Tanker off-loading of chemicals will take place within areas where the drainage is contained with the appropriate capacity to contain a spill during delivery.

Adequate quantities of spillage absorbent materials will be made available at easily accessible location(s), where chemicals are stored. A site drainage plan, including the location of process and surface water drainage will be made available on-site following completion of detailed design.

Any spillage that has the potential to cause environmental harm or to leave the installation will be reported to the site management and recorded in accordance with installations inspection, audit and reporting procedures. The relevant regulatory authorities (EA / Health and Safety Executive) will be informed as specified as required in accordance with the Facility's existing documented management procedures.

In the event of a fire, contaminated water used for fighting fires will be collected through the wastewater drainage system. Site drainage for external areas will be fitted with a manual shut off valve and will contain any firefighting water. Additional storage will be available from the site kerbing.

In accordance with the Facility's emergency response procedures, all spillages are reported to the site management and a record of the incident will be made. Where appropriate, the relevant authorities (EA / Health and Safety Executive) are informed if spillages/leaks. The effectiveness of the emergency response procedures is subject to periodic Management Review and is revised and updated as appropriate following any major incidents.

4.2 Energy consumption

4.2.1 Electrical power

The CC facility will require electrical power for pumps, fans and compressors. A breakdown of the estimated power requirements of the CC facility is provided in Table 2.

Table 2: Power consumption of CC facility

Power user	Unit	Value
Booster fan	kW	1,331
Compressor	kW	3,792
Cooling water pump	kW	513
DCC circulation pump	kW	38.8
Rich amine pump	kW	42.0
Lean amine pump	kW	53.2
Dry cooling fans	kW	778.2
Wet/dry cooling fans	kW	204.1
Dryer fan	kW	63.9
Dryer electric heater	kW	266.6
Reject CO_2 reheating demand (intermittent)	kW	475.8
Total	**MW**	**7.08**

4.2.2 Heat

The CC facility will need heat for the following functions.

1. Amine regeneration.
2. Amine reclamation.
3. Flue gas reheating.

The estimated quantity of heat required for each purpose is stated in Table 3.

Table 3: CC facility heat users

Parameter	Unit	Value
Amine regeneration heat demand	kW	51,800
Amine reclamation heat demand	kW	209
Flue gas reheating heat demand	kW	4,360
Total	**MW**	**56.4**

4.3 Emissions

4.3.1 Emissions to air

As outlined in Section 3 the process has been designed to optimise the recovery of solvents used within the process. However, the CC process has the potential to release point source emissions to air of both solvents used within the process and by-products from the process. Potential additional pollutants include:

- Primary amine used as a solvent within the process emitted with the residual flue gases;
- Trace amounts of secondary amines from the solvent used within the process emitted with the residual flue gases;
- Nitrosamines which may be formed by the reactions of amines with other species within the exhaust gases;
- Nitramines which may be formed by the reactions of amines with other species within the exhaust gases;
- Aldehydes which may be formed by the reactions of amines with other species within the exhaust gases; and
- Ammonia which may be formed by the reactions of amines with other species within the exhaust gases.

It has been assumed that the ERF would operate at the emission limits set in the existing EP and these emissions would be transferred to the CC facility to be emitted to atmosphere following the CC process. The CC process will utilise MEA as the amine solution. This will result in emissions of MEA and its associated nitramines. Noting that MEA is a primary amine and as such the nitrosamines produced are unstable and rapidly change structure to form imines within around 1 seconds of formation. Imines are not significantly harmful to human health and therefore have not been included in the assessment. Although an MEA based solution is being proposed it has been assumed that this system will also result in trace amounts of diethanolamine (DEA) and dimethylamine (DMA) and their associated nitrosamines and nitramines.

As described in Section 3, the CC facility will include a DCC which will function as a polishing scrubber and a water and acid wash will be incorporated into the CC facility. As the flue gases condense within the DCC, acidic gases within the flue gas will also condense, reducing the concentration in the final release. The water wash will be used to remove amines, nitrosamines and nitramines. The acid wash will be used to remove the ammonia. The water wash will also be effective at reducing particulate matter.

Encyclis has been informed by its technology supplier that 80-90% of the residual dust and hydrogen chloride in the flue gas will be removed in the quench stage and more than 90% of the sulphur dioxide is removed. Therefore, actual emissions of sulphur dioxide, hydrogen chloride and any substances in the particulate phase including metals and dioxins would be reduced by at least 80%. However, modelling has assumed no reduction as a conservative worst case.

The design of the CC facility has been optimised to have the greatest temperature of the release without significant loss of the efficiency on the ERF. An initial stack height analysis has shown that a stack height of 140 m would be needed to have a similar impact to the ERF. This is due to the significantly different temperature of the release and increased mass of pollutants per volume of air than the ERF. It has been deemed that a stack height of 105 m could be constructed without significant complexities to the civils works and the interface between the absorber and stack, as such this is deemed to be the maximum stack height for the CC facility. This is the stack height which is being applied for as part of this EP application.

It is expected that emissions of amines, nitrosamines and nitramines released from the CC facility will be no worse than those presented in the Dispersion Modelling Assessment provided in Appendix D.1. It is expected that the emissions of ammonia will remain compliant with the existing limit contained within the EP for the ERF. The expected worst-case emissions concentrations are summarised in Table 4.

Table 4: Expected worst case emissions concentrations

Parameter	Expected worst case emission concentration
Ammonia	15 mg/Nm^3
Primary amine – MEA	5 mg/Nm^3
Secondary amine – DEA	0.125 mg/Nm^3
Secondary amine – DMA	0.125 mg/Nm^3
Total nitrosamines and nitramines	0.2 ng/Nm^3
Aldehydes	5 mg/Nm^3

A detailed analysis of the impact of the Facility with the CC facility is set out in the Appendix D.1 this has concluded that:

> *"the impact as a result of implementing the CC system would not have a significant impact on local air quality, the general population or the local community".*

Through the commissioning process, Encyclis will complete monitoring of the exhaust gases CC facility to identify appropriate limits for the operational CC facility.

4.3.2 Emissions to water

As explained in section 3.9, all process effluents generated by the CC facility will be treated and re-used within the ERF and the CC facility. Therefore, there will be no discharges of process effluent.

Uncontaminated surface water run-off from to the Protos drainage network via an on-site drainage system (W3). The surface water drainage systems will be fitted with a penstock valve to isolate the drainage systems in the event of an environmental incident/chemical spill.

4.4 Monitoring

4.4.1 Emissions to air

A continuous emissions monitoring system (CEMS) will be located at both the outlet of the ERF (upstream of the CC facility) and at the outlet of the CC facility. The CEMS at the outlet of the ERF will monitor for all the parameters listed in the existing EP.

Monitoring of the flue gases prior to release to atmosphere as follows:

- Continuous monitoring:
  - ammonia
- Periodic monitoring:
  - primary amines;
  - secondary amines;
  - nitrosamines;
  - nitramines; and
  - aldehydes.

Apart from ammonia, the monitoring parameters and specific monitoring methods for these pollutants are not listed within EA guidance Monitoring stack emissions: techniques and standards for periodic monitoring. Therefore, following completion of detailed design, Encyclis would propose that a pre-operational condition is incorporated into the EP requiring details of the arrangements for the periodic monitoring of emissions from the CC facility are agreed with the EA.

4.4.2 Emissions to water

There are no process effluents discharged from the CC facility, so no monitoring is required.

4.4.3 Process monitoring

The design of the CC facility will incorporate aspects of process monitoring, these will include, but not be limited to the following.

- The quality of the solvent within the absorber column. Solvent quality will be measured by several methods:
  - gas chromatography to determine the composition of the solvent;
  - visual inspection of the solvent to determine solvent colour, which is a key indicator of the presence of degradation products;
  - periodic sampling of both the rich and lean solvent; and
  - measurement of the solvent density to determine amine loading and the presence of degradation products, heavy metals and soluble iron, using Coriolis type flowmeters in conjunction with chromatography.
- Amine loading is to be kept constant to ensure process stability and to reduce the formation of degradation products. This will be achieved by varying the solvent flow rates based on the measurement of the incoming gas, particularly concentration of CO_2 and flue gas flow rate.
- The temperature of the solvent to maintain a consistent temperature and optimise the CC process.

- The degradation of the amine solvent is a function of the maximum temperature within the cycle, which occurs within the stripper.
- Limiting the maximum temperature experienced by the amine will limit the formation of degradation products. This is controlled by limiting the temperature of the supplied steam to the CC facility. This also improves the efficiency of the process, by allowing for a lower pressure steam offtake from the process.

4.5 Heat demand and energy efficiency

The CC facility will draw heat from the ERF for use in the CC process. The following components within the CC facility will require heat:

1. the reboiler, which supplies the stripper with heat for amine regeneration and CO_2 separation;
2. the reclaimer, used to clean the amine and remove buildups of pollutants within the solvent; and
3. the flue gas reheater, which heats up the flue gas to aid dispersion.

The total expected heat demand is as follows.

Table 5: CC facility heat usage

Parameter	Unit	Value
Reboiler heat usage	MW	51.8
Reclaimer heat usage	MW	0.21
Flue gas reheater heat usage	MW	4.36
Total heat usage	MW	56.4

Heat will be drawn to maximise energy efficiency. High pressure steam will be drawn from the ERF and expanded through a back pressure turbine to the pressure required for the reboiler (3.5 bar (a)). During this process, electrical power will be generated which improves efficiency. The remainder of the steam generated from the ERF will be expanded in the existing condensing steam turbine, generating electrical power.

Heat for reheating the flue gas will be drawn from the hot condensate generated in the reboiler. This prevents drawing additional steam and increases the energy efficiency of the facility.

The energy efficiency of the CC facility has been considered within the CHP Report, refer to Appendix B.

4.6 Wastes and residues

Whilst the majority of the amine solvent used for the CC process will be recovered and re-used, there will be a small quantity of amine solvent which will become contaminated and not suitable for recovery/re-use. This residual sludge will be generated from the reclaimer and is understood to be hazardous and will be disposed of via high temperature hazardous incineration. The facility is expected to generate around 625 tonnes of reclaimer waste per annum.

This reclaimer waste will be transferred to a dedicated storage tank. The tank will be provided with suitable secondary containment. The tank will be periodically emptied and transferred to for recovery or disposal at a suitably licensed waste treatment facility.

4.7 Management arrangements

Encyclis's existing management systems for the Facility, including the preventative maintenance arrangements, will be extended to incorporate the CC facility. The following technical guidance will be followed when developing and implementing the EMS:

- BS EN ISO 14001:2015; and
- Environment Agency guidance to 'develop a management system: environmental permits'.

Encyclis has committed to achieve ISO 14001:2015 certification by a UKAS accredited certification body with 12 months of first commercial operation of the ERF. Following construction of the CC facility, the EMS will be extended to incorporate the operation of the CC facility. The EMS will include the relevant Encyclis policies, procedure, protocols and other documentation required for compliance with both the EP and operational requirements. All documents and records relating to the EMS will be made available to the EA upon request. All EMS documentation will be held electronically on the Protos Energy Recovery Facility Microsoft SharePoint system, to enable access by all personnel.

Section 4.7.1 provides a general summary of the proposed site EMS in accordance with Environment Agency (EA) guidance '*Develop a management system: environmental permits*'.

4.7.1 Summary of EMS and management systems

The EMS will clearly define the management structure as well as setting out the roles and responsibilities of all staff. The EMS will also include:

- An Environmental Policy;
- Health and Safety Procedures; and
- An operational guidance manual which will include process plant operating procedures for both standard and emergency conditions.

The Construction (Design and Management) Regulations will apply during the construction and commissioning period. In addition, management will undertake inspections and reviews for quality control, performance measurements, and staff appraisals.

4.7.1.1 Scope and structure

The scope of the ISO 14001 certification will cover three key areas:

- the design and development of the Facility;
- the operation of the Facility; and
- the incineration of waste and the carbon capture process.

Where applicable, documented procedures will detail specifically how each activity will be controlled. These will be contained in an Environmental Procedures Manual and identified related documents.

The site EMS will contain procedures for accident management that comply with the EA's requirements. This will be in the form of an accident management plan that will be developed for the Facility.

4.7.1.2 General requirements

The structure of the EMS documentation will include, but not be limited to, the following:

- an environmental policy;
- identification of potential environmental impacts;
- documented procedures to control operations that may have an adverse impact on the environment;
- ensuring adequate responsibility, authority and resources to management necessary to support the EMS;
- defined procedures for identifying, reviewing and prioritising items of plant and equipment for which preventative maintenance regimes are appropriate;
- establishing preventative maintenance programmes (and associated auditing) to cover all plant and equipment whose failure could lead to environmental impacts (including infrastructure such as pipework, drainage, bunds etc);
- documented procedures for monitoring relevant emissions or environmental impacts;
- establishing performance indicators to measure the effectiveness of the procedures;
- monitoring, measuring and analysing the procedures for effectiveness; and
- implementing actions as required based on the results of auditing to ensure continual improvements of the processes.

Where applicable, documented procedures will detail specifically how each activity will be controlled. These will be contained in an Environmental Procedures Manual or similar and identified related documents.

Encyclis will adapt and extend the scope of the current environmental policies for each company that make up the joint venture. The resulting environmental policy will act as a commitment to continual improvement of Encyclis's operations including a commitment to comply with relevant legislation.

4.7.1.3 Site operations

The Facility will operate as an Energy Recovery Facility with carbon capture, with the main activity being undertaken the incineration of non-hazardous waste to recover energy and the subsequent capture of carbon dioxide.

All permitted activities will take place within the Installation Boundary.

Steps to be taken to prevent or minimise risks to the environment from each activity/process – these are described within the Environmental Risk Assessment (presented in Appendix C). The environmental risks will be expanded on and incorporated into the final EMS document upon completion of detailed design.

4.7.1.4 Site plan(s)

Following completion of detailed design, the EMS will include for detailed plan(s) of the site which highlight where permitted activities are undertaken. The plan(s) will also show the location of the following, in accordance with EA guidance '*Develop a management system: environmental permits*':

- buildings and any other main constructions such as security fences;
- storage facilities for hazardous materials (oil or fuel tanks), chemical stores, waste materials;
- the location of items for use in accidents and emergencies, such as spill kits;
- entrances and exits for use by emergency services;
- any points designed to control pollution (e.g., containment facilities or penstock valves);

- effluent or water discharge points;
- areas vulnerable to pollution such as watercourses, adjacent industrial premises etc;
- drainage facilities; and
- utilities supplies (water, gas, electric) including stop taps, isolating valves, routes etc.

Preliminary site plans (including emissions points and installation boundary drawings) are presented within Appendix A.

4.7.1.5 Storage of waste and other residues/wastes

Upon completion of detailed design of the site, a waste/wastes/residues storage plan will be incorporated into the EMS, in accordance with the requirements of EA guidance '*Develop a management system: environmental permits*'.

4.7.1.6 Site and equipment maintenance plan

Upon completion of detailed design of the site, a site equipment and maintenance plan will be incorporated into the EMS, in accordance with the requirements of EA guidance '*Develop a management system: environmental permits*'. Preliminary information in relation to this plan is set out as follows:

- Plant and machinery (including any mobile plant) will be maintained in accordance with the manufacturers or supplier's recommendations. A preventative maintenance regime will be put in place.
- Records will be kept of any maintenance carried out on plant and machinery.

4.7.1.7 Personnel

Encyclis will ensure that sufficient numbers of staff, in various grades, are provided to manage, operate and maintain the site on a continuous basis, seven days per week throughout the year.

It is anticipated that the key environmental management responsibilities will be allocated as described below:

- The 'Plant' or 'General' Manager for each component at the site will have overall responsibility for management of the facility and compliance with all aspects of the EP. The Plant Manager will have extensive experience relevant to their responsibilities.
- The 'Operations' Manager(s) will have day-to-day responsibility for the operation of each component, to ensure that the facility is operated in accordance with the EP and that the environmental impact of operations is minimised. In this context, they will be responsible for designing and implementing operating procedures which incorporate environmental aspects.
- The 'Engineering' or 'Maintenance' Manager will be responsible for the management of maintenance activities, for maintenance planning and for ensuring that the facility continues to operate in accordance with its design.
- The Environment, Health and Safety (EHS) manager will be responsible for environmental and health and safety at the site, including compliance with the EP.

The majority of employees would be skilled operatives (electricians/fitters) or technical engineers (control and plant). In addition to the above, roles could include security officers, technicians, administrators, site operatives, etc.

4.7.1.8 Competence, training and awareness

Encyclis aims to ensure that any persons performing tasks for it, or on its behalf, which have the potential to cause significant environmental impact, are competent on the basis of appropriate education and training or experience.

Systems to assess competence and provide training for relevant staff will be provided. These may cover, but not be limited to, the following:

- awareness and importance of regulatory implications of the EP for the activities and operations undertaken at the site;
- awareness of potential environmental effects from operation under normal and abnormal circumstances (e.g., periods of shutdown);
- awareness of the need to report any significant deviations from the EP;
- prevention of accidental emissions and action to be taken when accidental emissions occur and
- roles and responsibilities in achieving conformity with the requirements of the EMS.

Skills, competencies and training requirements for staff will be documented and recorded as part of the internal management systems at the site. Encyclis will comply with industry standards or codes of practice for training, where they exist. The EMS will contain an archiving procedure to ensure all training is recorded and all associated records are retained.

Competence

Encyclis will identify the minimum competencies required for each role. These will then be applied to the recruitment process to ensure that key roles and responsibilities are satisfied. Particular attention will be paid to potential candidate's experience, qualifications, knowledge and skills.

Induction and awareness

Staff induction programmes are location and job role specific and will include, as a minimum, the induction of:

- the Environmental Policy;
- the requirements of the EP;
- the Health and Safety Policy and Procedures; and
- the EMS Awareness Training.

Staff will have access to the EMS via internal computer systems and will be required to understand any sections of the EMS relevant to the activities they carry out.

Training

Encyclis will be required to train staff during the commissioning of the Facility and prior to each of the activities becoming operational. Line Managers will be required to identify and monitor staff training needs as part of the appraisal system. The training needs of employees will be addressed using on-the-job training, mentoring, internal training and external training courses/events. As stated above, records of training will be documented and recorded, with industry standards or codes of practice for training complied with where relevant. Training records will be maintained onsite. The operation of the site will comply with industry standards or codes of practice for training where they exist.

For any contractors working on-site, potential environmental risks will be identified, and where relevant instructions provided to the contractors.

4.7.1.9 Accident management

The scope of the EMS will include for an 'accident prevention and management plan' or similar in accordance with the requirements of EA guidance '*Develop a management system: environmental permits*', which will identify the likelihood and consequences of any accidents and identify actions or measures to prevent accidents and mitigate any consequences (such as environmental pollution). The accident plan will include for written procedures and forms for recording, handling, investigating, communicating and reporting actual or potential non-compliance (e.g. complaints) with operating procedures/emission limits. Any incidents will be investigated thoroughly and documented, with the regulatory authorities informed if the incident is significant. Near misses will be reported and suitable corrective action/mitigation measures implemented and followed up.

For each potential accident or incident, the following will be identified:

- the likelihood of the accident happening;
- the consequences of the accident happening;
- proposed measures to be taken to avoid the accident happening; and
- proposed measures to be taken to minimise the impact if the accident does happen.

A list of substances stored at the site, and storage facilities, will also be incorporated into the accident management plan (either linked to part of the wider EMS or listed specifically within the accident management plan itself).

The accident plan will be regularly reviewed, no less than once per year, with records kept of the dates that reviews have occurred and planned future review dates. Furthermore, a list of emergency contacts will be included within the accident plan (such as the local fire service, EA etc.)

4.7.1.10 Climate change and flood risk

The potential impacts of climate change (including flood risk) have been and will continue to be considered in the context of the design and operation of the site. The proposed accident management and contingency plans presented within the sections above will include for relevant climate change impacts.

4.7.1.11 Keeping records

Any records required by the EP will be retained in accordance with the relevant timescales indicated within the EP. Should the EP not identify timescales for certain records, these will be defined within the EMS. Records will be kept as part of the EMS for the site.

The records that will be kept will include, but not be limited to, the following:

- the EP for the site;
- other legal requirements for the site;
- environmental risk assessments;
- environmental management plans;
- EMS plans;
- operating procedures;
- staff competence and training (such as qualifications, courses attended);
- emissions and any monitoring undertaken as required by the EP;
- compliance checks, findings of investigation and actions taken;
- complaints made, findings of investigation and actions taken;

- audits of management system, findings (reports) and actions taken;
- management reviews and changes made to the management system;
- where applicable, certification audit reports and any actions carried out;
- records of pre-acceptance and acceptance checks on waste delivered to the site (including
- quantity, EWC codes, origin, producer, date of arrival, any unacceptable wastes);
- records to show that the duty of care requirements are being met.

Copies of any approved plans (such as the fire prevention plan and dust management plan) will be kept with the EMS and records will be maintained of any updates to these plans. Furthermore, the Site Condition Report will be kept with the EMS and records will be maintained of any updates to the Site Condition Report.

A hard copy of the EMS will be kept at the gatehouse, with electronic copies of the EMS and supporting documents (including records) accessible to staff via internal computer systems.

4.7.1.12 Review of management systems

The EMS will be reviewed and updated regularly in response to changing internal and external factors, with records kept on any checks carried out and updates made. Updates may be made, for example, when changes are made to operations and activities carried out at the site, if new equipment is installed, if the EP is varied, following any accidents or complaints, or if a new environmental risk is identified. As a minimum, the EMS will be reviewed once per year.

4.7.1.13 Contingency

A contingency plan will be developed as part of the EMS following completion of detailed design. This will incorporate measures and procedures for the following scenarios in order to minimise environmental risk:

- breakdown scenarios;
- enforced shutdowns;
- planned shutdowns;
- any other abnormal operation (e.g. due to flooding or extreme weather).

The EA will be provided with a copy of the EMS (or relevant parts thereof) for the site if requested.

4.7.1.14 Contact information for the public

A notice board will be displaced at (or near) the entrance for the Facility which tells the public key information about the site. This will include, but not be limited to, the following:

- the EP holder’s name;
- an emergency contact name and telephone number;
- a statement that the site is permitted by the Environment Agency;
- the EP number;
- the Environment Agency telephone number 03708 506506 and the incident hotline 0800 807060.

4.7.1.15 Complaints

A complaints procedure will be in place and will form part of the EMS to record any complaints received in relation to activities covered by the EP. The procedure will include details on how complaints will be investigated, and any actions to be taken following complaints.

4.7.2 Operating and maintenance procedures

In addition to the EMS described above, an operating and maintenance (O&M) manual(s) or similar will be developed for the site. The O&M procedures will include, but not be limited to the following aspects:

- comprehensive description of each component at the site including operating hours and design details;
- as-built drawings of the site;
- maintenance and service plans;
- staffing and staff responsibilities;
- waste acceptance and pre-acceptance procedures;
- waste storage and handling procedures;
- copies of any guaranties/warranties/certificates; and
- health and safety procedures.

5 Additional EP Changes

5.1 Installation boundary

As presented in the layout and installation boundary drawings provided in Appendix A, the CC facility is proposed to be installed on land to the South East of the existing Facility. This area of land is not within the existing installation boundary for the Facility. Therefore, as part of this EP Variation Encyclis is proposing to extend the installation boundary to incorporate this additional area of land.

An updated site condition report for the additional land to be incorporated into the installation boundary is provided in Appendix F.

6 BAT Guidance Review

6.1 Post-combustion CO2 Capture BAT Guidance

The EA latest published Best Available Techniques (BAT) guidance for post-combustion CO_2 capture[2] is dated 2022. This has been updated but currently in draft form (proposed amendments v5). The following section demonstrates how the post-combustion carbon capture (PPC) plant (the CC facility) complies with the requirements.

6.1.1 Power plant selection and integration with the PCC plant

The thermal efficiency of the ERF has been maximised. The CHP Report contained in Appendix B, demonstrates that the gross electrical efficiency of the ERF will remain above the BAT AEELs with the CC facility.

The primary purpose of the ERF is to treat waste. Therefore, it needs to be able to be operated continuously. The CC facility has been designed so that the ERF can operate independently and efficiently during periods of power only mode.

The heat and electricity for the CC facility is being supplied from the ERF. High pressure steam will be drawn from the ERF and expanded through a back pressure turbine to the pressure required for the reboiler. Heat for reheating the flue gas will be drawn from the hot condensate generated in the reboiler.

6.1.2 PCC plant design and operation

The CC facility has been designed for a minimum CO_2 capture rate of 95% under normal operation. Whilst consideration will be given to capturing CO_2 during start-up and shut-down of the ERF, due to a lack of available heat and electricity for stable operation of the CC facility it is unlikely that the capture plant will be put into service prior to stable operation of the ERF.

In addition, the ERF combusts a different fuel during start up and shutdown events, which produces a flue gas for which the CC facility is not designed or optimised. However, once the ERF is in stable operation, the CC facility will be started, and will capture CO_2 during its own sequence of start-up and shut down.

6.1.3 Solvent selection

It is proposed to use an MEA based solvent. This has been proven to have a low formation rate of degradation products and high availability of information on the solvent properties, refer to section 3.3.

6.1.4 Features to control and minimise atmospheric and other emissions

The ERF includes a flue gas cleaning system to control emissions. This includes a SNCR system, a semi-dry lime acid gas abatement system, and bag filters. This will control emissions of pollutants going into the CC facility to ensure that there is not significant degradation of amine solution or creation of aerosols.

[2] EA (2022) Post-combustion carbon dioxide capture: best available techniques (BAT) – available at https://www.gov.uk/guidance/post-combustion-carbon-dioxide-capture-best-available-techniques-bat

The CC facility includes a water wash and an acid wash which will ensure effective removal of amines, ammonia and other basic species emissions to very low levels. Demisters are included in the absorber column to remove sulphur trioxide droplets and fine particulates as they can cause significant amine emissions. The temperature in the solvent stripping process will be controlled and solvent residence time in the absorber sump will be limited.

The stack height for the CC facility has been optimised. Detailed dispersion modelling has been carried out which shows that the temperature of the release has a significant effect on the level of dispersion of emissions. The temperature of the emissions from the CC facility have been increased by including flue gas reheating. The stack height proposed (105 m) is taller than the existing ERF and the highest which would be installed without significant civils works. The dispersion modelling has shown that the impact on air quality of the CC facility is not significant.

6.1.5 Process and emissions monitoring

As detailed within Section 4.4 the CC facility will include a series of measures to monitor the process and emissions to air.

As detailed in Section 4.4.1 a CEMS is included at the outlet of the ERF and the outlet of the CC facility. This will be used to demonstrate compliance with the EP requirements and to control the system to minimise the formation of solvent degradation products.

The proportion of biogenic CO_2 will also be monitored at the outlet of the ERF, in compliance with the requirements of the Waste Industrial Carbon Capture contract.

A range of methods for monitoring the process will be carried out as set out in Section 4.4. this will be used to show that resources are being used efficiently. These methods will include energy and resource efficiency, capture efficiency, and verification that the CO_2 is suitable for safe transport and storage.

A monitoring plant for the commissioning phase and routine operation will be developed.

Where appropriate monitoring will meet the MCERTS standards, and any lab used will be UKAS accredited.

6.1.6 Unplanned emissions to the environment

A leak detection and repair programme will be developed. A vent stack is included in the design to ensure adequate and safe dispersion of rejected CO_2 from the CC facility as detailed in Section 3.7.

6.1.7 Capture level, including during flexible operation

The CC facility has been designed to operate continuously when the ERF is in steady state normal operation.

6.1.8 CO2 Compression

Detailed CO_2 compression design will be developed by the EPC contractor during the FEED and design stages of the project. The compressor will be of multistage design and will include intercooling to increase efficiency.

6.1.9 Noise and odour

A Noise Assessment is provided in Appendix E. The assessment concludes that the combined noise impacts from the ERF and CC facility at sensitive receptors would have a low impact with noise levels at the sensitive receptors being no higher than 8 dB below the prevailing background sound levels in the worst-case which suggests that complaints are unlikely. Therefore, noise impacts are considered to be 'not significant'.

6.1.10 Planned and emergency venting of CO_2

Venting of CO_2 will occur when the CO_2 produced does not meet the requirements of the HyNet pipeline, or as an emergency response to relieve overpressure. CO_2 will be vented through a dedicated vent stack, located adjacent to the main emission stacks. If CO_2 is vented from high pressure it will require heating due to a temperature drop caused by the Joule-Thompson effect when the pressure is dropped. Full details of when unplanned venting of CO_2 may occur is detailed in Section 3.7.

6.1.11 Cooling

Cooling will be carried out by a mixture of dry air coolers and hybrid wet-dry cooling towers. Hybrid wet-dry cooling towers can provide a closer approach to the ambient air temperature, hence lower cooling water temperatures and lower flowrates are required. However, these towers require a top-up to replace water which evaporates as part of the cooling process. To balance this demand against water supply, the wet-dry towers are used in combination with dry cooling towers, minimising electricity requirements and water discharge.

6.1.12 Discharges to water

There will be no discharges of process effluent to water from the CC facility, with all process effluents being treated prior to re-used within the ERF or the CC facility.

The only discharges to water from the CC facility will be uncontaminated surface water run-off.

6.1.13 Climate change adaption

Climate change is likely to result in higher temperatures and more frequent and higher intensity of storm events, resulting in more frequent and severe flooding events.

Climate change adaption has been incorporated into the design of the CC facility as follows:

- Increased temperature - the CC facility is designed to operate within a range of temperatures which includes allowance for projected increases as a result of climate change.
- Increased wind speeds - the CC facility is designed with wind loading factors to comply with British Standards. These allow for a range of wind loadings on structures including those associated with the higher intensity of storm events.
- Increased flood events - the CC facility will be located on a platform at a height above the flood level, at least matching the minimum ERF platform height of 5.063m AOD.

This will be allowed for within the design as a requirement of the planning process.

6.1.14 Summary

As set out within sections 6.1.1 to 6.1.13, Encyclis considers that the design of the CC facility complies with the requirements of the EA's BAT guidance for post-combustion CO_2 capture.

6.2 BAT review for the water treatment plant

Whilst the water treatment plant is not regulated as an installation activity as it does not exceed any relevant thresholds which would mean that it would be regulated as an installation activity, to demonstrate that it represents BAT, the design and operation of the water treatment plant has been considered in relation to the "Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector", dated May 2016. Whilst this is not directly applicable to the CC facility, it is considered to be the most appropriate BREF to determine whether the water treatment plant represents BAT.

Table 6: BAT Review for Water Treatment Plan

#	BAT Requirement	How met or reference
1	In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the features as set out in the BREF.	An IMS (integrated management system) incorporating environmental management is being established by Encyclis for the ERF. The IMS will be extended to include the operation of the CC facility. On this basis, Encyclis considers that the water treatment plant is in accordance with BAT 1.
2	In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the techniques set out in the BREF.	An inventory of waste water and waste gas streams will be developed a part of the design process for the water treatment plant. This will be reviewed and updated throughout the design process, and maintained as part of the EMS for the CC facility when it is operational. On this basis, Encyclis considers that the water treatment plant is in accordance with BAT 2.
3	For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to pretreatment and influent to final treatment).	At each waste water generation, and/or treatment step, the key process parameters will be monitored. On this basis, Encyclis considers that the water treatment plant is in accordance with BAT 3.
4	BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	There are no emissions to water from the water treatment plant, as the treated effluent is re-used within the ERF. Therefore, Encyclis considers that the requirements of BAT 4 are not applicable.
5	BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I – III or, where large amounts of VOC are handled, all of the techniques I – III.	There are no diffuse emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 5 are not applicable.
6	BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards.	There are no diffuse emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 6 are not applicable.

#	BAT Requirement	How met or reference
7	In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.	The design of the process effluent treatment plan has been designed to maximise the re-use of water, to reduce water usage and result in the CC facility being zero discharges to water. On this basis, Encyclis considers that the design of the water treatment plant is in accordance with BAT 7.
8	In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated waste water streams from waste water streams that require treatment.	As explained in section 3.9 above and 3.10, surface water run-off from the CC facility will be collected separately to condensate from the DCC.
9	In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for waste water incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).	There will be no process effluent discharge from the facility as all waste water streams will be re-used within the CC and ERF. To accommodate changes in operating conditions a process water tank will be provided to provide buffer storage. On this basis, Encyclis considers that the design of the water balance for the CC facility is in accordance with BAT 9.
10	In order to reduce emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of the techniques set out the BREF in the priority order given.	The ERF is designed to minimise the concentrations of pollutants which are contained within the flue gases, and subsequently precipitated out of the flue gases within the DCC. The philosophy of re-using waste water streams within the installation is in line with the BAT requirements. On this basis, Encyclis considers that the design of the water balance for the CC facility is in accordance with BAT 10.
11	In order to reduce emissions to water, BAT is to pretreat waste water that contains pollutants that cannot be dealt with adequately during final waste water treatment by using appropriate techniques.	There are no process effluent emissions to water, with all treated effluents being re-used within the instalation. On this basis, Encyclis considers that the design of the water treatment plant is in accordance with BAT 11.
12	In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques as set out within the BREF.	

#	BAT Requirement	How met or reference
13	In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered.	Encyclis can confirm that it will set up and implement a waste management plan as part of the environmental management system for the Facility. The design of the water treatment plant enables all waste water generated by the CC facility to be re-used, and the overall installation to be a 'zero discharge' facility. On this basis, Encyclis considers that the design of the water treatment plant is in accordance with BAT 13.
14	In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques as set out within the BREF.	The water treatment plant will not generate a sludge requiring further treatment of disposal. Therefore, Encyclis considers that the requirements of BAT 15 are not applicable.
15	In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible.	There are no fugitive or point source emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 15 are not applicable.
16	In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques.	There are no fugitive or point source emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 16 are not applicable.
17	In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques set out in the BREF.	There are no fugitive or point source emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 17 are not applicable.
18	In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use one or both of the techniques set out in the BREF.	There are no fugitive or point source emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 18 are not applicable.

#	BAT Requirement	How met or reference
19	In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques set out in the BREF.	There are no fugitive or point source emissions to air from the water treatment plant. Therefore, Encyclis considers that the requirements of BAT 19 are not applicable.
20	In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the elements set out in the BREF.	Encyclis can confirm that it will set up and implement an odour management plan as part of the environmental management system for the ERF and the CC facility, which will include the water treatment plant. On this basis, Encyclis considers that the operation of the water treatment plant is in accordance with BAT 20.
21	In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques set out in the BREF.	The effluent treated within the water treatment plant will not contain putrescible contaminants. Therefore, the water treatment plant will not result in odours. Therefore, Encyclis considers that the requirements of BAT 21 are not applicable.
22	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the elements set out in the BREF.	Encyclis can confirm that it will set up and implement a noise management plan as part of the environmental management system for the ERF and the CC facility, which will include the water treatment plant. On this basis, Encyclis considers that the operation of the water treatment plant is in accordance with BAT 22.
23	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques set out in the BREF.	A noise assessment has been submitted with the EP application, refer to Appendix E. As concluded within the noise assessment, the noise impacts associated with the implementation of the CC facility will be 'not significant'. On this basis, Encyclis considers that the design of the water treatment plant is in accordance with BAT 23.

Appendices

A Plans and Drawings

A.1 Installation Boundary

Provided as separate document within the Application pack.

A.2 Emissions Points Drawing

Provided as separate document within the Application pack.

A.3 CCS Process Overview

Provided as separate document within the Application pack.

B CHP Report

Provided as separate document within the Application pack.

C Environmental Risk Assessment

Provided as separate document within the Application pack.

D Air Quality Assessments

D.1 Air Dispersion Modelling Assessment

Provided as separate document within the Application pack.

D.2 Dioxins Pathway Assessment

Provided as separate document within the Application pack.

E Noise Assessment

Provided as separate document within the Application pack.

F Site Condition Report

Provided as separate document within the Application pack.

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