Aldbrough Hydrogen Pathfinder - Permit Application

Operating Techniques

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
AGS	Aldbrough Gas Storage
AHP	Aldbrough Hydrogen Pathfinder
AST	Annual Surveillance Tests
BAT	Best Available Techniques
BAT-AEL	BAT-Associated Emission Limits
BREF	BAT Reference Document
CCGT	Combined Cycle Gas Turbine
CEMS	Continuous Emission Monitoring System
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COMAH	Control of Major Accident Hazards
Cu	Copper
CWW	BREF for Common Waste Water and Waste Gas Treatment in the Chemical Sector, 2016
DCS	Distributed Control System
Demin	Demineralisation
DeOxo	Deoxygenation
EA	Environment Agency

Acronym	Description
EDI	Electrodeionisation
EFS	BREF for Emissions from Storage, 2006
EMS	Environmental Management System
EPR	Environmental Permitting (England and Wales) Regulations 2016 (as amended)
ESD	Emergency Shut Down
FSE	Frontline Service Employees
GET	Guidance on Emerging Techniques
GS(M)R	Gas Safety (Management) Regulations
GWP	Global Warming Potential
h	Hour
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HP	High Pressure
H_2S	Hydrogen Sulphide
IED	Industrial Emissions Directive, 2010/75/EU
KO	Knock Out
KOH	Potassium Hydroxide
LCHS	Low Carbon Hydrogen Standard
LCP	Large Combustion Plant
LDAR	Leak Detection and Repair
LP	Low Pressure
MCERTS	Monitoring Certification Scheme
MCP	Medium Combustion Plant
MFC	Multi-Finger Caliper imaging tool
MFTT	Magnetic Thickness Tool
mg	Milligram
MWe	Megawatt Electrical
MWth	Megawatt Thermal
NCV	Net Calorific Value
Ni	Nickel
Nm^3	Normalised cubic metre
NO_x	Oxides of Nitrogen
O_2	Oxygen
OCGT	Open Cycle Gas Turbine
OTNOC	Other Than Normal Operating Conditions

Acronym	Description
PEM	Proton Exchange Membrane
PHA	Process Hazard Assessment
PLC	Programmable Logic Controller
PSV	Process Safety Valves
QAL	Quality Assurance Level
RO	Reverse Osmosis
SCR	Selective Catalytic Reduction
SHE	Safety, Health and Environmental
SSE	SSE Hornsea Limited
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UKAS	United Kingdom Accreditation Service
VOC	Volatile Organic Carbon
WGS	BREF for Common Waste Gas Management and Treatment Systems in the Chemical Sector, 2023
yr	Year
Zn	Zinc

1. INTRODUCTION

SSE Hornsea Ltd (SSE) is proposing to construct and operate an electrolytic hydrogen production, storage and energy generation facility, referred to as the Aldbrough Hydrogen Pathfinder (AHP) project. The facility will be operated at SSE's Aldbrough Gas Storage (AGS) site on Garton Road, East Riding of Yorkshire (hereafter referred to as the 'Site').

2. OPERATING TECHNIQUES

The primary Site activity (energy generation) falls under Schedule 1, Part 2 of the Environmental Permitting (England and Wales) Regulations 2016 (as amended) (EPR), namely Section 1.1 Part (A)(1): Combustion. To demonstrate that the Site will be designed as operated according to Best Available Techniques (BAT) for the range of activities carried out at the site, a review of the European Commission's relevant BAT Reference Documents (BREFs) has been carried out. The documents reviewed were:

1) Best Available Techniques (BAT) Reference Document for Large Combustion Plants (LCP), 2017[1], presented in Table 1

The production of hydrogen activity falls under EPR Section 4.2 Part (A)(1)(a): Producing inorganic chemicals such as gases (hydrogen). A review of the following BREF documents and technical guidance note has been carried out for hydrogen production:

2) Guidance for Speciality Inorganic Chemicals Sector (EPR 4.03), EA, 2009[2], presented in Table 2.
3) Hydrogen production by electrolysis of water: emerging techniques[3], EA, 2024, presented in Table 3.

The EA guidance for Specialty Inorganic Chemicals Section (EPR 4.03) has been defined on the basis of the Production of Speciality Inorganic Chemicals BREF 2007. EPR 4.03 was advised as the most applicable BAT requirement for the Site hydrogen production activity during pre-application engagement.

The EA also confirmed through pre-application that the following three documents should be considered in addition to the those above:

4) Best Available Techniques (BAT) Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW), 2016[4], presented in Table 4.
5) Best Available Techniques (BAT) Reference Document for Common Waste Gas Management and Treatment Systems in the Chemical Sector (WGC), 2023[5], presented in Table 5.
6) Best Available Techniques (BAT) Reference Document for Emissions from Storage (EFS), 2006[6], presented in Table 6.

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[1] https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf
[2] https://assets.publishing.service.gov.uk/media/5a7c343d40f0b67d0b11f8e5/geho0209bpit-e-e.pdf
[3] https://www.gov.uk/guidance/hydrogen-production-by-electrolysis-of-water-emerging-techniques
[4] eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/CWW_Bref_2016_published.pdf
[5] https://eippcb.jrc.ec.europa.eu/reference/common-waste-gas-treatment-chemical-sector
[6] https://eippcb.jrc.ec.europa.eu/reference/emissions-storage

Although the EFS BAT does not directly cover storage of gas (only liquid, liquified gases and solids), it has been considered for the cavern storage at the request of the Environment Agency (EA) during pre-application engagement.

While the WGC BAT Reference Document is technically applicable, it was issued in January 2023 and as such is not legally enforceable in the UK. SSE will consider the requirements under UK BAT once this is issued. At present SSE consider the LCP BREF and existing EPR 4.03 responses to sufficiently describe the control of waste gases from the Site activity.

Each of the documents considered above are presented in tabular form on the following pages and are to be read in conjunction with the Supporting Information Document. Best Available Techniques that are not considered applicable are greyed out.

TABLE 1 - BEST AVAILABLE TECHNIQUES (BAT) REFERENCE DOCUMENT FOR LARGE COMBUSTION PLANTS (LCP)

Section	Subsection	BAT #	BAT Text	BAT Requirements	Comments
1. General BAT conclusions	Environmental Management System	BAT 1	In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS) that incorporates the features presented in the BREF.	See BREF for detailed requirements. The BREF included 16 features to incorporate.	Details of the Site's EMS are presented in Section 6 of the Supporting Information Document. The proposed installation will be operated under an ISO14001:2015 accredited EMS and in line with the EA's guidance: 'Develop a management system: environmental permits". The EMS will include an environmental policy and other relevant management documents. The site-specific procedures define the roles and responsibilities for applicable site personnel. The EMS will incorporate all of the listed features under BAT 1 items and will be in place prior to the operational start date.
	Monitoring	BAT 2	BAT is to determine the net electrical efficiency and/or the net total fuel utilisation and/or the net mechanical energy efficiency of the gasification, IGCC and/or combustion units by carrying out a performance test at full load (1), according to EN standards, after the commissioning of the unit and after each modification that could significantly affect the net electrical efficiency and/or the net total fuel utilisation and/or the net mechanical energy efficiency of the unit. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	(1) In the case of CHP units, if for technical reasons the performance test cannot be carried out with the unit operated at full load for the heat supply, the test can be supplemented or substituted by a calculation using full load parameters	Operational performance testing will be conducted according to recognised standards at various stages during commissioning and acceptance testing as well as after any significant modification. This includes determination of the net total fuel utilisation. Periodic Operational Performance tests measuring the load, fuel used, and power output will be undertaken in accordance with applicable EN standards. The scope of installed instrumentation includes tariff metering of both fuel gas (hydrogen and/or natural gas) and electricity export; a high fidelity of routine testing & analysis is therefore envisaged.
	Monitoring process parameters for emissions to air and water	BAT 3	BAT is to monitor key process parameters relevant for emissions to air and water including those given below:	• Fuel gas • Flow • Oxygen content, temperature and pressure • Water vapour content • Waste water from flue-gas treatment	Oxygen content will be monitored continuously. Exhaust gas volume flow may be either by indirect measurement or by continuous monitoring (to EN ISO 16911) if applicable for correction to reference conditions based on the choice of Continuous Emission Monitoring System (CEMs) set-up (i.e. extractive vs in-situ) stack gas pressure, temperature and water vapour will also be monitored continuously. There are no flue gas treatment measures that generate wastewater as a result of the operation of the OCGT, so monitoring of wastewater from flue gas treatment is not applicable.
	Monitoring of emissions to air	BAT 4	BAT is to monitor emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	• NH_3 • Nox • N_2O • CO • SO_2 • SO_3 • Gaseous chlorides • HF • Dust • Metals and metalloids • Hg • TVOC • Formaldehyde • CH_4 • PCDD/F	The following substances will be monitored using MCERTS certified CEMS according to the relevant stated EN standards. This system will continuously monitor: • NH_3 (associated with Selective Catalytic Reduction (SCR) use) (EN 14181) • NO_x (EN 14181) • CO (EN 14181) Means for periodic stack testing will also be provided to enable parallel monitoring for Annual Surveillance Tests (ASTs) and Quality Assurance Level (QAL2) tests.
	Monitoring emissions to water from flue-gas treatment	BAT 5	BAT is to monitor emissions to water from flue-gas treatment with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.		Not applicable - The proposed installation will use SCR for the control of NO_x emissions in the flue gas. The SCR does not generate emissions to water.

Section	Subsection	BAT #	BAT Text	BAT Requirements	Comments
1. General BAT Conclusions (continued)	General environmental and combustion performance	BAT 6	In order to improve the general environmental performance of combustion plants and to reduce emissions to air of CO and unburnt substances, BAT is to ensure optimised combustion and to use an appropriate combination of the techniques given below.	*Techniques* a. Fuel blending and mixing b. Maintenance of the combustion system c. Advanced control system d. Good design of the combustion equipment e. Fuel choice	a. The OCGT will use a hydrogen/natural gas blend (75% hydrogen/25% natural gas) for the initial 2-3 years during extended commissioning /testing phases before building up to 100% hydrogen for the operational lifetime of the project. The OCGT is designed to operate over the full range of concentrations and will be subject to a fuel management and monitoring procedure. b. All plant and equipment and the Site will be regularly maintained, including the OCGT, by qualified staff or contractors, as per site procedures and in accordance with a planned preventative maintenance programme in line with Original Equipment Manufacturers' recommendations. c. The combustion plant will use an advanced control system to control combustion efficiency and reduce emissions. This will be implemented as part of the Distributed Control System (DCS) for the plant. Operating conditions will also be monitored by suitably trained site personnel. Any non-conformance or deviation in normal operating parameters shall be identified by the DCS to allow operators to take action to avoid breach of permitted emission levels. d. Combustion equipment has been sourced from reputable suppliers with experience in the design of combustion plant. e. The purpose of the facility is to generate electricity from hydrogen (hydrogen/ natural gas blend during extended commissioning/testing phase). The intention is to run on hydrogen where possible, to minimise CO_2 emissions. If hydrogen is not available, then the OCGT can run on natural gas to generate electricity.
		BAT 7	In order to reduce emissions of ammonia to air from the use of selective catalytic reduction (SCR) and/or selective non-catalytic reduction (SNCR) for the abatement of NO_X emissions, BAT is to optimise the design and/or operation of SCR and/or SNCR (e.g. optimised reagent to NO_X ratio, homogeneous reagent distribution and optimum size of the reagent drops).		The proposed installation will use SCR for the control of NO_x emissions in the flue gas, to ensure compliance with NO_x BAT-AELs using ammonia as a reagent. Data on emissions and combustion will be used to control the use of ammonia and minimise slip e.g. through the use of homogenous reagent distribution and optimum size of the reagent drops. The SCR plant will be appropriately designed and operated to maintain optimum ammonia injection rate and minimise ammonia slip emissions to air. Ammonia emissions will comply with the annual BAT-AEL range of 3 - 10 mg/Nm^3. This has been considered in the AQIA presented in Section 11 of the Supporting Information Document and is not shown to have a significant impact.
		BAT 8	In order to prevent or reduce emissions to air during normal operating conditions, BAT is to ensure, by appropriate design, operation and maintenance, that the emission abatement systems are used at optimal capacity and availability.		The proposed installation will use SCR and dry low NO_x burners for abatement of NO_x emissions from combustion. The SCR system will be designed to operate appropriately for all intended operating cases. Operating procedures for the abatement systems will be developed to ensure that these systems are available when required (e.g. including checks of supplies of ammonia). Maintenance procedures and schedules will be developed in line with supplier recommendations to ensure that planned maintenance is carried out, and a maintenance system will be used for reporting defects and tracking that repairs are carried out in good time.
		BAT 9	In order to improve the general environmental performance of combustion and/or gasification plants and to reduce emissions to air, BAT is to include the following elements in the quality assurance/quality control programmes for all the fuels used, as part of the environmental management system (see BAT 1):	(i) Initial full characterisation of the fuel used including at least the parameters listed below and in accordance with EN standards. ISO, national or other international standards may be used provided they ensure the provision of data of an equivalent scientific quality; (ii) Regular testing of the fuel quality to check that it is consistent with the initial characterisation and according to the plant design specifications. The frequency of testing and the parameters chosen from the table below are based on the variability of the fuel and an assessment of the relevance of pollutant releases (e.g. concentration in fuel, flue-gas treatment employed); (iii) Subsequent adjustment of the plant settings as and when needed and practicable (e.g. integration of the fuel characterisation and control in the advanced control system (see description in Section 8.1)).	The fuels being used by the OCGT will be a blend of hydrogen/natural gas during extended commissioning, building up to 100% hydrogen for the operational lifetime of the project. Natural gas will be supplied from the national grid supply. Hydrogen produced from the electrolyser will meet the defined quality standards for use in the OCGT. The natural gas supplied is subject to minima/maxima parameter as agreed in the conditions of supply with the gas grid operator. Natural gas fuel quality is stable within the UK and is prescribed by the Gas Safety (Management) Regulations (GS(M)R), with regards to Wobbe Index (47.2 – 51.4 MJ/m^3 at 15°C, 101.3 kPa, based on the Gross Calorific Value). Most gas turbines and boilers can tolerate this Wobbe Index variation, about the midrange point, but actual variations are currently smaller than this in practice. Natural Gas composition is not prescribed by the GS(M)R and there is some variation in the concentrations of methane, other hydrocarbons, and inert gas components. However, the methane concentration is always above 80%, in compliance with the IED definition of natural gas. The BAT 9 requirement is therefore satisfied by reference to the GS(M)R requirements, for Wobbe Index. A performance test of the OCGT will be carried out during plant commissioning including full characterisation of the fuel used. The fuel gas system is expected to include continuous online analysis of the fuel gas stream (including flow and operating hours to allow proportions and composition to be determined). Performance testing using online gas chromatography will be used to measure the load, fuel used, and power output to calculate overall efficiencies shall be undertaken in accordance with applicable EN standards. The Net Calorific Value (NCV) and the carbon content of the fuel are calculated from the natural gas composition for EU / UK ETS reporting purposes. Records of NCV and the fuel composition are held on site for additional regulatory inspection as required. The detailed data shall be used to confirm that the natural gas is within UK specifications and no further characterisation is required. The Wobbe Index may also be calculated from the fuel composition, if required, where not already undertaken.

Section	Subsection	BAT #	BAT Text	BAT Requirements	Comments
1. General BAT Conclusions (continued)		BAT 10	In order to reduce emissions to air and/or to water during other than normal operating conditions (OTNOC), BAT is to set up and implement a management plan as part of the environmental management system (see BAT 1), commensurate with the relevance of potential pollutant releases, that includes the following elements:	• Appropriate design of the systems considered relevant in causing OTNOC that may have an impact on emissions to air, water and/or soil (e.g. low-load design concepts for reducing the minimum start-up and shutdown loads for stable generation in gas turbines), • Set-up and implementation of a specific preventive maintenance plan for these relevant systems, • Review and recording of emissions caused by OTNOC and associated circumstances and implementation of corrective actions if necessary, • Periodic assessment of the overall emissions during OTNOC (e.g. frequency of events, duration, emissions quantification/estimation) and implementation of corrective actions if necessary.	The plant and associated control systems will be designed to minimise the potential for Other Than Normal Operating Condition (OTNOC) events to occur. The proposed installation will be operated using a DCS to continuously monitor the operation of the plant and equipment at the Site. Any non-conformances or deviation in normal operating parameters is expected to be identified by the automated control system to allow operators to take action to avoid OTNOC events. Site operators will be trained to monitor plant operation and take appropriate actions(s) in the event of a potential OTNOC event being identified. Start up and Shutdown procedures shall be put in place with the aim to minimise the time during which the plant is operating at non-optimal conditions and operators shall be trained in the appropriate actions required should the potential for an OTNOC event be identified. All plant and equipment at the site will be regularly maintained including those systems provided to minimise the potential for OTNOC conditions to occur. The proposed installation will be managed according to an Emergency Preparedness & Response Plan. OTNOC events will be logged in the SSE SEARs (hazard and incident) system and investigated and appropriate corrective or preventative actions identified as applicable. Annual performance will be reviewed as part of a management review process to consider any systematic issues or action required.
		BAT 11	BAT is to appropriately monitor emissions to air and/or to water during OTNOC.	The monitoring can be carried out by direct measurement of emissions or by monitoring of surrogate parameters if this proves to be of equal or better scientific quality than the direct measurement of emissions. Emissions during start-up and shutdown (SU/SD) may be assessed based on a detailed emission measurement carried out for a typical SU/SD procedure at least once every year, and using the results of this measurement to estimate the emissions for each and every SU/SD throughout the year.	Emissions monitoring procedures will be included in the EMS. These will cover monitoring requirements during OTNOC, not just steady operation. The flue gases from the Site will be monitored using MCERTS-certified CEMs, which will also monitor emissions during OTNOC.
	Energy Efficiency	BAT 12	In order to increase the energy efficiency of combustion, gasification and/or IGCC units operated ≥ 1 500 h/yr, BAT is to use an appropriate combination of the techniques below. See table in BREF for more details.	*Techniques* a. Combustion optimisation b. Optimisation of the working medium conditions c. Optimisation of the stead cycle d. Minimisation of energy consumption e. Preheating of combustion air f. Fuel preheating g. Advanced control system h. Feed-water preheating using recovered heat i. Heat recovery by cogeneration (CHP) j. CHP readiness k. Flue-gas condenser l. Heat accumulation m. Wet stack n. Cooling tower discharge o. Fuel pre-drying p. Minimisation of heat losses q. Advanced materials r. Steam turbine upgrades s. Supercritical and ultra-supercritical steam conditions	The OCGT will operate for <1500 h/yr on a 5-year rolling average. Nevertheless, the gas turbine will be equipped with combustion optimisation through an advanced control system. The anticipated electrical efficiency of the OCGT plant will be circa 38% at full load.
	Water usage and emissions to water	BAT 13	In order to reduce water usage and the volume of contaminated waste water discharged, BAT is to use one or both of the techniques given below.	*Technique* a. Water recycling b. Dry bottom ash handling	a. The proposed installation will be serviced by a closed loop cooling system (fin fan coolers), where air is utilised as the cooling medium rather than evaporation of water, and there is no significant water consumption (the amount of water used is much lower than for a fully wet cooling system). As such, small quantities of water treatment chemicals are expected to be used, primarily for prevention of scaling and corrosion and biofouling. As water from the cooling system is recirculated, there is limited further opportunity for recycling / reuse as part of the OCGT. b. Not applicable - no combustion of solids fuels

Section	Subsection	BAT #	BAT Text	BAT Requirements	Comments
1. General BAT Conclusions (continued)	Water usage and emissions to water (continued)	BAT 14	In order to prevent the contamination of uncontaminated waste water and to reduce emissions to water, BAT is to segregate waste water streams and to treat them separately, depending on the pollutant content.		Discharges generated at the proposed installation is anticipated to comprise of surface water run-off, process effluent from the demin plant, and brine water from salt cavern dewatering. All wastewater streams will be appropriately segregated prior to discharge. Records of volume of water being abstracted and composition of the effluent streams will be kept and made available as required. See Section 3.5.4 of the Supporting Information Document for more detail on site drainage. Surface water integration into the existing surface water drain network will be made at the Balancing Lagoon. The outlet pipe from water oil separator shall discharge into the existing lagoon at an elevation higher than the standing water elevation in the Lagoon to avoid any backflow into the separator. Bunds and curbs will not be directly integrated into the existing drainage system. Contaminated liquids will be retained/collected and sent-off site for further treatment and/or disposal by vacuum truck. Where bunds collect rainwater and fire water, this will be pumped out to a designated surface water manhole which will eventually reach the oil water separators and balancing lagoon. Closed drains onsite comprise of separated liquids from Knock Out (KO) drums and other gas streams that are sent back to the demin plant for reuse. Water, oil and chemical waste from the CIP collection in the equipment areas will be is discharged into a closed drain system which discharges in a closed drain drum. The contents of the drum require third party disposal offsite. Foul water will separately discharge to the existing Aldbrough Gas Storage (AGS) sewage treatment package (Klargester Septic Tank) for treatment before discharging to the Balancing Lagoon.
		BAT 15	In order to reduce emissions to water from flue-gas treatment, BAT is to use an appropriate combination of the techniques given [in the BREF document], and to use secondary techniques as close as possible to the source in order to avoid dilution.		Not applicable - The proposed installation will use SCR for the control of NOx emissions in the flue gas. The SCR does not generate emissions to water.
	Waste Management	BAT 16	In order to reduce the quantity of waste sent for disposal from the combustion and/or gasification process and abatement techniques, BAT is to organise operations so as to maximise, in order of priority and taking into account life-cycle thinking:	*Techniques* a. Generation of gypsum as a by-product b. Recycling or recovery of residues in the construction sector c. Energy recovery by using waste in the fuel mix d. Preparation of spent catalyst for reuse	As a gas-hydrogen fired OCGT, there will be minimal wastes generated by the process (primarily from maintenance) and no process solid waste streams are expected to be produced. The waste management procedures will include waste streams and the plant will periodically review waste generation to identify opportunities to further minimise waste and/or identify management routes further up the waste hierarchy. Anticipated quantities of waste streams from the installation are provided in Section 7 of the Supporting Information Document.
	Noise emissions	BAT 17	In order to reduce noise emissions, BAT is to use one or a combination of the techniques given below.	*Techniques* a. Operational measures b. Low-noise equipment c. Noise attenuation d. Noise-control equipment e. Appropriate location of equipment and buildings	a. The Site will have a maintenance schedule in place to ensure optimum operation of all plant and equipment. The OCGT will be situated within an acoustic enclosure and all outdoor equipment will have noise attenuation enclosures where required. Any maintenance work that is likely to cause significant noise that could pose a nuisance risk will be undertaken during daylight hours, where feasible. The maintenance schedule will include a system for reporting and scheduling unplanned maintenance and the plant will be operated and maintained by experienced staff. b. The proposed OCGT will be a new plant, and all equipment has been selected to avoid noise impacts either through the design or through the installation of noise attenuation measures. See Section 12 of the Supporting Information Document for further details on equipment selection. c/d/e. The OCGT will be situated within an acoustic enclosure and majority of equipment house within a building. All equipment being installed is new and mitigation will be in place where required to ensure levels of noise are not significant. This includes direct control of noisy equipment such as acoustic enclosures, retrofitting controls, regular inspection and maintenance of noise control measures. See Section 12 of the Supporting Information Document and Appendix I for the Noise Impact Assessment.
2. BAT conclusions for the combustion of solid fuels	BAT conclusion for the combustion of coal and/or lignite	BAT 18-23			Not applicable - no combustion of coal/lignite
	BAT conclusions for the combustion of solid biomass and/or peat	BAT 24-27			Not applicable - no combustion of solid biomass/peat

Section	Subsection	BAT #	BAT Text	BAT Requirements	Comments
3. BAT conclusions for the combustion of liquid fuels	HFO- and/or gas-oil-fired engines	BAT 28-30			Not applicable - no use of HFO/oil-fired boilers
	Gas-oil-fired engines	BAT 31-35			Not applicable - No use of HFO/oil-fired engines
	Gas-oil-fired gas turbines	BAT 36-39			Not applicable - No use of gas oil-fired gas turbines
4. BAT conclusions for the combustion of gaseous fuels	Energy efficiency	BAT 40	In order to increase the energy efficiency of natural gas combustion, BAT is to use an appropriate combination of the techniques given in BAT 12 and below.		Not applicable to the Site as the proposed OCGT as a peaking plant will operate for < 1500 h/yr on a 5-year rolling average. • OCGT has been selected as the most appropriate technology for operation. OCGT has been chosen for the following reasons: • Fast start up and shutdown times of the plant compared to a similar sized Combined Cycled Gas Turbine (CCGT) plant to be able to meet electricity demands of the grid at short notice. • CCGT is not appropriate for plant running limited hours. • Plant type and size is specified to align with the electrolytic hydrogen generation capacity. A mid merit or baseload plant would require a hydrogen production plant on a much larger scale which is not considered feasible due to site constraints. • No cooling is required for the plant for condensing steam, therefore cooling requirements are a lot lower for the OCGT compared to CCGT. • OCGT plant does not have any associated HRSG/Steam turbine plant, the provision of steam from an OCGT would not be possible without the provision of additional steam raising equipment which would require a larger footprint. The anticipated electrical efficiency of the OCGT plant will be 38% at full load.
	NOx, CO, NMVOC and CH_4 emissions to air	BAT 41	In order to prevent or reduce NOx emissions to air from the combustion of natural gas in boilers, BAT is to use one or a combination of the techniques given below		Not applicable - no boilers.
		BAT 42	In order to prevent or reduce NOx emissions to air from the combustion of natural gas in gas turbines, BAT is to use one or a combination of the techniques given below.	*Technique* a. Advance control system b. water/steam addition c. Dry low - NOx burners d. Low -load design concept e. Low - Nox burners f. Selective catalytic reduction (SCR)	The following techniques will be used: a. Operation of the OCGT will be controlled by trained site operators using an advanced control system, which will be used to control the operation of the plant and also record data on the plant performance. c. Dry low NO_x burners will be used as a primary techniques used to minimise NO_x. f. The proposed installation will use SCR for the control of NO_x emissions in the flue gas, to ensure compliance with NO_x BAT-AELs using ammonia as a reagent.
		BAT 43	In order to prevent or reduce NO_X emissions to air from the combustion of natural gas in engines, BAT is to use one or a combination of the techniques given below		Not applicable - no gas turbines.
		BAT 44	In order to prevent or reduce CO emissions to air from the combustion of natural gas, BAT is to ensure optimised combustion and/or to use oxidation catalysts		The OCGT will use optimised combustion techniques, including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and use of an advanced control system. The BAT-AELs are not relevant to hydrogen combustion. The proposed BAT-AELs are instead derived from using the EA's Guidance for Emerging Techniques on H_2 Combustion as detailed in Section 4.1 of the Supporting Information Document. This utilises the IED Emission Limit Values with the use of a hydrogen combustion factor proportionate to the Natural Gas/H_2 blend. An Air Quality Impact Assessment has been undertaken for the Site, to model the off-site effects of emissions at the upper range of the limits identified in Guidance for Emerging Techniques on H_2 Combustion (see Section 11 of the Supporting Information Document).
		BAT 45	In order to reduce non-methane volatile organic compounds (NMVOC) and methane (CH4) emissions to air from the combustion of natural gas in spark-ignited lean burn gas engines, BAT is to ensure optimised combustion and/or to use oxidation catalysts.		Not applicable - no gas engines.
	BAT Conclusions for the combustion of iron and steel process gases	BAT 46-51			Not applicable - no combustion of iron and steel process gases.

Section	Subsection	BAT #	BAT Text	BAT Requirements	Comments
4. BAT conclusions for the combustion of gaseous fuels (continued)	BAT conclusions from the combustion of gaseous and/or liquid fuels on offshore platforms	BAT 52-54			Not applicable - no combustion on offshore platforms.
5. BAT conclusions for multi fuel-fired plants	General environmental performance	BAT 55			Not applicable - no process fuel from the chemical industry used.
	NO_X and CO emissions to air	BAT 56			Not applicable - no process fuel from the chemical industry used.
	SO_X, HCl and HF emissions to air	BAT 57			Not applicable - no boilers onsite.
	Dust and particulate-bound metal emissions to air	BAT 58			Not applicable - no boilers onsite.
	Emissions of volatile organic compounds and polychlorinated dibenzo-dioxins and -furans to air	BAT 59			Not applicable - no boilers onsite.
6. BAT conclusions for the co-incineration of waste		BAT 60-71			Not applicable - no co-incineration of waste.
		BAT 72-75			Not applicable - no gasification.

TABLE 2 - GUIDANCE FOR SPECIALITY INORGANIC CHEMICALS SECTOR (EPR 4.03)

Section	Sub-Section	BAT Requirements	Comment
1. Managing your activities	Environmental Performance Indicators	1. Monitor and benchmark your environmental performance, and review this at least once a year. Your plans for minimising environmental impacts should be incorporated into on-going Improvement Programmes. Indicators can be derived using the Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1). It is suggested that indicators are based on tonnes of inorganics produced (top) as they provide a good basis for measuring performance within an installation or a single company year on year	See LCP BAT 1. The EMS will include management commitments for monitoring, reviewing and reporting procedures, as well as details on improvement programmes and how environmental impacts will be continually assessed onsite. Performance indicators will include tonnes of hydrogen produced.
	Energy Efficiency	1. Assess the environmental impact of each process and choose the one with the lowest environmental impact. (We recognise that your choice may be constrained, for example, by the integration of processes on a complex site).	As a proven technology, PEM has been selected over an alkaline electrolyser for hydrogen production due to the high-water splitting / hydrogen production efficiency, high turndown capability, rapid start up and response to load changes, low maintenance requirements, and low standby power consumption. KOH is also not used and therefore there is no caustic discharge. PEM waste is not hazardous. See LCP BAT 40 for choice of OCGT and energy efficiency. See Section 9 of the Supporting Information Document for energy efficiency measures implemented at the Site.
	Efficient use of raw materials and water	1. Maximise heat transfer between process streams where water is needed for cooling. Use a recirculating system with indirect heat exchangers and a cooling tower in preference to a once-through cooling system. 2. Where water is used in direct contact with process materials, recirculate the water after stripping out the absorbed substances. 3. Use cleaning techniques that reduce the quantity of water needed 4. Establish opportunities for reuse using pinch analysis.	Procurement of raw materials used in process streams will follow a procedure to ensure materials meet specifications. Raw materials will be purchased on a minimise usage basis to reduce costs and minimise waste generation. 1. There is integrated cooling between the OCGT and the electrolyser to maximise cooling efficiency. Both plant use a closed loop, fin fan cooling system which will minimise water / chemical usage (see LCP BAT 13). There is no identified user for waste heat. 2. A demin treatment plant with two stages and water recycle will be used for water supply to the electrolyser and cooling system. The electrolyser will also recycle recovered water from the KO drums for water conditioning/treatment to be re-fed into the hydrogen production process. Wastewater discharged from the demin plant to sea cannot be treated further for reuse. 3. Reverse Osmosis (RO) permeate will be used to flush the filters, minimising freshwater use. 4. At several locations in the process, water of good quality will be collected and recycled into the process to minimise overall water consumption. Condensate from the hydrogen and oxygen gas coolers will be returned to the electrolyser for use as process water. Condensate from the LP hydrogen compressor KO drums, and de-oxo separator will be recovered and sent to the to the borehole buffer tank (to re-enter the Greensand Filtrate Tank). Second pass RO reject will be directed to the first pass RO booster pumps for recycle and will supply the cooling water system. Additional opportunities for reuse will be reviewed throughout the final design and plant lifetime.
	Avoidance, recovery and disposal of wastes	1. Demonstrate that the chosen routes for recovery or disposal represent the best environmental option. Consider avenues for recycling back into the process or reworking for another process wherever possible 2. Where you cannot avoid disposing of waste, provide a detailed assessment identifying the best environmental options for waste disposal.	See LCP BAT 16. Waste management is discussed in Section 7 of the Supporting Information Document. The Site will implement a Waste Management Procedure as part of the EMS. The Waste Management Procedure will include an inventory of each waste stream, and identify optimal waste management solution for each stream, with reference to the EU waste management five-step "waste hierarchy". The decision was made in design to use Proton Exchange Membrane (PEM) rather than alkali electrolysis to eliminate caustic waste (no KOH required).
2. Operations	Design of a new process	1. Consider all potential environmental impacts from the outset in any new project for manufacturing chemicals. 2. Undertake the appropriate stages of a formal HAZOP study as the project progresses through the process design and plant design phases. The HAZOP studies should consider amongst other things the points noted above.	1. Potential environmental impacts of the Site's operations have been assessed as part of this permit application in the Environmental Risk Assessment (see Section 11,12, and 15 of the Supporting Information Document) and H1 assessment (see Section 10 of the Supporting Information Document). Indirect global warming potential of H_2 (fugitive emissions) has been considered. A fugitive emissions reduction plan will be prepared. Emissions of NO_x from OCGT have been considered and SCR is included in design for NO_x abatement. "Vented" emissions will be flared. 2. Assessment/studies required to understand the risk of equipment and processes (e.g. Hazard Identification (HAZID) and Hazard and Operability (HAZOP) studies) have been conducted where appropriate and according to legal requirements including accident management. Process Hazard Assessment (PHAs) will be developed for the Site as part of the review and for all new plant.

Section	Sub-Section	BAT Requirements	Comment
2. Operations (continued)	Storage and handling of raw materials, products and wastes	1. Store reactive chemicals in such a way that they remain stable, such as under a steady gas stream, for example. If chemical additions are necessary then tests should be carried out to ensure the required chemical composition is maintained. Inhibitors may also be added to prevent reactions 2. Vent storage tanks to a safe location 3. Use measures to reduce the risk of contamination from large storage tanks. In addition to sealed bunds, use double-walled tanks and leak detection channels 4. Use HAZOP studies to identify risks to the environment for all operations involving the storage and handling of chemicals and wastes. Where the risks are identified as significant, plans and timetables for improvements should be in place	1. Reactive chemicals (such as water treatment chemicals) will be stored separately and segregated from incompatible materials. Ammonia will be stored in aqueous solution. 2. Ammonia tank will be installed outdoors with high level vent. There is one low pressure H_2 buffer tank, one intermediate pressure H_2 buffer tank, both with vents to the flare. Two temporary degassing will also be provided for the dewatered cavern contents, that will be vented to the temporary flare (to be deployed if required). 3. Ammonia tank will be bunded with leak detection on tank. Small diesel storage tank serving firewater pump. Glycol header tank for cooling water system. All substances that are hazardous to the environment will be provided with secondary containment in accordance with CIRIA C736. 4. See BAT - Design of a new process. HAZOP has considered the storage and handling of chemicals and wastes. Actions relating to risks to the environment will be closed out prior to commissioning. Improvement plans will be incorporated into the EMS. Waste storage area will be on impermeable surface, drip trays, bunds provided for containers etc., interceptor in drainage system.
	Plant Systems and Equipment	1. Formally consider potential emissions from plant systems and equipment and have plans and timetables for improvements, where the potential for substance or noise pollution from plant systems and equipment has been identified. 2. Carry out systematic HAZOP studies on all plant systems and equipment to identify and quantify risks to the environment 3. Choose vacuum systems that are designed for the load and keep them well maintained. Install sufficient instrumentation to detect reduced performance and to warn that remedial action should be taken	1. See Section 4 of the Supporting Information Document for emissions identified from the Site activities. An H1 assessment of likely emissions to air and water from the process has also been carried out as part of the permit application. Performance improvement will be included in the Site EMS. Fugitive emissions will be minimised by means of proactive maintenance and a Leak Detection And Repair (LDAR) programme. Appropriate noise levels for plant are included in equipment specifications and will be verified. A noise management plan will be produced which defines actions to be taken in the event of increased noise levels. 2. See BAT - Design of a new process. A HAZID and HAZOP has been carried out. 3. Not applicable - no dedicated vacuum systems used onsite.
	Over pressure protection systems	1. Carry out a systematic HAZOP study for all relief systems, to identify and quantify significant risks to the environment from the technique chosen. 2. Identify procedures to protect against overpressure of equipment. This requires the identification of all conceivable over-pressure situations, calculation of relief rates, selection of relief method, design of the vent system, discharge and disposal considerations, and dispersion calculations. In some cases careful design can provide intrinsic protection against all conceivable over-pressure scenarios, so relief systems and their consequential emissions can be avoided. 3. Maintain in a state of readiness all equipment installed in the venting system even though the system is rarely used.	1. See BAT - Design of a new process. A HAZID and HAZOP has been carried out. 2. Pressure safety valves (PSV) will be installed for all equipment which has a potential for an overpressure scenario, following appropriate standards (e.g. API Standards). PSV relief rates will be determined by evaluation of all potential process upset scenarios requiring heat, vapour and liquid relief, using their associated calculations. Selection of PSV type will be based on relief device back pressure. An overpressure protection system will be provided downstream of the Cavern as a protective function of the production plant against the high cavern pressure (overpressure), to prevent a single relief scenario increasing the flare system size. The flare system shall safely discharge combustible gasses and hazardous materials produced by the facility PSV, repressuring valves, and manual vents. The sizing of flare headers, piping, KO drums, and flare tips will be based on hydraulic limitations and according to appropriate guidelines. Aqueous ammonia tank will be a pressurised tank. The vapor equalizing line allows pressure equalisation between the storage tank and the delivery tanker and recovers displaced air / vapours. 3. Procedures for maintenance and testing of relief devices will be developed prior to commissioning to ensure the reliability and safety of all overpressure protection systems.
	Heat exchangers and cooling systems	1. Consider leak detection, corrosion monitoring and materials of construction, preferably in a formal HAZOP study. Plans and timetables for improved procedures or replacement by higher integrity designs should be in place where the risks are identified as significant. 2. If corrosion is likely, ensure methods for rapid detection of leaks are in place and a regime of corrosion monitoring in operation at critical points. Alternatively, use materials of construction that are inert to the process and heating/cooling fluids under the conditions of operation. 3. For cooling water systems, use techniques that compare favourably with relevant techniques described in the "Industrial Cooling Systems" BREF.	1. Materials of construction have been selected for their suitability and compatibility with process materials. Storage of corrosive materials will be in bunded containers. 2. There is a closed loop cooling system containing glycol. Periodic maintenance regime and operator oversight/walkarounds to detect and repair leaks. The level in header tank is monitored to identify leaks. There is a control room on site. No heating fluids are used on site. 3. The Industrial Cooling Systems BREF includes closed circuit cooling as a relevant technique.
	Purging facilities	1. Assess the potential for the release to air of VOCs and other pollutants along with discharged purge gas and use abatement where necessary.	Nitrogen will be used as an inert gas in the electrolysis system to ensure continuous operation of the electrolyser plant by providing a safe inert atmosphere prior to commencing hydrogen production. This is only required after the system has been deactivated for an extended period (e.g. for regular maintenance work), or in the event of specific failures, or an emergency shutdown.

Section	Sub-Section	BAT Requirements	Comment
2. Operations (continued)	Reaction Stage	1. With a clear understanding of the physical chemistry, evaluate options for suitable reactor types using chemical engineering principles. 2. Select the reactor system from a number of potentially suitable reactor designs – conventional stirred tank reactor (STR), process-intensive or novel-technology - by formal comparison of costs and business risks against the assessment of raw material efficiencies and environmental impacts for each of the options. 3. Undertake studies to review reactor design options based on process-optimisation where the activity is an existing activity and achieved raw material efficiencies and waste generation suggest there is significant potential for improvement. The studies should formally compare the costs and business risks, and raw material efficiencies and environmental impacts of the alternative systems with those of the existing system. The scope and depth of the studies should be in proportion to the potential for environmental improvement over the existing reaction system. 4. Maximise process yields from the selected reactor design, and minimise losses and emissions, by the formalised use of optimised process control and management procedures (both manual and computerised where appropriate). 5. Minimise the potential for the release of vapours to air from pressure relief systems and the potential for emissions of organic solvents into air or water, by formal consideration at the design stage - or formal review of the existing arrangements if that stage has passed.	1/2/3. PEM has been selected for hydrogen production due to the high-water splitting efficiency, similar to alkaline electrolysis. PEM does not use KOH so there is no caustic discharge. 4. The electrolyser has been designed to maximise yield and minimise any H_2 losses. Optimised process control is also used to maximise yields and minimise losses. The electrolyser will be controlled by the DCS to monitor plant conditions and control performance. 5. See BAT - Over pressure protection systems for pressure relief systems (electrolyser uses a LP flare system and header size).
	Minimisation of liquid losses from reaction systems		Not applicable - there are no reactor vessels that would give rise to liquid losses in the process.
	Minimisation of vapour losses	1. Review your operating practices and review vent flows to see if improvements need to be made. 2. Consider opportunities to enhance the performance of abatement systems.	Potential vapour losses from the reaction stage includes fugitive losses of hydrogen and venting of oxygen. Overpressure protection is provided by incorporating several techniques into the design process (PSVs, overpressure protection, LP and HP flare systems). Refer to BAT - Over pressure protection systems for more details. Water seal is used to provide a tight seal in hydrogen service. Continuous purge from Recip H_2 compressors and small blowdown from electrolysers will be utilised as there is a mix of H_2 and nitrogen. There is no potential for recovery of these vent streams based on quantities. The feasibility of oxygen capture has been reviewed and concluded that it is not feasible to capture, process and store the oxygen produced for this project.
	Separation stage	1. Choose your separation technique following a detailed process design and HAZOP study. Follow formal operating instructions to ensure effective separation and minimisation of losses. Adhere to design conditions such as heat input, reflux flows and ratios, etc. 2. Install instrumentation to warn of faults in the system, such as a temperature, pressure or low coolant-flow alarms.	1. Hydrogen may contain brine from storage in cavern. This is removed by coalescing filter. Process equipment throughout the Site will be operated by a mixture of automated and manual processes to ensure high process efficiency, yield and operability, with some key indicators being relayed to central alarms (alarm settings to be defined as part of the design).
	Liquid-liquid separations		Not applicable - no liquid/liquid separation with exception of Oil interceptor in drainage system.
	Solid-liquid separations		Not applicable - no solid-liquid separation
	Chemical process controls	1. Monitor the relevant process controls and set with alarms to ensure they do not go out of the required range.	Process equipment throughout the Site will be operated by a mixture of automated and manual processes to ensure high process efficiency, yield and operability, with some key indicators being relayed to central alarms (alarm settings to be defined as part of the design). Operating conditions will be monitored in a manned control room. The facility will use a DCS housed in the main control room linked to various programmable logic controllers (PLCs) across the site, including to field instruments, safeguarding system, Fire & Gas system, and some external interfaces, including a borehole pumping system, custody transfer metering system and a cavern system. The control and monitoring of the facility will be from the main central control room provided within the facility. Alarms will alert the operator to take necessary action during an emergency shutdown scenario. Actions to be taken in the event of an alarm will be documented. The automated control system will be validated by a digital team, and alarms will be verified during site commissioning.

Section	Sub-Section	BAT Requirements	Comment
2. Operations (continued)	Analysis	1. Analyse the components and concentrations of by products and waste streams to ensure correct decisions are made regarding onward treatment or disposal. Keep detailed records of decisions based on this analysis in accordance with management systems.	See Section 7 of the Supporting Information Document for details on the different waste streams, quantities and their management, including minimisation, storage and disposal. All waste generated at the Site is managed by appropriately trained employees at the Site under the EMS, which includes requirements relating to waste inventory, waste storage, waste inspections, off-site waste management and waste prevention, reduction and recycling, There are no byproducts from the process. Oxygen is produced but it is not possible to use this within the available space on site. Analysis of wastewater is covered below/other BAT responses.
3. Emissions and Monitoring	Point Source Emissions to Air	1. Formally consider the information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (see Reference 1, Annex 2) as part of the assessment of BAT for point-source releases to air, in addition to the information in this note. 2. The benchmark values for point source emissions to air listed in Annex 1 should be achieved unless we have agreed alternative values. 3. Identify the main chemical constituents of the emissions, including VOC speciation where practicable. 4. Assess vent and chimney heights for dispersion capability and assess the fate of the substances emitted to the environment.	1. See CWW sheet. 2. See Section 4 and Section 11 of the Supporting Information Document for emissions inventory of substances to air. 3. See Section 4 of the Supporting Information Document for details of point source emissions to air and Section 11 of the Supporting Information Document for H1 assessment to air. 4. OCGT stack height has been determined by dispersion modelling - see Section 11 of the Supporting Information Document (no data available on 100% H_2 firing yet. The assessment has considered 75% hydrogen/25% natural gas with an uplift factor to assess the 100% hydrogen scenario, as agreed with the EA.
	Point Source Emissions to Water	You should where appropriate: 1. Control all emissions to avoid a breach of water quality standards as a minimum. Where another technique can deliver better results at reasonable cost it will be considered BAT and should be used. 2. Use the following measures to minimise water use and emissions to water: a. Where water is needed for cooling, minimize its use by maximising heat transfer between process streams b. Use water in recirculating systems with indirect heat exchangers and a cooling tower rather than a once through system. (A water make-up treatment plant and a concentrated purge stream from the system to avoid the build up of contaminants are likely to be necessary.) c. Leaks of process fluids into cooling water in heat exchangers are a frequent source of contamination. Monitoring of the cooling water at relevant points should be appropriate to the nature of the process fluids. In a recirculatory cooling system, leaks can be identified before significant emission to the environment has occurred. The potential for environmental impact is likely to be greater from a once through system. Planned maintenance can help to avoid such occurrences. d. Reduce water used for cleaning. e. Strip process liquor and treat if necessary, then recycle/reuse. f. Use wet air oxidation for low volumes of aqueous effluent with high levels of organic content, such as waste streams from condensers and scrubbers g. Neutralise waste streams containing acids or alkalis to achieve the required pH for the receiving water. h. Strip chlorinated hydrocarbons in waste streams with air or steam and recycle by returning to process where possible. i. Recover co-products for re-use or sale. j. Periodically regenerate ion exchange columns. k. Pass waste water containing solids through settling tanks, prior to disposal. l. Treat waste waters containing chlorinated hydrocarbons separately where possible to ensure proper control and treatment of the chlorinated compounds. Contain released volatile chlorinated hydrocarbons and vent to suitably designed incineration equipment. m. Non-biodegradable organic material can be treated by thermal incineration. However, the thermal destruction of mixed liquids can be highly inefficient and the waste should be dewatered prior to incineration.	1. The only direct point source emissions to water from the Site will be RO reject and brine discharge from cavern dewatering, both discharged to sea. See Section 10 of the Supporting Information Document for H1 assessment of emissions to water. Foul effluent will link into existing AGS sanitary system (comprising Klargester Septic Tank - see more details in Section 3.5.4.6 of the Supporting Information Document). Uncontaminated site drainage will be directed to the local watercourse. 2. The following measures will be used to minimise water use and emissions to water: a. Cooling water will be a closed loop system. b. Cooling Water will be used in recirculation systems with indirect heat exchanges. c. Planned maintenance procedures will be in place to check for leaks. d. Cleaning will be carried out for the gas turbines. Any wastewater to be contained and disposed offsite. e. Not applicable - no process liquors f. Not applicable g. Ammonia leaks would be high pH, but tank is bunded. Effluent from bunds will be quarantined and tankered offsite. Reject from demin plant has pH monitoring and would be neutralised before discharge to drainage system/sea. h. Not applicable - no chlorinated hydrocarbon used on site. i. Not applicable - no co-products j. Ion exchange columns will be periodically regenerated k. Wastewater from the RO plant is not expected to contain solids. Surface water run-off passes through site drainage with silt traps and an oil interceptor, which will allow solids to settle before discharge via existing lagoon. l. Not applicable- no chlorinated hydrocarbons used onsite. m. Not applicable - no non-biodegradable organics used onsite
	Point Source Emissions to Land	1. Use the following measures to minimise emissions to land: • Use settling ponds to separate out sludge (Note: Sludge can be disposed of to incinerator, encapsulation, land or lagoon depending upon its make up.) • Chlorinated residues should be incinerated and not released to land. (Chlorinated hydrocarbons are not to be released to the environment due to their high global warming and ozone depletion potentials.) • Either recycle off specification product into the process or blend to make lower grade products where possible • Many catalysts are based on precious metals and these should be recovered, usually by return to the supplier.	Not applicable - as described in Section 4.4.1 of the Supporting Information Document, there are no point source emissions to land.

Section	Sub-Section	BAT Requirements	Comment
3. Emissions and Monitoring (continued)	Fugitive Emissions To Air	1. Identify all potential sources and develop and maintain procedures for monitoring and eliminating or minimising leaks. 2. Choose vent systems to minimise breathing emissions (for example pressure/ vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment. 3. Use the following techniques (together or in any combination) to reduce losses from storage tanks at atmospheric pressure: • maintenance of bulk storage temperatures as low as practicable, taking into account changes due to solar heating etc. • tank paint with low solar absorbency • temperature control • tank insulation • inventory management • floating roof tanks • bladder roof tanks • pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations • specific release treatment (such as adsorption condensation)	1. See Section 4.1.2 of the Supporting Information Document for fugitive emissions to air and control measures. There is the potential for localised fugitive emissions to air of ammonia vapour from the liquid ammonia storage tank breathers (for SCR), and of hydrogen and natural gas in the instance of any leaks in the above ground piping (above ground pipe transports stored hydrogen to OCGT). Fugitive emissions from hydrocarbon delivery and storage are expected to be minimal due to the small quantities being delivered and stored. Pipework will be fully welded where possible to eliminate leaks. 2. Water seal will be fitted to LP buffer, as this provides a tight seal in hydrogen service. Vent systems will comply with all relevant codes and standards (ANSI, API, CGA, NFPA) and will be equipped PSV to prevent overpressure conditions/scenarios. KO drums to separate excess liquids out of gases, and considerations will be made during the design of the vent stack and piping to minimise any potential cases of deflagration/detonation scenarios, and any potential vibration impacts from internal acoustics and gas flow. 3. See Section 3.5.8 of the Supporting Information Document for details of bulk storage handling and containment design. All raw materials and products are kept in closed containers to protect the product and prevent fugitive emissions. Suitable bunding and alarms are provided for storage in addition to implementation of specific material delivery procedures. A Risk Reduction Plan will also be implemented as part of the Low Carbon Hydrogen Standard (LCHS) to demonstrate how the hydrogen production plant will be designed and operated to ensure that fugitive hydrogen emissions are kept as low as reasonably practicable. This includes monitoring and provision of an expected rate of expected annual fugitive hydrogen emissions.
	Fugitive Emissions to surface water, sewer and groundwater	1. Provide hard surfacing in areas where accidental spillage or leakage may occur, e.g. beneath prime movers, pumps, in storage areas, and in handling, loading and unloading areas. The surfacing should be impermeable to process liquors. 2. Drain hard surfacing of areas subject to potential contamination so that potentially contaminated surface run-off does not discharge to ground. 3. Hold stocks of suitable absorbents at appropriate locations for use in mopping up minor leaks and spills, and dispose of to leak-proof containers. 4. Take particular care in areas of inherent sensitivity to groundwater pollution. Poorly maintained drainage systems are known to be the main cause of groundwater contamination and surface/above-ground drains are preferred to facilitate leak detection (and to reduce explosion risks). 5. Additional measures could be justified in locations of particular environmental sensitivity. Decisions on the measures to be taken should take account of the risk to groundwater. 6. Surveys of plant that may continue to contribute to leakage should also be considered, as part of an overall environmental management system. In particular, you should consider undertaking leakage tests and/or integrity surveys to confirm the containment of underground drains and tanks.	1. Installation and storage areas will be built on hard surfacing. 2. See Section 3.5.4 of the Supporting Information Document for drainage arrangements and Section 4.4.2 of the Supporting Information Document for control of fugitive emissions to ground. 3. See Section 4.2.2 of the Supporting Information Document for details of spill kit use and disposal. SSE will have an emergency response procedure in place in the event of a leak. 4/5. The Site is not located in an area experiencing sensitivity to groundwater pollution (see Section 2.3 of the Supporting Information Document). 6. The installation will operate under an EMS, including appropriate procedures and controls for prevention and management of accidental spills; all site operatives will be trained in the application of the Site procedures including regular inspection of plant items and response to loss of containment.

Section	Sub-Section	BAT Requirements	Comment
3. Emissions and Monitoring (continued)	Odour	1. Manage the operations to prevent release of odour at all times. 2. Where odour releases are expected to be acknowledged in the permit, (i.e. contained and treated prior to discharge or discharged for atmospheric dispersion): • for existing installations, the releases should be modelled to demonstrate the odour impact at sensitive receptors. The target should be to minimise the frequency of exposure to ground level concentrations that are likely to cause annoyance • for new installations, or for significant changes, the releases should be modelled and it is expected that you will achieve the highest level of protection that is achievable with BAT from the outset • where there is no history of odour problems then modelling may not be required although it should be remembered that there can still be an underlying level of annoyance without complaints being made • where, despite all reasonable steps in the design of the plant, extreme weather or other incidents are liable, in our view, to increase the odour impact at receptors, you should take appropriate and timely action, as agreed with us, to prevent further annoyance (these agreed actions will be defined either in the permit or in an odour management statement). 3. Where odour generating activities take place in the open, or potentially odorous materials are stored outside, a high level of management control and use of best practice will be expected. 4. Where an installation releases odours but has a low environmental impact by virtue of its remoteness from sensitive receptors, it is expected that you will work towards achieving the standards described in this guidance note, but the timescales allowed to achieve this might be adjusted according to the perceived risk. 5. Where further guidance is needed to meet local needs, refer to Horizontal Guidance Note H4 Odour (see GTBR, Annex 1)	1. Aqueous ammonia will be stored in a bunded container with leak detection and a high-level vent. No odour issues anticipated as described in Section 13 of the Supporting Information Document. Odour emissions from the aqueous ammonia storage tank will be recovered via a vapor equalising line allowing back to the delivery tanker. There may be some ammonia slip from the SCR system, however The Process Contribution (PC) of ammonia from the OCGT stack (scenario 2) from the modelled air quality impact assessment is 2.59 µg/m3 (0.003 ppm), which is significantly lower than the odour threshold, therefore unlikely to be detected/cause an issue. As mentioned in Fugitive Emissions to Air, diesel storage is expected to be minimal, and therefore the risk of odours is considered to be minimal. 2. Not applicable - no odours expected to be acknowledged in the permit. See Section 13 of the Supporting Information Document for management of odour emissions. 3/4. Not applicable - no odours anticipated with the activities.
	Noise and Vibration	1. Install particularly noisy machines such as compactors and pelletisers in a noise control booth or encapsulate the noise source. 2. Where possible without compromising safety, fit suitable silencers on safety valves. 3. Minimise the blow-off from boilers and air compressors, for example during start up, and provide silencers	Noise is discussed in Section 12 of the Supporting Information Document. See LCP BAT 17.
	Monitoring	1. Carry out an analysis covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits. The need to repeat such a test will depend upon the potential variability in the process and, for example, the potential for contamination of raw materials. Where there is such potential, tests may be appropriate. 2. Monitor more regularly any substances found to be of concern, or any other individual substances to which the local environment may be susceptible and upon which the operations may impact. This would particularly apply to the common pesticides and heavy metals. Using composite samples is the technique most likely to be appropriate where the concentration does not vary excessively. 3. If there are releases of substances that are more difficult to measure and whose capacity for harm is uncertain, particularly when combined with other substances, then "whole effluent toxicity" monitoring techniques can be appropriate to provide direct measurements of harm, for example, direct toxicity assessment.	Monitoring of emissions to air Monitoring of emissions to air will comply with BATc from LCP BREF. Products of combustion of natural gas and hydrogen are well understood. See LCP BAT 2 - 4. Monitoring of emissions to water Monitoring of emissions to water will comply with BATc from CWW BREF. See CWW BAT 3 & 4.
	Monitoring and Reporting of waste emissions	1. Monitor and record: • the physical and chemical composition of the waste • its hazard characteristics • handling precautions and substances with which it cannot be mixed.	See LCP BAT 16 and Section 14 of the Supporting Information Document. Waste will be managed in accordance with the overarching SSE Risk Standards on Waste Management, which will be supported by a site waste inventory that maintains a waste register including the nature of waste, EWC, hazard classification (as hazardous or non-hazardous waste) and applicable handling procedures. This ensures compliance with the Site's waste duty of care requirements.

Section	Sub-Section	BAT Requirements	Comment
3. Emissions and Monitoring (continued)	Environmental Monitoring (beyond the installation)	1. Consider the following in drawing up proposals: • determinands to be monitored, standard reference methods, sampling protocols • monitoring strategy, selection of monitoring points, optimisation of monitoring approach • determination of background levels contributed by other sources • uncertainty for the employed methodologies and the resultant overall uncertainty of measurement • quality assurance (QA) and quality control (QC) protocols, equipment calibration and maintenance, sample storage and chain of custody/audit trail • reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information.	The potential impact of the Site has been considered in the Environmental Risk Assessment (see Section 15 of the Supporting Information Document) and H1 Assessment (See Section 10 of the Supporting Information Document). Additional monitoring (beyond the site boundary) is not deemed necessary or proportionate for the Site.
	Process Variables	1. Identify those process variables that may affect the environment and monitor as appropriate.	No process variables identified that may affect the environment.

TABLE 3 - HYDROGEN PRODUCTION BY ELECTROLYSIS OF WATER: EMERGING TECHNIQUES

Section	Sub-section	BAT Requirements	Comment
2. Technique Selection		When designing a hydrogen production plant and its associated activities, you should consider its overall environmental performance. You should justify your choice of technology at each stage using the principles of 'best available techniques' throughout your permit application including: • energy demand and efficiency • water demand, efficiency and evaluation for re-use • emissions to the environment These are the hydrogen production by electrolysis methods the regulators considered when producing this guidance: • alkaline electrolysis (ALK) • polymer or proton electrolyte membrane (PEM) • solid oxide electrolyser cell (SOEC) The guidance may also be generally applicable to other types of electrolysers using water for hydrogen production. Consider it where appropriate. The choice of technology will determine, for example, the energy required for compression. The selection will depend on the difference between the electrolyser system operating pressure and the pressure required by the user.	See ICS BAT - Energy Efficiency. The plant has been designed to be an efficient system which is powered through renewable electricity sourced from the grid through Renewable Power Purchase Agreements. This is used to power the electrolysis process and the production of (green) hydrogen, splitting water into hydrogen (stored) and oxygen (vented). In response to the demands of the grid operator, hydrogen will be burned within the OCGT and is expected to supply up to 50 MWe of power for export back to the grid during times of low renewable power availability and/or provide house load to the existing AGS development. The AHP project supports energy security in the UK, which is an important consideration for the UK Government and Department for Energy Security and Net Zero. This concept aims at reducing reliance on natural gas for power generation when renewable energy is unavailable and enables decarbonisation of the Humber region.
3. Plant Design & Operation	Operation	You must consider whether your hydrogen production plant may need to operate in steady state or on a flexible basis to balance variations in, for example: • supply of power to the plant • demand from hydrogen users You should consider whether this need for flexibility will affect the design, operation and maintenance of the plant.	The plant is designed to operate on a flexible basis as the sole user of hydrogen is the OCGT which will respond to peak electricity demand on the grid. The plant will generate electricity from the combustion of hydrogen (hydrogen/ natural gas blend during extended commissioning phase). If hydrogen is not available, then the OCGT can run on natural gas to generate electricity. Note that the hydrogen generated will only be used on site - there is no external demand.
		You should identify all operating scenarios. Include those due to providing flexible operations where environmental performance could be affected, or where additional emissions are expected. For example, these could be because of changes in demand, or start-up and shutdown. You should describe measures you would take to minimise the environmental impact of these scenarios. These could result in, for example: • reduced energy efficiency • reduced water efficiency • increased emissions to air, including venting and flaring • increased effluent or wastes produced • increased risk of accidents in non-steady state conditions	100% natural gas or a blend of hydrogen/Natural Gas will be used during start-up to ensure stable operation in the OCGT. The Site will either operate in hydrogen production mode or in generation mode as there is one import / export H_2 line to the cavern. As a result, there will be intermittent operation. The overall technology selection and design of the hydrogen production facility has considered this operation to minimise inefficiencies and safety risks / environmental impacts from intermittent operation.
	Reliability and availability	You will need to identify the equipment and systems, and their associated operating and maintenance techniques, that are critical in avoiding emissions or minimising environmental impact. You will need to design, operate and maintain these to make sure they are reliable and available. This should include providing installed back-up equipment, where necessary.	Environmentally critical equipment, systems and techniques relevant to H2 production have been identified to avoid emissions and minimise environmental impact: • Continuous monitoring of process effluent from the demin plant (see CWW BAT 4 and BAT 12). Controls include holding critical spares and shutdown of the demin plant if there is a risk of exceedance of emission limit values and/or a significant environmental risk. • Implementation of the H_2 flare system. If the flare system is not available, the plant will not be started / will be shut down. • Additional environmental critical considerations for plant onsite includes: • SCR system associated with the OCGT for NO_x abatement, including storage of ammonia. • CEMs for OCGT stack monitoring Critical equipment or tasks are identified through Process Hazard Reviews completed for onsite assets. Once these are defined, Safety, Health and Environmental (SHE) critical operating procedures and/or maintenance instructions are developed. These tasks have an increased level of training and competence and are developed with human factor considerations to reduce the potential for errors. Equipment is flagged as SHE critical in maintenance systems so they are prioritised for scheduling maintenance and reacting to plant defects. Operating and maintenance procedures will be in place prior to operation to ensure that critical equipment is operated and maintained according to suppliers' recommendations. The plant has been designed according to SSE's equipment sparing philosophy to ensure back-up equipment is available where appropriate.

Section	Sub-section	BAT Requirements	Comment
3. Plant Design & Operation (continued)		You should implement a risk-based other than normal operating conditions (OTNOC) management plan. This should identify potential scenarios, mitigation measures, monitoring and periodic assessment of the OTNOC management plan. This should be part of your environmental management system.	The EMS will include a risk-based OTNOC management plan covering abnormal and emergency conditions (this includes startup, shutdown (planned and emergency), and maintenance). The management plan will be developed to minimise duration and control OTNOC.
	Energy efficiency, process efficiency, cooling	You should design, operate and maintain your hydrogen production plant to maximise: • Energy efficiency (minimise the energy needed to produce each tonne of hydrogen) • Process efficiency (minimise the raw materials needed to produce each tonne of hydrogen)	The plant has been designed to be powered through renewable electricity sourced from the grid through Renewable Power Purchase Agreements. The Process uses abstracted borehole water to produce hydrogen. This water is a mixture of saline and freshwater (brackish) and therefore has a reduced demand on the water source. The abstracted water is treated through the onsite treatment plant to provide high quality demineralised water for the process. Hydrogen production using PEM electrolysis is an energy and water intensive process and, as a result, plant and process efficiency is critical for operation and commercial performance. The plant is being designed to provide the optimum combination of flexibility, efficiency and reliability for its intended operating regime. The plant design includes phased development of heat and mass balances for the process as the design evolves, which supports the use of conservation principles e.g. through identifying and analysing mass and energy flows, materials and energy can be optimised. As part of operations, key performance indicators will be developed that provide a metric to monitor the energy and water efficiency of the hydrogen production plant. These will be reported regularly to the management team to enable action or improvements. Periodic energy efficiency assessments will be completed to assess long term performance, any deterioration in efficiency and opportunities for improvement. The maintenance programme will be developed to ensure preventative checks and inspections and replacement of wear components to ensure efficient operations and minimisation of SHE risks. Performance testing will be carried out for hydrogen and natural gas as described in LCP BAT 9.
		You should consider the use or recovery of oxygen by-product when this is commercially and technically viable	The feasibility of recovering oxygen has been assessed by SSE. The study concluded that that purification and storage of oxygen produced by the electrolysers in the AHP development is not feasible via either compressed or liquified storage. Liquefaction was found to be the best option for oxygen processing and storage as the higher density of liquid oxygen provides the smallest area and road tanker requirements. However, this cannot be provided due to spatial constraints onsite. The power requirements for such a facility are likely to be very high, due to the compressor work required to achieve the very low temperatures necessary to liquefy oxygen. There are also significant health and safety implications of storage of large quantities of oxygen at a location with natural gas / hydrogen storage as oxygen concentrations in air above 24% presents a flammable risk hard to manage if ever ignited. Oxygen resulting from the electrolysis will be safely vented to atmosphere. The feasibility of recovering oxygen will be reconsidered in future if technically viable options arise.
		To decide on best available techniques (BAT) for your plant, you will have to balance how you achieve these efficiencies to optimise the environmental and economic requirements. You must explain how you have done this and what your considerations were. Main energy users will include: • Electrolysers • Hydrogen compressors • Hydrogen purification • Pumping or fan systems You should consider: • Electrical power needs and whether you will import or generate on Site • High pressure steam need and availability (if applicable) • Maximising any residual waste heat recovery (WHR) • Cooling needs • Cooling type and medium • Energy recovery devices on high pressure fluids, for example, reverse osmosis effluent, where applicable	The aim of the plant is to produce electrolytic hydrogen from electricity which will be supplied via the grid, and when possible, during periods of excess solar and wind power generation. Produced hydrogen will be used for the generation of low carbon power when renewable power is not available. Electricity will be procured through the wholesale market, with corresponding Renewable Energy Guarantee of Origin certificates used to demonstrate exclusive ownership over the energy attributes of the low carbon electricity generated. A contract will be developed to demonstrate the links to the claimed generation. Integrated cooling between the OCGT and the electrolyser is used to maximise cooling efficiency and minimise plant size / materials use. A closed loop fin fan air cooled system is used to minimise water consumption. At several locations in the process, water of good quality can be collected and recycled into the process, however there is no heat or energy recovery.
		You should also consider heat integration optimisation. For example, heat recovery at higher temperatures from hydrogen compression systems for power generation or drives, where this is feasible. You should reference the BREF documents, where appropriate: • Industrial Cooling Systems - https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/cvs_bref_1201.pdf • Energy Efficiency -https://eippcb.jrc.ec.europa.eu/sites/default/files/2021-09/ENE_Adopted_02-2009corrected20210914.pdf	There are no current plans for heat recovery. Process heat from water cooling system will be let off by an included battery of fin fan coolers.

Section	Sub-section	BAT Requirements	Comment
3. Plant Design & Operation (continued)	Water supply and use	You should: • Minimise the quantity of water you use • Segregate, treat and reuse water where possible • Identify how much contaminant needs to be removed to maintain the water quality necessary for effective operation • Determine the quantity of water to be purged, the characteristics of that purged water, and design the treatment process accordingly • Eliminate, minimise or treat any emissions to air or wastes that may result from the water treatment process • Choose a cooling method that takes account of the impact of temperature on process performance, energy efficiency and environmental impact on the receiving medium	See LCP BAT 13 and EPR 4.03 BAT - Efficient use of raw materials and water for how water usage is minimised, recycled and reused. Water will be supplied from the existing licensed Aldbrough borehole water supply, which is brackish and as such will require treatment before use in the electrolyser package. The demineralised water treatment system will provide high quality and clean demineralised water to the electrolyser package using RO, plus additional filtration. Borehole well water will be initially pumped to the borehole buffer storage tank. Prior to RO filtration, well water will be pre-treated using a Greensand Filtration system. The greensand filters are vessels filled with greensand media that is used to remove iron, manganese, and hydrogen sulphide. EDI system will be used to further reduce the dissolved solids from the RO permeate. The water is then transferred to the demineralised water storage tank. Discharge of wastewater from the demin plant (RO reject) will require pH adjustment prior to discharge to sea. Water Consumption will be minimised through a number of techniques, that includes the following: • Second pass RO reject is directed to the first pass RO booster pumps for recycle. • Cooling water for the plant will be provided from the second pass RO unit effluent. • Cooling water is air cooled and is recirculated in a closed loop system, which minimises consumption to top-ups or maintenance drain-down activities. • Water condensate from the respective hydrogen gas coolers and oxygen gas coolers will be returned to the electrolyser for use as process water. • Water from the Wiggins Holding Tank (H_2 storage), LP Hydrogen compressor KO drums will be routed to the Borehole buffer tank. • Following the de-oxo separator, condensate water will be recovered to the borehole buffer tank. • Demin plant is designed to meet a set water quality specification required for the process with consideration of maximising the use of abstracted water. • Appropriate segregation and management of drainage to avoid any cross contamination e.g. potential chemical handling / storage areas, general surface water run-off (with oil interceptors / water separator) and foul water systems. • The drain system will recycle as many clean streams as possible. Generated waters containing oil will be transported off site. The quality of recycled waters will be monitored & periodically sampled. Depending on contaminants, the water will either be removed from site or sent to the front end of the demin water system. A closed loop cooling system will be utilised onsite. A glycol/water mix will be used to fill the cooling water system through the cooling water expansion tank, which will feed the recirculation loop and water-cooling package. On the cooling water expansion tank, there will be a level transmitter to ensure that there is no over pressuring of the recirculation line due to heat up. The system will be equipped with high point vent valves to purge air following system maintenance. Control valves will determine how much cooling water to send to each unit operation or back to recirculation. These control loops will work off a temperature controller to determine if the water should be recirculated back to the air coolers in line. Each fan will be sized to provide the required cooling duty to bring the return water from 43 degrees down to 35 degrees. The electrolyser package has the largest cooling water demand at 1,510 m^3/h with the others being significantly lower.
	Electricity Supply	The source of power supply is not within the scope of this guidance. However, supply issues can affect the environmental performance of the hydrogen production process, such as through availability and variability. You should take this into account when you design and operate the hydrogen plant to eliminate or mitigate any environmental impact. It is likely that transformers and rectifiers, where needed as associated activities, would be considered part of the installation.	Electrical design shall comply with the latest editions of all local, statutory and regulatory requirements adhering to SSE specifications, BS EN standards, and IEC standards. The system consists of a radial feed for the distribution equipment and a 65.7 MVA generator feeding power back onto the grid. Two connections shall be made to the grid at the 132 kV level via motorized air-break switches and SF6 breakers. One feeder shall feed a 132 kV/20 kV transformer, which will serve the electrolysers and hydrogen high-pressure and low-pressure compressors, along with auxiliary loads. The other connection at the 132 kV level shall provide power to the grid via generator step-up transformer. Power will be generated on site by a 65.7 MVA, 11 kV gas-turbine generator. It will be connected to the 132 kV via a 11/132 kV step-up transformer. The generator will be synchronized across the 11 kV generator breaker. The design intent in relation to generated power is to be able to supply on-site facilities as needed, and/or export power to the grid.
	Hydrogen purification	Your hydrogen purification requirements will depend on: the hydrogen product quality specification the production technique chosen residual impurities in the hydrogen The impurities may include: • oxygen • water • other trace gases You should consider which other purification processes are appropriate, depending on the specification of hydrogen required. These may include: • deoxidiser system • dehydration system • other purification processes	The hydrogen produced in the electrolyser is anticipated to be saturated with water and contain traces of oxygen and hydrogen sulphide, therefore treatment is required to improve the purity of the hydrogen and remove water prior to cavern storage. The wet hydrogen gas will be passed through a filter separator to ensure that all particulates and water greater than 5 micron in size are removed from the inlet hydrogen gas stream. Gas is passed through a deoxidiser vessel which will remove any oxygen from the gas through catalytic oxidation with hydrogen. Condensate water will be pumped back to the borehole buffer tank for reuse. The filtered gas is then fed to a Sulphur Guard Bed. The Sulphur Guard Bed is a packed vessel sized to remove any potential hydrogen sulphide from hydrogen. This will be accomplished by packing the hydrogen purification vessel with scrubbing media (to be confirmed by vendor later) and running the hydrogen through the vessel to be captured. Purified hydrogen gas will be fed to the OCGT feed gas cooler to condensate water in gas. The hydrogen gas is cooled from chiller unit. This Chiller unit will be a package unit which will comprise of chiller and hydrogen chiller exchanger with temperature control within the package. The cooled hydrogen is then passed through OCGT knockout drum for separation of water from hydrogen stream. Water condensate will be returned to the electrolyser for use as process water.

Section	Sub-section	BAT Requirements	Comment
3. Plant Design & Operation (continued)		You should describe and justify your choice of techniques and the relevant aspects which will affect environmental criteria. For example: • consequential wastes and emissions • any recovery or treatment required	Through the deoxygenation (DeOxo) process oxygen content in the hydrogen is reduced and vented to atmosphere. Oxygen is not recovered during the process as there are no feasible options to undertake this, refer to BAT 3.3 Energy Efficiency, Process Efficiency, and Cooling. Uncontaminated water condensate from the DeOxo separator will be recovered to the borehole buffer tank, and water condensate from the respective hydrogen gas coolers and oxygen gas coolers will be returned to the electrolyser for use as process water. Water that cannot be recycled back into the process is removed and disposed offsite by a third-party contractor.
4. Emissions to Air		You should identify, eliminate, minimise or reduce any emissions to air that could cause pollution	The use of hydrogen as a fuel has been selected to reduce CO_2 emissions. It is understood that combustion of hydrogen can potentially lead to higher NO_x emissions than combustion of natural gas. The proposed installation will use SCR for the control of NO_x emissions in the flue gas, to ensure compliance with NO_x BAT-AELs (defined in Guidance on Emerging Techniques for H2 Combustion) using ammonia as a reagent. There will also be one diesel firewater pump linked with the fire water system. The diesel engine is expected to be less than 1 MWth and will be compliant with emissions standards. The diesel firewater pump will only be used in emergencies, and testing will be carried out for less than 50 hours per year.
		You should carry out a risk assessment, including detailed air quality modelling where appropriate, to assess the impact of these emissions	A H1 risk assessment and detailed air quality modelling also been carried out - see Section 11 of the Supporting Information Document.
	Emissions of hydrogen	Hydrogen has been identified as an indirect greenhouse gas and so is considered a pollutant. You should design and operate your plant to achieve the following, which are listed in priority order. (Where technically and economically viable, and ensuring safety is not compromised.) • Prevent or avoid emissions of hydrogen. • Recover or recycle hydrogen. • Avoid or minimise continuous or intermittent flaring of hydrogen. • Avoid or minimise continuous or intermittent venting of hydrogen, whether for operational or safety reasons.	Produced hydrogen will be stored in underground caverns and used as a fuel within the OCGT and will be transferred across site via pipeline. Measures to reduce/prevent fugitive emissions from hydrogen in process are provided in Section 4.1.2 of the Supporting Information Document. The Site will be equipped with an enclosed ground flare system to provide a safe disposal route for gaseous emissions (hydrogen). Flaring of hydrogen will be required to support OTNOC events such as periodic depressurisation of hydrogen systems to allow a safe shutdown for routine maintenance and emergency situations, as well as to prevent the accumulation of hazardous atmosphere within the plant. The flare system is expected to be used infrequently e.g. once a year during maintenance events and the process will last between 45 to 105 minutes in total.
		You should consider using these techniques: • Designing and operating your plant to maximise equipment availability and reliability • Designing and operating your plant to minimise the frequency of and amount of hydrogen purged, including during change of production rate, start-up and shutdown, abnormal operations and preparation for maintenance • Use of buffer storage of off-spec hydrogen or hydrogen product during start-up/shut-down to minimise intermittent operation • Recovery of hydrogen • Treatment of hydrogen, for example, by recombination with oxygen or storage and purification or purged hydrogen • Flaring rather than venting or hydrogen, where emissions cannot be eliminated and where practicable • Venting hydrogen safely, where the above techniques are not practicable You should explain your design and operational considerations behind your proposed techniques, including how you have considered overall environmental impact of their use.	The plant has been designed according to SSE's equipment sparing philosophy to maximise equipment availability. Maintenance procedures and schedules will be developed in line with supplier recommendations to ensure that planned maintenance is carried out, and a system for reporting faults will be in place such that repairs are carried out in good time. The plant will be started up using natural gas. Flaring of hydrogen will be required to support events such as periodic depressurisation of hydrogen systems, to allow a safe shutdown for routine and emergency situations, as well as to prevent the accumulation of a hazardous atmosphere within the plant. The application of flaring will be made based on technical, health, safety, and environmental reasoning, including guidance published by Government bodies. In these events, hydrogen from the electrolysers and the compression and distribution system will be routed to a single enclosed ground flare structure with a maximum height of 15 m above finished ground level. Enclosed ground flares have burner heads close to ground level and enclosed inside a shell that is internally insulated or shielded. Planned use of the flare system linked with maintenance is expected at an approximate frequency of once per year with a typical duration of 45 to 105 minutes. Unplanned or emergency use of the system are difficult to accurately quantify but are considered infrequent and of a shorter duration than during a full plant maintenance activity. Operational and maintenance procedures and processes will seek to minimise the need for flaring of hydrogen. There will be no venting of hydrogen directly from the electrolysers.
	Other emissions from venting or purging	You should quantify and assess other venting and purging requirements, identifying any pollutants that are expected to be present Requirements for other continuous venting during normal operations may include, for example: • Waste oxygen • Water vapour • Deaeration of steam condensate • Gases from processing wastewater streams • Purge of tanks, vent or flare headers Requirements for intermittent venting may include, for example, venting needed as part of the process of purging equipment for maintenance activities. Such as nitrogen purges which may contain hydrogen.	Oxygen will be vented as it cannot feasibly be recovered - see Section 11 of the Supporting Information Document for emissions to air. There will be no venting of hydrogen directly from the electrolysers. Flaring of hydrogen will be required to support events such as periodic depressurisation of hydrogen systems, to allow a safe shutdown for routine and emergency situations, as well as to prevent the accumulation of a hazardous atmosphere within the plant. Nitrogen or natural gas from a reliable source shall be continuously introduced as a purge into the vapor disposal system to help maintain a safe atmosphere.
	Other pollutants	You should identify, quantify and assess other pollutants. These may include, for example, nitrogen oxides (NOx) and hydrogen from flaring of hydrogen.	Flaring of hydrogen will generate NO_x, emissions. See Section 4.1 of the Supporting Information Document for details of emissions to air.

Section	Sub-section	BAT Requirements	Comment
5. Emissions to Water		You must identify and eliminate, minimise, recycle or treat any emissions to water that could cause pollution. You should carry out a risk assessment, including detailed modelling where appropriate, to assess the impact of these emissions. For emissions to surface water, you should refer to the guidance relevant to the location of your plant in UK through the information on 'Surface water pollution: risk assessment for your environmental permit'	Discharge of wastewater from the demin plant (RO reject) will require pH adjustment prior to release to sea. Systems and processes in place which utilise water have been designed to recover and recycle uncontaminated water back into the process where possible - refer to section 3.4 Water Supply and Use. All wastewater streams will be appropriately segregated and treated (if required) prior to discharge. H1 risk assessment for emissions to water has been carried out - see Section 10 of Supporting Information Document.
	Wastewater treatment	You should identify continuous and periodic effluent streams from the process and determine whether effluent treatment is required. These streams may include waste streams from water pre-treatment processes, cooling and steam systems; • Effluent from reverse osmosis (RO) containing ions from the feed water • Effluent from continuous deionisation • Effluent from desalination • Purges from cooling water systems • Purges from condensed water from steam systems These will contain contaminants, which may need treatment or removal before discharge, for example • High salinity effluents • Metal ions	Continuous wastewater stream will arise from the treatment of borehole water in the demineralisation treatment plant. Effluent from the demin treatment plant will be pH adjusted prior to release and is not expected to contain any solids. Waste water that cannot be recovered/recycled into the process, and from the cleaning of the gas turbine/site equipment will be containerised and sent offsite. Contents of the cavern when dewatered will be stored in temporary degassing tanks. No further treatment is proposed.
		You should decide how much water to treat and how to treat it before it is: • Reused • Discharged to surface water or sewage undertaker • Disposed of	Wastewater from the demin plant will be pH adjusted prior to discharge. Other process effluents will be disposed of off-site by a third-party contractor.
		You should identify how much contaminant can be removed to comply with discharge requirements and design the treatment process accordingly	Treatment of effluent is designed to meet BAT-AELs for discharge.
		You should identify any unavoidable emissions to air or wastes that may result from the water treatment process. Ensure they are minimised or treated appropriately. You should treat water for re-use, where practicable. You should refer to the appropriate BREF and BATC • BREF and BATC for common wastewater and waste gas treatment/management systems in the chemical sector • UK Cross-Cutting Interpretation Guidance and Permitting Advice on the Best Available Techniques (BAT) Conclusions published under the Industrial Emissions Directive (IED)	Wastewater treatment onsite will only involve pH adjustment of RO reject prior to discharge, which is not expected to produce any emissions to air. No water requiring treatment is reused in the process. Wastewater treatment/management will comply with BATC from CWW BREF.
6. Emissions to ground and groundwater		You must design your process to avoid emissions to ground and groundwater	The Site will be constructed with hard standing with storage and containment areas bunded according to CIRIA specifications and fitted with leak detection systems where necessary. See Section 4.4.2 of the Supporting Information Document for further details on measures to prevent emissions to ground and groundwater.
7. Waste		Before considering waste disposal, as far as practicable you must follow the waste hierarchy and: • Prevent • Minimize • re-use • recycle • recover • treat You should consider how to deal with the following wastes that may be generated and justify your choice following this waste hierarchy.	See LCP BAT 16 and Section 7 of the Supporting Information Document.

Section	Sub-section	BAT Requirements	Comment
7. Waste (continued)	Liquid wastes	Liquid wastes such as: Waste alkaline solutions, for example, potassium hydroxide Any residual liquid wastes from the water treatment processes	KOH is not used. Liquid waste produced onsite will be generated process water from the demin plant (to be pH adjusted and released via the existing brine water discharge pipe to the North Sea), waste water from the cleaning of equipment (removed from site by a third party), and foul wastes derived from the Site during operation (e.g. human wastewater), which will be incorporated into the existing site drainage system, which will undergo upgrade to accommodate the anticipated additional volume, if required. Additional liquid wastes include spent chemicals, and small amounts of waste oils from machinery (can include small amounts of hazardous waste from plant maintenance). Drains from chemical injection packages are collected and will be drained by truck. Chemicals that may need to be disposed of includes, gas turbine generator lube oil, waste cooling water from periodic drain down, Gas Turbine wash water, and HP Compressor lube oil.
	Solid wastes	Solid wastes such as: • Spent adsorbent materials from gas treatment, dehydrations, hydrogen purification • Spent/damaged membranes • Catalyst materials • Other solid consumables e.g. electrolyser components such as seals	Treatment of water for the electrolysers uses RO and EDI. This treatment will generate waste, which will be disposed of off-site. Additional routine solid waste includes general solid waste, dry mixed recyclables and empty chemical containers. See Section 7 of the Supporting Information Document for waste management
8. Monitoring and reporting		You must carry out monitoring to show that resources are being used efficiently. This may include: • Energy efficiency • Water efficiency • Resource efficiency e.g. electrolyser consumables • Verifying (when applicable) compliance with low carbon hydrogen standards, including any requirements relating to emissions of hydrogen	Monitoring will be carried out to show that resource are being used efficiently. This will include monitoring of: • electricity use • electricity generation • water use • wastewater discharge • natural gas use • hydrogen production • hydrogen consumption (OCGT) • electrolyser consumables use (e.g. electrolyser stack components (membranes) periodically / infrequently, air, oil and water filters, catalysts, maintenance type waste / consumables e.g. oils (lubricants), and Gas Turbine wash surfactants.)
		Your permit application should include a monitoring plan for: • Routine operation • Commissioning, where appropriate	The EMS will include monitoring, reviewing and reporting procedures, as well as details on improvement programmes and how environmental impacts will be continually assessed onsite. Performance indicators will include tonnes of hydrogen produced. A noise management plan will be developed and agreed with the EA prior to operation as detailed in Section 12 and 16 of the Supporting Information Document. Expected monitoring requirements are provided in Section 14 of the Supporting Information Document.
		You may need to do more extensive monitoring during the commissioning phase than during routine operation. As these production techniques for hydrogen by electrolysis of water are emerging techniques, you may need to develop monitoring methods and standards.	Commissioning plan to be developed and submitted to the Environment Agency (EA) in advance of commissioning. Commissioning plan will include an outline of pre-determined tests and checks to be carried out to confirm that equipment/facilities are ready for safe operation. This includes quality assurance testing and verification of environmental systems as applicable. Commissioning will include a series of procedural steps executed on a sub-system/system basis and involves functionally testing and operating these systems to verify system integrity. For the testing of specialized equipment and systems, commissioning will be carried out by specialist Vendors and Frontline Service Employees (FSEs) Commissioning procedures will be developed in line with suppliers' recommendations. Monitoring will use established methods and standards, where available. Where such methods are not available, they will be developed based on industry standards, adapted as appropriate. To be discussed further with the regulatory body.
		Where relevant, during the commissioning phase, you will need to assess any monitoring results and optimise the operation of the process. You may need to report on: • Your commissioning phase monitoring results • Your assessment of the results • Any changes you want to make to the operation	Monitoring will be undertaken during commissioning to validate performance of the equipment and plant as a whole. It will include any additional monitoring outside of that identified in permit conditions and will be developed and submitted to the EA in advance of commissioning.
		You must report on emissions and process monitoring as stated in your permit.	Emissions and process monitoring as stated in the permit will be reported on.

Section	Sub-section	BAT Requirements	Comment
8. Monitoring and Reporting (continued)	Monitoring point source emissions to air	You should eliminate or minimise emissions of hydrogen due to their global warming potential. You should provide a monitoring plan for monitoring emissions to air, based on expected pollutants such as hydrogen. You should do this using appropriate methods and measuring techniques. Your monitoring should consider, for example, any other sources of hydrogen emissions, such as venting and fugitive emissions, including vented oxygen.	See LCP BAT 2 - 4 and Section 14 of the Supporting Information Document. By using a flare, the hydrogen gas can be safely and efficiently converted into water vapor, which has a negligible Global Warming Potential (GWP) and can be released into the atmosphere without significant environmental impact. A commissioning plan and operational plan is to be developed and submitted to the EA in advance of commissioning. A measurement system will be supplied for continuous monitoring of the exhaust gas emissions, which is designed according to the regulations of the European Directive 2010/75/EU (IED) and the European Standards EN 14181 and EN 15267-3. In the standard configuration, the following components are measured continuously at the exhaust gas stack: Measured values: • NO_x • CO • NH_3 Reference values (as required): • O_2 • H_2O • Exhaust gas temperature • Stack Gas Pressure The following reference values are determined by indirect measurement: Exhaust gas volume flow (to EN ISO 16911)
	Monitoring emissions to water	You must monitor emissions to water based on expected impurities using appropriate methods and measuring techniques You should use monitoring standards for discharges to water following: BATC for common waste water and waste gas treatment/management system in the chemical sector	Refer to CWW BAT 3-4 and Section 14 of the Supporting Information Document.
	Monitoring emissions to ground and groundwater	Through the life of the permit, your regulator may require a: • Site condition and baseline report • Soil and groundwater monitoring plan You should seek advice from the appropriate regulator.	A site condition report has been prepared as part of the permit application that considers the baseline of the Site (see Section 2.4 of the Supporting Information Document and Appendix A).
	Monitoring standards	The person who carries out your monitoring must be competent and work to recognised standards, such as the monitoring certification scheme (MCERTS). MCERTS sets the monitoring standards you should meet. You can use another certified monitoring standard, but you must provide evidence that it is equivalent to the MCERTS standards. You must use a laboratory accredited for the required analysis method by the United Kingdom Accreditation Service (UKAS) to carry out analysis for your monitoring. You should also refer to the JRC Reference Report on Monitoring for IED Installations: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-12/ROM_2018_08_20.pdf	The following equipment will be MCERTS certified where available, or to other national / international standards: Monitoring of emissions to water (see CWW BAT 4) CEMS for the OCGT Flare stack A UKAS accredited laboratory will be used to carry out analyses for monitoring or any parallel stack testing for quality assurance.
	Monitoring process performance	You should identify the main requirements for monitoring process operations where these ultimately impact on environmental performance. This includes: • Energy efficiency per kg of hydrogen product • Water consumption per kg of hydrogen product	Refer to LCP BAT 9 for performance measures relating energy and efficiency for hydrogen production. The following KPIs will be used to benchmark the performance of hydrogen production: Energy efficiency per kg of hydrogen product Water consumption per kg of hydrogen product Optimum performance baselines will be established during commissioning and early operation and performance will be tracked to assess for deterioration over time.
		You should monitor energy efficiency in the hydrogen production by measuring energy consumption per kg of hydrogen produced to calculate overall energy consumption.	Electrical power consumption and hydrogen production rate will be measured. Monitoring of energy efficiency (kWh/kg H_2) will be a key performance indicator for the facility and included in the EMS.

Section	Sub-section	BAT Requirements	Comment
8. Monitoring and Reporting (continued)		You should monitor overall water use by quality of water and purpose of use by carrying out a water balance across the installation. This is to: • Identify opportunities for reduction in water use, where technically and economically feasible • Consider other environmental impacts, such as energy efficiency Requirements for process performance monitoring which relate to environmental performance, either continuous or periodic, may also be a condition of the permit. For example, frequency of operations leading to additional emissions.	A water balance for the installation forms part of the design. Water use will be monitored as a performance indicator for the plant, and changes in use will be investigated. Performance monitoring will be described as part of the EMS.
9. Unplanned emissions and accidents		You should design your plant to: • Inherently avoid leaks by good design practice • Ensure the plant is operated and maintained to appropriate industry standards.	The plant will be designed to the appropriate standards and good engineering practice. Leak testing will be carried out during commissioning and leak tightness will be monitored during operation. Control valves in flammable service will be provided with butt-weld connections, reducing the number of flanges where leaks can occur. The outlet block valve for both a duty and spare relief valve shall be Lock Open. This is to safeguard the low pressure rated outlet of a PRV against a closed but leaking inlet isolation valve. The plant/equipment will be operated and maintained in line with suppliers' recommendations and industry standards where appropriate. Containment will be in accordance with ASME/ANSI Standards, API Standards, Pipe Fabrication Institute Standards, ASTM Specifications, British Standards, MSS-SP Standards, Design basis, Piping Material Specifications, Plant layout and other standards, SSE Design Standards, and Piping Stress Analysis.
		You should propose a risk-based leak detection and repair (LDAR) programme that is appropriate for the fluids and their composition. This should use available industry best practice to minimise releases, including from: • Joints • Flanges • Seals • Glands	An LDAR procedure and programme will be developed for the facility and included in the EMS.
		You should include how you will use the principles of LDAR to eliminate or reduce fugitive emissions of hydrogen due to its global warming potential. Your hazard assessment and mitigation for the plant must consider the risks of accidental releases to the environment.	The results of LDAR surveys will be used to eliminate or reduce fugitive emissions by identifying leaks and scheduling repairs. A LDAR procedure and programme will be developed for the facility and included in the management system.
		You should consider sources that have potential for noise and vibration. Hydrogen compression, pumps and fans could be significant sources. Please refer to the guidance on noise and vibration management: environmental permits.	Equipment anticipated to emit noise during operations are the compressor, electrolyser, OCGT, and fin fan block. All equipment has been assessed and assigned appropriate mitigation measures to minimise noise. Mitigation methods include acoustic enclosures, noise barriers/walls, silencers, acoustic lagging/louvres, and housing of equipment within buildings. See LCP BAT 17 and Section 12 of the Supporting Information Document.

TABLE 4 - BEST AVAILABLE TECHNIQUES (BAT) REFERENCE DOCUMENT FOR COMMON WASTE WATER AND WASTE GAS TREATMENT/MANAGEMENT SYSTEMS IN THE CHEMICAL SECTOR (CWW)

Section	Subsection	BAT#	BAT Text	Requirement	Comments
Environmental management systems		BAT 1	In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features presented in the BREF.	See BREF for detailed requirements	See LCP BAT 1. The EMS will incorporate all of the listed features and will be in place prior to the operational start date.
		BAT 2	In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the following features presented in the BREF	See BREF for detailed requirements	The plant and process documentation as part of the EMS will incorporate: I. a. The Site process reactions including side reactions will be documented and maintained. Introduction of any new chemicals will be subject to review as part of the EMS. I. b. Simplified process flowsheets showing the origin of emissions will be made available in operating manuals I. c. A description of the process-integrated techniques and waste/waste gas treatment at source including their performance will be maintained. II. a/b/c. As part of the EMS, a comprehensive inventory of wastewater will be in place prior to operational start date. The inventory will be maintained and regularly reviewed through the operational lifespan of the Site, and when any substantial changes occur. Waste streams are well known and are detailed in Section 7 of the Supporting Information Document. Analysis of the abstracted borehole water has been undertaken to understand the characteristics of the wastewater arising from the demin plant and separately, the cavern dewatering discharge. III. a - d. As part of the EMS, a record of the characteristics of waste gas streams will be maintained, based on monitoring results. The record will be maintained throughout the operational lifespan of the Site. Data on waste water and waste gas streams will be maintained, including a record of design conditions as well as an ongoing operational record. Results outside the "typical" range will be highlighted and investigated.
		BAT 3	For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to pre-treatment and influent to final treatment).	*(No requirements specified)*	The Site will have five point source emissions to water (As described in Section 4.2 of the Supporting Information Document), namely: • W1 - W3 - Clean surface water (monitoring point M1) • W4 - Clean surface water from the Wellhead drainage area (monitoring point M2) • W5 - RO reject (process effluent) from the demineralisation plant (monitoring point M3) and Salt cavern dewatering discharge (monitoring point M4) <u>M1 & M2</u> W1 - W4 consists of uncontaminated surface water and therefore the following is proposed to be monitored at M1 and M2: No visible oil or grease (daily visual examination) <u>M3</u> Process effluent from the demin plant discharged to the North Sea via emission point W5 will be monitored at M3. Monitoring of flow and pH will be undertaken continuously. The monitoring point will be located upstream of the point at which it combines with cavern discharge in order to monitor the discharge parameters. The demin input and output will be monitored for performance throughout operation. <u>M4</u> Discharge from the salt cavern dewatering discharged to the North Sea via emission point W5 will be monitored at M4. Monitoring of flow, temperature and pH will be undertaken continuously. Monitoring of TSS and TDS will be undertaken using spot samples. The emission point/monitoring point will be located upstream of the point at which it combines with demin process discharge in order to monitor the discharge parameters. There is no wastewater treatment plant onsite. Water that cannot be discharged from site or recycled back into the process, will be removed from site by a third-party contractor.

Section	Subsection	BAT#	BAT Text	Requirement	Comments

Monitoring		BAT 4	BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	**TABLE** – Substance/Parameter | Standard | Minimum monitoring frequency
				Substance/Parameter
				• Total organic carbon (TOC)
				• Chemical oxygen demand (COD)
				• Total suspended solids (TSS)
				• Total nitrogen (TN)
				• Total inorganic nitrogen (N_{inorg})
				• Total phosphorus (TP)
				• Adsorbable organically bound halogens (AOX)
				• Metals
				  ○ Cr
				  ○ Cu
				  ○ Ni
				  ○ Pb
				  ○ Zn
				  ○ Other metals, if relevant
				• Toxicity
				  ○ Fish eggs (Danio rerio)
				  ○ Daphnia (Daphnia magna Straus)
				  ○ Luminescent bacteria (Vibrio fischeri)
				  ○ Duckweed (Lemna minor)
				  ○ Algae
					M1 and M2
					W1 - W4 will comprise clean surface water only, therefore it is not the intention to monitor for the parameters listed. However, the discharges will be checked daily for no visible oil or grease.
					
					M3 & M4
					Substances have been identified in monitoring data provided in the H1 assessment to water (see Appendix F) and expected to be found in the discharge.
					
					BAT-Associated Emission Levels (BAT-AELs) (see CWW BAT 12 section 5) have been assessed in relation to the process effluent discharge, however emissions do not exceed the annual thresholds and the BAT-AELs are therefore not applicable.
					
					BAT-AELs are not considered to be applicable to the cavern discharge as this effluent does not arise from the chemical production process and it is not considered a waste activity. Proposed limits (TSS) for the cavern discharge have been based on the existing AGS consent to discharge (permit reference WRA8220).
					
					TSS for the cavern dewatering discharge will be monitored daily according to BS EN 872 standard.

		BAT 5	BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I – III or, where large amounts of VOC are handled, all of the techniques I – III. I. sniffing methods associated with correlation curves for key equipment; II. optical gas imaging methods; III. Calculations of emissions based on emissions factors periodically validated (e.g. once every two years) by measurements.	Where large amounts of VOCs are handled, the screening and quantification of emissions from the installation by periodic campaigns with optical absorption-based techniques, such as Differential absorption light detection and ranging (DIAL) or Solar occultation flux (SOF), is a useful complementary technique to the techniques I to III. **Description** See BREF Section 6.2	H_2 fugitive emissions are covered under GET Hydrogen Production - Fugitive emissions of hydrogen and ICS EPR 4.03 - Fugitive Emissions to air. The Site are not expecting any material methane released. The natural gas supply, mixing station and supply to the OCGT will be the main potential for fugitive emissions of methane. Daily inspections will be carried out by onsite operators and gas detection will be located around the plant. Inspection programme will also form part of the LDAR programme for the Site. Diffuse VOC emissions from hydrocarbon storage and delivery is expected to be minimal. This will be captured in the EMS (refer to CWW BAT 1).
		BAT 6	BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards.	**Description** Emissions can be monitored by dynamic olfactometry according to EN 13725. Emission monitoring may be complemented by measurement/estimation of odour exposure or estimation of odour impact. **Applicability** The applicability is restricted to cases where odour nuisance can be expected or has been substantiated.	Odour emissions from the Site are described in Section 13 of the Supporting Information Document and in ICS EPR 4.03 - Odour. No significant odour emissions are anticipated from the activities onsite and therefore nuisance from odour isn't expected to occur.
Emissions to water	Water usage and waste water generation	BAT 7	In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.	*(No requirements specified)*	Refer to GET Guidance Section 3.4 Water supply and use.
	Waste water collection and segregation	BAT 8	In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated wastewater streams from waste water streams that require treatment.	**Applicability** The segregation of uncontaminated rainwater may not be applicable in the case of existing wastewater collection systems	See LCP BAT 4 for description of wastewater segregation of clean uncontaminated water from potentially contaminated water and process effluent. There will be no wastewater treatment onsite.

Section	Subsection	BAT#	BAT Text	Requirement	Comments
Emissions to water (continued)	Waste water collection and segregation (continued)	BAT 9	In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for wastewater incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).	**Applicability** The interim storage of contaminated rainwater requires segregation, which may not be applicable in the case of existing wastewater collection systems.	A firefighting and firewater containment system design is required to protect the plant equipment, personnel and the environment from the effects of a fire. In the event of a fire scenario, to prevent firefighting water entering the balancing pond via open drains, a penstock valve will be provided on the outlet into the balancing pond from the Site at M1 and M2. All firewater will be contained onsite and within drains, interceptors and bunds and will be disposed offsite. A firewater containment assessment will be completed as part of the detailed design stage.
	Waste water treatment	BAT 10	In order to reduce emissions to water, BAT is to use an integrated wastewater management and treatment strategy that includes an appropriate combination of the techniques in the priority order given.	*Technique* Process-integrated techniques Recovery of pollutants at source Waste water pre-treatment Final waste water treatment **Description** The integrated waste water management and treatment strategy is based on the inventory of waste water streams (see BAT 2). BAT-associated emission levels (BAT-AELs): see BREF Section 3.4.	Waste water management and treatment strategy to be included in the EMS see BAT 2. Refer to GET Guidance Section 5.1 Wastewater treatment. Continuous wastewater stream will arise from the borehole water demineralisation treatment plant, by using RO treatment, of abstracted borehole water. Wastewater only requires pH adjustment prior to discharge. Contaminated wastewater produced from other processes, that are not able to be recovered, are not integrated into the drainage system, but rather containerised and/or collected via vacuum truck to be disposed of off-site.
		BAT 11	In order to reduce emissions to water, BAT is to pre-treat wastewater that contains pollutants that cannot be dealt with adequately during final wastewater treatment by using appropriate techniques.	**Description** Waste water pre-treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10) and is generally necessary to: • protect the final waste water treatment plant (e.g. protection of a biological treatment plant against inhibitory or toxic compounds); • remove compounds that are insufficiently abated during final treatment (e.g. toxic compounds, poorly/non-biodegradable organic compounds, organic compounds that are present in high concentrations, or metals during biological treatment); • remove compounds that are otherwise stripped to air from the collection system or during final treatment (e.g. volatile halogenated organic compounds, benzene); • remove compounds that have other negative effects (e.g. corrosion of equipment; unwanted reaction with other substances; contamination of waste water sludge). In general, pre-treatment is carried out as close as possible to the source in order to avoid dilution, in particular for metals. Sometimes, waste water streams with appropriate characteristics can be segregated and collected in order to undergo a dedicated combined pre-treatment.	Refer to Bat 10 and GET Guidance Section 5.1 Wastewater treatment. Wastewater generated, that cannot be recycled into the process, will be containerised and sent offsite for disposal. Waste chemicals will be treated and disposed of (by a third-party contractor) per procedures listed in the material safety data sheet for each chemical. This includes: • GTG Lube Oil • Cooling water (Water + Glycol) • HP Compressor Lube Oil - Collected Liquids in HP Compressor KO Drums can be drained directly into the unloading truck

Section	Subsection	BAT#	BAT Text	Requirement	Comments
Emissions to water (continued)	Waste water treatment (continued)	BAT 12	In order to reduce emissions to water, BAT is to use an appropriate combination of final wastewater treatment techniques.	**Description** Final wastewater treatment is carried out as part of an integrated wastewater management and treatment strategy (see BAT 10). Appropriate final wastewater treatment techniques, depending on the pollutant, include: **TABLE** – Technique | Typical pollutants abated | Applicability *Technique* Preliminary and primary treatment a. Equalisation b. Neutralisation c. Physical separation, e.g. screens, sieves, grit separators, grease separators or primary settlement tanks Biological treatment (secondary treatment), e.g. d. Activated sludge process e. Membrane bioreactor Nitrogen removal f. Nitrification/denitrification Phosphorus removal g. Chemical precipitation Final solids removal h. Coagulation and flocculation i. Sedimentation j. Filtration (e.g. sand filtration, microfiltration, ultrafiltration) k. Flotation See BREF Table 1,2,3 for BAT-AELs	To reduce emissions to water, the Site will utilise a combination of the following final wastewater treatment techniques: W1- W4 Physical separation: Surface water run-off passes through an oil interceptor to contain and separate any accidental hydrocarbon contamination before discharging to the Cess Dale Drain and/or East Newton Drain via the Balancing Lagoon. No BAT AELs are proposed for discharge via W1 - W4 since this is expected to comprise only of clean, uncontaminated water. W5 The effluent discharged at emission point W5 will consist of process effluent (RO reject) from the demin plant and dewatered cavern contents in Phase 1, and then only process effluent in Phase 2. BAT-AELs have been assessed in relation to the process effluent discharge, however annual emission loads do not exceed the thresholds, therefore the BAT-AELs are not applicable. BAT-AELs are not considered to be applicable to the cavern discharge as this effluent does not arise from the chemical production process and nor is it considered to be a waste activity. Proposed TSS limits for the cavern discharge have been based on the existing AGS consent to discharge (permit reference WRA8220): • TSS: 550 mg/l
Waste		BAT 13	In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered.		See LCP BAT 16 and ICS EPR 4.03 - Avoidance, recovery and disposal of wastes.
		BAT 14	In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques given below.	**TABLE** – Technique | Description | Applicability *Technique* a. Conditioning b. Thickening/dewatering c. Stabilisation d. Drying	Not applicable - Wastewater sludge is not expected to arise from water treatment.
Emissions to air	Waste gas collection	BAT 15	In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible.	**Applicability** The applicability may be restricted by concerns on operability (access to equipment), safety (avoiding concentrations close to the lower explosive limit) and health (where operator access is required inside the enclosure).	See LCP BAT 7 and BAT 16 - there will be minimal waste gases generated by the OCGT, and so no opportunity to recover, however, waste gases will be treated using SCR to reduce emissions to air.

Section	Subsection	BAT#	BAT Text	Requirement	Comments
Emissions to air (continued)	Waste gas treatment	BAT 16	In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques.	**Description** The integrated waste gas management and treatment strategy is based on the inventory of waste gas streams (see BAT 2) giving priority to process-integrated techniques.	The OCGT can run on hydrogen, natural gas or a blend. Hydrogen produced from the electrolyser unit will be stored until used. There will be no waste hydrogen/natural gas. The feasibility of oxygen capture from the electrolysers has been reviewed and concluded that it is not feasible to capture, process and store the oxygen produced (Refer to GET Guidance Section 3.3).
	Flaring	BAT 17	In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques given below.	**TABLE** – Technique | Description | Applicability *Technique* a. Correct Plant Design b. Plant management	Flaring (both H_2 and the temporary H_2S flare) to only occur during OTNOC for non-routine operational and safety reasons. The vent and flare system will capture hydrogen gas exhaust from the process and combust it using an enclosed flare system. The vent and flare system will be used for startup, shutdown, emergencies, and maintenance purposes only. Where there are high quantities of H_2S detected in the brine water degassing tanks, it is proposed to tie-in a temporary hired flare package to prevent venting of H_2S to atmosphere. Refer to GET Guidance Section 4.1 Emissions of hydrogen for more details on flaring.
		BAT 18	In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use one or both of the techniques given below.	**TABLE** – Technique | Description | Applicability *Technique* a. Correct design of flaring devices b. Monitoring and recording as part of flare management	In the event that flaring is unavoidable, the following techniques have been considered to reduce emissions to air: a. Refer to ICS Operations - Over pressure protection systems for flare design details, and GET Section 4.1 Emissions of hydrogen - for flare details. An enclosed ground flare has been selected to minimise the impact of Nosie, light and visible flames. b. Continuous monitoring of the gas sent to the flare (flow, temperature and pressure) will be undertaken. Other parameters will be estimated (e.g. emissions, heat content, velocity). Periodic analysis of composition of gas streams will enable the estimate of flare emissions. All flare events will be recorded and periodically assessed to help reduce the frequency of, and emissions to air from future flare events and any opportunities to reduce recurrent flaring events. As part of routine operations, a check list will be used check relief valves and control valves for passing.
	Diffuse VOC emissions	BAT 19	In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below.	**TABLE** – Technique | Applicability *Technique* Techniques related to plant design a. Limit the number of potential emission sources b. Maximise process-inherent containment features c. Select high-integrity equipment (see the description in Section 4.6.2) d. Facilitate maintenance activities by ensuring access to potentially leaky equipment Techniques related to plant/equipment construction, assembly and commissioning e. Ensure well-defined and comprehensive procedures for plant/equipment construction and assembly. This includes using the designed gasket stress for flanged joint assembly (see the description in Section 4.6.2) f. Ensure robust plant/equipment commissioning and handover procedures in line with the design requirements Techniques related to plant operation g. Ensure good maintenance and timely replacement of equipment h. Use a risk-based leak detection and repair (LDAR) programme (see the description in Section 4.6.2) i. As far as it is reasonable, prevent diffuse VOC emissions, collect them at source, and treat them The associated monitoring is in BREF BAT 5.	The following techniques will be applied to reduce diffuse VOC emissions to air: <u>Plant design</u> a. Measures to minimise the potential pathways for fugitive emissions of VOCs to air are incorporated into the design. The plant will be designed to the appropriate standards and good engineering practice. Leak testing will be carried out during commissioning and leak tightness will be monitored during operation. Control valves in flammable services shall be provided with butt-weld connections, reducing the number of flanges where leaks can occur. The plant/equipment will be operated and maintained in line with suppliers' recommendations and industry standards where appropriate. Containment will be in accordance with ASME/ANSI Standards, API Standards, Pipe Fabrication Institute Standards, ASTM Specifications, British Standards, MSS-SP Standards, Design basis, Piping Material Specifications, Plant layout and other standards, SSE Design Standards, and Piping Stress Analysis. B. Plant will be designed in a contained system to ensure product quality c. High-integrity equipment will be used to maintain product quality and ensure a safe working environment. d. Maintenance access will be provided to equipment with potential for leakage (e.g. pumps, compressors and control valves). <u>Plant/equipment construction, assembly and commissioning</u> e. Maintenance procedures will be available and followed during construction and assembly, which includes flange tightening and quality assurance requirements f. Commissioning procedures will include pressure and leak tests. The criteria for replacement and repair of leaky equipment will be provided in the EMS. <u>Techniques related to plant operation</u> g. A preventative maintenance programme will be developed during the detailed design stage. h. An LDAR procedure and programme will be developed for the facility and included in the EMS. i. Quality joint making, LDAR and maintenance system. Diffuse emissions are minimised to support inherent safety management.

Section	Subsection	BAT#	BAT Text	Requirement	Comments
Emissions to air (continued)	Odour emissions	BAT 20	In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting odour monitoring; (iii) a protocol for response to identified odour incidents; (iv) an odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures.	**Applicability** The applicability is restricted to cases where odour nuisance can be expected or has been substantiated.	No odour nuisance is expected for the Site as described in CWW BAT 6.
		BAT 21	In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques given below.	**TABLE** – Technique | Description | Applicability *Technique* a. Minimise residence times b. Chemical treatment c. Optimise aerobic treatment d. Enclosure e. End of pipe treatment	No odour nuisance is expected for the Site as described in CWW BAT 6.
	Noise emissions	BAT 22	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting noise monitoring; (iii) a protocol for response to identified noise incidents; (iv) a noise prevention and reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.	**Applicability** The applicability is restricted to cases where noise nuisance can be expected or has been substantiated	Noise at the Site is not expected to be significant and nuisance outside of the site boundary is not expected to arise (See Section 12 of the Supporting Information Document for noise impact assessment). Mitigation measures will be secured via a noise management plan. The plan will include measures to demonstrate that noise from the operation of the Site is minimised as far as reasonably practicable.
		BAT 23	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.	**TABLE** – Technique | Description | Applicability *Technique* a. Appropriate location of equipment and buildings b. Operational measures c. Low-noise equipment d. Noise-control equipment e. Noise abatement	The Noise Management Plan considers mitigation measures and procedures to manage noise/vibration incidents to ensure there is no pollution to the environment. Design measures have been adopted to reduce noise emissions from the Site during normal operation. Techniques include: a. Likely sources of noise emissions have been identified and located appropriately across the Site to reduce noise impact. This includes the selection of an enclosed ground flare to minimise the impact of noise. b. Planning of maintenance and abnormal operating activities will minimise high-noise activities during night-time as far as practicable. c. Equipment has been selected to control noise at the source as detailed in the Noise Impact Assessment in Section 12 of the Supporting Information Document and Appendix I e. Noise abatement including silencers and acoustic louvres are proposed where required and as detailed in the Noise Impact Assessment. Noise abatement will be confirmed during detailed design.

TABLE 5 - BEST AVAILABLE TECHNIQUES (BAT) REFERENCE DOCUMENT FOR COMMON WASTE GAS MANAGEMENT AND TREATMENT IN THE CHEMICAL SECTOR (WGC)

Section	Subsection	BAT#	BAT Text	Requirement	Comments
1. General BAT conclusions	Environmental management systems	BAT 1	In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features presented in the BREF.	See BREF for detailed requirements	See LCP BAT 1 and CWW BAT 1. The Site's EMS is based on and aligned to the environmental management standard ISO 14001. The EMS will incorporate all of the listed features and will be in place prior to the operational start date.
		BAT 2	In order to facilitate the reduction of emissions to air, BAT is to establish, maintain and regularly review (including when a substantial change occurs) an inventory of channelled and diffuse emissions to air, as part of the environmental management system (see BAT 1), that incorporates all of the following features presented in the BREF.	See BREF for detailed requirements	The following characteristics will form part of the EMS detailed in CWW BAT 1: i. a-b. See CWW BAT 2. ii. a - d. Channelled emissions have been identified as described in Section 4 of the Supporting Information Document. e. See CWW BAT 2 and CWW BAT 16 f. Data on flammability, lower and higher explosive limits, and reactivity will be provided in Safety Data Sheets, site operating manuals and the COMAH report. g. See LCP BAT 4. h. Not applicable - no known carcinogenic emissions. iii. See CWW BAT5 for monitoring of diffuse emissions and BAT 19 for techniques used to reduce diffuse Volatile Organic Carbons (VOC) emissions.
	Other than normal operating conditions (OTNOC)	BAT 3	In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions to air during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the environmental management system (see BAT 1) that includes all of the following features presented in the BREF.	See BREF for detailed requirements	Risk-based OTNOC management plans will be incorporated into the EMS (refer to BAT 1) and cover all of the listed features. i. OTNOC events include start up/shut down, black start reinstatement, and periodic depressurisation of hydrogen systems. ii. Refer to GET Guidance 3.2 Reliability and availability iii/iv/v/vi. Refer to LCP BAT 10 vi. The list of identified OTNOC will be reviewed and updated following periodic assessment of emissions.
	Channelled emissions to air	BAT 4	In order to reduce channelled emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes, in order of priority, process-integrated recovery and abatement techniques.	**Description** The integrated waste gas management and treatment strategy is based on the inventory in BAT 2. It takes into account factors such as greenhouse gas emissions and the consumption or reuse of energy, water and materials associated with the use of the different techniques.	Refer to CWW BAT 2 and WGC BAT 10.
		BAT 5	In order to facilitate the recovery of materials and the reduction of channelled emissions to air, as well as to increase energy efficiency, BAT is to combine waste gas streams with similar characteristics, thus minimising the number of emission points.	**Description** The combined treatment of waste gases with similar characteristics ensures more effective and efficient treatment compared to the separate treatment of individual waste gas streams. The combination of waste gases is carried out considering plant safety (e.g. avoiding concentrations close to the lower/upper explosive limit), technical (e.g. compatibility of the individual waste gas streams, concentration of the substances concerned), environmental (e.g. maximising recovery of materials or pollutant abatement) and economic factors (e.g. distance between different production units). Care is taken that the combination of waste gases does not lead to the dilution of emissions.	It is not feasible to combine waste gas streams. Waste gas from the electrolysers is vented and flared during hydrogen production, with no practicable options for waste gas recovery (given the frequency / volumes). Waste gas from the OCGT is abated using an SCR system.
		BAT 6	In order to reduce channelled emissions to air, BAT is to ensure that the waste gas treatment systems are appropriately designed (e.g. considering the maximum flow rate and pollutant concentrations), operated within their design ranges, and maintained (through preventive, corrective, regular and unplanned maintenance) so as to ensure optimal availability, effectiveness and efficiency of the equipment.	*(No requirements specified)*	See CWW BAT 18 for reduction of emissions to air during flaring. See LCP BAT 7. SCR will be installed on the OCGT. This will use aqueous ammonia injection to reduce nitrogen oxide emissions from the combustion gas turbine.

Section	Subsection	BAT#	BAT Text	Requirement	Comments
1.General BAT conclusions (continued)	Channelled emissions to air (continued)	BAT 7	BAT is to continuously monitor key process parameters (e.g. waste gas flow and temperature) of waste gas streams being sent to pre-treatment and/or final treatment.	*(No requirements specified)*	Refer to LCP BAT 3-4.
		BAT 8	BAT is to monitor channelled emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	See BREF for detailed requirements	LCP: Refer to LCP BAT 3-4. Hydrogen Flare: Emissions from the flare will be periodically calculated based on flows and composition of process off-gas and fuel gas. Temporary H_2S Flare: A H_2S detector will be located next to the brine degassing tanks. If either of these instruments detect a high H_2S level, an Emergency Shutdown Device (ESD) trip of the dewatering process will take place. This will stop booster and HP pumps, stop injection of H_2, shut in all wellhead ESD valves and stop the brine discharge pumps. Due to the emergency and infrequent nature of the flare, no periodic monitoring is proposed. Firewater Pump Engine Emissions from the diesel firewater pump are not considered to be Medium Combustion Plants (MCPs) or LCPs and are for the purpose of emergency generation only, therefore no monitoring is proposed.
		BAT 9	In order to increase resource efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to recover organic compounds from process off-gases by using one or a combination of the techniques given below and to reuse them.		Not applicable - no organic compounds in waste gas.
		BAT 10	In order to increase energy efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to send process off-gases with a sufficient calorific value to a combustion unit that is, if technically possible, combined with heat recovery. BAT 9 has priority over sending process off-gases to a combustion unit.		Not applicable - no organic compounds in waste gas.
		BAT 11	In order to reduce channelled emissions to air of organic compounds, BAT is to use one or a combination of the techniques given below.		Not applicable - No channelled emissions of organic compounds are expected.
		BAT 12	In order to reduce channelled emissions to air of PCDD/F from thermal treatment of waste gases containing chlorine and/or chlorinated compounds, BAT is to use techniques a. and b., and one or a combination of techniques c. to e., given below.		Not applicable - no thermal treatment of waste gases
		BAT 13	In order to increase resource efficiency and to reduce the mass flow of dust and particulate-bound metals sent to the final waste gas treatment, BAT is to recover materials from process off-gases by using one or a combination of the techniques given below and to reuse them.		Not applicable - no dust/particulate-bound metals in waste gas streams
		BAT 14	In order to reduce channelled emissions to air of dust and particulate-bound metals, BAT is to use one or a combination of the techniques given below.		Not applicable - no dust/particulate-bound metals in waste gas

Section	Subsection	BAT#	BAT Text	Requirement	Comments
1.General BAT conclusions (continued)	Channelled emissions to air (continued)	BAT 15	In order to increase resource efficiency and to reduce the mass flow of inorganic compounds sent to the final waste gas treatment, BAT is to recover inorganic compounds from process off-gases by using absorption and to reuse them.		Not applicable - No off gas recovery. See GET-Energy Efficiency for O_2 recovery.
		BAT 16	In order to reduce channelled emissions to air of CO, NOX and SOX from thermal treatment, BAT is to use technique c. and one or a combination of the other techniques given below.		Not Applicable - no thermal treatment
		BAT 17	In order to reduce channelled emissions to air of ammonia from the use of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NOX emissions (ammonia slip), BAT is to optimise the design and/or operation of SCR or SNCR (e.g. optimised reagent to NOX ratio, homogeneous reagent distribution and optimum size of the reagent drops)	See BREF Table 4.5 for BAT-AELs	SCR will be installed on the OCGT to mitigate generated NO_x emissions. Emissions of Ammonia from ammonia slip will be mitigated by passing flue gas over an SCR catalyst designed to optimise gas flow, ensure proper mixing of the reductant and exhaust gases and facilitate ammonia and NO_x reactions. An injection system will be used to control the amount and timing of reductant injection into the exhaust stream based on the NO_x concentration to minimise the required use of ammonia. Ammonia slip sensors are proposed to monitor releases.
		BAT 18	In order to reduce channelled emissions to air of inorganic compounds other than channelled emissions to air of ammonia from the use of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NOX emissions), channelled emissions to air of CO, NOX and SOX from the use of thermal treatment, and channelled emissions to air of NOX from process furnaces/heaters, BAT is to use one or a combination of the techniques given below.		Not Applicable - No channelled emissions of inorganics (other than ammonia from SCR), no thermal treatment and no process furnaces/heaters onsite.
	Diffuse VOC emissions to air	BAT 19	In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to elaborate and implement a management system for diffuse VOC emissions, as part of the environmental management system (see BAT 1), that includes all of the following features presented in the BREF.	See BREF for detailed requirements	i. See CWW BAT 19. ii. Not applicable. The Site processes do not use organic solvents as defined in Article 3(46) of Directive 2010/75/EU. iii. A risk based LDAR programme will be in place prior to the operational start date that will use the listed features. This will be developed in line with the final design. v. See ICS EPR 4.03 - Fugitive Emissions to Air. A Fugitive Hydrogen Risk Reduction Plan will be developed as part of the LCHS to demonstrate how the hydrogen production plant will be designed and operated to ensure that fugitive hydrogen emissions are kept as low as reasonably practicable. vi. A LDAR program will be developed as part of the EMS and updated periodically.
		BAT 20	BAT is to estimate fugitive and non-fugitive VOC emissions to air separately at least once every year by using one or a combination of the techniques given below, as well as to determine the uncertainty of this estimation. The estimation distinguishes between VOCs classified as CMR 1A or 1B and VOCs that are not classified as CMR 1A or 1B.	The estimation of the diffuse VOC emissions to air takes into account the results of the monitoring carried out according to BAT 21 and/or to BAT 22. For the purpose of the estimation, channelled emissions may be counted as non-fugitive emissions when the inherent characteristics of the waste gas stream (e.g. low velocities, variability of the flow rate and concentration) do not allow an accurate measurement according to BAT 8. **TABLE** – Technique | Applicability *Technique* a. Use of emission factors b. Use of mass balance c. Use of thermodynamic models	CWW BAT 5 describes the techniques that will be used to monitor diffuse VOC emissions, particularly if large volumes of VOC emissions are identified. Fugitive VOC emissions will be monitored using a LDAR programme in accordance with the relevant EN standards and will be defined in the EMS. Fugitive H_2 emissions will be monitored annually in accordance with the relevant EN standard and in line with the Fugitive Hydrogen Risk Reduction Plan.

Section	Subsection	BAT#	BAT Text	Requirement	Comments
1.General BAT conclusions (continued)	Diffuse VOC emissions to air (continued)	BAT 21	BAT is to monitor diffuse VOC emissions from the use of solvents by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant, as defined in Part 7 of Annex VII to Directive 2010/75/EU and to minimise the uncertainty of the solvent mass balance data by using all of the techniques given below.		Not applicable - no use of solvents
		BAT 22	BAT is to monitor diffuse VOC emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	**Applicability** BAT 22 only applies when the annual quantity of diffuse VOC emissions from the plant estimated according to BAT 20 is greater than the following: For fugitive emissions: • 1 tonne of VOCs per year in the case of VOCs classified as CMR 1A or 1B; or • 5 tonnes of VOCs per year in the case of other VOCs. • For non-fugitive emissions: • 1 tonne of VOCs per year in the case of VOCs classified as CMR 1A or 1B; or • 5 tonnes of VOCs per year in the case of other VOCs.	See CWW BAT 5.
		BAT 23	In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below with the following order of priority	**TABLE** – Technique | Description | Type of emissions | *Technique* Prevention Techniques a. Limiting the number of emission sources b. Use of high integrity equipment c. Collecting diffuse emissions and treating off gases Other Techniques d. Facilitating access and/or monitoring activities e. Tightening f. Replacement of leaky equipment and/or parts g. Reviewing and updating process designs h. Reviewing and updating operating conditions i. Using closed systems j. Using techniques to minimise emissions from source	The following techniques will be applied to reduce diffuse VOC emissions to air: <u>Prevention Techniques</u> a. See CWW BAT 19. b. See ICS - Overpressure and Protection Systems. c. Aqueous ammonia tank will be a pressurised tank. The vapor equalising line allows pressure equalisation between the storage tank and the delivery tanker and recovers displaced air / vapours. <u>Other Techniques</u> d. See CWW BAT 19. e. A procedure will be available and followed during construction, assembly and maintenance, which includes flange tightening and quality assurance requirements. f. See CWW BAT 19. g. See CWW BAT 19. Process design may be reviewed and updated at times as requirement (and following management of change procedures) to improve performance h. Optimising requirement to open equipment for maintenance throughout the operation based on process monitoring and risk-based inspection methodology. i. See CWW BAT 19 j. See CWW BAT 19.
2.Polymers and Synthetic Rubbers		BAT 24 - 35			Not applicable – No polymers or synthetic rubbers produced on site
3. Process Furnaces/Heaters		BAT 36			Not applicable - No process furnace or heaters.

TABLE 6 - BEST AVAILABLE TECHNIQUES (BAT) REFERENCE DOCUMENT FOR EMISSIONS FROM STORAGE (EFS)

Section	Subsection		BAT Text	Comments
5.1 Storage of liquids and liquified gases	5.1.1 Tanks	*General principals to prevent or reduce emissions - Tank Design*	BAT for a proper design is to take into account at least the following: • the physico-chemical properties of the substance being stored • how the storage is operated, what level of instrumentation is needed, how many operators are required, and what their workload will be • how the operators are informed of deviations from normal process conditions (alarms) • how the storage is protected against deviations from normal process conditions (safety instructions, interlock systems, pressure relief devices, leak detection and containment, etc.) • what equipment has to be installed, largely taking account of past experiences of the product (construction materials, valve quality, etc.) • which maintenance and inspection plan needs to be implemented and how to ease the maintenance and inspection work (access, layout, etc.) • how to deal with emergency situations (distances to other tanks, facilities and to the boundary, fire protection, access for emergency services such as the fire brigade, etc.).	The physico-chemical properties of the substance(s) to be stored are primarily flammable in nature along with being toxic to the environment. These properties are well understood by the Site. Storage onsite has been designed taking into account the materials stored and Environmental Health and Safety (EHS) considerations. Assessment/studies required to understand the risk of equipment and processes (e.g. HAZID and HAZOP studies) have been conducted where appropriate and according to legal requirements, including accident management. Process Hazard Assessments (PHAs) will be undertaken for the Site as part of the review and for all new plant. The installation will operate under an EMS, including appropriate procedures and controls for prevention and management of accidental spills; all site operatives will be trained in the application of the Site procedures including regular inspection of plant/storage items and response to loss of containment. Notably, all external above ground chemical storage tanks will be located within bunds and designed to meet best practice as detailed in EPR 4.03 - Storage and handling of raw materials, products and wastes. Bulk storage operations will be controlled using the DCS to monitor conditions and control performance. See EPR 4.03 Chemical process controls for further details on controls. Bulk tanks will include level indication, and high and low level alarm functions with appropriate trip functions for safety and environmental control. Hydrogen emissions from storage will be routinely monitored as part of the Fugitive Hydrogen Risk Reduction Plan that is to be developed as part of the Low Carbon Hydrogen Standard (LCHS) to demonstrate how the hydrogen production plant will be designed and operated to ensure that fugitive hydrogen emissions are kept as low as reasonably practicable. Site emergency plans will be in place and prepared in compliance with the COMAH Regulations. An Emergency Plan will be prepared by SSE in consultation with the emergency services, the local health authority, local authority and relevant Agencies. An External Emergency Plan will be produced by East Riding Yorkshire Council (EYRC). An emergency response manual is provided by the establishment and emergency procedures are to be initiated for the following: • Fire • Major gas release • Leak or spillage of hazardous liquid (e.g. diesel, condensate) • Any other incident which, in the opinion of the Production Engineer can be classified as a major emergency
		General principals to prevent or reduce emissions - Inspection and maintenance	BAT is to apply a tool to determine proactive maintenance plans and to develop risk-based inspection plans such as the risk and reliability based maintenance approach; see Section 4.1.2.2.1.	See GET - Monitoring. The Site will have commissioning and operational performance testing. All plant and equipment on the Site will be regularly maintained by qualified staff or contractors, as per site procedures and in accordance with a Planned Preventative Maintenance programme in line with Original Equipment Manufacturers' recommendations. The maintenance schedule will include an electronic asset management system (Maximo) for reporting and scheduling unplanned maintenance. Where plant issues, hazards or incidents are identified, this will be logged as a defect in Maximo. The defect will be assessed and categorised to identify its priority, and added to the work programme to be addressed, as detailed below. Aldbrough maintenance work is carried out by first raising a work order. The maintenance coordinator compiles weekly maintenance plan for the forward week, which is reviewed in the weekly planning meeting, identifying: • The planned tasks, • The Work Sponsor, Working Party Leader and Working Party Members; • The hours allocated to the task per day / per person; and • The type of Work Control Document required, hence any requirements for the Production Team to provide process isolations. The plan is reviewed again in the daily morning meeting and adjusted as required based on any newly-identified corrective maintenance requirements. An equivalent plan is also produced and reviewed in advance of site or plant outages to ensure sufficient resources are available for the work to be undertaken. As part of the planning process, the Maintenance Coordinator assigns the task to a competent Work Sponsor (typically an SSE Maintenance Technician), who produces a Method Statement for carrying out the task and an associated Pre-Task Risk Assessment identifying the hazards associated with the activity, assessing the likelihood and consequences to determine the level of risk, and identifying suitable controls. For planned maintenance, this is done by reviewing and where necessary revising the existing Risk Assessment and Method Statement held in Maximo. The Work Sponsor also identifies and obtains the resources required to complete the task – this includes identifying and obtaining sufficient competent personnel (SSE and / or contractor) to carry out the task. Once the Risk Assessment and Method Statement have been approved, the task is progressed through the Work Control Document system
		General principals to prevent or reduce emissions - Location and layout	BAT is to locate a tank operating at, or close to, atmospheric pressure above ground. However, for storing flammable liquids on a site with restricted space, underground tanks can also be considered. For liquefied gases, underground, mounded storage or spheres can be considered, depending on the storage volume.	All tanks storing liquid hazardous products onsite will be above ground at atmospheric pressure with the exception of: • Aqueous ammonia tank. This will be a pressurised tank. The vapor equalizing line will allow pressure equalization between the storage tank and the delivery tanker and recovers displaced air / vapours. • The existing underground ALD1 storage cavern which will be used to store hydrogen. The Site will store hydrogen in the existing ALD1 underground cavern. The cavities were created in a 150 m thick layer of salt at a depth of approximately 2000 m by solution mining. The minimum inventory, when the storage gas (hydrogen) has been removed and temperatures are stabilised, is called Cushion Gas and this maintains sufficient pressure in the cavity to prevent

Section	Subsection		BAT Text	Comments
				high rates of shrinkage of the cavity. Ultimate below-ground safeguarding is provided by using primary and secondary barrier systems. Ultimate above-ground safeguarding is provided by using an overpressure protection system and pressure relief valves to protect downstream pipework from experiencing cavern pressure.
5.1 Storage of liquids and liquified gases (Continued)	5.1.1 Tanks (continued)	*General principals to prevent or reduce emissions - Tank colour*	BAT is to apply either a tank colour with a reflectivity of thermal or light radiation of at least 70 %, or a solar shield on above ground tanks which contain volatile substances, see Section 4.1.3.6 and 4.1.3.7 respectively.	Not Applicable - There are no tanks containing volatile substances.
		General principals to prevent or reduce emissions - Emissions minimisation principle in tank storage	BAT is to abate emissions from tank storage, transfer and handling that have a significant negative environmental effect, as described in Section 4.1.3.1. This is applicable to large storage facilities allowing a certain time frame for implementation.	Temporary degassing tanks (open to atmosphere) processing displaced water from the cavern storage dewatering process will vent any entrained gases (hydrogen / methane) to atmosphere. If H_2S is detected at levels above 1 ppm it is proposed that a rental flare package is utilised to ensure that the gases including quantities of hydrogen sulphide can be sent to flare. The Ammonia tank will be located outdoors and fitted with high level vent and leak detection. The ammonia tank will also be a pressurised tank. A vapor equalising line will allow pressure equalization between the storage tank and the delivery tanker and recovers displaced air / vapours. See EPR 4.03 - Storage and handling of raw materials, products and wastes for details on bulk storage containment design.
		General principals to prevent or reduce emissions - Monitoring of VOC	On sites where significant VOC emissions are to be expected, BAT includes calculating the VOC emissions regularly. The calculation model may occasionally need to be validated by applying a measurement method.	Not applicable - There are no tanks containing volatile substances
		General principals to prevent or reduce emissions - Dedicated systems	BAT is to apply dedicated systems.	All above ground liquid storage tanks will be dedicated systems (i.e. no changes in products).
		Tank specific considerations - open top tanks		Not Applicable - No open top tanks onsite
		Tank specific considerations - external floating roof tank		Not Applicable - No external floating roof tanks onsite
		Tank specific considerations - fixed roof tanks	For the storage of volatile substances which are toxic (T), very toxic (T+), or carcinogenic, mutagenic and reproductive toxic (CMR) categories 1 and 2 in a fixed roof tank, BAT is to apply a vapour treatment installation	Not Applicable - No volatile substances which are toxic or carcinogenic, CMR onsite.
			For other substances, BAT is to apply a vapour treatment installation, or to install an internal floating roof (see Sections 4.1.3.15 and 4.1.3.10 respectively).	Not Applicable - No vapour treatment or internal floating roof tanks required on above ground liquid storage tanks as there are no tanks containing volatile substances.
			For tanks < 50 m3, BAT is to apply a pressure relief valve set at the highest possible value consistent with the tank design criteria.	The ammonia tank will be a pressurised tank with a pressure relief valve set according to tank design. No pressure relief valves anticipated for other above ground storage tanks.
			For liquids containing a high level of particles (e.g. crude oil) BAT is to mix the stored substance to prevent deposition that would call for an additional cleaning step, see Section 4.1.5.1.	Not Applicable - No liquids stored onsite that contain high level of particles.
		Tank specific considerations -	For the storage of volatile substances which are toxic (T), very toxic (T+), or CMR categories 1 and 2 in an atmospheric horizontal tank, BAT is to apply a vapour treatment installation.	Not Applicable - No atmospheric horizontal tanks onsite that contain toxic, very toxic or CMR substances.

Section	Subsection		BAT Text	Comments
5.1 Storage of liquids and liquified gases (Continued)	5.1.1 Tanks (continued)	*Atmospheric horizontal tanks*	For other substances, BAT is to do all, or a combination, of the following techniques, depending on the substances stored: • apply pressure vacuum relief valves; see Section 4.1.3.11 up rate to 56 mbar; see Section 4.1.3.11 • apply vapour balancing; see Section 4.1.3.13 • apply a vapour holding tank, see Section 4.1.3.14, or • apply vapour treatment; see Section 4.1.3.15. The selection of the vapour treatment technology has to be decided on a case-by-case basis.	The ammonia tank will be a horizontal tank with a pressure relief valve set according to tank design. There will be a vapour balancing line to return vapour from the ammonia tank to the delivery tanker to minimise emissions.
		Tank specific considerations - Pressurised storage	BAT for draining depends on the tank type but may be the application of a closed drain system connected to a vapour treatment installation, see Section 4.1.4. The selection of the vapour treatment technology has to be decided on a case-by-case basis.	Ammonia tank will require very limited need for draining off inventory to a vapour treatment installation due to infrequent tank inspections, therefore no drainage proposed.
		Tank specific considerations - Lifter roof tanks		Not Applicable - no lifter roof tanks onsite.
		Tank specific considerations - Refrigerated tanks		Not Applicable - no refrigerated tanks onsite.
		Tank specific considerations - Underground and mounded tanks		Not Applicable - no underground/mounded storage of liquids/liquified gases.
		Preventing incidents and major accidents - safety risk management	BAT in preventing incidents and accidents is to apply a safety management system as described in Section 4.1.6.1.	Site Emergency Plans will be in place and prepared in compliance with the COMAH Regulations. A Major Accident Prevention Policy will be in place, which will be implemented by the SHE Management System. Maintenance strategies and instructions in force or in development in SSEHL include an Environmental Instrumentation Maintenance Strategy which references various standards relating to emissions. The main control measures in place will include: • HAZOPs • Emergency response plans • New Operational and Maintenance procedures will be developed for the plant and will be developed ahead of operational handover of the plant
		Preventing incidents and major accidents - operational procedures and training	BAT is to implement and follow adequate organisational measures and to enable training and instruction of employees for safe and responsible operation of the installation as described in Section 4.1.6.1.1.	Site Emergency Plans will be in place and prepared in compliance with the COMAH Regulations. All staff will be qualified and appropriately trained for the activities carried out onsite. The SSE Thermal Competence Management Process implemented across SSE's Thermal Energy and Renewables divisions, including the Gas Storage business, has four main stages: • Establishing the competency requirements for each role; • Developing individuals' competency; • Assessing individuals' competency; • Auditing Competence Management System performance. A comprehensive training programme as part of the Site EMS will be In place and includes training for all staff in the Emergency Response, Spill Response and Incident Investigation. All training records will be maintained.
		Preventing incidents and major accidents - Leakage due to corrosion and/or erosion	BAT is to prevent corrosion by: • selecting construction material that is resistant to the product stored • applying proper construction methods • preventing rainwater or groundwater entering the tank and if necessary, removing water that has accumulated in the tank • applying rainwater management to bund drainage • applying preventive maintenance, and • where applicable, adding corrosion inhibitors, or applying cathodic protection on the inside of the tank.	During the design process, consideration has been given to the structural integrity of equipment used to contain gas and other process fluids. Materials of construction suitable for pressure containing plant were investigated and the proposed selections documented in a Materials Selection Report. The impact of corrosion has been considered, and allowance made either in the selection of material or by ensuring adequate corrosion allowance for the anticipated plant life. Any bund water will be pumped into a corner sump and tankered offsite by a third-party truck for disposal. Regular visual inspections of tank bunds will be completed by operational staff during plant rounds, with formalised periodic bund condition inspections identified according to a planned preventative maintenance programme, and will be developed for the plant through design, construction and commissioning based on the contractor/OEM recommendations. Not applicable - no underground tanks (underground storage is a natural cavern).

Section	Subsection		BAT Text	Comments
5.1 Storage of liquids and liquified gases (Continued)	5.1.1 Tanks (continued)		Additionally for an underground tank, BAT is to apply to the outside of the tank: • a corrosion-resistant coating • plating, and/or • a cathodic protection system.	Not applicable - no underground tanks (underground storage is a natural cavern).
		Preventing incidents and major accidents - Operational procedures and instrumentation to prevent overfill	BAT is to implement and maintain operational procedures – e.g. by means of a management system – as described in Section 4.1.6.1.5, to ensure that: • high level or high pressure instrumentation with alarm settings and/or auto closing of valves is installed • proper operating instructions are applied to prevent overfill during a tank filling operation, and • sufficient ullage is available to receive a batch filling	The proposed installation will be operated under an ISO14001:2015 accredited EMS and in line with the EA's guidance: 'Develop a management system: environmental permits". This will assure continual improvement in environmental performance. Tanks where a risk of overfilling has been identified are fitted with high level alarms enunciating in the control room. Tank filling operations are carried out as per specific operating instructions for the task.
		Preventing incidents and major accidents - Instrumentation and automation to detect leakage	BAT is to apply leak detection on storage tanks containing liquids that can potentially cause soil pollution. The applicability of the different techniques depends on the tank type and is discussed in detail in Section 4.1.6.1.7.	The controls to reduce the impact of soil pollution consist of primary and secondary containment as well as operational procedures including regular routine inspection of containment to identify any issues. Storage tanks/containers will be bunded. Oil interface sensors will be used to detect oil in the bunds to reduce the potential risk of soil pollution.
		Preventing incidents and major accidents - Risk-based approach to emissions to soil below tanks	BAT is to achieve a 'negligible risk level' of soil pollution from bottom and bottom-wall connections of aboveground storage tanks. However, on a case-by-case basis, situations might be identified where an 'acceptable risk level' is sufficient.	Above ground storage tanks onsite will be designed and installed to appropriate engineering design standards and will be routinely inspected for defects. All bulk storage will be within concrete bunds to contain any leaks/accidental released to prevent pollution. All bund water will be directed to a sump onsite for offsite removal.
		Preventing incidents and major accidents - Soil protection around tanks - containment	BAT for aboveground tanks containing flammable liquids or liquids that pose a risk for significant soil pollution or a significant pollution of adjacent watercourses is to provide secondary containment, such as: • tank bunds around single wall tanks; see Section 4.1.6.1.11 • double wall tanks; see +D34:E34 discharge; see Section 4.1.6.1.15	Storage tanks containing liquids that may be hazardous to the environment are located within impervious bunds with a capacity of > 110% of the largest tank or 25% of the total tankage. Tank fill points are contained within the bund wherever possible or otherwise provided with adequate containment. Bunds are fitted with pumps to discharge any accumulated rainwater. Oil / fuel bunds are equipped with Oil Sensitive Class 1 Automatic bund dewatering system which will pump water if less than 5ppm oil. For Other bunds, pumps will be operated by local manually control as needed to manage rainwater accumulation. Above ground storage tanks and bunding containing hazardous material will be subject to routine integrity checks.
			For building new single walled tanks containing liquids that pose a risk for significant soil pollution or a significant pollution of adjacent watercourses, BAT is to apply a full, impervious, barrier in the bund, see Section 4.1.6.1.10.	All single walled tanks located onsite will be located within a fully impervious, barrier in the bund.
			For existing tanks within a bund, BAT is to apply a risk-based approach, considering the significance of risk from product spillage to the soil, to determine if and which barrier is best applicable. This risk-based approach can also be applied to determine if a partial impervious barrier in a tank bund is sufficient or if the whole bund needs to be equipped with an impervious barrier. See Section 4.1.6.1.11.	Not applicable - no existing tanks onsite.
			For chlorinated hydrocarbon solvents (CHC) in single walled tanks, BAT is to apply CHC proof laminates to concrete barriers (and containments), based on phenolic or furan resins. One form of epoxy resin is also CHC-proof. See Section 4.1.6.1.12.	Not applicable - no CHC stored onsite.
			BAT for underground and mounded tanks containing products that can potentially cause soil pollution is to: • apply a double walled tank with leak detection, see Section 4.1.6.1.16, or • to apply a single walled tank with secondary containment and leak detection, see Section 4.1.6.1.17.	Not applicable - no underground tanks other than the storage salt cavern which will store hydrogen.

Section	Subsection		BAT Text	Comments
5.1 Storage of liquids and liquified gases (Continued)	5.1.1 Tanks (continued)	*Preventing incidents and major accidents - Containment of contaminated extinguishant*	For toxic, carcinogenic or other hazardous substances, BAT is to apply full containment.	Storage tanks containing liquids that may be hazardous to the environment are installed in impervious bunds with a capacity of > 110% of the largest tank or 25% of the total capacity. Tank fill points are contained within the bund wherever possible or otherwise provided with adequate containment. Bunds are sized to provide capacity for at least 110% of the maximum tank contents and fitted with pumps to discharge any accumulated rainwater, and these are operated from local pushbuttons manually at least weekly or after heavy rainfall. No carcinogenic substances will be stored onsite.
	5.1.2 Storage of packaged dangerous substances	*See BAT*		Not applicable - no storage of packaged dangerous substances onsite.
	5.1.3 Basins and Lagoons		Basins and lagoons are used for the storage of, e.g. manure slurry in agricultural premises and water and other non-flammable or volatile liquids in industrial facilities. Where emissions to air from normal operation are significant, e.g. with the storage of pig slurry, BAT is to cover basins and lagoons using one of the following options: • a plastic cover; see Section 4.1.8.2 • a floating cover; see Section 4.1.8.1, or • only small basins, a rigid cover; see Section 4.1.8.2. Additionally, where a rigid cover is used, a vapour treatment installation can be applied to achieve an extra emission reduction, see Section 4.1.3.15. The need for and type of vapour treatment must be decided on a case-by-case basis. To prevent overfilling due to rainfall in situations where the basin or lagoon is not covered,	Not Applicable - All tanks onsite are enclosed and the only lagoon onsite is the existing AGS balancing lagoon used to collected clean/uncontaminated surface water runoff.
			To prevent overfilling due to rainfall in situations where the basin or lagoon is not covered, BAT is to apply a sufficient freeboard, see Section 4.1.11.1.	Not Applicable - All tanks onsite are enclosed and the only lagoon onsite is the existing AGS balancing lagoon used to collected clean/uncontaminated surface water runoff. The existing balancing lagoon has been designed in accordance with CIRIA 790 guidelines to include for a rainwater event. The level of rainwater accumulation in the balancing lagoon in monitored.
			BAT is to apply a sufficient freeboard, see Section 4.1.11.1. Where substances are stored in a basin or lagoon with a risk of soil contamination, BAT is to apply an impervious barrier. This can be a flexible membrane, a sufficient clay layer or concrete, see Section 4.1.9.1.	Not Applicable - All tanks onsite are enclosed and the only lagoon onsite is the existing AGS balancing lagoon used to collected clean/uncontaminated surface water runoff.
	5.1.4 Atmospheric mined caverns	*See BAT*		Not Applicable - No atmospheric mined caverns onsite.
	5.1.5 Pressurised Mined Caverns	*See BAT*		Not Applicable - No pressurised mined caverns onsite.
	5.1.6 Salt Leached Caverns	*Emissions from incidents and (major) accidents*	BAT, in preventing incidents and accidents, is to apply a safety management system as described in Section 4.1.6.1.	A Major Accident Prevention Policy will be in place, which will be implemented by an integrated SHE Management System and will be updated to include hydrogen storage in ALD1 cavern. The risks of accidents and incidents onsite have also been assessed in detail and an overview of the methodology and results of relevant safety studies provided within a COMAH safety report, HAZID study, Process Hazard Review, HAZOP, and QRA.

Section	Subsection		BAT Text	Comments
5.1 Storage of liquids and liquified gases (Continued)	5.1.6 Salt Leached Caverns (continued)	*Emissions from incidents and (major) accidents (continued)*	BAT is to apply, and then regularly evaluate a monitoring programme which at least includes the following (see Section 4.1.15.2): • assessment of cavern stability by seismic monitoring • corrosion monitoring, including periodic casing evaluation • carrying out of regular sonar evaluations to monitor eventual shape variations, particularly if undersaturated brine is used.	Well and cavern inspection and testing requirements have been defined in Performance Standards. The frequencies of these are based on a risk-based approach with input from external specialists, relevant legislation and good industry practice. A review of the cavern integrity in its rock salt formation and leakage rate has been completed. No operational history of leakage/corrosion of ALD1 has been observed in the cavern to date. The continued integrity and stability of the cavities is monitored by sonar surveys of the cavern shape and mass balance of the stored product. Severe changes of cavern shape, especially rises of the cavern floor and/or roof falls, are indicators of cavern instability. Small reductions in cavern spatial volume are expected but loss of volume of more than 2% per year would cause concern. Cavern sonar surveys are typically completed five to six yearly. Routine production tubing corrosion surveys are undertaken (typically every five to six years) to monitor for corrosion. Multi-finger caliper (MFC) imaging tool surveys, magnetic thickness tool (MTT) and Echometer surveys will be used to measure and log data on the loss of wall thickness and pitting in the production tubing along its length. The Echometer survey is used to determine annulus fluid level. These assessments are carried out periodically, the frequency of which is dependent on the categorisation status of the well, and as directed by the SSE Technical Authority.
			Small traces of hydrocarbons may be present at the brine/hydrocarbon interface due to filling and emptying the caverns. If this is the case, BAT is to separate these hydrocarbon products in a brine treatment unit and to collect and dispose of them safely	Not Applicable - Cavern will be filled with hydrogen, so there is no brine/hydrocarbon interface during filling and emptying of the salt caverns.
5.2 Transfer and handling of liquids and liquefied gases	5.2.1 General principals to prevent and reduce emissions	*Inspection and maintenance*	BAT is to apply a tool to determine proactive maintenance plans and to develop risk-based inspection plans such as, the risk and reliability based maintenance approach; see Section 4.1.2.2.1.	See EFS - General principals to prevent or reduce emissions - Inspection and maintenance
		Leak detection and repair programme	For large storage facilities, according to the properties of the products stored, BAT is to apply a leak detection and repair programme. Focus needs to be on those situations most likely to cause emissions (such as gas/light liquid, under high pressure and/or temperature duties). See Section 4.2.1.3.	See CWW BAT 5.
		Emissions minimisation principle in storage tanks	BAT is to abate emissions from tank storage, transfer and handling that have a significant negative environmental effect, as described in Section 4.1.3.1. This is applicable to large storage facilities, allowing a certain time frame for implementation.	See EFS - General principals to prevent or reduce emissions - Emissions minimisation principle in tank storage
		Safety and risk management	BAT in preventing incidents and accidents is to apply a safety management system as described in Section 4.1.6.1.	See EFS - Preventing incidents and major accidents - safety risk management
		Operational procedures and training	BAT is to implement and follow adequate organisational measures and to enable the training and instruction of employees for safe and responsible operation of the installation as described in Section 4.1.6.1.1.	See EFS - Preventing incidents and major accidents - operational procedures and training
	5.2.2 Considerations on transfer and handling techniques	*Piping*	BAT is to apply aboveground closed piping in new situations, see Section 4.2.4.1. For existing underground piping it is BAT to apply a risk and reliability based maintenance approach as described in Section 4.1.2.2.1.	All on-site pipework for handling of liquids and liquefied gases will be above ground with the exception of the road crossing where pipework will be within culverts. Firewater pipework will be below ground but is only expected to be plastic pipes with a low environmental risk.
			BAT is to minimise the number of flanges by replacing them with welded connections, within the limitation of operational requirements for equipment maintenance or transfer system flexibility, see Section 4.2.2.1	Pipework will be fully welded where possible to eliminate leaks.

Section	Subsection		BAT Text	Comments
5.2 Transfer and handling of liquids and liquefied gases (continued)	5.2.2 Considerations on transfer and handling techniques (continued)	*Piping (continued)*	BAT for bolted flange connections (see Section 4.2.2.2.) include: • fitting blind flanges to infrequently used fittings to prevent accidental opening • using end caps or plugs on open-ended lines and not valves • ensuring gaskets are selected appropriate to the process application • ensuring the gasket is installed correctly • ensuring the flange joint is assembled and loaded correctly • where toxic, carcinogenic or other hazardous substances are transferred, fitting high integrity gaskets, such as spiral wound, kammprofile or ring joints.	Robust commissioning procedures will be in place to ensure that the plant is installed in line with the design requirements and relevant standards. Flanges and gasket will be selected during detailed design in accordance with appropriate standards and codes of practice and based on the materials handled. Operations and maintenance personnel will have suitable training and following procedures for making bolted flange connections.
			BAT is to prevent corrosion by: • selecting construction material that is resistant to the product • applying proper construction methods • applying preventive maintenance, and • where applicable, applying an internal coating or adding corrosion inhibitors.	During the design process, consideration was given to the structural integrity of equipment used. Materials of construction suitable for pressure-containing plant have been investigated and the proposed selections have been documented. The impact of corrosion has been considered, and allowance made either in the selection of material or by ensuring adequate corrosion allowance for the anticipated plant life. See LCP BAT 6 - All plant and equipment and the Site will be regularly maintained by qualified staff or contractors, as per site procedures and in accordance with a planned preventative maintenance programme in line with Original Equipment Manufacturers' recommendations.
			To prevent the piping from external corrosion, BAT is to apply a one, two, or three layer coating system depending on the site-specific conditions (e.g. close to sea). Coating is normally not applied to plastic or stainless steel pipelines. See Section 4.2.3.2.	Pipework is expected to generally be carbon steel and painted/coated to prevent corrosion. The number of layers and thickness of coating will depend on the whether the pipe is insulated or not, the temperature of fluid within the pipe and the manufacturers recommendations. Typically, it is expected to be 2 - 3 layers.
		Vapour treatment	BAT is to apply vapour balancing or treatment on significant emissions from the loading and unloading of volatile substances to (or from) trucks, barges and ships. The significance of the emission depends on the substance and the volume that is emitted, and has to be decided on a case-by-case basis. For more detail see Section 4.2.8. For example, according to Dutch regulations, the emission of methanol is significant when over 500 kg/yr is emitted.	Ammonia loading from tanker will have a vapour balancing line back to tanker to reduce potential emissions.
		Valves	BAT for valves include: • correct selection of the packing material and construction for the process application • with monitoring, focus on those valves most at risk (such as rising stem control valves in continual operation) • applying rotating control valves or variable speed pumps instead of rising stem control valves • where toxic, carcinogenic or other hazardous substances are involved, fit diaphragm, bellows, or double walled valves • route relief valves back into the transfer or storage system or to a vapour treatment system. See Sections 3.2.2.6 and 4.2.9.	Valves will be selected at detailed design in accordance with appropriate standards and codes of practice and will be based on the materials handled. Monitoring will be focused on those valves most at risk and on SHE critical assets. Valve choice will be based on risk assessments and HAZOPs. There may potentially be rising stem valves, if appropriate for the duty. Relief valves are primarily routed to flare or atmosphere.
		Pumps and compressors - Installation and maintenance of pumps and compressors	The following are some of the main factors which constitute BAT: • proper fixing of the pump or compressor unit to its base-plate or frame • having connecting pipe forces within producers' recommendations • proper design of suction pipework to minimise hydraulic imbalance • alignment of shaft and casing within producers' recommendations • alignment of driver/pump or compressor coupling within producers' recommendations when fitted • correct level of balance of rotating parts • effective priming of pumps and compressors prior to start-up • operation of the pump and compressor within producers' recommended performance range (The optimum performance is achieved at its best efficiency point.) • the level of net positive suction head available should always be in excess of the pump or compressor • regular monitoring and maintenance of both rotating equipment and seal systems, combined with a repair or replacement programme.	Pumps are being designed and will be installed in accordance with the latest engineering standards and supplier recommendations, including the fixings, pipe forces, pipework design, alignment and balance. Pumps will be primed and subject to commissioning/testing prior to first use. Pumps and compressors will be operated within recommended performance range, and with appropriate NPSH. Monitoring and maintenance of pumps will be carried out routinely as part of the Site's maintenance procedure.

Section	Subsection		BAT Text	Comments
5.2 Transfer and handling of liquids and liquefied gases (continued)	5.2.2 Considerations on transfer and handling techniques (continued)	*Pumps and compressors - Sealing system in pumps*	BAT is to use the correct selection of pump and seal types for the process application, preferably pumps that are technologically designed to be tight such as canned motor pumps, magnetically coupled pumps, pumps with multiple mechanical seals and a quench or buffer system, pumps with multiple mechanical seals and seals dry to the atmosphere, diaphragm pumps or bellow pumps. For more details see Sections 3.2.2.2, 3.2.4.1 and 4.2.9.	Pumps have been selected to meet process requirements. They will be on a preventative maintenance schedule to reduce the likelihood of leaks.
		Pumps and compressors - Sealing system in compressors	BAT for compressors transferring non-toxic gases is to apply gas lubricated mechanical seals.	Reciprocating piston-type compressor with non-lubricated cylinder design is expected to be used for hydrogen compression but will be confirmed at detailed design (note that this BAT strictly applies to liquids and liquified gases and so is not directly applicable to hydrogen).
			BAT for compressors, transferring toxic gases is to apply double seals with a liquid or gas barrier and to purge the process side of the containment seal with an inert buffer gas.	Not applicable - no toxic gases will be transferred in compressors.
			In very high-pressure services, BAT is to apply a triple tandem seal system.	Not Applicable - Pump and compressor equipment onsite will not be very high pressure requiring a triple tandem seal system. Not applicable for ammonia storage as this won't be a very high-pressure system. The ALD1 cavern will be 300 bar and will comply with the requirements of the Hazardous Substance Consent.
		Sampling connections	BAT, for sample points for volatile products, is to apply a ram type sampling valve or a needle valve and a block valve. Where sampling lines require purging, BAT is to apply closed-loop sampling lines. See Section 4.2.9.14.	Not applicable - no liquid/liquified gas sampling lines onsite.
5.3 Storage of solids	5.3.1 Open Storage	*See Bat*		Not applicable - no open storage of solid materials onsite.
	5.3.2 Closed Storage		BAT is to apply enclosed storage by using, for example, silos, bunkers, hoppers and containers. Where silos are not applicable, storage in sheds can be an alternative. This is, e.g. the case if apart from storage, the mixing of batches is needed.	No process solids on site. Solid waste from activities on site such as maintenance is segregated and stored in skips or other approved storage vessels as required, in a designated area away from the process plant. The quantities of waste generated are generally small, and the hazards presented (including escalation to process plant) are minor
			BAT for silos is to apply a proper design to provide stability and prevent the silo from collapsing. See Sections 4.3.4.1 and 4.3.4.5.	Not applicable - No silos onsite.
			BAT for sheds is to apply proper designed ventilation and filtering systems and to keep the doors closed. See Section 4.3.4.2.	Not applicable - No sheds onsite.
			BAT is to apply dust abatement and a BAT associated emission level of 1 – 10 mg/m3,depending on the nature/type of substance stored. The type of abatement technique has to be decided on a case-by-case basis. See Section 4.3.7.	Not applicable - No sources of substances that could give rise to dust emissions are expected to be present onsite.
			For a silo containing organic solids, BAT is to apply an explosion resistant silo (see Section 4.3.8.3), equipped with a relief valve that closes rapidly after the explosion to prevent oxygen entering the silo, as described in Section 4.3.8.4.	Not applicable - No silos onsite.
	5.3.4 Preventing incidents and (major) accidents	*Safety risk management*	BAT in preventing incidents and accidents is applying a safety management system as described in Section 4.1.7.1.	See EFS - Preventing incidents and major accidents - safety risk management
5.4 Transfer and handling of solids	5.4.1 General approaches to minimise dust from transfer and handling		BAT is to prevent dust dispersion due to loading and unloading activities in the open air, by scheduling the transfer as much as possible when the wind speed is low. However, and taking into account the local situation, this type of measure cannot be generalised to the whole EU and to any situation irrespective of the possible high costs. See Section 4.4.3.1.	Not Applicable - No solids loaded/unloaded onsite that could give rise to dust emissions.
			BAT is to make transport distances as short as possible and to apply, wherever possible, continuous transport modes. For existing plants, this might be a very expensive measure. See Section 4.4.3.5.1.	Not Applicable - No solids loaded/unloaded onsite that could give rise to dust emissions.

Section	Subsection		BAT Text	Comments
5.4 Transfer and handling of solids (continued)	5.4.1 General approaches to minimise dust from transfer and handling (continued)		When applying a mechanical shovel, BAT is to reduce the drop height and to choose the best position during discharging into a truck; see Section 4.4.3.4.	Not Applicable - No mechanical shovels used onsite.
			While driving, vehicles might swirl up dust from solids spread on the ground. BAT then is to adjust the speed of vehicles on-site to avoid or minimise dust being swirled up; see Section 4.4.3.5.2.	Not Applicable - no solid spreading on ground.
			BAT for roads that are used by trucks and cars only, is applying hard surfaces to the roads of, for example, concrete or asphalt, because these can be cleaned easily to avoid dust being swirled up by vehicles, see Section 4.4.3.5.3.	Not Applicable - emissions of dust from site operations are minimal. The site will be covered by concrete hard standing and roads will be tarmac or concrete.
			BAT is to clean roads that are fitted with hard surfaces according to Section 4.4.6.12.	Not Applicable - emissions of dust from site operations are minimal.
			Cleaning of vehicle tyres is BAT. The frequency of cleaning and type of cleaning facility applied (see Section 4.4.6.13) has to be decided on a case-by-case basis.	Not Applicable - emissions of dust from site operations are minimal.
			Where it neither compromises product quality, plant safety, nor water resources, BAT for loading/unloading drift sensitive, wettable products is to moisten the product as described in Sections 4.4.6.8, 4.4.6.9 and 4.3.6.1. Risk of freezing of the product, risk of slippery situations because of ice forming or wet product on the road and shortage of water are examples when this BAT might not be applicable.	Not Applicable - No sources of substances that could give rise to dust emissions are expected to be present onsite.
			For loading/unloading activities, BAT is to minimise the speed of descent and the free fall height of the product; see Sections 4.4.5.6 and 4.4.5.7 respectively. Minimising the speed of descent can be achieved by the following techniques that are BAT: • installing baffles inside fill pipes • applying a loading head at the end of the pipe or tube to regulate the output speed • applying a cascade (e.g. cascade tube or hopper) • applying a minimum slope angle with, e.g. chutes.	Not Applicable - no loading/unloading activities.
			To minimise the free fall height of the product, the outlet of the discharger should reach down onto the bottom of the cargo space or onto the material already piled up. Loading techniques that can achieve this, and that are BAT, are: • height adjustable fill pipes • height adjustable fill tubes, and • height adjustable cascade tubes.	Not Applicable - no loading/unloading activities.
	5.4.2 Consideration on transfer techniques	*Grabs*	For applying a grab, BAT is to follow the decision diagram as shown in Section 4.4.3.2 and to leave the grab in the hopper for a sufficient time after the material discharge.	Not Applicable - No grabs onsite.
			BAT for new grabs, is to apply grabs with the following properties (see Section 4.4.5.1): • geometric shape and optimal load capacity • the grab volume is always higher than the volume that is given by the grab curve • the surface is smooth to avoid material adhering, and • a good closure capacity during permanent operation.	Not Applicable - No grabs onsite.
		Conveyors and transfer chutes	For all types of substances, BAT is to design conveyor to conveyor transfer chutes in such a way that spillage is reduced to a minimum. A modelling process is available to generate detail designs for new and existing transfer points. For more details see Section 4.4.5.5.	Not Applicable - no conveyors or transfer chutes onsite.
			For non or very slightly drift sensitive products (S5) and moderately drift sensitive, wettable products (S4), BAT is to apply an open belt conveyor and additionally, depending on the local circumstances, one or a proper combination of the following techniques: • lateral wind protection, see Section 4.4.6.1 • spraying water and jet spraying at the transfer points, see Sections 4.4.6.8 and 4.4.6.9, and/or • belt cleaning, see Section 4.4.6.10.	Not Applicable - no conveyors or transfer chutes onsite.

Section	Subsection		BAT Text	Comments
5.4 Transfer and handling of solids (continued)	5.4.2 Consideration on transfer techniques (continued)	*Conveyors and transfer chutes (continued)*	For highly drift sensitive products (S1 and S2) and moderately drift sensitive, not wettable products (S3) BAT for new situations, is to: apply closed conveyors, or types where the belt itself or a second belt locks the material (see Section 4.4.5.2), such as: • pneumatic conveyors • trough chain conveyors • screw conveyors • tube belt conveyor • loop belt conveyor • double belt conveyor or to apply enclosed conveyor belts without support pulleys (see Section 4.4.5.3), such as: • aerobelt conveyor • low friction conveyor • conveyor with diabolos. The type of conveyor depends on the substance to be transported and on the location and has to be decided on a case-by-case basis	Not Applicable - no conveyors or transfer chutes onsite.
			For existing conventional conveyors, transporting highly drift sensitive products (S1 and S2) and moderately drift sensitive, not wettable products (S3), BAT is to apply housing; see Section 4.4.6.2. When applying an extraction system, BAT is to filter the outgoing air stream; see Section 4.4.6.4.	Not Applicable - no conveyors or transfer chutes onsite.
			To reduce energy consumption for conveyor belts (see Section 4.4.5.2), BAT is to apply: • a good conveyor design, including idlers and idler spacing • an accurate installation tolerance, and • a belt with low rolling resistance.	Not Applicable - no conveyors or transfer chutes onsite.

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