FICHTNER
Consulting Engineers Limited

Parc Adfer - Carbon Capture Facility

enfinium Parc Adfer Operations Ltd

Supporting Information

ENGINEERING + CONSULTING

Document approval

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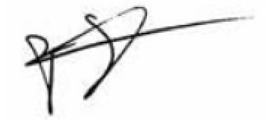
Prepared by:	James Sturman		Principal Consultant	01/08/2025
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Non-technical Summary

An Environmental Permit (EP) (Ref: EPR/AB3092CV) was granted by Natural Resources Wales (NRW) for the Parc Adfer Energy Recovery Facility (herein referred to as the ERF) on 28 October 2015. The ERF comprises a single waste incineration line, and associated flue gas treatment systems.

The EP (EPR/AB3092CV) has been varied 7 times. The latest variation to the EP was granted by NRW to enfinium Parc Adfer Operations Limited (enfinium) on 8 August 2023 to increase the capacity of the ERF from 200,000 tpa to 232,000 tpa.

Within this application, enfinium is applying for a variation to the EP to incorporate the proposed carbon capture facility (CC facility). The CC facility will have a capture efficiency of approximately 95%, and is expected to capture approximately 241,000 tonnes of CO_2 from the ERF flue gases per annum. To facilitate the implementation of the CC facility, enfinium is applying for the following changes to the EP:

1. Inclusion of an additional Schedule 1 regulated activity (Section 6.10), incorporating a CC facility, and its directly associated activities:
    a. Treatment of wastewaters for re-use within the installation; and
    b. Compression of captured CO_2 for transfer for geological storage.
2. Update the Site Layout to incorporate the layout changes associated with the CC facility.
3. Update the provisions for emissions monitoring associated with the implementation of the CC facility.

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, enfinium 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 NRW during pre-application discussions.

The environmental assessments have been reviewed/updated where appropriate, which has included undertaking detailed air quality and noise modelling. The updated assessments have concluded that the proposed incorporation of the CC facility will not result in unacceptable environmental impacts.

The application includes a review of BAT requirements for the guidance titled '*Post-combustion CO_2 Capture BAT Guidance*' and the BREF for the '*Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector*'. Within this review, it has been concluded that the proposed CC facility and its directly associated activities represent BAT.

Contents

1 Introduction

1.1 Background

An Environmental Permit (EP) (Ref: EPR/AB3092CV) was granted by Natural Resource Wales (NRW) for the Parc Adfer Energy Recovery Facility (herein referred to as the ERF) on 28 October 2015. The ERF comprises a single waste incineration line, and associated flue gas treatment systems.

The EP (EPR/AB3092CV) has been varied 7 times. The latest variation to the EP was granted by NRW to enfinium Parc Adfer Operations Limited (enfinium) on 8 August 2023 to increase the capacity of the ERF from 200,000 tpa to 232,000 tpa.

Within this application, enfinium is applying for a variation to the EP to incorporate the proposed carbon capture facility (CC facility). The CC facility will capture carbon dioxide (CO_2) from the flue gas of the ERF, separating this from the other flue gases, and compressing the CO_2 for onward transport and geological storage. The captured CO_2 will be exported to a pipeline transmission and storage network for offshore sequestration.

The CC facility will have a capture efficiency of approximately 95% and is expected to capture approximately 241,000 tonnes of CO_2 from the ERF flue gases per annum.

1.2 Summary of proposed changes

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

4. Inclusion of an additional Schedule 1 regulated activity (Section 6.10), incorporating a CC facility, and its directly associated activities:
   a. Treatment of wastewaters for re-use within the installation; and
   b. Compression of captured CO_2 for transfer for geological storage.
5. Update the Site Layout to incorporate the layout changes associated with the CC facility.
6. Update the provisions for emissions monitoring associated with the implementation of the CC facility.

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

1.3 Type of variation

NRW's guidance titled 'Environmental Permitting Charging Scheme 2025/26' identifies that there are four types of EP variation – administrative, minor technical, normal and substantial.

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

NRW has published guidance (Regulatory Guidance Note 8 – Substantial Change) which defines a substantial change. 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, enfinium 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 NRW 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. Where CO_2 is captured for storage, 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 and commercial wastes are combusted for power generation, such as at the Parc Adfer 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.

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

2.2 CCS technologies

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

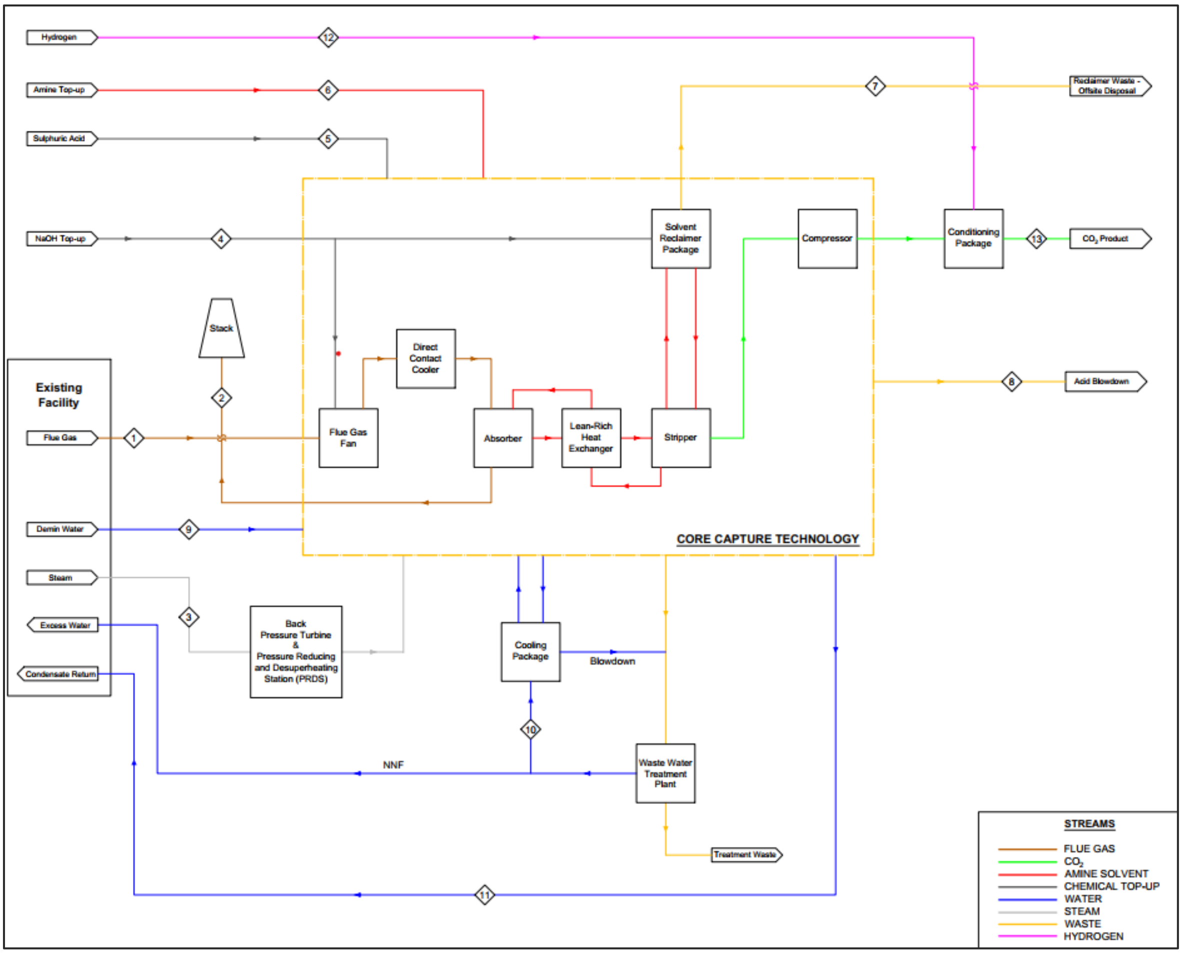
1. pre-combustion;
2. post-combustion;
3. oxyfuel combustion; and
4. direct air capture (DAC).

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

The carbon capture facility will be located fully within the existing installation boundary. The main process equipment and buildings for the CC facility will be along the western side of the site adjacent to the ERF buildings. The site access will remain as existing, off Weighbridge Road, with new internal circulation roads to the CC facility structures and staff car parking.

The full flue gas flow from the Parc Adfer ERF will be diverted using a damper from the flue directed from the existing stack to the CC facility. A process schematic for the CC facility is provided below, a larger version 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. 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 NRW, 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 within the existing installation boundary.

3.1 Booster fan

Prior to treatment for the flue gases, a booster fan will be used to increase the pressure sufficiently to overcome the pressure drop across the carbon capture (CC) process. The flue gas fan will work in tandem with the ERF's induced draught (ID) fan to manage the pressures across the flue gas stream.

3.2 Flue gas cooling

The Direct Contact Cooler (DCC) is effectively a wet scrubber. It has the dual purpose of cooling the incoming flue gas and acts as a pre-treatment step to remove the acid gas impurities from the flue gas, i.e. sulphur dioxide (SO_2), hydrochloric acid (HCl) and hydrogen fluoride (HF).

This will be achieved by direct contact with a sodium hydroxide solution (NaOH solution) that reacts with the acid gases to produce water soluble salts, this is referred to as a caustic wash. The excess water in the flue gas will be condensed into the NaOH solution, creating a condensate bleed stream that will be routed to the wastewater treatment plant for processing.

Once treated, this water will be re-circulated as make-up water for the cooling system (refer to section 3.7). The NaOH solution will be cooled and recirculated, with additional NaOH solution dosed to maintain a slightly alkaline pH and neutralise any acids condensed from the flue gas.

3.3 CO_2 gas absorption

The flue gas will be routed into a packed bed absorption column for CO_2 scrubbing using a solution of monoethanolamine (MEA). MEA is a primary amine solvent, which absorbs CO_2 from the flue gas. Before CO2 absorption, this is referred to as the lean amine. Once CO_2 has been absorbed, it is referred to as rich amine, as the amine is rich in CO_2.

The flue gas will be scrubbed in the absorber through contact with the lean amine in a counter current flow regime. The CO_2 will be absorbed by the MEA, leaving the remaining flue gas (predominantly nitrogen, oxygen and water) to enter the post-scrubber stage, where washing occurs. An initial water wash will be used to scrub emissions of amine and degradation products from the treated flue gas, which is followed by an acid wash, using a concentration of sulphuric acid to remove further contaminants. The water wash, in combination with the mist eliminator which is located after the absorber, will remove entrained mist droplets and solvent vapour from the flue gas prior to release to atmosphere. To prevent the build-up of dissolved contaminants in the recirculating acid solution, blowdown will be periodically bled from the system for transfer off-site to a suitably licensed waste management facility.

The temperature of the flue gas entering the absorber column is approximately 40°C. The absorption of CO_2 by MEA is exothermic so releases heat into the absorber, increasing the temperature in the absorber and requiring intercooling to maintain a favourable temperature for CO_2 absorption. The treated flue gas leaving the absorber column will be reheated to 80°C, using waste heat drawn from the hot condensate generated in the Reboiler, to minimise the extent of visible plumes and assist in the dispersion of the flue gases when released to atmosphere.

3.4 Gas Desorption/Solvent Regeneration

Once the CO_2 has been absorbed, the rich amine must be regenerated for recirculation back to the absorber. This is achieved by heating the rich amine, causing the CO_2 gas to be released.

The rich amine is pumped from the absorber sump to a packed column, referred to as a Stripper. Heat is provided to the Stripper in the form of low-pressure steam (LP steam), which is taken from the ERF and let down to the required pressure via a back pressure turbine. This will raise the temperature of the rich amine to release the captured CO_2, leaving hot lean amine that is cooled and recirculated back to the absorber tower. CO_2 gas, saturated with water, flows up the stripper and is cooled in the condenser, knocking out some of the entrained water, before it is compressed and conditioned for export, refer to section 3.5.

The continued use and thermal cycling of the amine solution will result in degradation of the solvent, particularly due to the presence of other gaseous species in the flue gas, such as sulphur dioxide and oxides of nitrogen. These species react with the amine and form degradation products, which can be heat stable salts, non-volatile organic compounds or suspended solids. These degradation products are corrosive and reduce the effectiveness of the solvent solution in capturing CO_2. Reclaiming is required to remove these products and restore the effectiveness of the amine solution.

The reclaiming process treats a slip stream of amine from the stripper. This is treated with NaOH solution and then heated using medium pressure steam until the liquid has been boiled off. The vapour which is boiled off is condensed and returned to the solvent circuit. The residual sludge, referred to as Reclaimer waste is classified as a hazardous waste, and will be stored within a bunded storage tank. The Reclaimer waste will be unloaded into a road tanker for transfer to a suitably licensed waste management facility.

Solvent make-up is added to the solvent recirculation loop to replace the solvent lost through the reclaiming process.

Measures will be employed to minimise the volume of waste generated from the Reclaimer, including reducing the production of heat stable salts by reducing incoming pollutants using the DCC, and careful control of the temperature within the Reboiler to reduce the formation of thermal degradation products.

The Reclaimer will be operated as either a continuous or intermittent process, depending on the level of degradation and sizing of the Reclaimer. This will be determined once a more detailed analysis of the expected levels of degradation has been undertaken as part of the detailed design process.

3.5 Captured CO_2 Conditioning and Export

The CO_2 rich stream from the stripper will be saturated with water and contain traces of oxygen. In order to meet the stringent CO_2 transport network requirements, additional treatment, referred to as conditioning, and compression are required before CO_2 export. Compression is carried out in a multistage compressor with intercooling. Conditioning, consisting of dehydration and deoxygenation will produce a CO_2 product which satisfies the transport and export requirements. Water condensed from the CO_2 stream is returned to the solvent circuit.

3.6 CO_2 Venting

The CC facility is designed to treat and compress the CO_2 stream for export by pipeline. However, there are possible operational scenarios during which it will not be possible to export the CO_2 product that has been captured. There are five scenarios that would require occasional CO_2 venting:

1. Venting of out of specification CO_2;
2. Venting of CO_2 due to operational upset of the CC facility;
3. Depressurisation of equipment to perform maintenance or inspections;
4. Plant commissioning; and
5. Start-up and shutdown.

The proposed design of the CC facility includes a CO_2 vent header system. In all scenarios which will require venting of CO_2, all CO_2 within the CC facility will be directed to the header and then to the CO_2 vent stack. It is proposed that the CO_2 vent release point will be at the top of the 85 m stack for the CC facility. High-pressure CO_2 vent pipework may require heating to compensate for the temperature drop on expansion as CO_2 pressure reduces. A venting strategy for CO_2 is provided in Appendix F.

3.7 Cooling systems

Cooling water will be required to cool the incoming flue gas, the lean amine, the water wash flow water and CO_2 product. Cooling capacity will be provided via a hybrid cooling system.

Make-up water for the hybrid cooling system will be provided by a combination of mains water, and the treated process effluent from the process effluent treatment plant.

The cooling water will be dosed with sulphuric acid (H_2SO_4) to reduce its mineral content and prevent scaling. It will also be dosed with sodium hypochlorite (NaOCl) to kill bacteria such as legionella.

Blowdown from the cooling towers will be transferred to the process effluent treatment plant to maintain the water quality parameters within the hybrid coolers.

3.8 Process effluent treatment plant

The on-site process effluent treatment plant will primarily treat the following effluent streams:

- Blowdown from the hybrid cooling towers; and
- Condensate from the DCC.

The process effluent will be treated using reverse osmosis to remove the contaminants from the effluents, and ensure that they are suitable for re-use within the hybrid cooling towers. The reject effluent from the water treatment plant, will be transferred to the ERF for re-use within the ash quench.

The residual sludge from the reverse osmosis plant, will be transferred for disposal or recovery in a suitably licensed waste management facility.

On this basis, there will be zero-discharges of process effluent from the CC facility with all process effluents generated by the CC facility being processed within the effluent treatment plant for re-use within the installation.

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

3.9 Drainage and domestic effluent treatment

Uncontaminated surface water run-off from building roofs and roadways will be discharged to the existing surface water drainage network prior, which is subsequently collected in the on-site attenuation pond.

Surface water run-off from roadways will pass through an interceptor prior to discharge into the attenuation pond.

The surface water drainage systems for the CC facility will be fitted with a penstock valve to isolate the drainage systems in this area in the event of an environmental incident/chemical spill.

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 within the ERF. However, the CC facility will require the following additional consumables:

1. Amine solvent, solvent make-up for replacing degraded solvent. The Material Safety Data Sheet (MSDS) for the MEA solvent is provided in Appendix I.
2. Sulphuric acid (96% solution), acid stage make-up in the flue gas post-treatment.
3. Hydrochloric acid (32% solution), to be used in the effluent treatment plant.
4. Sodium hydroxide (50% solution), used for regeneration of MEA from heat stable salts in the Reclaimer and neutralisation of DCC wash water in the effluent treatment plant.
5. Nitrogen, used for blanketing of the amine tank.
6. Hydrogen, used in the oxygen removal reactor.
7. Activated Carbon, annual replacement of activated carbon filters.
8. Water treatment chemicals.

The CC facility will also need heat as steam, and electrical power, which are considered separately, refer to section 4.4. The estimated quantity of each consumable required is stated in Table 1.

Table 1: Reagent consumption

Substance	On-site storage facilities	Annual consumption (tpa)
Amine - MEA Solution at 85wt% solution	1 amine tank - 40m^3	448
Sulphuric acid (H_2SO_4) - 96% solution	2 x IBC (1m^3 each)	38
Hydrochloric Acid (HCl) - 32% solution	2 x IBC (1m^3 each)	8
Sodium hydroxide (NaOH) - 50% solution	6 x IBC (1m^3 each)	315
Nitrogen (N_2)	1 Nitrogen bundle	0.5
Hydrogen (H_2)	2 x tube trailers	17
Activated Carbon	No onsite storage, filter replacement	6
Water treatment chemicals, including corrosion inhibitor, biocide and oxygen scavenger	6 x IBC (1m^3 each)	<50 tpa

Apart from MEA solution, all solid and liquid reagents and chemicals will be delivered to the Facility by road via HGVs in drums and intermediate bulk containers (IBCs). MEA solution will be delivered via road tanker, and transferred to the on-site storage tank via fixed pipework. Nitrogen and hydrogen will be delivered via road tanker and transferred to pressurised storage vessels.

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

Facilities for the handling and storage of chemicals will be designed in accordance with the relevant Guidance for Pollution Prevention (GPP) documents, including the following:

- GPP 1 Understanding your environmental responsibilities – good environmental practices;
- GPP 3 Use and design of oil separators in surface water drainage systems;
- GPP 18: Containing major spillages and firewater at industrial sites;
- GPP 22: Dealing with spills; and
- GPP 26 Safe storage - drums and intermediate bulk containers.

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 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 drainage system, areas of kerbing and any sub-surface pits/tanks. 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 existing 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) will be 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 Emissions

4.2.1 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.

The ERF would continue to 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 second 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.

As a result, particulates and the residual acid gases within the flue gas will be removed in the DCC. Therefore, actual emissions of acid gases and any substances in the particulate phase including metals and dioxins would be further abated. However, within the modelling it has been assumed that there will be no reduction in the concentrations of pollutants within the flue gas as a conservative worst case.

A stack height assessment has been undertaken, and this has identified that a stack height of 85m is deemed to be a suitable stack height for the CC facility. It is noted that the planning application has applied for a stack height of up to 95m in the event that detailed design indicates a taller stack is required. For the purposes of this EP application, the stack height being applied for is 85m and if a taller stack was required, a further variation to the EP would also be applied for.

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. 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 2: Expected worst case emissions concentrations

Parameter	Proposed emission limits
Ammonia	10 mg/Nm^3
Primary amine – MEA	5 mg/Nm^3
Secondary amine – DEA	0. 25 mg/Nm^3
Secondary amine – DMA	0.25 mg/Nm^3
Nitrosamines	2 µg/Nm^3
Nitramines	0.1 µg/Nm^3

Parameter	Proposed emission limits
Aldehydes	5 mg/Nm^3
Note: All emissions are expressed at reference conditions of dry gas, 11% oxygen, 273.15K, 101.3 kPa.	

A detailed Dispersion Modelling Assessment of the air quality impact of the Facility with the CC facility has been undertaken, refer to Appendix D. The Dispersion Modelling Assessment has concluded as follows:

1. *In relation to the impact on human health:*
    a. *Emissions from the operation of the CC facility will not cause a breach of any AQAL.*
    b. *There is predicted to be an increase in the impacts as a result of the operation of the CC facility. For all pollutants already emitted by the ERF, the change in impact can be screened out as 'insignificant', and the overall impact of the emissions from the CC facility is not significant.*
    c. *For additional products released from the CC facility such as amines, nitrosamines and nitramines the impact can either be screened out as 'insignificant' or is considered 'not significant' when baseline concentrations are taken into consideration.*
    d. *There are no likely significant cumulative effects from other local plans or projects.*
2. *In relation to the impact on ecologically sensitive sites:*
    a. *All impacts at local nature sites can be screened out as 'insignificant';*
    b. *The change in impact due to the operation of the CC facility and overall impact of emissions from the CC facility at the Dee Estuary designated site cannot be screened out for airborne ammonia impacts and nitrogen deposition impacts. Further assessment of the spatial extent of impacts and the sensitivity of the affected habitats has shown that no significant effects are likely.*
    c. *There are no likely significant cumulative effects from other local plans or projects.*

Through the commissioning process, enfinium will undertake monitoring of the treated flue gases generated by the CC facility to determine if it is appropriate to add or to refine the emission limits stated in Table 2.

4.2.2 Emissions to water or sewer

As explained in section 3.8, all process effluents generated by the CC facility will be treated for re-use within the installation. On this basis, there will be no emissions of process effluents discharged to water or sewer from the CC facility.

Uncontaminated surface water run-off from the CC facility will be discharged into the existing attenuation pond and combined with the surface water run-off from the CC facility.

In the event of an environmental incident/chemical spill within the CC facility, there will be a penstock valve to prevent potentially contaminated run-off being discharged into the attenuation pond and the contaminated run-off will be collected through the drainage system, areas of kerbing and any sub-surface pits/tanks.

4.2.3 Odour

The CC facility is not anticipated to introduce any additional risk of odour impacts to the installation.

4.2.4 Noise

The change in noise impacts associated with the installation of the CCP plant and the ERF has been assessed, and is provided in Appendix G. To support the development of the noise assessment modelling has been undertaken using the Soundplan modelling software.

The conclusions of the noise assessment are summarised as follows:

> *Operation of the proposed Parc Adfer CC facility would result in impacts of no or negligible magnitude at 'noise sensitive receptors' (NSRs), with highest Rating Levels at least 9 dB below the background sound level at all times. Consequently, significant adverse impacts would be very unlikely.*

4.3 Monitoring

4.3.1 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 from the CC facility is proposed 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, enfinium 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 and also any additional continuous monitoring requirements are required by NRW.

4.3.2 Emissions to water or sewer

All process effluents generated by the CC facility will be treated for re-use within the installation. On this basis, there will be no monitoring of point source emissions to water or sewer from the CC facility.

4.3.3 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.

4.4 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 CC facility will have the following heat and power demand:

- Heat: 25.2 MWth, with approximately 24.5 MWth for the re-boiler and 0.7 MWth for the Reclaimer.
- Power: 4.9 MWe of electrical power.

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 to supply steam to the CC facility. This will enable electrical energy to be generated which will improve the overall efficiency of the CC facility. 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 overall energy efficiency of the CC facility, and its interactions with the ERF, has been considered within the CHP Report, refer to Appendix B.

4.5 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 considered likely to be hazardous, in which case it will be disposed of at a suitably licenced waste management facility. The CC facility is expected to generate approximately 750 tonnes of waste from the Reclaimer per annum.

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

4.6 Site Condition Report

As stated previously, the CC facility will be located within the existing installation boundary. Therefore, it is not proposed to change the installation boundary with this application. However, it is noted that the implementation of the CC facility will introduce an additional regulated activity and additional chemicals being stored within the installation boundary. Taking this into consideration, an Addendum to the Site Condition Report is provided in Appendix H.

5 Post combustion capture technologies

The main types of post-combustion capture technologies currently being promoted by technology providers of CC systems include?:

1. chemical absorption;
2. adsorption;
3. membrane separation;
4. chemical-looping combustion;
5. calcium-looping; and
6. cryogenic separation.

For the purposes of this application, the available technologies have been considered, as follows.

5.1 Chemical absorption

In chemical absorption, a liquid sorbent, typically an amine-based solvent, is used to separate the CO_2 from the flue gas. The sorbent is then regenerated through a stripping or regeneration process by heating and/or depressurisation. The energy for regeneration is supplied by steam.

Chemical absorption using amine solvents is a well-established and proven technology having been implemented for a number of years in the oil and gas industry for the removal of CO_2 from raw natural gas.

A challenge of using amine-based solvent is amine degradation, resulting in solvent loss, equipment corrosion and generation of volatile degradation compounds. Furthermore, amine emissions can degrade into nitrosamines and nitramines, which if the process is not appropriately managed can result in elevated concentrations of these pollutants.

Chemical absorption is considered to be a proven technology on a commercial scale and represents BAT for the capture of carbon emissions from the Facility.

5.2 Adsorption

In an adsorption system, a solid sorbent is used to separate the CO_2 from the flue gas by binding the CO_2 onto its surface. Typical sorbents include molecular sieves, activated carbon, zeolites, calcium oxides, hydrotalcites and lithium zirconate. Chemical adsorption is considered to be a mature technology that is widely used in industries for the separation of gases.

Although the energy usage of adsorption systems is significantly lower, currently within the industry it is considered unlikely that solid adsorbent technology will be competitive against established liquid absorption systems due to the complexity of large-scale solids handling systems. In addition, although some of the solid sorbents being considered can be regenerated like liquid amines, over time as the efficiency of capture reduces, these substances will be classified as hazardous waste and would require specialist waste treatment prior to disposal.

Due to the nature and potential quantities of hazardous waste which would be produced by an adsorption system, it is not currently considered that adsorption is a suitable technology for the CC facility.

5.3 Membrane separation

Membrane separation can be used for selective separation of CO_2 from flue gases and from air. Therefore, membrane separation systems are considered to be versatile as they can be used for CO_2 removal in both pre and post combustion capture systems. Membrane separation has also been used to separate other gases such as O_2 from N_2.

The main operational problems associated with membrane separation include:

1. low fluxes;
2. fouling of the membranes from the particulates entrained in the flue gas stream; and
3. low stability on exposure to high temperature and pressure.

As the use of separating agents and phase changes are not needed in membrane systems, it has been projected that membrane separation technologies will have lower capital and operating costs compared to other separation technologies. However, although membrane technologies have been commercialised for gas separation processes such as air separation and natural gas sweetening, CO_2 separation membranes are currently considered to be at pilot scale, with several types of membranes being trialled at power plants in Europe.

Due to the unproven nature of membrane separation systems, enfinium does not currently consider that membrane separation is a suitable technology for the CC facility.

5.4 Chemical-looping combustion

Chemical looping combustion (CLC) is an indirect combustion process in which fuel is combusted without direct contact with air. Unlike oxyfuel combustion, a solid metal oxide is used as an O_2 carrier instead of pure O_2. CLC technologies are currently under development and there are no facilities operating at a scale to enable enfinium to consider that they are a proven technology.

Due to the unproven nature of CLC technologies, it is not currently considered that they are a suitable technology for the CC facility.

5.5 Calcium-looping

Calcium-looping utilises the reversible chemical reaction between calcium oxide (CaO) and CO_2 in order to capture CO_2 from the gas stream. The chemical reaction is then reversed into CaO and CO_2 in a calciner. CO_2 capture in a carbonator occurs at a temperature of around 650°C and calcination reaction occurs at a temperature of 950°C.

The high temperatures required for the adoption of calcium-looping would require a very high energy input, and/or potentially significant re-design of the existing waste incineration process to be implemented at the Facility.

enfinium understands that calcium looping has been proposed as a key route for decarbonisation of both the power generation and the cement sector and there is a small-scale demonstration project in Italy. However, due to the unproven nature of the calcium-looping technology on a commercial scale, it is not currently considered that it is a suitable technology for the CC facility.

5.6 Cryogenic separation

Cryogenic distillation is a gas separation process using distillation at very low temperature and high pressure based on the different boiling points of the components within the flue gases. For CO_2 separation, flue gases containing CO_2 are cooled to the de-sublimation temperature (- 100°C to

- 135°C), the solidified CO_2 is separated from other light gases and then compressed at a high pressure. Whilst cryogenic distillation can recover up to 95% of the CO_2 in the flue gas, as distillation is conducted at extremely low temperature and high pressure the energy demand to capture the CO_2 is very high and would require the installation of a separate power station to supply the heat and power required to operate the cryogenic separation system.

Due to the very high energy demands for cryogenic distillation, it is not currently considered that it is a suitable technology for the CC facility.

6 Management arrangements

enfinium'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 extending the EMS to include the CC facility:

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

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 enfinium 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 NRW upon request.

6.1 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 for the CC facility. In addition, management will undertake inspections and reviews for quality control, performance measurements, and staff appraisals.

6.1.1 Scope and structure

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

- the design and development of the CC facility;
- the operation of the CC 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 Defra guidance '*Develop a management system: environmental permits*'. This will be in the form of an accident management plan that will be developed for the Facility.

6.1.2 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.

6.1.3 Site operations

Following implementation of the CC facility, the installation will be an Energy Recovery Facility with carbon capture, with the main activity being the incineration of non-hazardous waste to recover energy.

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 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.

6.1.4 Site plan(s)

Following completion of detailed design, the EMS will include for detailed layout and process 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 Defra 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);
- 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.

Site plans (including an emissions point and installation boundary drawings; and a process flow diagram for the carbon capture process) are presented within Appendix A.

6.1.5 Storage of waste and other residues/wastes

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

6.1.6 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 Defra 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.

6.1.7 Personnel

enfinium 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 associated with the operation of the CC facility will be extended to the following roles within the ERF:

- The Plant Manager for each component at the site will have overall responsibility for management of the ERF and CC facility and compliance with all aspects of the EP. The Plant Manager will have extensive experience relevant to their responsibilities.
- The Operations Manager will have day-to-day responsibility for the operation of each component, to ensure that the ERF and CC facility are 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 Maintenance Manager will be responsible for the management of maintenance activities, for maintenance planning and for ensuring that the ERF and CC facility is operated in accordance with its design.
- The Health and Safety (H&S) manager will be responsible for environmental and health and safety at the ERF and CCfacility, including compliance with the EP.

The majority of employees which will be recruited to operate the CC facility will include skilled operatives (electricians/fitters) or technical engineers (control and plant).

6.1.8 Competence, training and awareness

enfinium will 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. enfinium will comply with industry standards or codes of practice for training, where they exist. The EMS will contain a procedure for archiving training records to ensure all training records are retained throughout the lifetime of the EP.

6.1.8.1 Competence

enfinium will identify the minimum competencies required for each role associated with the operation of the CC facility. 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.

6.1.8.2 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.

6.1.8.3 Training

enfinium 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.

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

6.1.9 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, NRW, HSE, etc.)

6.1.10 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 installation. The proposed accident management and contingency plans presented within the sections above will include for relevant climate change impacts.

6.1.11 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 installation.

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

- the EP;
- other legal requirements;
- 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.

6.1.12 Review of management systems

As per the existing EMS arrangements, it 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.

6.1.13 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).

NRW will be provided with a copy of the EMS (or relevant parts thereof) if requested.

6.1.14 Complaints

enfinium has a complaints procedure to record any complaints received in relation to activities covered by the EP which forms part of the existing EMS. The procedure includes details on how complaints are investigated, and any actions to be taken following complaints.

6.2 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;
- procedures for the receipt and handling of chemicals and raw materials;
- waste storage and handling procedures;
- copies of any guaranties/warranties/certificates; and

- health and safety procedures.

7 BAT Guidance Review

7.1 Post-combustion CO_2 Capture BAT Guidance

The latest published Best Available Techniques (BAT) guidance for post-combustion CO_2 capture[1] is dated March 2024 and applies to waste incineration plants, such as the ERF. Sections 7.1.1 to 7.1.14 explain how the design of the CC facility complies with the requirements of the guidance.

7.1.1 Power plant selection and integration with the CC facility

The primary purpose of the ERF is to treat waste, and it needs to be able to be operated continuously. The CC facility has been designed to fully integrate with this design basis and is able to operate continuously, and allow for turndown of the ERF.

Prior to the implementation of the CC facility, the electrical efficiency of the ERF has been optimised with the export of power to the national grid.

The CHP Report contained in Appendix B, demonstrates that the ERF is in accordance with the electrical efficiency requirements of the BAT Associated Energy Efficiency Limits (AEELs).

Furthermore, as presented in the CHP Report, the heat and power required for the operation of the CC facility will typically be 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.

7.1.2 CC facility design and operation

In normal operation, the CC facility has been designed to capture approximately 95% of the CO_2 in the flue gas from the ERF.

7.1.3 Solvent selection

As explained in section 3.3, it is proposed to use an MEA based solvent within the CC process. MEA is a proven solvent for the capture of CO_2, and information on how it reacts in the atmosphere and any subsequent degradation products has been published in various sources including the UKCCSRC in its report titled '*Evidence Review of emerging techniques for Carbon Dioxide Capture Using Amine-Based and Hot Potassium Carbonate Technologies under the IED for the UK*'[2], dated March 2024; and the CERC report titled '*Improving Post-Combustion Carbon Capture Air Quality Risk Assessment Techniques*'[3], dated May 2024.

7.1.4 Features to control and minimise atmospheric and other emissions

The Parc Adfer ERF includes a flue gas cleaning system to control and minimise emissions from the combustion of waste prior to the flue gases being passed to the CC facility. The flue gas cleaning systems include:

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[1] EA (2024) Guidance: Post-combustion carbon dioxide capture - emerging techniques, Emerging techniques on how to prevent or minimise the environmental impacts of post-combustion carbon dioxide capture.
Available at https://www.gov.uk/guidance/post-combustion-carbon-dioxide-capture-best-available-techniques-bat

[2] https://ukccsrc.ac.uk/wp-content/uploads/2024/03/ER-for-PCC_v4_4_power_EfW_industry_b.pdf

[3] https://ukccsrc.ac.uk/wp-content/uploads/2024/05/CERC_2024_Improving_Post-Combustion_Carbon_Capture_Air_Quality_Risk_Assessment_Techniques.pdf

- an SNCR system to abate NOx;
- a dry lime dosing system to abate acid gases;
- activated carbon dosing to abate volatiles; and
- bag filters to abate particulates.

The flue gas treatment and monitoring systems will ensure that emissions of these pollutants are not passed to the CC facility resulting in the significant degradation of the amine solvent or the creation of aerosols.

The design of the CC facility includes the following steps to minimise emissions released to atmosphere from the process:

- a caustic wash within the DCC for removal of acid gases; and
- an acid wash prior to release to atmosphere from the absorber column for the abatement of amines, ammonia and other basic species.

The stack height for the CC facility has been optimised. The stack height proposed (85 m) has shown that the impact on air quality of the CC facility is not significant, refer to Appendix D and section 4.3.1.

7.1.5 Process and emissions monitoring

As detailed within sections 4.3.1 and 4.3.3, the CC facility will include a series of measures to monitor the emissions to air and process. This will include for monitoring of the flue gases from the ERF prior to them being treated within the CC facility to demonstrate compliance with the existing emission limits.

A range of methods of monitoring the process will be carried out as set out in section 4.3.3. Where appropriate, monitoring will meet the MCERTS standards, and external laboratories utilised to undertake monitoring/analysis will be UKAS accredited.

7.1.6 Unplanned emissions to the environment

During normal operation the captured CO_2 will be exported from the site via pipeline for offshore sequestration. However, there will be operational scenarios where the captured CO_2 cannot be exported. In such scenarios the captured CO_2 will be vented to atmosphere.

The proposed design of the CC facility includes a CO_2 vent header system. In all scenarios which will require venting of CO_2, all CO_2 within the CC facility will be directed to the header and then to the CO_2 vent stack. It is proposed that the CO_2 vent release point will be at the top of the 85 m stack for the CC facility. High-pressure CO_2 vent pipework may require heating to compensate for the temperature drop on expansion as CO_2 pressure reduces.

The CO_2 Venting Strategy for the CC facility, is provided in Appendix F.

7.1.7 Capture level, including during flexible operation

As detailed within section 1.1, the CC process is designed to capture approximately 95% of the carbon dioxide generated by the ERF.

During periods of start-up and shutdown of the ERF, the CC facility will not capture CO_2 as there will not be sufficient heat and power required to operate the CC facility.

When the ERF has completed the start-up sequencing and it is in stable operation, the flue gases will be diverted to the CC facility and the CO_2 capture process will be commenced.

The CC facility is designed to operate within the full operating window, as presented in the firing diagram for the ERF.

7.1.8 CO_2 Compression

Detailed CO_2 compression design will be developed by the EPC contractor during the FEED and design stages of the project. At this stage, it is assumed that the compressor will be of a 3-stage design with intercoolers and liquid knockout drums/vessels.

7.1.9 Noise

A Noise Assessment is provided in Appendix G. The conclusions of the noise assessment are summarised as follows:

> *Operation of the proposed Parc Adfer CC facility would result in impacts of no or negligible magnitude at 'noise sensitive receptors' (NSRs), with highest Rating Levels at least 9 dB below the background sound level at all times. Consequently, significant adverse impacts would be very unlikely.*

7.1.10 Odour

Under normal operation, the CC facility is not anticipated to result in additional odour impacts. Therefore, this application has not considered any change in odour associated with the operation of the CC facility.

7.1.11 Planned and emergency venting of CO_2

The expected scenarios for venting of CO_2 have been considered within the venting strategy, refer to Appendix F.

7.1.12 Cooling systems

The options for cooling include:

- once through water cooling systems;
- air cooled condensers; and
- hybrid cooling systems.

Cooling provision within the DCC will be provided through the use of a hybrid cooling system. The hybrid evaporative condensers require a make-up/feedwater, and the condensate which condenses in the DCC can be re-used for this purpose, following treatment. The re-use of this effluent enables the CC facility to be zero-discharge.

Wet cooling systems require a large volume of water. Whilst the River Dee is located approximately 1.5km from the installation, to extract water for cooling and discharge the used water back to the River Dee would require pipework which is significantly longer than this and would be very expensive. For this reason a wet cooling system is not considered to represent BAT for the CC facility.

Hybrid cooling systems are more energy efficient and less noisy than conventional air cooled condensing systems. Due to the high energy efficiency associated with hybrid systems, and the fact that they can be designed to achieve zero discharge to surface water or sewer, they are considered to represent BAT for the cooling systems.

7.1.13 Discharges to water

Surface water run-off from building roofs and areas of vehicle movement within the CC facility will be discharged to water as 'uncontaminated surface water run-off'. A penstock valve will be installed on the surface water drainage system to enable the surface water system to be isolated to prevent discharges to the existing surface water in the event of an incident, such as a chemical spill or a fire.

The CC facility has been designed as a 'zero-discharge' facility. The condensate from the direct contact coolers will be treated within the effluent treatment plant prior to use within the hybrid cooling system; and the reject effluent from the water treatment plant will be transferred to the ERF for re-use within the ash quench.

7.1.14 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. The design of the CC facility is currently being developed such that adaptation to potentially changing climate change impacts will be considered within the design, and will include, but not be limited to the following:

- Increased ambient temperatures – the CC facility will be designed to operate within a range of ambient temperatures which will include allowances for projected increases in ambient temperatures as a result of climate change.
- Increased flood events – the development platform for the CC facility will be set at a height which is above the flood level.
- Increased rainfall events – the surface water management and runoff attenuation capacity includes an appropriate uplift for peak rainfall intensity

7.2 BAT for the water treatment plant

The water treatment plant is not regulated as a schedule 1 'installation activity' as it is treating the condensate generated by the CC facility for re-use. However, 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 3: 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 environmental management system (EMS) has already been implemented by enfinium for the ERF. The EMS will be extended to include the operation of the CC facility, refer to section 6. On this basis, it is considered 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 wastewater and waste gas streams will be developed as 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, it is considered 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, it is considered 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 will be no emissions to water from installation facility, as process effluents are treated and/or re-used within the installation. Therefore, it is considered that the water treatment plant is in accordance with BAT 4.
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, it is considered 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, it is considered 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 and reduce the consumption of main water within the CC facility. On this basis, it is considered that the design of the effluent 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 sections 3.8 and 3.9, surface water run-off from the CC facility will be collected separately to the process effluents generated by the CC facility. On this basis, it is considered that the drainage design for the CC facility is in accordance with BAT 9.
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).	A process water tank to collect DCC condensate prior treatment within the effluent treatment plant will provide buffer storage. On this basis, it is considered 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 wastewater streams within the installation is in line with the BAT requirements. On this basis, it is considered 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.	As explained in section 3.8, the effluent treatment plant has been designed to enable all process effluents generated by the CC facility to be re-used within the installation. On this basis, it is considered that the design of the effluent treatment plant is in accordance with BAT 11.

#	BAT Requirement	How met or reference
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.	As set out in section 3.8, the design of the effluent treatment plant includes a reverse osmosis stage, referred to as filtration within BAT 12. On this basis, it is considered that the design of the water treatment plant is in accordance with BAT 12.
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.	enfinium can confirm that it has an existing a waste management plan as part of its EMS. The design of the effluent treatment plant will enable effluents generated by the CC facility to be re-used within the installation. On this basis, it is considered 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.	As set out in section 3.8, the design of the effluent treatment plant includes a reverse osmosis stage, referred to as filtration within BAT 12. On this basis, it is considered that the design of the water treatment plant is in accordance with BAT 12.
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 will be no fugitive or point source emissions to air from the effluent treatment plant. Therefore, it is considered 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 will be no fugitive or point source emissions to air from the effluent treatment plant. Therefore, it is considered 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 will be no fugitive or point source emissions to air from the effluent treatment plant. Therefore, it is considered 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 will be no flaring of emissions from the effluent treatment plant.

#	BAT Requirement	How met or reference
		Therefore, it is considered that the requirements of BAT 18 are not applicable.
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 will be no fugitive or point source emissions to air from the effluent treatment plant. Therefore, it is considered 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.	As explained in section 4.2.3, the CC facility, which includes the effluent treatment plant, is not anticipated to introduce any additional risk of odour impacts to the installation. enfinium already has controls in place for the management of odour for the ERF in the event that complaints were to be received. These will be extended to include the operation of the CC facility and the effluent treatment plant, if required. On this basis, it is considered that the operation of the effluent 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, it is considered 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.	As explained in section 4.2.4, the CC facility, which includes the effluent treatment plant, is not anticipated to introduce any unacceptable noise impacts from the installation. The noise assessment provided in Appendix G has demonstrated that the operation of the CC facility will not result in '*significant adverse impacts*'. enfinium has controls in place for the management of noise from the installation in the event that complaints were to be received. These will be

#	BAT Requirement	How met or reference
		extended to include the operation of the CC facility and the effluent treatment plant, if required. On this basis, it is considered that the operation of the effluent 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 G. As concluded within the noise assessment, the noise impacts associated with the operation of the CC facility will not result in '*significant adverse impacts*'. On this basis, it is considered that the design of the effluent treatment plant is in accordance with BAT 23.

Appendices

A Plans and drawings

B CHP Report

C Environmental Risk Assessment

D Dispersion Modelling Assessment

E Dioxin Pathway Assessment

F CO_2 Venting Strategy

G Noise Assessment

H Addendum to the Site Condition Report

I MSDS for MEA solvent

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