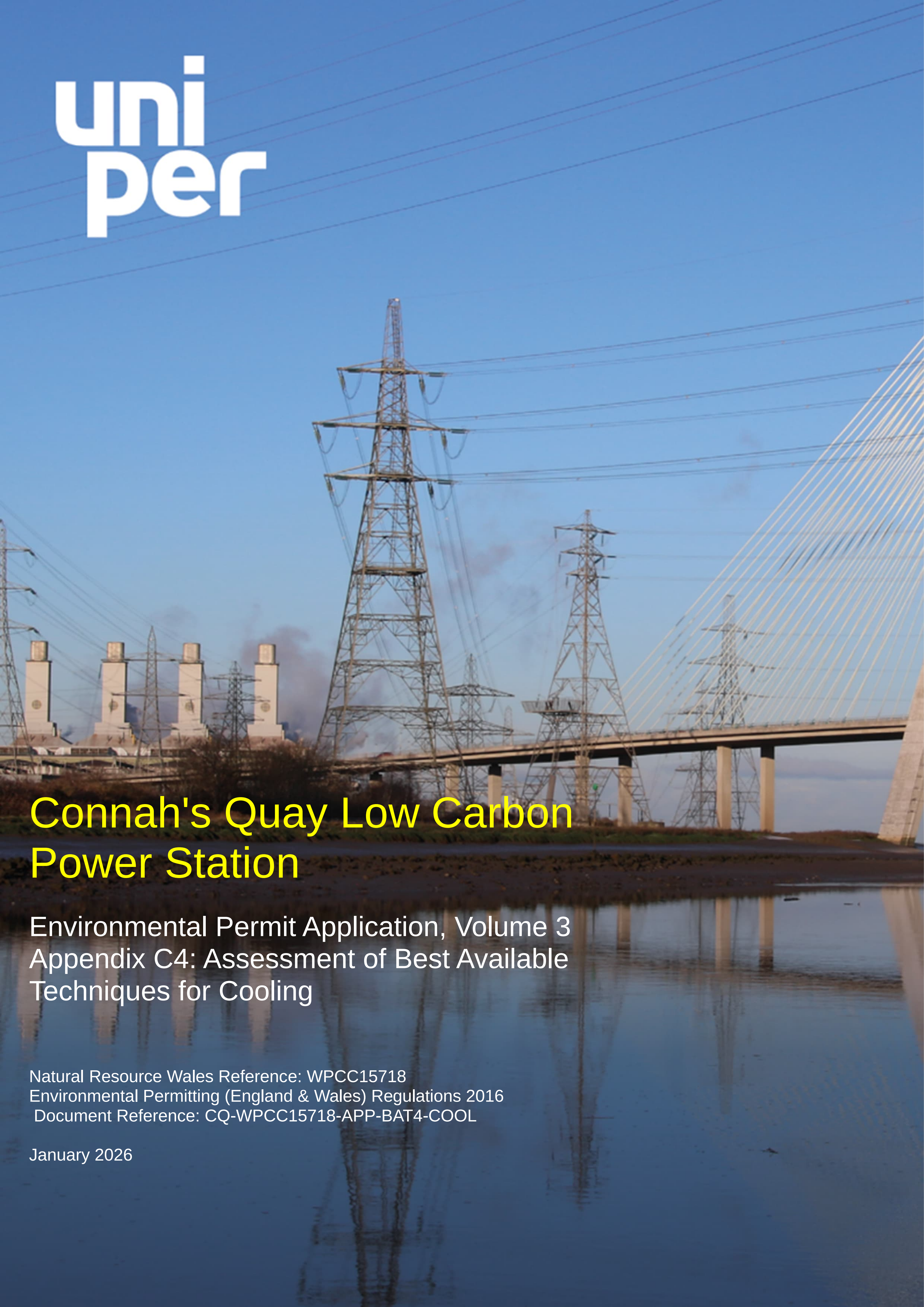

Connah's Quay Low Carbon Power Station

Environmental Permit Application, Volume 3 Appendix C4: Assessment of Best Available Techniques for Cooling

Natural Resource Wales Reference: WPCC15718
Environmental Permitting (England & Wales) Regulations 2016
Document Reference: CQ-WPCC15718-APP-BAT4-COOL

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Table of Contents

Glossary 1
1. Introduction 5
  1.1 Overview 5
  1.2 Proposed Installation 5
  1.3 BAT Considerations 6
  1.4 Cooling Load Assessment 7
  1.5 Location Considerations 7
2. Water Source and Discharge Considerations 8
  2.1 Water Supply 8
  2.2 Cooling Water Discharge 8
3. Proposed Installation Cooling Options 11
  3.1 Indicative BAT for Power Station Cooling Systems 11
  3.2 Options Overview 11
  3.3 Once-Through Cooling 11
  3.4 Wet Cooling Towers 12
  3.5 Hybrid (‘Wet-Dry’) Cooling 13
  3.6 Air Cooled Condenser 14
4. Existing Environment 16
  4.1 Residential Receptors 16
  4.2 Ecological Receptors 16
  4.3 Climate Change Considerations 17
  4.4 Key Environmental Considerations 17
  4.4.1 Abstraction 18
  4.4.2 Discharge 18
  4.4.2.1 Existing Cooling Purge Discharge 18
  4.4.2.2 Cooling Purge Discharge from Proposed Installation 18
  4.4.2.3 Process Water Drainage 19
5. Costs and Benefits of the Cooling Options 21
6. Assessment Against BREF for Industrial Cooling 22
7. Conclusion 30

Figures

Figure 1. Flow of Cooling Water Showing New, Existing and Shared Infrastructure 10

Tables

Table 1 Existing Limits- Abstraction (24/67/10/124/V004) 8
Table 2 Internal Operational Criteria for Cooling Water Purge Discharge to W1 9
Table 3 Existing Environmental Permit Limits- Cooling Discharge (EPR/NP3037AF) 9
Table 4 Summary of Sensitive Land Uses 16
Table 5 Indicative Performance and Operating Parameters (for CO_2 – abated mode), ... 21
Table 6 Comparison of Potential Cooling Options 21
Table 7 BAT Assessment Against BRef for Industrial Cooling Systems 22

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
NSR	Noise Sensitive Receptor
NVZ	Nitrate Vulnerability Zones
O_2	Oxygen
OEM	Original Equipment Manufacturer
OTNOC	Other Than Normal Operating Conditions
PAH	Polycyclic Aromatic Hydrocarbons
PC	Process Contributions
PCC	Post-combustion Carbon Capture
PCB	Polychlorinated Biphenyls
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
WTTP	Waste Water Treatment Plant

1. Introduction

1.1 Overview

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) project ("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 cooling.

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 combined cycle gas turbine (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 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 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 was 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 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) confirmed 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 wastewater from the site will also be discharged to the existing sites 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. BAT assessments have been prepared to demonstrate the Proposed Installation will be designed and operated in accordance with BAT for LCP, Energy Efficiency, 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, and the BAT Reference Document (BRef) for cooling systems[1].

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 CCP for the Proposed 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 cooling plant against the BAT techniques identified in the Cooling BRef. For assessment of BAT for Large combustion plant (LCP), carbon capture plant (CCP), and energy efficiency please refer to the separate assessments:

- BAT Assessment for Large Combustion Plant (Appendix C1; Document Reference WPCC15718-APP-BAT1-LCP).
- BAT Assessment for Post-Combustion Carbon Capture (Appendix C2; Document Reference: WPCC15718-APP-BAT2-PCC).
- BAT Assessment for Energy Efficiency (Appendix C3; Document Reference: WPCC15718-APP-BAT3-EE).

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[1] European Commission, December 2001, Reference Document on the application of Best Available Techniques to Industrial Cooling Systems. Available online: https://circabc.europa.eu/ui/group/6e55c617-a04a-4244-9a59-19382de29990/library/9b56accb-b417-4aca-92b1-529b9a402be0

1.4 Cooling Load Assessment

Cooling will be required for the CCGT units to condense the steam after it has passed through the low pressure (LP) section of the ST; a vacuum is maintained in the condenser in order to minimise the steam condensation temperature and therefore maximise the electrical generation from the ST. By condensing the steam to the lowest temperature, the thermal efficiency of the steam cycle is maximised, and thus the highest electrical efficiency is obtained. The CCGT total cooling load will be circa 150 to 200 MW_{th} per train.

The CCP uses cooling to lower the flue gas temperature (via a direct contact cooler, DCC) prior to amine stripping, for solvent condensation and steam condensate cooling; the compression of CO_2 also generates heat and has an associated cooling requirement. The CCP adds considerably to the number of heat-exchangers that would typically be required for a CCGT power station. The CCP cooling requirement will be circa 450 – 500 MW_{th} per train).

The principal cooling loads for the CCP are associated with:

- the Direct Contact Cooler (DCC) circulation cooler;
- the overhead condenser to the Regenerator for condensation of solvent vapour;
- flue gas water-wash stage(s) cooling;
- lean solvent cooling prior to storage; and
- CO_2 compression package.

Make-up water to the cooling water system will be provided from the existing cooling water abstraction. A cooling water dosing package will be required to prevent algae growth, scale and corrosion.

Cooling water will be sent to the existing purge pond prior to testing and final discharge to the River Dee at the existing W1 outfall.

1.5 Location Considerations

The Proposed Installation is surrounded by the existing Connah's Quay Power Station to the south-east and agricultural fields to the north-west. The Proposed Installation is bordered to the north and north-east by the Dee Estuary, including peripheral floodplain marshland. It is bordered to south and west by the A548 Chester Road and the Kelsterton Road.

The site has flat, low-lying coastal topography with typical ground levels ranging between approximately 6 to 8 m Above Ordnance Datum (AOD).

The Dee Estuary is designated as a Ramsar site, Special Area of Conservation (SAC) (River Dee and Bala Lake / Afon Dyfrdwy a Llyn Tegid SAC), Special Protection Area (SPA) (Dee Estuary / Aber Afon Dyfrdwy SPA) and Site of Special Scientific Interest (SSSI) (Afon Dyfrdwy (River Dee) SSSI) due to its size and topography, its assemblage of diverse marine, coastal, and intertidal habitats, and its importance for passage and wintering waterfowl and intertidal plant species.

Site-specific environmental considerations are discussed in Section 4.

2. Water Source and Discharge Considerations

2.1 Water Supply

A separate abstraction licence (24/67/10/124/V004) is held by the Applicant which permits abstraction of water for the purposes of cooling. The Proposed Installation will be designed to operate so that the river water demands remains within the conditions of the existing abstraction licence.

The cooling water required for the Proposed Installation will be sourced via a new make-up connection pipe from each train to the existing cooling water settling pond. New make-up transfer pumps will be required to facilitate the transfer of water from the settling pond to each train of the Proposed Installation cooling system. The new infrastructure may be above or below ground.

The Applicant proposes to maintain the abstraction licence parameters (see Table 1) for the Proposed Installation, where abstraction is intermittent and limited to no more than three hours abstraction per tide around high water (one hour before and two hours after) but only when the water level recorder at Victoria Doc, Liverpool is high enough during the specific period.

Table 1 Existing Limits- Abstraction (24/67/10/124/V004)

Specified Period	Maximum Quantity of Water to Be Abstracted During the Specified Period
Per Hour	11,000 m^3
Per High Tide	33,000 m^3
Per Year	24,090,000 m^3
Instantaneous Rate Not to be Exceeded	3,040 litres per second

2.2 Cooling Water Discharge

The cooling water discharge infrastructure consists of two purge ponds (purge pond A and purge pond B), two process water tanks (that are also referred to as SDX tank A and B) as well as two sludge holding tanks (tank 1 and 2). The purge ponds will mainly receive cooling tower blowdown and some process waters. The SDX tanks will receive only process waters. The sludge holding tanks will receive sludge from different areas of the plant, but mainly from the settlement pond. These six tanks are interconnected via the “Common Discharge Chamber”. Discharge from those six tanks to the “Common Discharge Chamber” can be controlled via automatic penstock valves.

Purge discharge would also be consistent with the existing Connah’s Quay Power Station operation and the Proposed Installation will be designed to operate so discharge of cooling purge water remains within the conditions and limits of the existing Environmental Permit.

Purge discharge will be facilitated by the installation of a new purge discharge pipeline and associated pumps (above or below ground) which would pump purge water from the Proposed Installation to the existing purge storage pond.

Technically it shall be possible to route either cooling water blowdown and process waters (from the existing Power Station and the Proposed Installation) to either purge pond. Additionally, it shall be possible to route further process water streams to either SDX tank. However, normal operation foresees to assign one purge pond and one SDX tank to one site only. For instance, purge pond A and SDX tank A could be assigned to the Proposed Installation and purge pond B and SDX tank B to the existing Power Station.

During normal operation there will be a transfer from the Proposed Installation to the existing Power Station via the “Common Discharge Chamber”. Any discharge from the Proposed Installation to the existing Power Station needs to be permit compliant. Permit compliance can be guaranteed with the help of online analysers in the inlet to the purge pond or SDX tank.

The cooling water from the Proposed Installation will be monitored on the purge pipeline from the new cooling towers to ensure that it meets the following quality parameters before release to the purge storage pond. These points are marked by red dots on Figure 1 on the following page..

Table 2 Internal Operational Criteria for Cooling Water Purge Discharge to W1

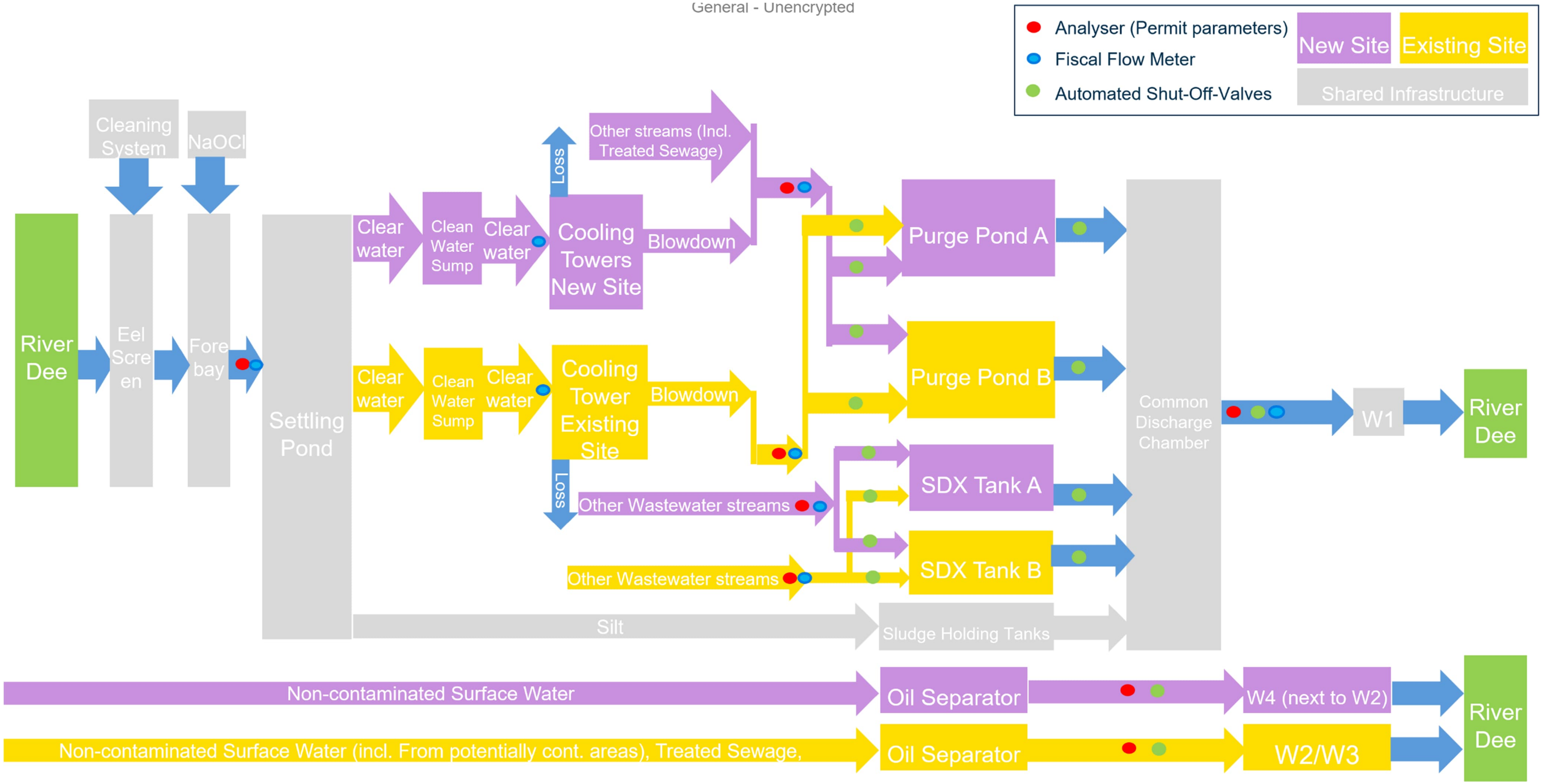
Parameter	Limit	Reference Period	Monitoring Frequency
Flow	2.5 m^3/s	Instantaneous	Continuous
Maximum temperature	25°C		
Maximum temperature difference	13°C		
Maximum temperature difference (Nov-March)	20°C		
Salinity	60g/l		
pH range	6 - 9		
Total Residual Oxidant	0.2 mg/l		
Oil and grease	20 mg/l		

Purge discharge to the River Dee occurs at discharge point W1 and would be regulated under the existing Environmental Permit (EPR/NP3037AF). No changes are proposed to the existing permit conditions and discharge would be no more than three hours commencing on the ebb tide one hour after high water with temperature and water quality, and would comply with the existing Environmental Permit limits (see Table 3 below).

Table 3 Existing Environmental Permit Limits- Cooling Discharge (EPR/NP3037AF)

Parameter	Limit	Reference Period	Monitoring Frequency
Flow	2.5 m^3/s	Instantaneous	Continuous
Maximum temperature	25°C		
Maximum temperature difference (April-October)	13°C		
Maximum temperature difference (November-March)	20°C		
Salinity	60 g/l		
pH maximum	9		
pH minimum	6		
Total Residual Oxidant	0.2 mg/l	Instantaneous	
Oil and grease	20 mg/l		

Figure 1. Flow of Cooling Water Showing New, Existing and Shared Infrastructure



3. Proposed Installation Cooling Options

3.1 Indicative BAT for Power Station Cooling Systems

BAT for cooling systems (for CCGT only) is defined in the Industrial Cooling Systems BRef document[1]. This document is referenced in the Large Combustion Plant BRef[2]. Both BRef standards are accepted as BAT by NRW. Indicative BAT for cooling in relation to power stations is defined as follows:

"*In an integrated approach to cooling an industrial process, both the direct and indirect use of energy are taken into account. In terms of the overall energy efficiency of an installation, the use of a once-through system is BAT, in particular for processes requiring large cooling capacities (e.g. >10MWth). In the case of rivers and/ or estuaries once-through can be acceptable if also:*

- *Extension of heat plume in the surface water leaves passage for fish migration;*
- *Cooling water intake is designed aiming at reduced fish entrainment; and*
- *Heat load does not interfere with other users of receiving surface water.*

For power stations, if once-through is not possible, natural draught wet cooling towers are more energy-efficient than other cooling configurations, but application can be restricted because of the visual impact of their overall height."

3.2 Options Overview

Based on the cooling load assessment provided in Section 1.4 above, the total cooling duty for the Proposed Installation operating both trains will be 1030 – 1280 MW_{th}.

The Proposed Installation will be designed to maximise energy efficiency, including where optimal, integration of steam system, water supply and cooling circuits, in accordance with indicative BAT. This will be carried out during FEED as part of, and following, the technology selections.

The assessment has been made on the basis of continuous operation of the Proposed Installation and four main options are available:

- Once-through water cooling;
- Wet cooling tower;
- Hybrid (wet/ dry) cooling tower; and,
- Air-cooled condenser (ACC) (dry cooling).

These options are considered in more detail below.

3.3 Once-Through Cooling

Once-through cooling uses water pumped from controlled waters (such as an estuary, river or other surface water feature) via a large water inlet, directly through a heat exchanger or condenser, after which the heated water is discharged directly back into the surface water. Once through cooling represents one of the most efficient cooling processes due to the low cooling water temperature and the high heat transfer characteristic of water-cooled condensers.

However, once-through cooling systems involve significant water use (some 50-100 times more than with hybrid cooling towers) with the Industrial Cooling Systems BRef stating that such cooling systems can consume up to 86t/h/MWth for a delta T of 10°C for a simple CCGT alone. For use on a CCGT with

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[2] EU Best Available Techniques (BAT) Reference Document for Large Combustion Plants (July 2017)

CCP this is likely to be more than double. This would present a significant impact on the River Dee in terms of both intake volume and thermal impact of discharge.

Once-through systems are affected by the availability of sufficient surface water and the water quality, as well as discharge limitations, for example the effect of the thermal load on the receiving water body and its ecological sensitivity. As all the cooling water used in once-through systems is usually discharged (rather than being recirculated), it undergoes only mechanical screening and coarse filtration to prevent serious damage to downstream equipment, so that there is no change in water chemistry between the circulating water and the source water. Scale deposition of biological fouling is a common issue with once-through cooling systems and if the water is more corrosive (i.e. sea water or estuary water, as in the case of the proposed Installation) the impact on material costs can be significant.

Other environmental considerations include:

- the use of energy for pumping;
- the risk of fish entrainment and need to restrict approach velocity; and
- the use of additives, such as scale treatment, with subsequent discharge to the controlled water.

Significant refurbishment and upgrade would be required on the existing intake arrangement to meet the additional volume requirements for once-through cooling, including installation of larger pipework, equipment and pumphouse. Additionally, a new abstraction licence or revision to the existing one would be required to accommodate additional volumetric flow (to accommodate the discharge temperature requirement), it is therefore considered unviable for the site.

3.4 Wet Cooling Towers

Wet cooling towers use water as the main cooling medium with the heat lost through contact with air. The heat load in the cooling water is removed by evaporation within the cooling towers and the cooled water is recirculated within the system typically via a reservoir (cooling tower basin). A percentage of the cooling water (c.1-2%) is lost through evaporation and drift (entrainment of droplets); blow-down is required to maintain water quality resulting from cycles of concentration. The system level is maintained through make-up water from the abstraction. The Industrial Cooling Systems BRef states that the volume of make-up water required for power stations using an open loop wet cooling system can be 1-5% of that required for similar sized once-through cooling systems.

Cooling water from the steam condenser is pumped to the top of the cooling tower and the water is distributed, by spray, over the cooling tower packing, to maximise the contact with steam flow though the packing.

Drift eliminators are employed at the top of the tower to minimise the entrainment of water droplets within the air flow. The air exiting the tower will be saturated with water, and therefore visible plumes will frequently occur as the warm air mixes with colder atmospheric air causing condensation of the water vapour. The extent of the plume formation is dependent on weather conditions, with colder or more humid air resulting in larger plumes.

The continuous evaporation of the cooling water can result in a concentration of dissolved salts present within the cooling water. To maintain the dissolved solid content to within design parameters of the cooling towers, a small amount of water is removed (purge/blow-down), and make-up water is added to the cooling tower recirculation system to compensate for the volume losses from evaporation and purging (make-up).

Several alternative designs for the water-air evaporative cooling stage can be employed:

- natural-draught air flow, which relies on a pressure differential between top and bottom of the tower, generated by the change in density of the air, to induce a draught of air up the tower in a counter-flow to the cooling water; and
- mechanical-draught air flow, which uses mechanically generated air flow using fans either at the top (induced-draught) or bottom (forced draught) of the tower; within these systems the air flow

can be perpendicular to the water flow (cross- current) or in the opposite direction to the water flow (counter-current).

Natural Draught Towers

Natural draught towers are made from reinforced concrete and are high capital cost; they may be 80-150m in height and can emit continuous visible plumes when operational and therefore can present significant visual impact, as well as the potential for generating large visible plumes, plume grounding and the risk of icing of roads during certain weather conditions. Natural draught towers are best suited for areas of high relative humidity; therefore, natural draught towers are considered to be inefficient for the location of the Proposed Installation, having a design relative humidity of 72%.

Natural draught towers are not considered to be appropriate for the site due to efficiency issues arising from typically lower relative air humidity, limited turndown and flexibility, cost effectiveness for the cooling duty required and the visual impact of water plumes and the towers themselves. The use of natural draught cooling towers has therefore been discounted from this assessment. Their use, generally, is rare in the UK of recent times.

Mechanical Draught Towers

Mechanical draught towers are typically smaller than natural draught towers, and therefore the capital investment is lower; Mechanical draught systems also produce visible plumes, albeit at lower tower exit height than for natural draught systems. The impacts from visible plumes depend on the proximity and sightlines of nearby receptors. Their disadvantage compared to natural draught is that they require motorised fans to assist the air flow, which requires use of auxiliary power and potentially results in higher noise emissions.

Mechanical draught cooling towers can be saline or non-saline. In both cases, the water intake system needs to be protected from organic growth to prevent blockages. Disinfection processes (e.g. chlorination) can be employed, although this has a potential environmental impact from the discharge; alternatively, thermal treatment can be employed although this is more complicated to operate and may affect thermal efficiency of the installation. Saline cooling towers have the added disadvantage that the exchanger equipment materials need to be of higher specification and therefore this increases the equipment cost.

It is known that there is sufficient water supply of appropriate quality available for application of this cooling technology at the site from the nearby River Dee, as described in Section 2.

The assessment has therefore included consideration of a single wet cooling system for the proposed installation with mechanical draught cooling towers, using water from the River Dee.

3.5 Hybrid ('Wet-Dry') Cooling

Hybrid cooling (also known as plume-abated mechanical draught cooling) also uses water as the main cooling medium. The heat load in the cooling water is removed in the hybrid cooling towers by a combination of dry air cooling, and evaporative cooling. This technique is already in use at the existing power plant.

The cooling water is first dry-cooled, by passing through tube banks in the hybrid cooling towers over which air is drawn by forced draught fans; this reduces the evaporative cooling load in the wet stage. The cooling water then passes to a wet cooling stage where it is sprayed over packed bed elements, to provide an extended, and therefore more efficient, air/ water contact surface area. In the wet cooling stage, the water is cooled by two effects: the direct contact of the cold air flow with the water, and the cooling effect of the evaporation of a small proportion of the water.

Drift eliminators are employed at the top of the tower to minimise the entrainment of water droplets within the air flow. The air exiting the tower will be saturated with water, and therefore visible plumes will frequently occur as the warm air mixes with colder atmospheric air causing condensation of the water vapour. The extent of the plume formation is dependent on weather conditions, with colder or more humid air resulting in larger plumes.

The cooling water demand for a hybrid cooling system at the site could be sourced from the River Dee.

This method of cooling is more efficient than ACC; it benefits from the more efficient water-cooling heat exchange characteristics but still relies on the ambient air conditions to achieve some cooling. Hybrid tower systems are comparable in size to mechanical draught cooling towers. However, the additional fans result in a higher associated auxiliary power load and greater noise generation than fully wet cooling methods.

The hybrid tower system also requires make-up water to compensate the losses through evaporation and the purge of concentrated salts in the recirculated water; however, the water consumption is typically c.25% of that for wet cooling systems. The Industrial Cooling Systems BRef states that the consumption of water for an open hybrid tower is typically around 0.5m^3/h/MWth.

Hybrid cooling towers can, however, still produce visible plumes of water vapour under certain weather conditions, in particular during cold or humid weather, however the incidence of such plumes is significantly less than for fully wet-cooling systems as the dry-cooled stage reduces the evaporation requirement, and the evaporated water is heated (thus increasing the saturated vapour pressure of water in the emission from the hybrid tower) as the vapour passes across the dry cooled section.

Hybrid cooling capital costs are significantly more than other mechanical draught cooling, and also uses more power than once through cooling thereby lowering the overall plant efficiency. They are, therefore, only considered to be the most suitable cooling option where plume-abatement is considered important such as given the proximity of the A548 and the Kelsterton Road.

Hybrid cooling towers are taken forward in the assessment as they are currently used on the site and are:

- Comparable to mechanical draft towers in terms of efficiency and is better than air cooling;
- Has the lowest risk of plume formation; and
- The lowest water demand of the waster based cooling options.

. Refer to Table 6, for comparison of cooling options.

3.6 Air Cooled Condenser

Dry air-cooled condensers (ACC) provide cooling by passing a cooling flow of air over finned tubes within a bank of condensing heat exchangers which contain the medium to be cooled (typically steam). These banks of heat exchangers are normally mounted in an elevated structure to allow good and even air flow across the heat exchange surfaces; the air flow is created by large fans. Direct ACC circulates the process stream (steam in the case of CCGT) through the heat exchanger, whereas indirect ACC circulates a secondary cooling medium (typically water) through the heat-exchanger and this returns to cool the process stream via a condenser.

ACCs require no off-site infrastructure and rely solely on the supply of electrical energy to operate the fans; however, this can be a very considerable auxiliary load that significantly reduces the overall plant efficiency. ACCs are rarely the cooling option of choice unless there is a scarcity of water available to a power station site.

The heat transfer characteristics of the air-cooled heat exchangers, and the fact that the air temperature is normally higher than water-cooled options, means that this arrangement is the least favourable arrangement from an efficiency point of view; this is particularly marked at higher ambient air temperatures, as the ST output is dependent on the condenser efficiency to generate the necessary vacuum through the low pressure (LP) turbine. These systems are best suited for locations with consistently high relative humidity, with efficiency decreasing with lower relative humidity levels, as is likely at the Proposed Installation location.

ACCs have the added disadvantage of the significant noise generated by the fans and the larger footprint required to achieve the necessary level of cooling.

However, ACCs offer benefits in other areas such as avoiding the environmental impacts associated with water abstraction and discharge as well as the construction effects of the associated infrastructure; and heat is discharged directly to the air without the generation of visible plumes created by wet methods.

ACC for the CCGT has been discounted as it is not expected to achieve the necessary level of generation efficiency with the available space, which combined with the parasitic load of the CCP, would make the operation unviable. ACC would have lower net electrical efficiency, relative to other cooling techniques which are broadly comparable.

Consideration of using ACC for the CCP cooling (with separate, alternative cooling system for the CCGT identified that to achieve the required cooling for the CCP (approximately double that of the CCGT) a substantial sized ACC cooling bank will be required and is expected to be larger than the size of the plant, and this option is therefore not considered viable for the CCP due to space limitations.

This option has therefore been discounted from this assessment.

4. Existing Environment

This section describes the environmental context for the Proposed Installation, in particular the local environment with the potential to be impacted by the cooling options under consideration.

A number of environmental receptors have been identified in the vicinity of the Proposed Installation. All distances are given as the shortest distance between the receptor and the closest point of the Proposed Installation boundary.

4.1 Residential Receptors

Settlements in the vicinity of the Proposed Installation are generally concentrated around the Dee Estuary south-east of the Proposed Installation or form a chain of semi-continuous development along the A548 north-west of the Proposed Installation. Some settlements lack an obvious centre or include isolated farm properties; others are heavily suburbanised or lack a defined boundary between two named locations.

The nearest residential receptors to the Proposed Installation are located along Kelsterton Road, with the closest receptor being approximately 20 m from the site. The nearest main settlement is the town of Connah's Quay. Its approximate centre is located approximately 2.1 km south-east of the Proposed Installation, though residential areas of the settlement reach to within approximately 90 m of the Proposed Installation.

The sensitivity of these receptors to visible impacts, such as visible plumes and buildings and structures, is considered to be relatively low given the prevalence of industrial land use in the surrounding area.

4.2 Ecological Receptors

A number of nationally designated ecological sites are situated within close proximity of the Proposed Installation; including Dee Estuary Site of Special Scientific Interest (SSSI)/ Special Protection Area (SPA)/ Special Area of Conservation (SAC)/ Ramsar site located immediately off the Proposed Installation. Details are summarised in Table 4.

Table 4 Summary of Sensitive Land Uses

Sensitive land use	Distance and direction from the Site
SPA – Dee Estuary	Located within the Water Connection Corridor and slightly overlapping the Main Installation Area to the north and west, and adjacent to the Repurposed CO_2 Connection Corridor and the C&IEA.
SAC – Dee Estuary	Located within the Water Connection Corridor and adjacent to the northern boundaries of the Main Installation Area (slightly overlapping along the western boundary), the Repurposed CO_2 Connection Corridor and the C&IEA.
SSSI – River Dee and Dee Estuary	Located within the Water Connection Corridor and adjacent to the northern boundaries of the Main Installation Area (slightly overlapping along the western boundary), the Repurposed CO_2 Connection Corridor the C&IEA.
Conserved Wetland Sites (RAMSAR)	Located within the Water Connection Corridor, slightly overlapping the Main Installation Area to the north and west, and adjacent to the northern boundaries of the Repurposed CO_2 Connection Corridor and the C&IEA.
Connah's Quay Power Station Nature Reserve (non-statutory)	Located within Water Connection Corridor and to the west and north of the Main Installation Area and in association with River Dee and its plains.
Green Wedge	Located approximately 35 m south of the Access to the Main Installation Area.

A further four European designated sites are located within 15km of the Site:

- River Dee and Bala Lake/ Afon Dyfrdwy a Llyn Tegid, Special Areas of Conservation (SAC) located 520m north;
- Deeside and Buckley Newt Sites, SAC located 2.1 km south;
- Halkyn Mountain / Mynydd Helygain, SAC located 5.3km west;
- Alyn Valley Woods / Coedwigoedd Dyffryn Alun, SAC located 8.5 km south west;

There are number of Local Wildlife Sites (LWS) within 2 km of the sites: Leadbrook Wood LWS, Top-y-fron Dingle and Kelsterton Brook LWS, Llwyn-onn LWS, Caeau Alt-vois LWS, Cheshire Farm LWS.

There are no National Parks, National Nature Reserves, Local Nature Reserves, Biosphere Reserves, Forest Parks, Marine Conservation Zones, National Landscapes or Conservation Areas in and around the Proposed Installation.

The whole of the Proposed Installation is located within a SSSI Impact Risk Zone.

4.3 Climate Change Considerations

Considerations include:

Effects of air temperature change – The exchange of heat is driven by the temperature difference between the 'hot' and 'cold' side of a heat exchanger. Therefore, the efficiency of any cooling system is dependent on the temperature of the cooling medium. For air-cooled systems, the dry bulb temperature, which is higher than the wet-bulb temperature, defines the minimum temperature for cooling.

In effect this means that during hot, dry weather, air-cooled systems are much more limited in the cooling performance achievable compared with wet-cooled systems and are affected more generally by fluctuations in air temperature than wet systems.

The condenser performance and consequently the ST output (and generation efficiency) is limited by the ambient temperature.

Effects of water temperature change – As outlined above, the efficiency of any cooling system is dependent on the temperature of the cooling medium. For wet (evaporative) cooling systems, the wet bulb temperature (that is dependent on the measured atmospheric temperature, relative humidity and air pressure) influences the rate of evaporation as this is the theoretical lowest temperature to which water can be cooled by evaporation.

In addition, the difference between air and water temperatures in winter further reduces any efficiency gains; most efficiency gains are seen in summer months when the water temperature is relatively low when compared to ambient air.

4.4 Key Environmental Considerations

Of the identified receptors, the nationally and internationally designated ecological conservation areas presented in Table 4 are considered to be the most sensitive to impacts from the cooling options.

Potentially significant impacts would be:

- the abstraction of water, with mitigation required to avoid entrainment of aquatic organisms;
- impacts on water chemistry and biodiversity from the discharge of water with thermal plume and potential water treatment chemicals; and
- noise impacts from fans with potential disturbance of birdlife.

Noise impacts on local residential receptors from any of the cooling options are considered to be of lower importance because of the distance to receptors, and the existing industrial environment in which the proposed development would be located. It is considered that such impacts could be adequately mitigated for with appropriate selection of equipment and screening measures as necessary.

4.4.1 Abstraction

Based on the concept design for the Proposed Installation the predicted water demand and thermal discharge for the of the plant is:

- CCGT cooling demand of circa 150 to 200 MW_{th} per train or up to 400 MWth total;
- CCP cooling demand of circa 450 to 500 MW_{th} per train or up to 1,000 MWth total;
- Cooling water make up requirement for both trains is 3,450 tph.

4.4.2 Discharge

With respect to discharges:

- Cooling blowdown water will discharge via the relevant purge pond;
- Process wastewaters will discharge via the relevant SDX tank; and
- Domestic and sanitary effluent will discharge through an underground septic system for settlement prior to discharge.

Further detail on the operation of the discharges for existing and proposed purge discharge and the process water discharge are provided in the sections to follow.

4.4.2.1 Existing Cooling Purge Discharge

Purge discharge to the River Dee occurs at discharge point W1 and is regulated under the existing Environmental Permit (EPR/NP3037AF) which allows discharge during a three-hour period on every tide (a tidal cycle is approximately 12.5 hours), from 1 hour after the predicted time of high water (HW) to 4 hours after the predicted time of HW. The discharge from the common discharge chamber to the Dee is continuous during this period. The discharge flow is controlled by control valves in the outlet of the common discharge chamber and is limited to 2.5 m^3/s.

The discharge from the purge pond is sampled and analysed, before opening the discharge in the designated discharge period. Moreover, an online analyser measures temperature, pH, conductivity/salinity, oil and total residual oxidant during the discharge. In case of exceeding the limits (see Table 1), automatic penstock valves prevent further discharge from the common discharge chamber to the estuary. In addition to the analysers at the inlet to the purge ponds and the discharge of the common discharge chamber, process relevant parameters are being measured at different locations throughout the process. This multi-barrier system reduces the risk of discharge of non-compliant water due to the failure of a single sensor. Regular maintenance of the online analysers adds to that security.

A common discharge chamber interconnects the purge ponds with the sludge holding tanks (two tanks) and the process water tanks (also called SDX-tanks). See Figure 1 for a better overview. The process water tanks contain any treated non-cooling process water from the existing power station.

Silt from the settling pond (via sludge holding tanks), the process waters and the cooling tower blowdown from the existing power station all get discharged via the common discharge chamber to the outfall structure (outfall W1).

4.4.2.2 Cooling Purge Discharge from Proposed Installation

Apart from drift and evaporation loss, cooling water will be discharged from the new cooling towers towards the two existing purge ponds (A &B). During normal operation, water from the Proposed Installation would discharge into purge pond A with cooling water from the existing Connah's Quay Power Station discharging to purge pond B. However, during abnormal operations for instance due to equipment failure or maintenance the cooling water from both the existing Power Station and Proposed Installation can be discharged into the same purge pond.

Online analysers will control automated penstock valves, together preventing the discharge of out-of-spec waters to the purge ponds.

Any discharge from Proposed Installation to the shared infrastructure will need to be permit compliant at all times. As all tanks and ponds are hydraulically connected via the "Common Discharge Chamber", the discharge will have to be coordinated based on level measurement to prevent mixing of the waters. It is anticipated to have a level prioritized discharge order. Ultimately once the existing power plant is fully decommissioned, the Proposed Installation will have full flexibility and can use the purge ponds and SDX tanks in a similar way to the existing site today.

In the event of an abnormal operation, if there is a requirement to discharge cooling water from both existing and Proposed Installations to the same pond and same SDX tank, both need to be permit compliant and it needs to be agreed by both sites.

If the inlet analysers at either the existing power station or the Proposed Installation detect values above permit limits, discharge to the purge pond from the respective site automatically gets stopped. The purge pond that last received water from the site that showed a potential permit breach, closes its inlet to not further increase the amount of water that potentially needs to be treated and more importantly, stops the discharge to the common discharge chamber.

The site with the compliant discharge will continue to discharge into the remaining purge pond, discharge valves to common discharge chamber will be open and water can be discharged from that pond. Therefore, the site with the compliant discharge can continue to operate without interruption.

The site with the potentially non-compliant discharge will be able to operate as long as buffer storage tanks or the water chemistry in the cooling towers allows it to do so. While operators must investigate the potential source of the contamination, they can manually take the decision to continue discharging into the potentially contaminated purge pond, while the discharge valve from the respective purge pond to the common discharge chamber stays closed. Water in the potentially contaminated purge pond must be sampled and analysed. When water is confirmed as not contaminated, it can be discharged.

4.4.2.3 Process Water Drainage

There will be several potential sources of process wastewater that may be generated at the Proposed Installation. The largest sources of process wastewater are detailed below but this is not an exhaustive list:

- neutralised effluent streams from the demineralisation plant;
- blowdown from the CCP and CCGT;
- treated effluent from the CCP; and
- contaminated surface water arising from process areas, that may contain chemicals such as oils or flue gas treatment products.

Wastewater treatment will be provided for process wastewaters to optimise the volume of water being recirculated. Process water that can't be recirculated will:

- need to meet the internal environmental quality criteria for transfer to the purge pond to allow discharge under the existing permitted discharge limits; or
- disposal of degraded amine or other contaminated wastewater not suitable for discharge will be removed via tanker for off-site disposal at a suitably permitted waste facility.

The Proposed Installation will discharge its process waters to the common discharge chamber during normal operations via SDX tank A

Any potentially contaminated process waters from the Proposed Installation or existing site will be discharged to their respective SDX-tank . This means the same mechanism, as to the purge ponds, applies. All inlet flow needs to be controlled for permit values. If values are exceeded, automatic penstock valves shuts-off the discharge to the common discharge chamber of the potentially contaminated SDX Tank, while the other plant can continue to operate, while using the second SDX tank.

4.4.2.4 Domestic and Sanitary Effluent

Black and grey wastewater (i.e. non-cooling and non-process wastewater) from the existing Connah's Quay Power Station is currently directed to an underground septic tank system for storage and settling (as treatment). Current permitted practice is to treat sewage on site and discharge treated sewage waters with main cooling water purge discharge to the River Dee at W1.

It is expected that the Proposed Installation will use a new similar system for black and grey wastewater including foul drainage from permanent welfare facilities, with treated black and grey wastewater to be discharged to the River Dee with main cooling water purge discharge (in accordance with the existing permit). Connection to the closest public sewer is not considered feasible due to the presence of the railway line that would need to be crossed.

In the event of a plant malfunction, or where a new contaminant stream is generated that is not authorised under the existing environmental permit, the material shall be removed by vacuum tanker and disposed of at an approved off-site facility.

4.4.2.5 Temporary Domestic and Sanitary Wastewater Management During Construction

During the construction phase, a temporary wastewater management arrangement will be required due to increased personnel numbers on site. Black and grey wastewater arisings are currently estimated to be approximately 45,000 litres per day, equivalent to around 300 population equivalent, based on a standard per-capita wastewater generation rate of 150 litres per person per day. At this volume, removal solely by tanker would not be practicable.

A temporary on-site wastewater treatment system, comprising a Moving Bed Biofilm Reactor (MBBR), will therefore be installed to treat black and grey wastewater prior to discharge. This will ensure that untreated sewage is not discharged. Treated effluent will be discharged via the existing permitted outfall with the main cooling water purge to the River Dee, in accordance with permit conditions.

Treated effluent quality will be managed to be comparable to that of nearby municipal wastewater treatment works, specifically the Flint and Queensferry treatment works. Target parameters are: biochemical oxygen demand (BOD_5) of less than 25 mg/L O_2 (or greater than 70% reduction), chemical oxygen demand (COD) of less than 125 mg/L O_2 (or greater than 75% reduction), and total suspended solids (TSS) of less than 60 mg/L.

The discharge volume will vary in line with construction workforce numbers. The temporary treatment and discharge arrangement will be in place from establishment of the temporary site facilities through to completion of commissioning and performance testing, after which it will be removed and permanent wastewater arrangements reinstated.

5. Costs and Benefits of the Cooling Options

Table 5 shows a summary of the key performance and other operating parameters of the different cooling technologies.

Table 5 Indicative Performance and Operating Parameters (for CO_2 – abated mode)[3,4]

Parameter	Once Through	Mechanical draught Cooling Tower	Hybrid Cooling Tower	Air Cooled Condenser
Net Power Output (MWe)	1,380	1,380	1,380	1,380
Cooling Requirement (MWth)	1,313	1,313	1,313	1,313
Parasitic loading for cooling (MWe)	32.8	23.6	30.2	>34.1
Potential noise emissions (dB(A))	70 -120	80-120	<85[5]	90 - 130
Average cooling water make up (t/hr)	75,384*	3,769	3,450	N/A
Specific parasitic load (kWe/MWth cooling)	25	18	23	>26[4]

*This is cooling water flow rate for once through cooling system. It is calculated based on 15-degree temperature difference.

The relative performance of each of the options is summarised in Table 6 below for ease of comparison. Each option is rated "best", "average" or "worst" for each category assessed and considering the local sensitivities. Where the performance of multiple systems is similar, they have all been classified as 'average' with the 'best' and 'worst' performances identified as such.

Table 6 Comparison of Potential Cooling Options

Cooling Option	Once Through	Mechanical draught Cooling Tower	Hybrid Cooling Tower	Air Cooled Condenser
Generation efficiency	Best	Average	Average	Worst
Water demand	Worst	Average	Best	N/A
Noise	Best	Average	Average	Worst
Pollutant emissions to air	N/A	Average	Best	Average
Impact on local water environment	Worst	Best	Best	N/A
Capital cost	Worst	Best	Average	Average
Operating cost (*subject to 3rd party costs)	Best	Average	Average	Best
Plume formation	N/A	Average	Best	N/A
Space Requirement	Best	Average	Average	Worst

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[3] Uniper, 2023; Environment Impact Assessment Inputs Summary, p24.
[4] Pieve, Maurizio, et al. *Performance of an air-cooled steam condenser for a waste-to-energy plant over its whole operating range.* Available online: https://www.researchgate.net/publication/215640616_Performance_of_an_air-cooled_steam_condenser_for_a_waste-to-energy_plant_over_its_whole_operating_range

6. Assessment Against BRef for Industrial Cooling

Table 7 BAT Assessment Against BRef for Industrial Cooling Systems

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
1	**BAT1 Integrated Heat Management** BAT for all installations is an integrated approach to reduce the environmental impact of industrial cooling systems maintaining the balance between both the direct and indirect impacts. In other words, the effect of an emission reduction has to be balanced against the potential change in the overall energy efficiency. There is currently no minimum ratio in terms of the environmental benefits and the possible loss in overall energy efficiency that can be used as a benchmark to arrive at techniques that can be considered BAT. Nevertheless, this concept can be used to compare alternatives (Chapter 3.2 and Annex II).	Cooling systems will be correctly designed during the detailed design phase to ensure there is no unnecessary energy consumption at the Proposed Installation. Energy efficient pumps and motors will be used in all cooling systems. Materials selected will be fit for purpose to allow for maximum rate of heat transfer.	Yes
2	**BAT2 Reduction of the level of heat discharge by optimisation of internal/external heat reuse** Reduction of the level of heat discharge by optimization of internal/external heat reuse. In a greenfield situation, assessment of the required heat capacity can only be BAT if it is the outcome of maximum use of the internal and external available and applicable options for reuse of excess heat. In an existing installation, optimizing internal and external reuse and reducing the amount and level of heat to be discharged must also precede any change to the potential capacity of the applied cooling system. Increasing the efficiency of an existing cooling system by improving systems operation must be evaluated against an increase of efficiency by technological measures through retrofit or technological change. In general and for large existing cooling systems, the improvement of the systems operation is considered to be more cost effective than the application of new or improved technology and can therefore be regarded as BAT.	To limit heat discharge, the system will be a hybrid cooling system instead of once through. Cooling system design will be optimised to facilitate reuse of cooling medium, and reduce purging. Water that will be due to be discharged will be tested to ensure that it meets specified internal quality criteria prior to being directed to the existing purge pond via new pipes and pumps. Discharge of water from the purge pond will continue to meet the current water quality limits (i.e. ELVs in EPR/**NP3037AF)** which has been previously assessed as being acceptable.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
3	**BAT 3 Cooling System and Process Requirements** a) A change in cooling technology to reduce the environmental impact can only be considered BAT if the efficiency of cooling is maintained at the same level or, even better, at an increased level. See table 4.1' Examples of process requirements and BAT'. b) Hazardous process substances, which involve a high environmental risk to the aquatic environment in case of leakage, should be cooled by means of indirect cooling systems to prevent an uncontrollable situation. c) A change in cooling technology to reduce the environmental impact can only be considered BAT if the efficiency of cooling is maintained at the same level or, even better, at an increased level.	All cooling systems installed at the Proposed Installation will be new and designed in accordance with BAT and applicable standards. Energy efficient motors and pumps shall be used under all circumstances. Materials selected will be fit for purpose to allow for maximum rate of heat transfer. Any hazardous substances to be cooled involving high environmental risk will use indirect methods as per Table 4.1 in the Integrated Pollution Prevention and Control (IPPC) Reference Document on the application of Best Available Techniques to Industrial Cooling Systems December 2001 (Industrial Cooling BRef).	Yes
4	**BAT 4 Cooling System and Site Requirements** For temperature-sensitive processes it is BAT to select the site with the required availability of cooling water. See table 4.2 Examples of site characteristics and BAT. Groundwater - it can be BAT to apply a dry cooling system to minimise GW use.	For either the hybrid cooling options being taken forward into FEED: • climate has been considered in the pre-FEED design and either solution is suitable for cooling at the Proposed Installation; • space: No issue with space constraints at the site; • water availability: Water is available at the site via the existing abstracted supply from the River Dee; • sensitivity of receiving waterbody: this is considered with the hybrid cooling option and discharges will be in accordance with the existing discharge limits. Heat reuse will be optimise where possible and both options will employ recirculation.	Yes
5 - 7	**BAT 5/6/7 Reduction of energy consumption** It is BAT in the design phase of a cooling system: • To reduce resistance to water and airflow • To apply high efficiency/low energy equipment • To reduce the amount of energy demanding equipment (Annex XI.8.1)	The following techniques will be used to reduce energy consumption: • modulation of air/ water flow; • optimised water treatment and pipe surface treatment to avoid scaling, fouling and corrosion; • applying pumping heads and fans with reduced energy consumption this may include flow-throttling or use of variable speed drives;	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	• To apply optimised cooling water treatment in once-through systems and wet cooling towers to keep surfaces clean and avoid scaling, fouling and corrosion. For each individual case a combination of the above-mentioned factors should lead to the lowest attainable energy consumption to operate a cooling system. Concerning BAT a number of techniques/approaches have been identified. In an integrated approach to cooling an industrial process, both the direct and indirect use of energy are taken into account. In terms of the overall energy efficiency of an installation, the use of a once-through systems is BAT, in particular for processes requiring large cooling capacities (e.g. > 10 MWth). In the case of rivers and/or estuaries once-through can be acceptable if also: • extension of heat plume in the surface water leaves passage for fish migration; • cooling water intake is designed aiming at reduced fish entrainment; • heat load does not interfere with other users of receiving surface water. For power stations, if once-through is not possible, natural draught wet cooling towers are most energy-efficient than other cooling configurations, but application can be restricted because of the visual impact of their overall height.	• regular maintenance. The Operator will use a hybrid (wet/dry) cooling system which has similar energy consumptions to the wet cooling options. See section 3 above for the comparison between the different cooling systems. Cooling water comes from the River Dee via the existing abstraction system. The abstraction point is equipped with eel screens to reduce fish/eel entrainment. New pumping systems and transfer pipework will transfer cooling water from the existing intake settlement pond.	
8 / 9	**BAT 8/9 Reduction of water requirements** For new systems the following statements can be made: • In the light of the overall energy balance, cooling with water is most efficient; • For new installations a site should be selected for the availability of sufficient quantities of (surface) water in the case of large cooling water demand; • The cooling demand should be reduced by optimising heat reuse; • For new installations a site should be selected for the availability of an adequate receiving water, particularly in case of large cooling water discharges;	The proposed cooling system will be use a hybrid (wet/dry) cooling system which uses water for cooling and in light of the energy balance will be the most efficient. Water supply will be from an existing non-potable source thus protecting groundwater and potable supplies. The peak demand for water top up in the hybrid cooling system will be slightly better than the wet cooling systems. The techniques used at the Proposed Installation for reducing water requirements will include: • optimisation of heat reuse to reduce the need of cooling; • using an open loop water recirculation system; • optimization of cycles of concentration;	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	• Where water availability is limited, a technology should be chosen that enables different modes of operation requiring less water for achieving the required cooling capacity at all times; • In all cases recirculating cooling is an option, but this needs careful balancing with other factors, such as the required water conditioning and a lower overall Energy efficiency. For existing water cooling systems, increasing heat reuse and improving operation of the system can reduce the required amount of cooling water. In the case of rivers with limited availability of surface water, a change from a once-through system to a recirculating cooling systems is a technological option and may be considered BAT. For power stations with large cooling capacities, this is generally considered as a cost-intensive exercise requiring a new construction. Space requirements must be taken into account.	• installation of a water treatment package to facilitate reuse of blowdown water where possible with discharge of final treated effluent to existing purge water pond prior to discharge via the existing W1 discharge point.	
10 / 11	**BAT 10/11 Reduction of entrainment of organisms** The adaptation of water intake devices to lower the entrainment of fish and other organisms is highly complex and site-specific. Changes to an existing water intake are possible but costly. From the applied or tested fish protection or repulsive technologies, no particular techniques can yet be identified as BAT. The local situation will determine which fish protection or repulsive technique will be BAT. Some general applied strategies in design and position of the intake can be considered as BAT, but these are particularly valid for new systems. On the application of sieves it should be noted that costs of disposal of the resulting organic waste collected from the sieves can be considerable.	The Proposed Installation will be using water pumped from the existing intake settlement pond which is sourced via the existing abstraction point. The intake is routed through concrete piping, which may help reduce turbulence and provide a controlled flow path, further minimising the risk of entrainment. There will be improvements to the intake with regards to eel screens as part of a separate variation to existing permit EPR/**NP3037AF.**	Yes
12 - 14	**BAT 12/13/14 Reduction of emissions to water** **a) approach to reduce heat emissions** Whether heat emissions into the surface water will have an environmental impact strongly depends on the local conditions. Such site conditions have been described, but do not lead to a conclusion on BAT in general terms. Where, in practice, limits to heat discharge were applicable, the solution was to change from once-through technology to open recirculating cooling (open wet cooling tower). From the available information, and considering all possible	To limit heat discharge, the system will be a hybrid cooling system instead of once through. Cooling system design will be optimised to facilitate reuse of cooling medium, and reduce purging. Water that will be due to be discharged will be tested to ensure that it meets specified internal criteria prior to being directed to the existing purge pond via new pipes and pumps. Discharge of water from the purge pond will continue to meet the current water quality limits (i.e. ELVs in EPR/**NP3037AF)** which has been previously assessed as being acceptable.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	aspects, care must be taken in concluding that this can be qualified as BAT. It would need to balance the penalty increase in overall energy efficiency of applying a wet cooling tower (Chapter 3.2) against the effect of reduced environmental impact of reduced heat discharge. In a fully integrated assessment at the level of a river catchment, this could for example include the raised overall efficiency levels of other processes using the same, but now colder, water source, which becomes available because there is no longer a large warm water discharge into it. Where the measures generally aim at reducing the ΔT of the discharged cooling water, a few conclusions on BAT can be drawn. Pre-cooling (Annex XII) has been applied for large power plants where the specific situation requires this, e.g. to avoid raised temperature of the intake water. Discharges will have to be limited with reference to the constraints of the requirements of Directive 78/659/EEC for fresh water sources. The criteria are summarised in Table 3.6. Reference is made to a provision in Article 11 of this directive regarding derogation of the requirements in certain circumstances		
	b) approach to reduce chemical emissions to water Measures should be taken in the design phase of wet cooling system using the following order of approach: • identify process conditions (pressure, T, corrosiveness of substance), • identify chemical characteristics of cooling water source, • select the appropriate material for heat exchanger combining both process conditions and cooling water characteristics, • select the appropriate material for other parts of the cooling system, • identify operational requirements of the cooling system, • select feasible cooling water treatment (chemical composition) using less hazardous chemicals or chemicals that have lower potential for impact on the environment (Section 3.4.5, Annex VI and VIII) • apply the biocide selection scheme (Chapter 3, Figure 3.2) and	The design and maintenance techniques for minimising chemical emissions to water that will be used at the Proposed Installation include: • cooling system design will be optimised taking into consideration process conditions and the expected chemical characteristics of the cooling water supply; • during operation, monitoring the corrosive properties within the process and cooling waters to optimise the additive selection and reduce the use of hazardous chemicals where possible; • water velocity will be controlled to reduce deposition (fouling) in condensers and heat exchangers; • debris filters will be used to protect the heat exchangers where clogging is a risk; • monitoring and control of cooling water chemistry will take place to reduce additive application.	

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	• optimise dosage regime by monitoring of cooling water and systems conditions. This approach intends to reduce the need for cooling water treatment in the first place. For existing systems technological changes or changes to the equipment are difficult and generally cost-intensive. Focus should be on the operation of the systems using monitoring linked to optimized dosage. A few examples of techniques with good performances have been identified. They are generally applicable for certain categories of systems; they are considered cost effective and do not need large changes to the cooling installation. After reducing the sensitivity of the cooling system to fouling and corrosion, treatment may still be needed to maintain an efficient heat exchange. Selecting cooling water additives less harmful to the aquatic environment and to applying them in the most efficient way is then the next step. With respect to the selection of chemicals, it has been concluded that a ranking of treatments and the chemicals of which they are composed is difficult if not impossible to carry out in a general way and would be unlikely to lead to BAT conclusions. Due to the large variation in conditions and treatments only a site-by-site assessment will lead to the appropriate solution. Chapter 4 130 Industrial Cooling Systems Such an assessment and its constituent parts could represent an approach that can be considered BAT.		
15 / 16	**BAT 15/16 Reduction of emissions to air** Comparatively, air emissions from cooling towers have not been given much attention, except for the effects of plume formation. From some reported data it is concluded that levels are generally low but that these emissions should not be neglected. Lowering concentration levels in the circulating cooling water will obviously affect the potential emission of substances in the plume. Some general recommendations can be made which have a BAT-character.	Techniques to be used at the Proposed Installation for reductions of emissions to air include: • using techniques to avoid plume formation; • designing and positioning tower outlet to avoid intake of air through air conditioning systems and affecting air quality; • reducing drift loss by applying drift eliminators.	Yes
17	**BAT 17 Reduction of noise emissions** Noise emissions have local impact. Noise emissions of cooling installations are part of the total noise emissions from the site. A number of primary and secondary measures have been identified that can be applied to reduce noise emissions where necessary. The primary measures change the sound power level of the source, where the secondary measures reduce the emitted noise level. The secondary measures in particular will lead to pressure loss, which has	The design of the cooling system is subject to FEED and based on the noise assessment, consideration will be given to: • a selection of low noise fans; • optimising the sizing of the fan coolers; • using of anti-vibration supports and interconnections for the equipment;	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	to be compensated by extra energy input, which reduces overall energy efficiency of the cooling system. The ultimate choice for a noise abatement technique will be an individual matter, as will the resulting associated performance level. The following measures and minimum reduction levels are considered as BAT.	• locating equipment to provide screening by other buildings and structures or orientating fans and air inlets away from sensitive receptors. • the hybrid system will be capable of achieving an overall rating of <85 dBA.	
18/19	**BAT 18/19 Reduction of risk of leakage** To reduce the risk of leakage, attention must be paid to the design of the heat exchanger, the hazardousness of the process substances and the cooling configuration. The following general measures to reduce the occurrence of leakages can be applied: • select material for equipment of wet cooling systems according to the applied water quality. • operate the system according to its design, • if cooling water treatment is needed, select the right cooling water treatment programme, • monitor leakage in cooling water discharge in recirculating wet cooling systems by analysing the blowdown.	To reduce the risk of leakage, the Proposed Installation will: • select the equipment material based on the expected chemical characteristics of the cooling water supply; • implement effective planned preventative maintenance and monitor the performance of the heat exchanger for signs of deterioration; • during operation, monitor the corrosive properties within the process and cooling water to optimise the additive addition to maintain water quality and reduce the risk of corrosive conditions occurring.	Yes
20/21	**BAT 20/21 Reduction of biological risk** To reduce the biological risk due to cooling systems operation, it is important to control temperature, maintain the system on a regular basis and avoid scale and corrosion. All measures are more or less within the good maintenance practice that would apply to a recirculating wet cooling system in general. The more critical moments are start-up periods, where systems' operation is not optimal, and standstill for repair or maintenance. For new towers consideration must be given to design and position with respect to surrounding sensitive objects, such as hospitals, schools and accommodation for elderly people.	To reduce biological risk from the hybrid cooling system, the Proposed Installation will demonstrate good maintenance practices and take the following primary approaches: • reduce light energy reaching the cooling water to reduce algae formation; • avoid stagnant zones (design) and apply optimised chemical treatment to reduce biological growth; • a combination of mechanical and chemical cleaning after outbreak (e.g. legionella); • periodic monitoring of pathogens in the cooling systems to control the pathogens.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
		To reduce the risk of hybrid cooling towers to personnel, the operators will wear nose and mouth protection (P3-mask) when entering wet areas of the cooling tower. The Proposed Installation will follow Approved Code of Practice (ACoP) L8 and GH S274 guidelines and will have a competent person appointed at site to manage the risk of legionella. Water will be treated to municipal standard.	

7. Conclusion

Although once-through cooling using estuarine water is usually identified as indicative BAT in published guidance, the specific geographical and technical conditions (including the CCP elements) for the Proposed Installation, as outlined previously, lead to the conclusion that once-through cooling does not represent BAT for this Installation, because:

- The increased volumetric flow required would place additional burden on the River Dee water supply as additional abstraction would be needed and the associated environmental effects of the additional water abstraction and thermal plume discharge are significant; and
- The costs and environmental effects outweigh the potential efficiency benefits.

ACC was discounted as representing BAT primarily due to significant noise and vibration impact on sensitive receptors and associated restrictions on plant layout and energy impact. ACC also had higher complexity and lower reliability than wet cooling.

The use of either wet or hybrid cooling towers, using water sourced via the existing abstraction licence could represent BAT for the Proposed Installation for the following principal reasons:

- Less vibration and noise impact to ecological systems and residential receptors than alternatives;
- Lower complexity and higher reliability than alternatives;
- The Proposed Installation is not considered to be particularly sensitive to visual impacts given the industrial landscape and the distances to sensitive receptors;
- Water requirements can be met from the existing abstracted supply without the need for additional abstraction; and
- Lower human factor risk than alternatives.

However, it is noted that the proximity of the A458 and the Kelsterton Road along the boundary to the south and west, means that consideration needs to be given to the potential for plume formation and associated grounding effects. For this reason the hybrid cooling option which is an already established cooling option for the existing Connah’s Quay Power Station has been selected as BAT for the Proposed Installation.