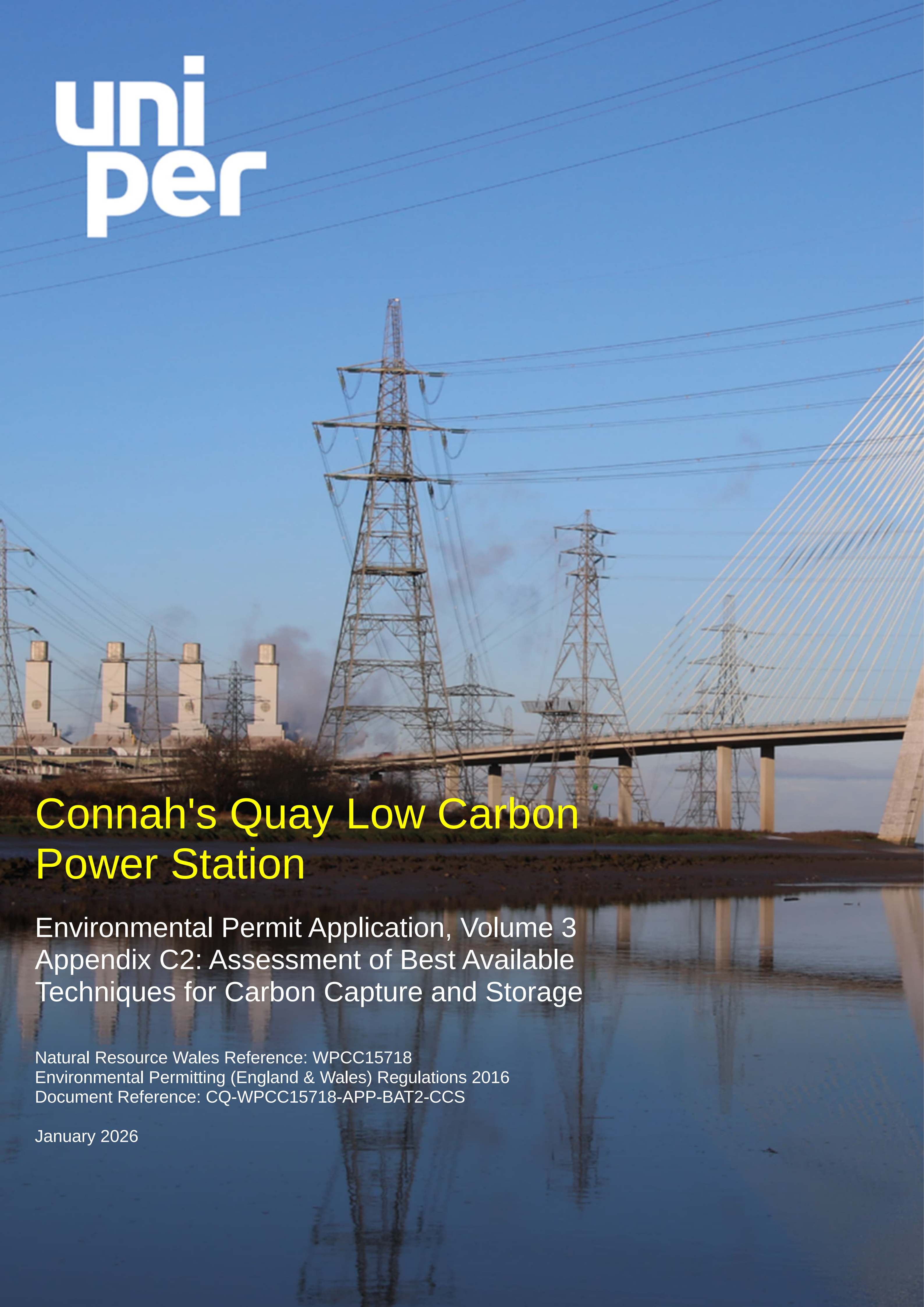

Connah's Quay Low Carbon Power Station

Environmental Permit Application, Volume 3 Appendix C2: Assessment of Best Available Techniques for Carbon Capture and Storage

Natural Resource Wales Reference: WPCC15718
Environmental Permitting (England & Wales) Regulations 2016
Document Reference: CQ-WPCC15718-APP-BAT2-CCS

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Glossary

Abbreviation	Term
ADMS	Atmospheric Dispersion Modelling System
AEELs	Associated Energy Efficiency Levels
AELs	Associated Emission Levels
AEP	Annual Exceedance Probability
AGI	Above-Ground Installation
AMP	Accident Management Plan
AN	Absolute Non-hazardous
AoD	Above Ordnance Datum
AQAL	Air Quality Assessment Levels
ASME PTC	American Society of Mechanical Engineers Performance Test Codes
BAT	Best Available Techniques
BAT AEL	Best Available Technique-Associated Emission Level
BAT-AEEL	Best Available Technique Associated Energy Efficiency Level
BATc	Best Available Technique Conclusions
bgl	Below Ground Level
BGS	British Geological Survey
BRef	Best Available Techniques Reference Document
BS ISO	British Standards (BS) Versions of International Organization for Standardization (ISO) Standards
BS EN	British Standard (BS) Implementations of European Standards (EN)
CBM	Condition-Based Maintenance
CCGT	Combined Cycle Gas Turbine
CCP	Carbon Capture Plant
CCS	Carbon Capture Storage
CEMP	Construction Environmental Management Plan
CEMs	Continuous Emissions Monitors
CHP	Combined Heat and Power
C&IEA	Construction and Indicative Enhancement Area
CM	Corrective Maintenance
COO	Chief Operating Officer
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoPC	Contaminants of Potential Concern
CQPS	Connah's Quay Power Station
CSM	Conceptual Site Model
DAHS	Data Acquisition and Handling System
DCC	Direct Contact Cooling
DCO	Development Consent Order

DCS	Distributed Control System
DLN	Dry Low-Nox
DPA	Dispatchable Power Agreement
ECP	Environmentally Critical Plant
ELV	Emission Limit Value
EMS	Environmental Management System
ENI	Operator of the CO_2 transport and storage network.
EPR	Environmental Permitting Regulations
EQS	Environmental Quality Standards
ES	Environmental Statement
ESOS	Energy Savings Opportunity Scheme
FCC	Flintshire County Council
FEED	Front-End Engineering Design
FEH	Flood Estimation Handbook
g	Gram
GC	Gas Chromatograph
GIS	Geographic Information System
GMIs	Generation Management Instructions
GT	Gas Turbine
GTP	Gas Treatment Plant
GW	Gigawatt
ha	hectare
HP	High Pressure
HRSGs	Heat Recovery Steam Generators
HSSE	Health, Safety, Security, Environment
HVO	Hydrotreated Vegetable Oil
IED	Industrial Emissions Directive
IP	Intermediate Pressure
ISO	International Organization for Standardization
Keq	Kiliequivalent
kg	Kilogram
km	Kilometre
kV	Kilovolt
kW	Kilowatt
LCP	Large Combustion Plant
LEL	Lower Explosive Limits
LHV	Lower Heating Value
LNB	Low NOx Burners
LoW	List of Waste
LP	Low Pressure
LWS	Local Wildlife Sites
m	Meters
m^3	Cubic Meter

MCERTs	Monitoring Certification Scheme
MCP	Medium Combustion Plant
MH	Mirror Hazardous
MSDS	Material Safety Data Sheet
MSUL	Minimum Start-Up Load
MW	Megawatt
MWe	Megawatt Electrical
MWth	Megawatt Thermal
N_2	Nitrogen
NGET	National Grid Electricity Transmission Plc
NH_3	Ammonia
Nm^3	Normal Cubic Meter
NOx	Oxides of Nitrogen
NRW	Natural Resources Wales
NTS	National Transmission System
NVZ	Nitrate Vulnerability Zones
O_2	Oxygen
OEM	Original Equipment Manufacturer
OTNOC	Other Than Normal Operating Conditions
PAH	Polycyclic Aromatic Hydrocarbons
PC	Process Contributions
PCB	Polychlorinated Biphenyls
PCC	Post Combustion Carbon Capture
PdM	Predictive Maintenance
PFA	Paraformaldehyde
PEIR	Preliminary Environmental Information Report
PM	Preventive Maintenance
RAMS	Risk Assessment and Method Statement
SAC	Special Area of Conservation
SAP	Systems, Applications, Products
SCR	Selective Catalytic Reduction
SECR	Streamlined Energy and Carbon Reporting
SOx	Sulphur Oxides
SPA	Special Protection Area
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
ST	Steam turbine
SuDS	Sustainable Drainage Systems
SVOC	Semi-Volatile Organic Compounds
TBC	To Be Confirmed
Te/Yr	Temperature Element per Year
T&S	Transport and Storage
TPH	Total Petroleum Hydrocarbons

UK	United Kingdom
VOC	Volatile Organic Compounds
WEEE	Waste Electrical and Electronic Equipment
WFD	Water Framework Directive
WWTP	Waste Water Treatment Plant

1. Report Context

1.1 Introduction

This report has been prepared by AECOM Limited ('AECOM') on behalf of Uniper UK Limited referred to as "the Operator", in support of a new bespoke Environmental Permit application for the proposed Connah's Quay Combined Cycle Gas Turbine (CCGT) with Carbon Capture Plant (CCP) ("Proposed Installation").

The purpose of this report is to demonstrate that the Proposed Installation will be designed and operated in accordance with indicative best available techniques (BAT) for post-combustion carbon dioxide (CO_2) capture.

1.2 Proposed Installation

The design of the Proposed Installation is subject to ongoing technical studies, to provide flexibility and to align with the current grid connection, but it is expected to comprise the development of up to two CCGT units achieving a net electrical output capacity of up to 1,380 megawatts (MW; referred to as MWe for electrical output) (with CCP operational) onto the national electricity transmission network.

The Proposed Installation will generate electricity from combustion of natural gas within a CCGT. Hot exhaust gas from the combustion process will be used to drive the gas turbine (GT), and steam which will be generated from the heat of the exhaust gas, in the heat recovery steam generator (HRSG), will be used to drive the steam turbine (ST). The exhaust gas will then pass through pre-treatment stages including selective catalytic reduction (SCR) using ammonia (NH_3) to reduce oxides of nitrogen (NOx) in the gas and subsequently cooled via a direct contact cooler (DCC), in the CCP. The CCP will use an amine-based solvent to absorb carbon dioxide (CO_2) from the exhaust gas within a packed column (absorber), via a weak acid-base reaction. The CO_2-depleted exhaust gas then passes through water and acid wash sections and is released to atmosphere via an absorber emissions stack. Continuous Emissions Monitoring System (CEMs) equipment will be located within the stack to monitor pollutants to air.

The CO_2-rich solvent exits the absorber, and passes through a lean/rich heat exchanger, and then into the desorber. The CO_2 is liberated from the solvent by heat, supplied by low pressure steam from the HRSG in normal operation. This steam is supplied to the desorber reboiler. The now lean/rich solvent will be recirculated within the plant. The CO_2 rich vapour exits the top of the desorber, and passes through a reflux stage to maximise solvent-CO_2 separation. The CO_2 vapour is conditioned to reduce water and oxygen to the transport and storage network's specifications, after entering a low pressure compressor to compress the gas to the export pipeline pressure (8-43 Bara). The CO_2 is then metered and exported to the transport and storage network's CO_2 pipeline which is operated by ENI. The solvent will accumulate impurities over time, and these will be removed via a solvent reclaiming process which will be a thermal process, either continuously via a slipstream or as a batch process.

The CCP emissions will be residual pollutants from the combustion and treatment processes, including NOx, (NH_3 and carbon monoxide (CO). The CCP will be designed to capture a minimum of 95% of the CO_2 emissions from the CCP as an annual average of all normal operating conditions. There may also be trace pollutants within the flue gas, including trace levels of solvent and solvent break-down products from within the process. Emissions will be minimised using the water and acid wash steps on the absorber and monitored at the emission point within the abated flue gas stack prior to release. In addition to the CCP emission point, there will be an intermittent-use emission point from the stack, serving the HRSG exhaust. Emissions from the CCP emissions stack, and HRSG stack will meet the emission limits for LCP under the Industrial Emissions Directive (IED).

Other supporting infrastructure and plant to the Proposed Installation will include the storage of solvent, caustic soda, sulphuric acid and water-treatment chemicals, demineralisation water treatment plant to produce high-purity water for use in boilers, blending, closed loop cooling and other processes. It will include an electric auxiliary boiler for start-up and dispatchability support, emergency diesel generators for safe-shutdown during a power failure scenario, closed surface water drainage and appropriate treatment facilities, and infrastructure for natural gas import and conditioning and CO_2 conditioning and export. The number and thermal rating of the emergency generator(s) will be determined during detailed design and will be classed as medium combustion plant (MCP).

The Proposed Installation will also be supported by natural gas supply, existing potable water supply, existing water abstraction and discharge, electrical connections, utilities, access works and CO_2 export connection. The water abstraction for the Proposed Installation's cooling system will be in line with the extraction at the existing Connah's Quay Power Station and is not expected to exceed the current abstraction permit requirements. Process water and/or waste water from the site will also be discharged to the existing Connah's Quay Power Station lagoon before being purged into the River Dee.

The Proposed Installation will make use of CO_2 transport and storage networks owned and operated by Liverpool Bay CCS Limited, currently under development as part of the HyNet Carbon Dioxide Pipeline Project (referred to as the 'HyNet CO_2 Pipeline Project'), which will transport CO_2 captured from existing and new industries in North Wales and North-West England, as well as from new hydrogen production facilities that are proposed as part of HyNet North West Project. The captured CO_2 will be stored in depleted offshore gas reservoirs in Liverpool Bay.

A high-level process flow diagram for the Proposed Installation is provided in Volume IV of the permit application.

The Proposed Installation will be designed to optimise the capture of CO_2 operating in dispatchable mode, while minimising emissions and waste generation and maximising energy efficiency. Best Available Techniques (BAT) assessments have been prepared to demonstrate the Proposed Installation will be design and operated in accordance with BAT for Large Combustion Plant (LCP), Energy Efficiency (EE), Post-Combustion Carbon Capture (PCC) plant design and Cooling.

1.3 BAT Considerations

This BAT assessment has been prepared using concept engineering information provided by the Operator related to the initial design parameters of the Proposed Installation, available information about the local environment, the draft BAT conclusions from the Environment Agency technical working group on Carbon Capture and Storage (CCS)[1] and the emerging techniques guidance on post combustion carbon dioxide capture from the UK Government[2].

The main application document ('Supporting Statement') (Document reference: WPCC15718-APP-SS) provides an overall view of the permit application being made for the installation. Separate BAT assessments have been prepared for the LCP CCGT technology and operation, the energy efficiency of the installation and also the choice of cooling technique for the installation.

This document should be read in conjunction with the Supporting Statement (Document reference: WPCC15718-APP-SS). A detailed description of the operations to be undertaken at the Proposed Installation and how it will be operated is provided in Section 4 of the Supporting Statement and has not been included here to avoid repetition.

This document only covers the assessment of the selection and operation of the CCP plant against the BAT techniques identified in the PCC emerging techniques guidance. For assessment of BAT for carbon capture, energy efficiency and cooling please refer to the separate assessments:

- BAT Assessment for Large Combustion Plant (Appendix C1; Document Reference WPCC15718-APP-BAT1-LCP).
- BAT Assessment for Energy Efficiency (Appendix C3; Document Reference: WPCC15718-APP-BAT3-EE).
- BAT Assessment for Cooling (Appendix C4; Document Reference: WPCC15718-APP-BAT4-COOL).

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[1] J.Gibbins, UKCCS (2024) Evidence Review of emerging techniques for Carbon Dioxide Capture Using Amine-Based and Hot Potassium Carbonate Technologies under the IED for the UK, Ver.4.4, March 2024. Accessed at: https://ukccsrc.ac.uk/best-available-technology-bat-information-for-ccs/ (28/05/2025)

[2] Environment Agency (2021) Guidance- Post-combustion carbon dioxide capture: emerging techniques. Updated 27 March 2024. Accessed at: https://www.gov.uk/guidance/post-combustion-carbon-dioxide-capture-best-available-techniques-bat (29/05/2025)

2. Approach to BAT Appraisal

Article 3 (10) of the Industrial Emissions Directive (IED)[3] defines BAT as "the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where not practicable, generally reduce emission and impact on the environment as a whole".

The Directive continues to provide further definition as follows:

- "available techniques" are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages, whether or not the techniques are used or produced inside the United Kingdom, as long as they are reasonably accessible to the Operator.
- "best techniques" are the most effective in achieving a high general level of protection of the environment as a whole.
- "techniques" are both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

BAT may be demonstrated by either:

- compliance with the sector-level, indicative BAT performance such as Sector Guidance Notes provided by the Environment Agency or in the European Commission 'Reference Documents on BAT' (BRefs) and their associated BAT conclusions; or
- by conducting an installation-specific, options appraisal of candidate techniques.

The indicative BAT provided in the European BRef/BAT Conclusion documents is based on an analysis of the costs and typical benefits for typical, or representative, plants within that sector. When assessing the applicability of the sectoral, indicative BAT standards at the installation level, departures may be justified on the grounds of the technical characteristics of the Proposed Installation concerned, its geographical location and the local environment.

2.1 Site Specific Consideration of BAT

At this early stage of development from concept to full scale operational plants, and in recognition of the novel technology associated with the CCP, there is a need to apply a 'technology-neutral' approach within the derivation of BAT. This is driven by the combined requirements:

- of the carbon capture Technology Licensors requiring commercial confidentiality of their process and solvent blend to be maintained;
- to allow the Front-End Engineering Design (FEED) process to progress post consent without limiting the options for later technology selection; and
- to determine indicative BAT and BAT-Achievable Emission Levels (AELs) for plant within this development stage such that they are consentable, taking into account environmental sensitivities and conditions at a particular site, with site-specific BAT assessments for choice of solvent and technology to be undertaken at the detailed design stage.

At the time of writing, there are currently two competitive FEED designs under consideration by the Applicant. Therefore, we have approached the appraisal of BAT by considering:

- the information available from each Technology Licensor with respect to its proposed capture process;
- a technology neutral approach where technology specific information is not yet developed; and

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[3] European Parliament and Council of European Union, November 2010, Directive 2010/75/EU on Industrial Emissions (Integrated Pollution Prevention Control)

- assessment of a worst-case emissions profile for each Technology Licensor.

The design of the Proposed Installation will continue to be refined until the completion of the detailed design stage. A number of the design aspects and features of the Proposed Installation cannot be confirmed until the Principal Contractor(s) have been appointed. Wherever an element of flexibility is maintained, a worst-case scenario has been considered.

Uniper will confirm the final technology selected as part of Permit pre-operational conditions.

The approach to BAT has been agreed with Natural Resource Wales (NRW) during the pre-application discussions.

3. Carbon Capture Plant Process Description

3.1 Carbon Capture Technology

Post-combustion carbon capture (PCC) removes CO_2 from the exhaust stream of a conventional combustion process using an amine-based chemical absorption technology. The CO_2 is typically present in the flue gas composition at 3-15% (depending on the process and ratio of fuel to air), with nitrogen (N_2) as the main constituent of the gas. e.g.

- Flue gas from a gas fired power station is circa 4-7% CO_2
- Flue gas from a coal fired power station is circa 12% CO_2
- Flue gas from other processes e.g. reformer can be up to 15-20% CO_2

The selection of Original Equipment Manufacturer (OEM) for the CCGT plant and the Technology Licensor for the CCP have not yet been made at this competitive FEED stage. Both FEED technologies will, however, use amine-based PCC which will remove CO_2 from the exhaust stream of a conventional combustion process using amine-based chemical absorption technology.

Chemical absorption of CO_2 is the most commercially proven method due to considerable experience with the process in the crude oil refining, gas treating and sulphur recovery industries.

The selection of the OEM for the CCGT plant and the Technology Licensor for the CCP have not yet been made at this competitive FEED stage. However, data from both FEED contractors and their respective OEMs and Technology Licensors has been used in the preparation of process flow diagrams and outline heat and mass balance, in order to identify maximum operating parameters and emissions.

The PCC plant design will be provided by the Technology Licensor and therefore the design described below may be subject to minor amendments.

3.1.1 Flue Gas Pre-Treatment

3.1.1.1 Sulphur Dioxide and Particulate Matter

Combustion of natural gas is highly efficient and due to the nature of the fuel, the combustion gases from a typical CCGT plant contain negligible amounts of sulphur dioxide (SO_2) and particulate matter. Abatement of these species therefore is not considered to be necessary either for the purpose of solvent efficiency, or for minimisation of emissions to air.

3.1.1.2 Oxides of Nitrogen

The LCP BRef includes a requirement for NOx emissions from new CCGT plant >50 MW to be at or below a BAT-AEL annual average of 30mg/Nm^3 and a daily average of 40mg/Nm^3.

The optimisation of combustion within a GT is well understood, such that the NOx and CO are carefully integrated through the FEED design and typically controlled through the implementation of primary control measures such as burner design and staged combustion.

Most (but not all) OEMs of GTs have indicated that the required BAT-AELs can be achieved by means of primary abatement measures such as Dry Low NOx burners alone, however NO_2 can preferentially react with the amine solvent within the CCP, causing degradation of the solvent, and therefore more solvent is required to replenish.

As such, at this stage of technology design, additional abatement of NOx is required to minimise potential for oxidative solvent degradation in the CCP. Therefore, SCR based on NH_3 injection has been included on the CCP (abated operation mode) to remove NOx that would otherwise preferentially react with the amine solvent. When the plant is operating in unabated mode the exhaust from the HRSG will be through the HRSG bypass stack and no SCR will be used.

The level of NOx removal required is therefore the subject of on-going technical studies and will be partially dependent upon the sensitivity of the Technology Licensor's solvent to NO_2. These studies will seek to optimise the operation of the Proposed Installation in order to maximise efficiency and minimise emissions and waste.

3.1.1.3 Exhaust Gas Cooling

The exhaust gas (< 100°C) will be cooled in a DCC or exhaust gas quencher to condition the gas to the minimum necessary temperature (circa 32-42°C) for the absorber. The exhaust gas contacts a fine water spray in a packed column to cool it to the required temperature. The conditioned gas then passes to a counter flow absorption column for absorption of CO_2.

3.1.1.4 Booster fan

A booster fan will be employed to overcome the pressure loss through the flue gas path to the CCP stack, this may be located either upstream or downstream of the DCC depending on the technology selection. The backpressure imposed by the CCP on the exhaust from the HRSG of a modern H-class CCGT would be approximately 120 - 140mbar. Backpressure is the main issue for compatibility between the CCGT and CCP. The main constituents creating this pressure drop are expected to be, in order of significance:

- CCP Absorber column(s); and
- Direct-Contact Cooler column.

The conditioned flue gas then passes to a counter flow absorption column for absorption of CO_2.

3.1.2 Flue Gas Absorption

The actual CCP design will be provided by the Technology Licensor selected and therefore the details described below may be subject to amendments.

The cooled flue gas will be fed to the bottom of the packed section of the absorber. Lean solvent at a temperature of circa 40°C, will be fed to the top of the absorption section and contacts the exhaust gas. The acid-base reaction between the CO_2 present in the flue gas and the solvent will cause the absorption of CO_2 into the liquid phase. The equilibrium limit for this reaction is reached at the absorber top where the leanest solvent contacts the exhaust gas with minimum CO_2 concentration. The overall carbon capture efficiency will be determined by calculating the CO_2 generated based on fuel gas data and the quantity of CO_2 exported to the transmission and storage network.

The treated exhaust gas (CO_2-lean gas) then exits the top of the absorber and passes through solvent retention and air emissions mitigation stages, and will be subsequently released to atmosphere via a dedicated stack.

The CO_2 rich vapour from the top of the desorber passes through a reflux stage to maximise the solvent-CO_2 separation. The CO_2 is saturated with water and is sent to the compression stage.

Overall CO_2 absorption rates are solvent-specific, and the height of the packed section of the CCP absorber(s) varies between solvents. Flue gas pressure throughout the CCP absorber(s) section will be low, typically below 100mbarg to balance the pressure drop of the absorber equipment before the atmospheric stack.

Typical operating temperatures in the absorber include a range from 30°C to 80°C, depending on the process design parameters such as the compositions of the solvent and exhaust gas, as well as the presence of any intercooling arrangement in the absorber. The final operating temperatures within the absorber will be confirmed by the Technology Licensor. Note that towards the exit point from the absorber, the exhaust gas will generally approach a temperature within 5-10°C of the lean solvent supply temperature.

The CO_2-depleted exhaust gas then passes through water and acid wash sections and is released to atmosphere. The water wash will remove entrained solvent and the acid wash will remove degradation products like ammonia.

3.1.3 Solvent Storage

The solvent will be stored in dedicated storage tank(s). The requirement for, and the size and location of a storage tank for the solvent will be determined following FEED verification studies.

3.1.4 Solvent Regeneration

Following treatment, the CO_2 abated flue gases then pass through a mist eliminator where they will be treated to remove entrained mist droplets. A flue gas heater will be included in the absorber column(s) . In the heater , waste heat from the steam condensate stream will be used to increase the thermal buoyancy of the treated, washed flue gas, before release from the top of the absorber column(s) via dedicated absorber stack(s) for dispersion to the atmosphere.

The CO_2-rich solvent exits the bottom of the absorber, via a lean-rich solvent interchanger (heat exchanger) and passes to the top of the stripper column (desorber) which uses hot rising vapour to break the CO_2-amine bond and release the CO_2 from the solvent at a pressure slightly above atmospheric pressure.

The hot CO_2-lean solvent enters the sump at the bottom of the desorber and will be passed to the desorber-reboiler.

The desorber-reboiler boils the lean amine using saturated low pressure (LP)-steam heat-exchanger, and some of this is passed back to the base of the desorber column to strip the residual CO_2 from the falling lean solvent.

Lean amine from the reboiler will also be recirculated back to the absorber via the lean/rich heat exchangers, to cool the lean solvent and heat the rich solvent from the absorber. Cooled lean amine solvent may be returned to the Lean Amine Storage Tank.

3.1.5 Thermal Reclaimer

The efficient management of the solvent will be fundamental to the performance of the CCP and hence the efficiency of carbon capture, and the Proposed Installation as a whole.

Thermal degradation and oxidative degradation of the solvent will be minimised through application of appropriate process control measures, for temperature and exhaust gas trace species, as required by and specific to the Technology Licensor design.

Selection of appropriate materials of construction will also be necessary to minimise the risk of oxidative degradation, which will be specified at the FEED stage once the specific solvent requirements are known.

Nevertheless, some solvent degradation is expected to occur over time and degradation products and corrosion products must be removed, via thermal reclamation. The use of solvent management techniques specific to the solvent will ensure minimum waste generation and optimum capture performance in accordance with indicative BAT.

Depending on the Technology Licensor's design thermal reclaiming for the solvent may be a continuous or a batch process. In a continuous process a bleed (circa <5%) of the hot lean solvent returning to the solvent storage tank (from the desorber reboiler) will be passed to the thermal reclaimer where it will be heat treated to break down heat-stable salts formed in the process, to recover solvent and remove degradation products, prior to return to the solvent system.

In a batch process, the thermal reclaiming process may occur for 1 week or so every 2-4 months depending on the degradation profile of the solvent.

The specific design for a thermal reclaimer will be confirmed at FEED stage but it is expected to use low/ intermediate pressure (LP / IP)) steam. The operating regime will also be confirmed in the FEED stage based on the individual Technology Licensor's preference for treating the solvent continuously or in batches.

Impurities removed in the Reclaimer, including heat-stable salts, amine by-products and any metals will be sent for processing off-site.

3.1.6 CO_2 Conditioning and Compression

The CO_2 is compressed in several stages to approximately 8-43 barg, and then passes through conditioning plant, which will include oxygen removal using a catalyst and dehydration using a desiccant to meet the specification for CO_2 export. Cooling is undertaken in stages during the compression process.

3.2 Capture Efficiency

The CCP is expected to be designed to be capable of capturing 95% of the CO_2 emissions (by mass) from the generating station as an annual average of all normal operating conditions (subject to completion of FEED) verification studies and commercial agreement). However, for demonstrating compliance with absorber capture rate efficiency, periods of other than normal operating conditions (OTNOC), such as loads below minimum start-up load (MSUL) will not be included in the calculation. The capture rate of the absorber will be optimised by:

- maximising the contact time between solvent and gas through use of a packed column specific to the solvent;
- maintenance of solvent condition through reclaiming, with backup bleed/feed (See solvent management Section 4.3);
- optimised operational parameters (temperature/ solvent concentration/ pressure/ solvent flows) to be determined during the commissioning, start-up and early operational phase.

CO_2 emissions during start-ups can have lower than 95% capture rates because the CCP process can take time to reach operational temperatures, pressures, and flows depending on whether the plant was in a hot, warm, or cold state prior to start-up. Additionally, during initial stages of CCGT start-up sequence, the flue gas will be diverted to atmosphere via a HRSG stack (damper closed to CCP). This is because of high concentration of contaminants like NOx present in the flue gas that can potentially accelerate amine solvent degradation.

Upon introducing flue gas to the CCP, CO_2 absorption will begin via the lean solvent stored within the CCP system. As the stored lean solvent continues to absorb CO_2, without the desorber being at operational temperature, the CO_2 absorption capacity will decrease. Once the desorber is at operational conditions, capture rate will return to design performance.

To reduce the duration where capture rate performance isn't at design performance, the CCP will have a Hot Stand-by mode, which is expected to be in use for warm and hot start-ups. These types of start-ups are expected to be the most common, and thereby Hot Stand-by mode will increase the annualised average CO_2 capture rate.

This will help to ensure the plant meets the Dispatchable Power Agreement (DPA) requirements.

Optimisation of the start-up process to reduce start-up times and minimise CO_2 emissions will be a key optimisation activity during FEED.

4. Solvent System

4.1 Licensed Technology and Commercial Confidentiality

Monoethanolamine (MEA) is the most widely studied solvent for use in CCP and is the base-case process against which other solvent development is typically measured. However, over the last 20 years, Technology Licensors have developed other solvent blends, mainly - but not exclusively - based on amines, that could out-perform the generic MEA solvent in carbon capture, enhance CO_2 capture efficiency, lower energy consumption, lower solvent degradation within the integrated solvent recycling system, and lower solvent / degradation products emissions.

CCP are designed and integrated around the bespoke solvent, with equipment sizing optimised around the solvent properties to minimise capital and operating costs and to maximise CO_2 capture. The development of solvents that offer a lower regeneration energy penalty and higher capture efficiency may represent Best Available Technique (BAT). Generic “MEA-type” solvents and, by inference, the design of the facilities are typically less efficient, and may require larger, more expensive plant that represents a higher deployment cost and investment risk to potential investors[4].

MEA, although compliant, has a greater level of emissions than the proprietary solvents. Therefore, reverting back to MEA would lead to a greater level of emissions into the environment and associated toxicity. More stringent emission mitigation measures would be needed that further add to the cost. Proprietary amines would provide a better solution.

Most existing carbon capture plants operating around the world today use proprietary amines. The Technology Licensors provide an integrated process design package for the bespoke solvent, according to the solvent’s properties. Both FEED technologies being considered will use a Technology Licensor specific amine-based chemical absorption technology that have been used on other projects. The individual solvent blends represent confidential intellectual property of the Technology Licensors, with commercial value, and are the product of extensive and expensive research and development programmes. Specific performance data for the selected solvent will be provided during the FEED stage.

The protection of proprietary solvent information is fundamental to successful CCUS deployment in the UK and without it, Technology Licensors may choose not to market their products in the UK, as international competitors would be able to copy their solvent. Licensors also may choose not to invest in further solvent development and optimisation in the UK market, which will stifle innovation. Hence restricted access to detailed solvent composition and emissions data is needed.

It is therefore proposed that proprietary data, including solvent characterisation, solvent performance (degradation in service) and emissions monitoring data be made available to the regulator in a controlled way under the provision it is not disclosed to the general public.

4.2 Solvent Selection

The selection of CCP technology and the associated solvent will take into consideration a number of factors, including (but not limited to) the energy requirement for solvent regeneration, the volatility of the solvent and expected losses to atmosphere, and the performance in long term, thermal and oxidative degradation tests. There are significant cost impacts associated with these elements, both Capex and Opex and so selection of the licensor is a critical aspect. The Operator will secure performance guarantees from the Technology Licensor under the terms of contract during the FEED stage.

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[4] Overview of World Bank CCUS Program Activities in Mexico, World Bank Group, Secretaría de Energía de México, 2016. Accessed at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/985941518159405536/overview-of-world-bank-ccus-program-activities-in-mexico (02/06/2025)

4.3 Solvent Management Techniques

4.3.1 Solvent Management

The efficient management of the solvent is fundamental to the maximisation of efficiency of the Proposed Installation as a whole.

Thermal degradation of the solvent will be minimised by reduction in temperature of the regeneration process to circa 120 - 140°C (solvent dependent), as described above. Oxidative degradation, which is a separate mechanism where amines react with oxygen or NOx to form corrosion products including ammonia, can occur at temperatures between 40 - 55°C and particularly in the presence of catalytic impurities. The extent of oxidative degradation within a gas-fired plant are likely to be much lower than for coal or biomass plants, as the concentration of catalyst species in the flue gas will be much lower with a natural gas-type flue gas than that from a solid fuel. NOx emissions will be minimised using SCR as described.

Selection of appropriate materials of construction is also necessary to minimise this risk, and will be specified at the FEED stage once the specific solvent requirements are known.

Nevertheless, some solvent degradation is expected to occur over time and degradation products and corrosion products must be removed, via a thermal reclaimer , to be determined as part of the Technology Licensor selection. The use of solvent management techniques specific to the selected solvent will minimise waste generation and optimise capture performance in accordance with indicative BAT.

At this FEED stage thermal solvent reclaiming will be carried out either by continuous processing of a small slip-stream fraction of the hot lean amine from the bottom of the desorber, or as a batch process as described in Section 3.1.

Proprietary amine solvent blends are expected to have significantly lower degradation rates at normal process conditions compared to MEA and the required bleed rate for the specific solvent selected for use in the CCP will therefore be based on supplier recommendation, and refined during commissioning.

Impurities removed in the reclaimer, including heat-stable salts, amine by-products and any transition metals will be sent for processing off-site.

The specific heat requirement for solvent regeneration will be a key performance indicator and will be dependent of the final solvent selected. This will therefore be established at FEED stage and refined during commissioning

4.3.2 Amine Storage

The CCP will use an amine-based solvent for capture of CO_2, which will be stored, conditioned, regenerated and re-conditioned for subsequent re-use, in accordance with Technology Licensor recommendations. The amine-based solvent is likely to be hazardous. Materials of construction will be appropriate to the selected solvent characteristics to avoid degradation of the solvent during storage and use.

Amine storage and dilution tanks, pipework materials and operating conditions will be confirmed at FEED stage, however it is anticipated that this is likely to include stainless steel tanks, with no heat tracing, and atmospheric fixed roof with nitrogen blanketing.

It is typical practice to include a breather vent in the storage tank to allow for vapour maintenance/ displacement during tank filling, fire exposure relieving rate from the tank and/ or nitrogen purging when unloading road tankers or cleaning lines. Due to the potential toxicity and odorous nature of emissions associated with the venting of amine, it is considered that abatement may be required on the breather vent for the storage tank. These requirements, with full consideration of BAT, will be considered at FEED stage.

5. Control of Emissions

5.1 Emissions to Air

The final detailed design of the CCP is dependent on the selection of Technology Licensor, but an overview of the emissions controls is provided here. Details on proposals for monitoring are provided in the main application document.

During normal operation, the CCP Absorber stack(s) would be the primary source of emissions from both the combustion and carbon capture processes associated with the Proposed Installation as the exhaust gas from the CCGT plant will pass directly into the CCP for CO_2 removal. This emission during abated mode will therefore comprise the combustion emissions of NOx and CO from the CCGT plant, additional emissions of NH_3 slip from the SCR and amines and their degradation products from the CCP process.

In addition, there would be bypass stacks (HRSG stack(s)) associated with Proposed Installations CCGT units (one per train), which would only be operational when the Proposed Installation is operating in an unabated mode (i.e. combustion emissions only, with no carbon capture taking place) and during transient states such as start-up and shutdown. These emissions will therefore comprise emissions of NOx and CO. The use of natural gas means that emissions of sulphur dioxide (SO_2) and particulate matter (PM) from the CCGT plant will be negligible. This mode of operation represents an abnormal mode of operation and will only occur for short periods of time, after unplanned shutdown of the carbon capture unit, estimated to be <5% of the year or during periods of CO_2 transport and storage (T&S) outages.

When the plant is operating abated (with carbon capture), there are additional emissions of amines and potentially their degradation compounds (nitrosamines and nitramines, collectively referred to as N-amines). N-amines are both within the carbon capture process itself and also in the environment following release. Depending on the amine solvent, other degradation products, such as acetaldehyde, formaldehyde and ketones may be formed. Formaldehyde has been included as a representative degradation product.

The modelled pollutant emission rates (in grammes per second (g/s)) have been calculated by multiplying the emission concentration by the volumetric flow rate at normalised reference conditions.

Each Technology Licensor's proprietary amine solution (i.e. FEED Technology Licensor 1 and FEED Technology Licensor 2) contains a different mix of amines. The emission limits assumed for the CCP Absorber stacks are summarised in Table 1 below, showing the different suppliers.

With respect to Table 1, it should noted that:

- the annual average concentration is based on nominal load; and

the short term emissions are based on the BATc limits adjusted for the removal of CO_2.

Table 1 Emissions to air from the CCP

Technology Provider	Emission Point ID	Description	x	y	Pollutant	Annual Average		Short Term Emissions (where applicable)	
						Emission Concentration (mg/Nm^3)	Release Rate (g/s)	Emission Concentration (mg/Nm^3)	Release Rate (g/s)
FEED Technology Licensor 1	A3 Train 1 & A4 Train 2	Single Absorber Stack (per Train)	327409 327372	371426 371372	NOx	11.3*	7.6	45.2* (daily)113.0* (Hourly)	30.2 75.6
					CO	-	-	226.0* (hourly)	151.2
					NH3	1	0.67	-	-
					Amine 1	0.99	0.662	-	-
					Amine 2	0.01	0.007	-	--
					Nitrosamine 2	0.00495	0.0033	-	-
					Nitramine 1	0.0000495	0.000033	-	-
					Nitramine 2	0.0000005	0.00000034	-	-
					Formaldehyde	4.0	2.0	-	-
					Ketones	8.0	5.35	-	-
					Acetaldehyde	6.0	4.01	-	-
FEED Technology Licensor 2	A3 Train 1 & A4 Train 2	Single Absorber Stack (per Train)	327444 327383	371434 371348	NOx	11.3*	11.3	45.2* (daily) 113.0* (hourly)	45.2 112.9
					CO	-	-	226.0* (hourly)	225.8
					NH3	0.75	0.75	-	-
					Amine 1	0.087	0.087	-	-
					Amine 2	0.019	0.019	-	-
					Nitrosamine 1	0.0028	0.00284	-	-
					Nitrosamine 2	0.0005	0.00051	-	-
					Formaldehyde	0.13	0.134	-	-
					Acetonitrile	0.18	0.183	-	-
					Acetaldehyde	0.39	0.392	-	-
					Ethanol	0.01	0.010	-	-
					Acetone	0.52	0.517	-	-
					Amide 1	0.032	0.032	-	-
					Formamide 1	0.035	0.035	-	-

Note * Emission limit values adjusted to account for CO_2 removal by the CCP

5.1.1 NOx

Emission concentrations of NO_x will be no higher than the BAT-AEL range provided in the Large Combustion Plant BRef 10 - 30 mg/Nm^3 as a yearly average and 15 - 40 mg/Nm^3 as a daily average). The Proposed Installation's emissions must also comply with the Industrial Emissions Directive (IED)'s hourly maximum Emission Limit Value (ELV) of 100 mg/Nm^3.

NO_x has been modelled at the upper end of the daily BAT-AEL range for daily average impacts and at the upper end of the hourly IED ELV range for hourly average impacts but at a yearly emission level lower than the upper end of the BAT-AEL range for annual average impacts, as provided by the design team. It is considered that this represents the worst-case NO_x emissions; in practice the emission is likely to be lower than these concentrations, as it is desirable to reduce the NO_x emissions entering the inlet of the CCP.

A NO_x abatement system such as SCR may be required to achieve the required NO_x emission on inlet to the CCP and is used during abated mode only. SCR reduces NO_x concentrations by spraying NH_3 into the flue gas and therefore has the potential to result in 'ammonia slip' with a resulting emission of NH_3. Emissions of NH_3 have therefore also been included in the assessment of emissions when operating in abated mode.

SCR will not be used when the plant is operating in unabated mode and emissions are discharge through the HRSG stack.

5.1.2 CO_2-Abated Flue Gas

In addition, depending on the amine solution used, ammonia can result as a degradation product during the carbon capture process itself. As there is uncertainty in the level of potential ammonia emission, the design for the CCP will include provision for an acid wash to remove ammonia from the absorber stack gas, if required.

An acid-wash stage is therefore included in the current design, which would have a continuous recirculation of concentrated sulphuric acid to abate NH_3, and simultaneously act as a final amine removal (polishing) step. Trace nitrosamine and other volatile solvent degradation products entrained in the flue gas are also expected to be soluble within the acid wash and further abated. The acid wash effluent would be disposed of off-site in a hazardous waste treatment facility.

Emissions of NH_3 have therefore been assessed at a concentration considered to be achievable through the use of acid wash abatement (1 mg/Nm^3).

5.1.3 Amines

The CCP design will employ a solvent retention system that minimises the solvent emissions to atmosphere post CO_2 absorption. The system is expected to include one or two water-wash sections at the top of the CCP Absorber(s), which will circulate water to cool the flue gas, condensing volatile compounds carried up in the flue gas from the absorption section. The effectiveness of a water wash is likely to be enhanced if multiple stages are used.

The wash-water is recycled into the solvent circulation system to ensure entrained solvent is recycled back into the system and to minimise water consumption.

5.1.4 NH_3

Some NH_3 will not react with the NO_x in the SCR process, and can therefore be found in the flue gas as NH_3 'slip'. Some NH_3 from the SCR will be removed from the flue gas via dissolution in the DCC water, which will have a continuous bleed to also remove water accumulated from the flue gas. The DCC bleed water will be directed to a Wastewater Treatment Plant (WWTP) which will reduce the nitrogen content of the bleed prior to onward use within the process.

If reuse is not feasible, the treatment process will enable discharge into the River Dee at the existing permitted discharge point in accordance with the existing discharge limits.

In addition to NH_3 slip, NH_3 may also be generated through oxidative degradation of the solvent within the CCP, depending on the solvent selected. As a result, this oxidative degradation of the solvent within the CCP may be the dominant NH_3 source within the final flue gas. To counter this the CCP absorber will be equipped with both a water wash section and an acid wash section. The acid wash would include continuous recirculation of concentrated sulphuric acid to remove NH_3 and simultaneously act as a final amine removal (polishing) step. Trace nitrosamine and other volatile solvent degradation products entrained in the flue gas are also expected to be soluble within the acid wash and would be further abated. The acid wash effluent would need to be disposed of off-site via a licenced waste contractor.

5.1.5 CO_2 Emissions During OTNOC

During plant commissioning activities (including performance testing) there will be periods when CO_2 will be vented when the CO_2 quality specification from the transmission and storage network cannot be met.

Additionally venting at the Proposed Installation once it becomes operational will be used only for safety reasons or for non-routine operational conditions (e.g., start-ups, shutdowns). No continuous routine venting shall take place, and venting shall be reduced using good engineering design practice and in accordance with BAT. The vent arrangements will be specific to the Technology Licensor selected and the CO_2 capture solvent used, however, detailed design will consider the following:

- Use of high integrity relief valves;
- Sectioning of vent and isolation pipework;
- Steam and inert gas vent streams will be discharged to atmosphere in a safe location;
- Vent gases containing ammonia vapour rerouting back through process equipment.

5.2 Aerosols

Wash sections are not effective at removing fine aerosol droplets, if present. The design currently includes a flue gas reheater, which would use steam condensate to heat the treated flue gas prior to release which may aid droplet removal and dispersion.

The need for a further droplet removal section will be dependent on the final technology selected, and during FEED consideration will be given to the need to include a mist eliminator.

5.3 Odour

The use of amine-based solvent could lead to fugitive emissions of odour, discussed in Section 7 of the Supporting Statement. It is considered that the potential for odour to occur will be dependent on the final Technology Licensor solvent selection, and appropriate abatement will be installed to mitigate any odour emissions.

5.4 Emissions To Water

Both Technology Licensors will as far as practicable, treat and recycle process wastewaters that are not contaminated with amine and do not have excessive salt content for reuse within the plant. In the event the treated wastewater cannot be recirculated then the treated wastewater would be subject to quality testing prior to being sent to the existing SDX tank. The quality testing will ensure the treated wastewater can meet the existing CQLCP permit (EPR/NP3037AF) discharge limits for ultimate discharge to the River Dee before it is transferred to the purge pond.

Amine contaminated process water from the CCP plant and degraded amine solvent will be removed from site via tanker for off-site disposal at a suitably permitted waste facility.

6. Water Use Efficiency

The Proposed Installation would require the following sources of water:

- Demineralised water will be sourced through an existing potable water supply from Welsh Water and used to provide make up water to the steam / water cycle, and other processes that require high purity water.
- Cooling water will be sourced from the River Dee in accordance with the existing Abstraction Licence (24/67/10/124/V004) limits. Abstracted water will be stored in the existing settlement/make-up pond and pumped to the new Proposed Installation.
- Water for domestic and sanitary use would be sourced from the existing towns water pipelines supplied by Welsh Water.

The opportunities for re-use and recovery of water within the process will be confirmed during FEED, but for the CCP are anticipated to include:

- The DCC effluent will be treated and reused;
- Condensate from the desorber reboiler will be reused within steam/water cycle;
- The DCC cooling system will utilise a recirculating water-cooling circuit that includes chemical treatment packages to maintain the water quality for longer, thus optimising water reuse and reducing the volume of blowdown;
- Recovery of flue gas wash water to solvent system;
- Wastewater streams will be segregated to allow recoverable water to be reused.

7. Waste Minimisation

The main waste from the CCP is anticipated to be amine reclaimer sludge. The key operating parameters that affect the generation of reclaimer sludge are:

- Solvent selection;
- Combustion technology efficiency (increased efficiency leads to increased NOx generation which can degrade the solvent);
- Temperature control within Absorber and desorber (minimises thermal solvent degradation); and
- The efficiency of the reclaiming process.

The maintenance of solvent quality is critical to the efficiency of the CCP operation and therefore is higher in the BAT hierarchy to the minimisation of reclaimer waste generation. The efficiency of the Reclaiming process to maximise the quantity of reclaimed solvent, will be optimised during the design process, as far as practicable to achieve the primary aim of maintain solvent quality and the secondary aim of waste minimisation.

The amine reclaimer sludge (e.g. Heat Stable Salts) is considered a hazardous waste contaminated with metals and amine degradation products. Reclaimer sludge shall be drained on an ad-hoc basis, neutralised and removed for processing off-site by a suitably qualified waste processing contractor.

A reclaimer sludge storage unit will be part of each Technology Licensor’s package. The capacity is subject to completion of the FEED studies. Other waste from the CPP will be technology dependant but is likely to include:

- Oxygen removal catalyst – CO_2 conditioning;
- Solid desiccant dehydration – CO_2 conditioning;
- Acid wash waste;
- Mechanical filters and contaminants from the CO_2 dryers;
- Filter coalescer elements from the CO_2 dryers;
- Spent activated carbon from the solvent bed filtration; and
- Amine cartridge filters.

The Proposed Installation will be required to comply with a centrally held management instruction procedure that sets out duty of care requirements and other legal requirements for dealing with generated waste. Most sites have a local procedure or a management plan "appendix" that deals with waste compliance at the site. The Proposed Installation will develop a site-specific waste management procedure prior to commencement of operations detailing the waste storage and handling procedures.

Uniper competency frameworks also require that certain staff at installations have the appropriate training and knowledge in order to advise on waste matters.

8. BAT Assessment for the Carbon Capture and Storage

Table 2 BAT Conclusions for the Carbon Capture Process (and CCGT operation with CCS) (1)

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
1	Overall performance: Including emissions and environmental performance, suitability for required duties, capture rates, energy use	Provided in this BAT CCS assessment and associated BAT assessments.	Yes
2	BAT justification of overall technology	See below.	Yes
Exhaust Gas Pre-treatment			
2.1	Exhaust gas heat recovery to be used for stack heater after Absorber -Reduces cooling load, aids dispersion; provision to retrofit if not actually included	Condensate heat recovery is being integrated into the design by both Technology Licensors for stack gas reheat as it is considered more efficient than exhaust gas heat recovery. Therefore, exhaust gas heat recovery will not be required for the installation.	Yes
2.2	DCC or fogging to saturate exhaust gas and reduce temperature -Both likely to be viable with suitable water management strategy for whole plant. DCC will be more expensive and will trap NH$_3$. Fogging can use recycled water from stripper reflux condenser and will allow NH$_3$ to pass through to acid wash.	Fogging will accumulate additional water in the solvent which would require bleed and purification. A DCC will be used by both Technology Licensors instead to maintain an effectively neutral water balance across the CCP.	Yes
Capture Plant - General			
2.3	Materials of construction to allow range of solvents (i.e. stainless or better)	Both Technology Licensors will select appropriate materials for their proposed technology solution to minimise corrosion and maximise plant design life.	Yes
2.4	BAT solvent will have been properly tested – 12 months, real HRSG exhaust gas, actual system design, multiple reclaiming cycles- solvent has to be reclaimable and to be able to be operated to meet environmental emission requirements.	Solvent testing has been undertaken for a variety of HRSG exhaust gas conditions by both Technology Licensors and will be undertaken further during commissioning.	Yes
2.5	The solvent management system needs to be able to get rid of everything that gets added, or gets formed, in the solvent at high enough rates to maintain their concentrations at levels at which satisfactory operation can be maintained	A flue gas washing unit will be located within the Absorber column(s) to remove entrained solvent and NH$_3$ from the flue gases. Following treatment, the CO$_2$ abated flue gases then pass through a mist eliminator where they are treated to remove entrained mist droplets. This will apply for both Technology Licensors.	Yes
2.6	Intrinsic heat requirements for solvent regeneration; expected range would correspond to approximately a 3% range in net CCGT+PCC electrical output	Use of a modern enhanced solvent is proposed by both Technology Licensors; thus solvent heat regeneration requirements are minimised.	Yes
2.7	Designed for 95% CO$_2$ capture but level must be allowed to vary over time to suit ambient conditions, electricity supply requirements etc.; future upgrade options for higher capture levels consistent with net-zero emissions should also have been considered (e.g. reduce lean loading)	The CCP would be designed to be capable of capturing 95% of the CO$_2$ emissions (by mass) from the Proposed Installation as an annual average of all normal operating conditions. The capture rate of the absorber will be optimised by: • maximising the contact time between solvent and gas through use of a packed column specific to the solvent; • maintenance of solvent condition through reclaiming, with backup bleed/feed; • optimised operational parameters (temperature/ solvent concentration/pressure) to be determined during the commissioning, start-up and early operational phase. Capture efficiency will be determined using fuel gas composition and flows to determine CO$_2$ generated and metered CO$_2$ which is exported to the transmission and storage network. Capture rate will be maximised during start up, however for demonstrating compliance with the capture rate efficiency, periods of other than normal operating conditions (OTNOC), such as loads below MSUL will not be included in the calculation.	Yes
Absorber			

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
2.8	Bed height to allow routine 95% capture without excessive energy consumption; need to consider being able to add some packing height for new solvents	Absorber packing height base case will be designed for the selected Technology Licensor's guaranteed capture rate. This is anticipated to be 95% but will be confirmed during FEED. Therefore, the packing height is expected to allow enough solvent contact time with the exhaust gas without relying on excessive (inefficient) additional circulation rate and lean amine loading.	Yes
2.9	Water wash – single stage water wash will be satisfactory for emissions with acid wash, but could be two stage for better solvent recovery with more volatile solvents. Acid wash, or provision to retrofit if not actually included	A flue gas water wash unit and an acid wash unit will be located within the absorber column(s) to remove entrained solvent and NH_3 from the flue gases. This applies to both Technology Licensors.	Yes
2.10	Absorber circuit able to be operated independently with lean and rich amine storage tanks for start-up and other transients; provision to retrofit if not actually included	Optimisation of the start-up and shutdown processes to reduce start-up/shutdown times and minimise CO_2 emissions will be a key optimisation activity during FEED.	Yes
2.11	Likely that flue gas will be vented from top of absorber rather than a separate stack, but not essential; adequate stack height for emissions sampling and plume dispersion required in either case	For both Technology Licensors, during normal operation, the CCP absorber stack for each Train would be the primary source of emissions from both the combustion and carbon capture processes associated with the Proposed Installation as the exhaust gas from the CCGT plant will pass directly into the CCP for CO_2 removal. Stack height and dispersion assessments are included in the Air Quality Assessment in Appendix H of the Supporting Statement. Considerations for monitoring are included in the Supporting Statement.	Yes
2.12	Stack flue gas heating; provision to retrofit if not actually included	A flue gas heater will be included in the absorber column(s). Waste heat from the steam condensate stream would be used to increase the thermal buoyancy of the treated, washed flue gas, before release from the top of the absorber column(s) via dedicated absorber stack(s) for dispersion to the atmosphere.	Yes
2.13	Continuous monitoring of stack emissions (may be multiple stacks) and process parameters. Operational envelopes for process parameters for satisfactory emissions control must be established on commissioning	The operation of the Proposed Installation will be highly automated, with a site wide Distributed Control System (DCS) providing monitoring and control. See Section 4.3.7 of the Supporting Statement (Document reference: WPCC15718/APP/SS). Parameters for emissions to air will be continuously monitored at each stack in line with BS EN methods. See Section 6.3 of the Supporting Statement (Document reference: WPCC15718/APP/SS) for further detail.	Yes
2.14	Sampling of stack emissions at frequent intervals (could be continuous sampling with intermittent analysis) for trace emissions (e.g. nitrosamines).	Trace emissions from each stack will be monitored periodically in accordance with appropriate BS/CEN standards. See Section 6.3 of the Supporting Statement (Document reference: WPCC15718/APP/SS) for further detail.	Yes
Regenerator			
2.15	XFHE approach temperature <10K; XFHE capacity to be able to be increased for other solvents	Use of modern heat exchanger technology will ensure exchanger approach temperatures are optimised for heat integration, dispatchability, pressure drop and CAPEX.	Yes
2.16	Optimisations that split off some rich solvent before the XFHE to match lean solvent heat capacity to be considered	To be considered in FEED.	Yes
2.17	Vessel designed for range of operating pressures and temperatures to allow operating condition and solvent changes (not expected to be an issue). Packing height able to accommodate a range of solvents; provision to retrofit if not actually included.	The selection of solvent will be an ongoing action as part of the overall optimisation process, and the Operator could potentially change the solvent used if a better alternative is identified, which can be safely retrofitted without any loss in capture efficiency.	Yes
2.18	Water wash at exit to reduce solvent carryover (this will help if water removal is from reflux condensate); provision to retrofit if not actually included	See Section 3.1.2	Yes
2.19	Reflux condenser able to accommodate range of solvents/operating conditions including closed-circuit operation for startup, high rates of thermal reclaiming; provision to retrofit to add capacity if not actually included	Reflux condenser will be designed for the selected solvent by each Technology Licensor and will consider the most likely operating modes for the life of the plant.	Yes

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
2.20	Reboiler able to support 95% capture rate; provision to be able to increase reboiler duty in the future for future solvents/higher capture levels	The CCP would be designed to be capable of capturing 95% of the CO_2 emissions (by mass) from the generating station as an annual average of all normal operating conditions. The lean amine from the reboiler will be recirculated back to the absorber via the lean/rich heat exchangers, to cool the lean solvent and heat the rich solvent from Absorber. Cooled lean amine solvent may be returned to the Lean Amine Storage Tank.	Yes
2.21	Stripper/XFHE have to be able to be operated with recycle flow while warming up; provision to retrofit if not actually included.	This option will be considered as part of the start-up optimisation process during FEED.	Yes
CO_2 Compression and conditioning			
3.1	Compression system may be integrally-geared compressors but has to be able to accommodate flexible operation (e.g. with recycle).	Efficient operation of the compressor train(s) at all expected operating loads will be part of each FEED Technology Licensor's scope to consider. During start-up CO_2 will be imported from the transmission and storage network to prime the compressors and will be subsequently re-exported, however, in the event of an OTNOC situation occurring during this period there may be need to vent this CO_2 to atmosphere.	Yes
3.2	Compression train may alternatively be optimised for flexibility (various approaches likely to be reasonable, e.g. multiple trains, different machinery types for different stages).	As above.	Yes
3.3	CO_2 drying as part of compression, but may be at remote site for gas-phase transport on land with compression to dense phase at the shoreline, commercially available technology to suit pipeline requirements	N/A compression is completed to achieve pipeline pressure followed by drying which takes place on site prior to export via pipeline.	N/A
3.4	O_2 removal may be required (ideally, to be confirmed by pilot testing), currently expected to be cryogenic but may be achieved in the PCC in the future (direct oxygen removal from the rich solvent). Duct firing would help, but would reduce power plant efficiency for routine use	Each Technology Licensor will include a de-oxygenation package - vertical packed catalytic recombination reactor and pre-heater and Capture plant treatment chemicals (hydrogen) will be used for the deoxygenation of the produced CO_2 stream. Wet CO2 will be first deoxygenated in a catalytic reactor using hydrogen injection to convert oxygen to water. The hydrogen injection will be set on constant flow control, with a small stoichiometric excess, and then dried, first by cooling prior to a coalescing filter, and then by desiccant dryers Dependent on Technology Licensor, hydrogen will be either generated onsite via a small electrolysis generation package (<2tpd) or will be imported via tube trailers and injected downstream of the final compression package.	Yes
3.5	Heat recovery from compressors to be considered (but no scope for steam cycle condensate heating with CCGT).	Heat integration options will be reviewed as part of each Technology Licensor's study. However, due to the low grade of the heat available from compressors it will likely make the option of heat recovery inefficient.	Yes
3.6	For gas phase CO_2 transport section onshore, consider (slight) line packing as aid to flexibility	N/A Line packing is being considered for dense phase CO_2, but opportunities are limited due to its almost incompressible nature.	N/A
Solvent			
	BAT justification of the selected solvent, considering the following based on the composition and performance of the solvent inventory in the plant in normal long-term service (i.e. after at least one year of continuous operation: • Known and potential toxicity for the environment of the solvent and its degradation products that are formed due to the presence of NOx and other factors • Emissions to air of amine and amine degradation products including ammonia (and taking into account any ammonia slip from SCR) • Further reactions of the amine and amine degradation products in the atmosphere to form, e.g. nitrosamines	The solvent to be used will be specific to each Technology Licensor but would be an aqueous solution of amines. Currently two solvent scenarios have been assessed for their environmental impacts, including emissions to air of amine and amine degradation products and ammonia from the use of SCR. Details are provided in the Supporting Statement and in the Air Quality Assessment in Appendix H of the Supporting Statement.	Yes

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
	• Solvent reclaimability and factors impacting this • Wastes (wastewater/reclaimer sludge) produced and disposal/recovery/treatment options • Solvent consumption in long-term use • Electricity Output Penalty consequences for the capture plant • Availability and cost of the fresh solvent • Consequences for the relative capital cost of the plant		

Table 3 Guidance on Post-combustion carbon dioxide capture: emerging techniques (2)

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
2	**Power plant selection and integration with the PCC plant**		
2.1	**Energy efficiency in plants with PCC** You must maximise the thermal energy efficiency of the plant and of the supply of heat for the associated PCC plant. You should refer to the LCP BRef or waste incineration BRef which give BAT definitions (BAT AELs) for the efficiencies of new and existing plants. Also refer to section 4.13 of the IED environmental permitting regulations guidance on Part A installations. For natural gas power plants, lower heating value efficiencies of 60% or above without CO_2 capture are reported in the LCP BRef to be achievable for large-scale new combined cycle gas turbine installations. You can reduce the impact of adding PCC by using power plant technologies that have the highest thermal efficiencies, since these have low specific CO_2 emissions (tonnes CO_2 per megawatt hour). If you expect to use more fuel to meet the heat or power needs of PCC, you should select the most efficient power plant technologies for that fuel and capture any additional CO_2 from that process. You should apply fuel input, electricity output and CO_2 emission metrics in the same way as you would to a power plant with fully integrated PCC.	See • Assessment of Best Available Techniques for Energy Efficiency (Document reference: CQ-WPCC15718-APP-BAT3-EE in Environmental Permit Application, Volume III); and • Assessment of Best Available Techniques for Large Combustion Plant (Document reference: CQ-WPCC15718-APP-BAT1-LCP in Environmental Permit Application, Volume III).	Yes
2.2	**Dispatchable operation** In line with the needs of a UK electricity system with a large amount of intermittent renewable generation, all thermal power plants, including those with CO_2 capture, are likely to be dispatchable. This means that the power plant operator can be asked to operate the plant at any required output, up to its full load, at any time, and sustain this output indefinitely.	Following commissioning, the Proposed Installation is designed to be operated in dispatchable mode i.e. being able to export power to match the anticipated intermittency of renewable power in the future power market.	Yes
2.3	**Supplying heat and power for PCC operation** You will need to use low grade (for example 130°C) heat and electrical power to operate the PCC plant. You should work out the amounts needed based on factors that include the: • selected solvent • PCC plant configuration • CO_2 capture rate • CO_2 delivery pressure You should supply this heat and electricity from the main plant. Where not possible, this will need to be by fuel combustion in ancillary plants (with CO_2 capture) that are then also treated as a power or CHP plant system for performance calculations. The ratio between heat supplied as steam (or otherwise) and electricity output lost will depend on the: • temperature at which you need to supply heat. • steam condenser cooling water temperature. You should consider using a back-pressure turbine if it is not possible to supply enough steam to the PCC plant by extracting steam from a condensing turbine. If the plant needs to supply heat for district heating, and extracting steam to supply the PCC plant will mean there is insufficient steam to do this, you should consider using heat pumps or other plant to reduce the amount of steam required to meet that heat demand.	The CCP is supplied with steam and electrical energy from a high efficiency CCGTs to minimise losses and maximising the integration of 'waste' heat within the plant. Useful heat is recovered from the gas turbine's exhaust gas through the HRSG. This heat is used to produce steam, at various pressures, which generates further power via a separate steam turbine. The carbon capture process uses steam from the steam turbine. Most of the steam provision required in the CCP is used to generate the heat necessary to separate the captured CO_2 from the rich amine within the desorber.	Yes
3	**PCC plant design and operation**		

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
3.1	**Purpose** The purpose of the PCC plant is to maximise the capture of CO_2 emissions for either use or secure geological storage. You should aim to design your plant to achieve a CO_2 capture rate of at least 95% during normal operating conditions, although operationally this can vary, up or down. You will need to justify proposing a design CO_2 capture rate of less than 95% as an annual average of all normal operating conditions. You can submit a cost benefit analysis as part of your application. You will need to deliver CO_2: • at local transport system pressures (gas phase such as 35 bar or dense phase such as 100 bar) • with levels of water, oxygen and other impurities as required for transport and storage such as that for the system operator National Grid (NGC/SP/PIP/25 Dec.2019) The PCC plant must also have acceptable environmental risks through preventing or minimising emissions or render them harmless. You must achieve environmental quality standards for air emissions from the PCC plant and their subsequent atmospheric degradation products (including, for example, nitrosamines and nitramines). You should confirm this using: • atmospheric dispersion and reaction modelling tools • specific site parameters which will define plant-specific ELVs	The Proposed Installation is expected to be designed to be capable of capturing 95% of the CO_2 emissions (by mass) from the generating station as an annual average of all normal operating conditions. The capture rate of the absorber will be optimised by: • maximising the contact time between solvent and gas through use of a packed column specific to the solvent; • maintenance of solvent condition through reclaiming, with backup bleed/feed; • optimised operational parameters (temperature/ solvent concentration/pressure) to be determined during the commissioning, start-up and early operational phase. Capture will be maximised during start up, however for demonstrating compliance with absorber capture rate efficiency, periods of other than normal operating conditions (OTNOC), such as loads below MSUL will not be included in the calculation. Environmental risks are discussed in Section 7 of the Supporting Statement (Document reference: WPCC15718/APP/SS) and the Environmental Risk Assessment (Document reference: WPCC15718/APP/ERA) in Appendix J of the Supporting Statement. The technology proposed by each Technology Licensor will meet relevant BAT-AEL standards. The environmental quality standards (EQS) for air emissions will be achieved. Dispersion modelling has been undertaken and is shown in Appendix G of the Supporting Statement.	Yes
3.2	**Solvent selection** While the process design for the PCC plant is likely to be generally similar for all solvents, the amine solvent you select will determine details of the design and performance.	The solvent to be used will be specific to each Technology Licensor but would be an aqueous solution of amines. Each Technology Licensor will select their solvent based on: • its environmental impacts, including emissions to air of amine and amine degradation products and ammonia from the use of SCR; • solvent reclaimability ; • wastes generated; • solvent consumption in long-term use; • electricity Output Penalty consequences for the capture plant; • availability and cost of the fresh solvent; • consequences for the relative capital cost of the plant.	Yes
3.3	**Features to control and minimise atmospheric and other emissions**		
3.3.1	**Flue gas cleaning** You will need to consider the following, depending on the flue gas source and the solvent selected. • Sulphur oxides (SO_x) removal • NO_x • Aerosols • Other flue gas impurities	For each Technology Licensor the flue gases are expected to be treated with selective catalytic reduction (SCR) to ensure that NO_x concentrations remain within the required emissions limits and to prevent the degradation of solvent within the CCP in order to optimise the CO_2 capture efficiency.	Yes
3.3.2	**PCC system operation** Operating temperatures You must establish and maintain optimum temperature and appropriate limits in the solvent stripping process. Solvent degradation	For each Technology Licensor: • optimum temperature and limits will be maintained during the stripping process. • Solvent selection will consider degradation properties to ensure that residence times in the absorber sump is minimised.	Yes

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
	You should minimise oxidative degradation of the solvent by limiting solvent residence times in the absorber sump and other hold-up areas. Direct O_2 removal from rich solvent may be developed in the future but has not yet been proven at scale.		
3.3.3	**Absorber emissions abatement** Water wash You must use 1 or 2 water washes or a scrubber before returning amine or other species to the solvent inventory. Capture levels are limited by vapour or liquid equilibrium, with volatile amines captured less effectively. Any aerosols present will also not be captured effectively. Water washes alone are ineffective in preventing NH_3 emissions, as concentrations will increase until the rate of release balances the rate of formation (and possibly addition from SCR or SNCR slip). Acid wash An acid or other chemically active wash or scrubber after the water wash will react with amines, NH_3 and other basic species and reduce them to very low levels (for example, 0.5mg to 5mg per m^3 per species or lower). Droplet removal You must prevent emissions of aerosols. To do this you could use standard droplet removal sections after washes. These will prevent droplet carryover from the wash. However, they are not effective against very fine aerosols arising from SO_3 or other aerosol mists. Stack height Where modelling predicts that you may need to raise the temperature at the point of release to aid dispersion, you can: • increase the design stack height. • add flue gas reheating. Flue gas reheating can also reduce the plume visibility. Heat from cooling the flue gas before the PCC plant or waste heat from the PCC process should be used for flue gas reheating.	Each Technology Licensor will include: • a flue gas water wash unit located within the absorber column(s) to remove entrained solvent from the flue gases. • a flue gas acid wash unit in the absorber column(s) to remove NH3 and other degradation products. • a flue gas heater in the absorber which would use steam condensate to heat the treated flue gas prior to release which may aid droplet removal and dispersion During FEED, the need for passing the CO_2 abated flue gases through a mist eliminator where they are treated to remove entrained mist droplets will be assessed. The proposed heights of the CCPs' absorber stacks and HRSG stacks for the Proposed Installation have been assessed as a robust case with consideration given to minimisation of ground-level air quality impacts and the visual impacts of taller stacks, based on the largest building massing for the primary structures of the Proposed Installation.	Yes
3.4	**Process and emissions monitoring**		
3.4.1	**Role of monitoring** The main purpose of monitoring the PCC process is to show that the emissions from the process, primarily to air, are not causing harm to the environment. You must also carry out monitoring to show that resources are being used efficiently. This includes: • energy and resource efficiency • CO_2 capture rate • verification that the CO_2 product is suitable for safe transport and storage. You will need to develop a monitoring plan for both a commissioning phase and routine operation. During the commissioning phase you will need to optimise the operating envelope for the process. When you have achieved this the process operation will then become routine, along with the monitoring.	The operation of the Proposed Installation will be highly automated, with a site wide Distributed Control System (DCS) providing monitoring and control. See Section 4.3.7 of the Supporting Statement (Document reference: WPCC15718/APP/SS). Parameters for emissions to air will be continuously monitored at each stack in line with BS EN methods. See Section 6.3 of the Supporting Statement (Document reference: WPCC15718/APP/SS) for further detail. Natural gas input, CO_2 absorber efficiency and CO_2 quality monitoring at the transport entry point will be measured.	Yes
3.4.2	**Point source emissions to air** You must include monitoring to demonstrate compliance with: • IED Chapter III ELVs and Chapter IV • LCP BRefBAT AELs • WI BRef BAT AELs at normalised conditions You must also monitor for: • ammonia • volatile components of the capture solvent • likely degradation products such as nitrosamines and nitramines	Monitoring of point source emissions to air is demonstrated in the LCP BAT and Section 6 of the Supporting Statement. Parameters for primary emissions to air will be continuously monitored at each stack in line with BS EN methods and trace emissions from each stack will be monitored periodically in accordance with appropriate BS/CEN standards. See Section 6.3 of the Supporting Statement (Document reference: WPCC15718/APP/SS) for further detail.	Yes

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
	Your monitoring may be by either: • continuous emissions monitoring (online') • periodic extractive sampling ('offline') – where aerosol formation is expected, this must be isokinetic		
3.4.3	**Process control monitoring** You should use process control monitoring or periodic sampling with offline analysis to control the CO_2 capture and the solvent reclaiming performance. Parameters you should consider monitoring include: • absorber solvent quality – percentage active solvent • CO_2 loading both rich and lean solvent • maximum solvent temperature • heat stable solvent content. • solvent colour or opacity • soluble iron and other metals and degradation products • in water or acid washes and scrubbers – pH, conductivity, loading of abated substances, flow rate. • solvent usage	The operation of the Proposed Installation will be highly automated, with a site wide Distributed Control System (DCS) providing monitoring and control. See Section 4.3.7 of the Supporting Statement (Document reference: WPCC15718/APP/SS).	Yes
3.4.4	**Monitoring of CO_2** You should also include: • CO_2 mass balance • CO_2 in fuel combusted. • CO_2 capture rate (as a percentage) • CO_2 released to the environment. • CO_2 quality	The operation of the Proposed Installation will be highly automated, with a site wide Distributed Control System (DCS) providing monitoring and control. This system will facilitate the monitoring of: • Flow and composition of the natural gas; • Temperature, pressure, and flow of CO_2 being exported. CO_2 capture performance will also be confirmed in accordance with standards recognised under the UK ETS. See Section 4.3.7 and Section 6 of the Supporting Statement (Document reference: WPCC15718/APP/SS) Monitoring of the CO_2 will be completed at the Proposed Installation as part of the monitoring plan developed prior to commissioning.	Yes
3.4.5	**Monitoring standards** The person who carries out your monitoring must be competent and work to recognised standards such as the Environment Agency's monitoring certification scheme (MCERTS).	In line with the Operators management system, all monitoring on site will be completed by a competent, trained individual to the appropriate standards. Details on specific monitoring at the site can be found in Section 6 of the Supporting Statement (Document reference: WPCC15718/APP/SS).	Yes
3.5	**Unplanned emissions to the environment** You should propose a leak detection and repair programme that is appropriate to the solvent composition. This should use industry best practice to manage releases, including from joints, flanges, seals and glands. You must provide a hazard and mitigation assessment for the plant. This must consider the risks of accidental releases to environment. This should also consider the actual composition of the fluids, gases and vapours that could be released from the plant after an extended period of operation. (Not only fresh solvent as initially charged.)	A leak detection and repair programme will be set up as part of the Operator's management plan prior to commissioning in relation to the use of solvents and potential leaks of natural gas. The Environmental Risk Assessment in Appendix J of the Supporting Statement (Document reference: WPCC15718/APP/ERA) includes the evaluation of accident and fire risks and includes the potential risks and mitigation at the Proposed Installation. Each Technology Licensor is required to consider the risks of accidental releases to the environment as part of FEED and HAZID/ENVID/HAZOP processes will be progressed at detailed design once the technology has been chosen.	Yes
3.6	**Capture level, including during flexible operation, start-up and shutdown** Capturing at least 95% of the CO_2 in the flue gas during normal operating conditions is considered BAT. You can base this on average performance over an extended period (for example, a year). To achieve this, you should make sure the design capture level for flue gas passing through the absorber equates to at least 95% of the CO_2 in the total flue gas from the plant. Over the averaging period, your capture level may vary up or down.	The CCP would be designed to be capable of capturing a minimum of 95% of the CO_2 emissions (by mass) from the generating station as an annual average of all normal operating conditions (subject to completion of FEED verification studies and commercial agreement). The capture rate of the absorber will be optimised by:	Yes

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
	You should set out any potential 'other than normal operating conditions' (OTNOC) for the CO_2 capture plant in your permit application. You should include a PCC OTNOC management plan in your management system to measure and minimise occurrence and impact of these periods. OTNOC includes periods of start-up and shutdown. Your PCC OTNOC management plan must compliment any OTNOC management plan for the facility it serves and consider internal and external causes of OTNOC. An example of OTNOC would be when the CO_2 transport and storage network is down. As the fraction of intermittent renewable generation in the UK rises, many CCS enabled plants will need to start and stop more often, and possibly also operate at variable loads. It is therefore important, for current or future intermittent operation plant, that you aim to maximise CO_2 capture during these periods, including during start-up and shutdown, to maintain high average capture levels. You should therefore capture CO_2 during plant start-up and shutdown as part of using BAT. A method to maintain capture during start-up and shutdown using solvent storage has been identified in chapter 7 of the PCC evidence review. This, or alternatives that can achieve equivalent results, is considered BAT. You will need to provide justification and a cost benefit analysis if you are not proposing capture during start-up and shutdown. If your PCC plant is not initially constructed with this capability, your permit application should show how you may retrofit it. Your PCC OTNOC management plan should include measures to minimise any CO_2 emitted during start-up and shutdown periods.	• maximising the contact time between solvent and gas through use of a packed column specific to the solvent; • maintenance of solvent condition through reclaiming, with backup bleed/feed; • optimised operational parameters (temperature/ solvent concentration/pressure) to be determined during the commissioning, start-up and early operational phase. Capture will be maximised during start up, however for demonstrating compliance with absorber capture rate efficiency, periods of other than normal operating conditions (OTNOC), such as loads below MSUL will not be included in the calculation. Design features to maximise capture during start up include warm keeping capabilities that include increased insulation and auxiliary boiler to maintain sufficient regenerator (desorber) temperature for faster start-up times for solvent regeneration. Appendix J of the Support Statement (Document reference: WPCC15718/APP/ERA) includes the evaluation of OTNOC and includes the evaluation of OTNOC scenarios along with the proposed management and mitigation measures. An OTNOC management plan will be developed for operation of the Proposed Installation.	
3.7	**Compression** You should select CO_2 compressors based on the expected duty. You should consider how any waste heat arising may be used.	CO_2 compressors will be specific to each Technology Licensor and will take in to account the expected duty for their chosen technology. Heat integration options will be reviewed as part of each Technology Licensor's study. However, due to the low grade of the heat available from compressors it will likely make the option of heat recovery inefficient.	Yes
3.8	**Noise and odour** The LCP BRef and EfW BRef already cover noise impacts for the main power plant. You only need to consider additional process steps in PCC technology that have high potential for noise and vibration. In particular, CO_2 compression could be an area of concern. Once you have identified the main sources and transmission pathways, you should consider the use of common noise and vibration abatement techniques and mitigation at source wherever possible. For example: • use of embankments to screen the source of noise • enclosure of noisy plant or components in sound-absorbing structures • use of anti-vibration supports and interconnections for equipment. • orientation and location of noise-emitting machinery • change of the frequency of the sound The handling, storage and use of some amines may result in odour emissions, so you should always use best practice containment methods. Where there is increased risk that odour from activities will cause pollution beyond the site boundary, you will need to send an odour management plan with your permit application.	Sound of tonal, impulsive or intermittent nature will be designed out of the Proposed Installation during detail design by the selection of appropriate plant, building cladding, louvres and silencers/attenuators as necessary. Mitigation measures may include, but are not limited to, the following depending on the potential benefits achievable: • enclosure of key sound sources; • use of quieter plant (including limits on sound emissions from plant and equipment at source); • reducing air inlet noise emissions by addition of further in-line attenuation • reducing stack outline noise emissions by addition of silencers or sound proofing panels; • orientation of plant within the site to provide screening of low-levels sound sources by other buildings, structures and dedicated barriers, or orientating fans and the air inlets away from sensitive receptors; and • use of additional acoustic barriers/screens or earth bunds to reduce transmission of sound from the Proposed Installation to NSRs. Provision of a package of sound insulation to nearby NSRs may also be considered, as a last resort, where other measures are unlikely to be adequate. More details on noise at the Proposed Installation are detailed in Supporting Statement Appendix J Noise Impact Assessment and Appendix K Noise Management Plan.	Yes

Ref	Indicative BAT	Operator Response/Section	Indicative BAT employed?
		The risk of odour from the Proposed Installation is likely to be minimal and therefore an odour management plan is not required. The risk of odour from fugitive emissions at the Proposed Installation will be managed using the planned preventative maintenance on site, eliminating the risk of leaks and spillages.	
3.9	**Hot potassium carbonate post combustion capture plant** Using electrically powered hot potassium carbonate as an alternative solvent to amines for capturing CO_2 is an emerging technique that may have some advantages where the on-site availability of steam supply is insufficient for amine regeneration.	Not applicable to the Proposed Installation.	N/A
4	**Cooling** You will be able to achieve the best power and CO_2 capture plant performance by using the lowest temperature cooling available. You should use the hierarchy of cooling methods as follows: • direct water cooling (such as seawater) • wet cooling towers • hybrid cooling towers • dry cooling – direct air-cooled condensers and dry cooling towers	Cooling water would be abstracted from and discharged to the River Dee, in line with the current process and permitting requirements for the existing Connah's Quay Power Station. Subject to minor modification and alteration, the Proposed Development would utilise the existing Connah's Quay Power Station cooling water abstraction and discharge infrastructure located within the River Dee. The cooling method is subject to the completion of FEED and further studies on cooling water quality and would be a recirculating hybrid cooling of both the CCGT and CCP.	Yes

9. Conclusion

The plant will be designed to align with and help to develop the BAT principles based on the measures indicated and no departures from indicative BAT have been identified.