Immingham Green Energy Terminal
Green Hydrogen Production Facility

EPR/VP3425SV/A001

Environmental Permit Application

Appendix D3 – Assessment of Best Available Techniques for Technology and Process

Environmental Permitting (England and Wales) Regulations 2016

Applicant: Air Products (BR) Ltd

September 2024

Environmental Permitting (England and Wales) Regulations 2016

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Table of contents

Chapter **Pages**

Tables

1 Introduction

1.1 Purpose of the Report

1.1.1 This report has been prepared by AECOM Limited ('AECOM') on behalf of Air Products (BR) Limited ('APBRL'), referred to as 'the Operator' or 'AP' in support of an Environmental Permit application for the proposed Green Hydrogen (H_2) Production Facility ('proposed installation') which forms part of the wider Immingham Green Energy Terminal ('IGET') Nationally Significant Infrastructure Project (NSIP) being developed by Associated British Ports ('ABP') on the eastern side of the Port of Immingham, situated in northeast Lincolnshire on the south bank of the Humber Estuary.

1.1.2 The purpose of this report is to demonstrate that the proposed installation will be designed and operated in accordance with indicative Best Available Techniques (BAT) for process and technology. The report should be read in conjunction with other supporting application documents.

1.1.3 AECOM has prepared this BAT assessment using concept engineering information related to the initial design parameters of the proposed installation, available information about the local environment and the existing standards and guidelines presented in published guidance, including:

- Emerging Techniques for Hydrogen Production with Carbon Capture
- Large Volumes of Inorganic Chemicals – Ammonia, acids and fertilizers.

1.1.4 The main Supporting Statement provides an overall view of the Permit variation application being made for the proposed installation. In addition to the assessment for process and technology, BAT assessments have been prepared for emissions (Appendix D1), energy efficiency (Appendix D2), and cooling (Appendix D4), recognising that the overall integration of these aspects will determine BAT for the proposed installation.

1.2 Proposed Installation Description

1.2.1 The proposed installation comprises the development of a green H_2 production facility which includes infrastructure for the offloading and transfer of green ammonia (NH_3) from ships to ammonia storage facilities, the main H_2 production facility and vehicle and trailer H_2 refuelling facilities.

1.2.2 The proposed installation will be located in North East Lincolnshire on the south bank of the Humber Estuary on the eastern side of the Port of Immingham. The installation location will be approximately centred on National Grid Reference (NGR) E520783 N415271.

1.2.3 The environmental permit application is therefore for an H_2 production facility which will comprise the following within the installation boundary:

- NH_3 ship offloading infrastructure to facilitate the receipt of NH_3 for H_2 production. The offloading infrastructure will be located on a new jetty being constructed by Associated British Ports (ABP). Only the offloading infrastructure is incorporated in the application and the jetty itself remains outside the installation boundary.

- NH_3 transfer pipeline which links the ship offloading infrastructure with the NH_3 storage tanks located on the east site.

- East site which will comprise:

  (a) NH_3 storage tank and related plant including an NH_3 tank flare stack and boil-off gas compression system to liquefy the generated boil-off gas during offloading from Ship and static boil-off from Ammonia Tank.
  (b) H_2 production facility comprising up to three H_2 production units including associated flue gas and flare stacks.
  (c) Power distribution buildings for NH_3 and H_2 production plant.
  (d) Instrumentation buildings for NH_3 and H_2 processes.
  (e) Analyser shelters for the H_2 production plant.
  (f) Pipe-racks, pipelines, pipes, utilities and other infrastructure associated with both NH_3 and H_2 equipment.
  (g) Welfare facility.

- West site which will comprise:

  (a) H_2 production facility comprising up to three H_2 production units including associated flue gas and flare stacks.
  (b) Up to four liquefier units.
  (c) H_2 storage tanks.
  (d) H_2 trailer filling stations.
  (e) H_2 vent stack and associated process equipment.
  (f) H_2 vehicle and trailer filling stations.
  (g) H_2 compressors and associated process equipment.
  (h) Control room and workshop building.
  (i) Security and visitor building.
  (j) Contractor building.
  (k) Warehouse.
  (l) Driver administration building.
  (m) Safe haven building.
  (n) Electrical substation and metering station.
  (o) Power distribution buildings.
  (p) Process instrumentation buildings.
  (q) Analyser buildings.
  (r) Process and utility plant including cooling towers and pumps, fire water tank, instrument air equipment, pipe racks, pipelines, pipes, cable racks, utilities and other infrastructure, nitrogen generation

package (HPN) with LIN Tank and LIN Vaporizers and steam generation package.

(s) Pipeline corridor for underground pipelines, pipes, cables and other conducting media for the transfer of NH_3, H_2, nitrogen (N_2) and utilities, with cathodic protection against saline corrosion.

2 Best Available Techniques

2.1 Definition of Best Available Techniques

2.1.1 The Industrial Emissions Directive (2010/75/EU) defines BAT as “the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and where that is not practicable, generally reduce emission and the impact on the environment as a whole”.

2.1.2 The Directive continues to provide further definition as follows:

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

2.1.3 BAT may be demonstrated by either:

- Compliance with the sector-level, indicative BAT performance described guidance such as Sector Guidance Notes provided by the Environment Agency or in the European Commission ‘Reference Documents on BAT’ (BREFs) or BAT conclusions; or
- By conducting an installation-specific, options appraisal of candidate techniques.

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

2.2 BAT for the Installation

2.2.1 The development of the H_2 production plant from concept to full commercial scale must proceed alongside the emerging BAT regulatory positions, so there is confidence that the project meets indicative BAT before it proceeds with Front-End Engineering Design (FEED) and to drive the vendor procurement processes, whilst maintaining the best protection for the environment as a whole.

2.2.2 At this stage of project development, the Jetty and Pipelines, Ammonia storage tank and associated utilities are on east site, FEED is complete for other part of the installation, and we have therefore applied an approach to the derivation of BAT which is driven by:

- To allow the FEED process to progress without limiting options for later technology optimisations;
- To determine indicative BAT and BAT Achievable Emission Levels (BAT-AELs) for the plant which are consentable, taking into consideration the environmental sensitivities and conditions at the site.

2.2.3 The techniques described in this report and the associated BAT assessments are therefore based on the currently anticipated approaches to optimising H_2 production and its associated emissions management requirements.

2.2.4 A number of BAT reference documents were confirmed applicable during pre-application discussions with the Environment Agency (EA) to cover the process and technology related to hydrogen production at Immingham Green Energy Terminal. This section provides an overview of each relevant guidance document, followed by the BAT conclusions in tabulated form in the subsequent sections.

Emerging Techniques For Hydrogen Production With Carbon Capture

2.2.5 "*Emerging Techniques for Hydrogen production with carbon capture*" provides current indicative Best Available Techniques for Operators when designing H_2 production plants and preparing an environmental permit application. Although this set of guidance notes does not entirely align with the green H_2 processes taking place at the proposed installation, it is the most current document which has been advised during the enhanced pre-application discussions with the EA that the techniques can be applied to the different aspects of hydrogen production and is also appropriate for some of the directly associated activities such as venting and flaring. It should be noted that the current installation uses a method of green H_2 production and does not incorporate carbon capture at this time so those elements of this guidance will not be applicable. The BAT conclusions against this guidance have been tabulated in Section 3 below and justifications provided for each relevant section of the guidance.

Large Volumes of Inorganic Chemicals – Ammonia, Acids and Fertilizers.

2.2.6 "*Large Volumes of Inorganic Chemicals – Ammonia, Acids and Fertilizers*" is the appropriate Best Available Technique for the Use and Storage of Large Volumes of NH_3 as part of the process. The document largely links out to other guidance for the purpose if this BAT assessment, including IPPC Reference Document on Best Available Techniques on Emissions from Storage (July 2006). BAT conclusions are presented, and approaches justified in section 4 below.

Emergency backup diesel engines on installations: best available techniques

2.2.7 This relates to the use of diesel generators for emergency/back-up power on installations which fall under the Industrial Emissions Directive (IED) that are not expected to operate for more than 500 hours per annum in normal operation. Such diesel engines are classed as new medium combustion plant, operating up to 500 hours a year that are exempt from emission limit values (ELVs). Section 5 below focuses on the approach to satisfy this guidance.

2.3 Conclusions

2.3.1 On the basis of the assessment against the required BAT Conclusions for Process and Technology, as shown in Sections 3, 4 and 5, it is considered that the proposed installation will be designed and operated in compliance with and in accordance with BAT.

3 BAT Conclusions For Hydrogen Production

Table 31 BAT Assessment Against Emerging Techniques for Hydrogen Production with Carbon Capture

BAT No.	BATC Requirements	Operators Response	Operating to BAT
2	Technique selection should consider the following in relation to overall environmental performance: • energy efficiency • resource efficiency • CO_2 capture efficiency • emissions to the environment	Energy and resource efficiency have been considered – please refer to VP3425SV/APP/BAT02 Energy Efficiency BAT. Emissions to Environment is reviewed in the Supporting Statement (Document ref: VP3425SV/APP/SS), Impact Assessment Section 7. The direct emissions of constructing and operating the Project will be exceeded by the carbon reduction benefits the Project will bring in its contribution to the UK achieving its net zero targets by 2050.However, as this is a new technology producing green H_2 from a green NH_3 source, it currently does not include Carbon capture as part of the process, however, the Operator will seek options to further decarbonise the process as a future process development.	
3.1	**Flexible Operation** You must consider whether your hydrogen production plant may need to operate on a flexible basis to balance variations in demand from hydrogen users. You should consider whether this need for flexibility will affect the design, operation and maintenance of the plant. You should identify flexible operating scenarios where environmental performance could be affected, or where additional emissions are expected. For example, these could be as a result of rapid changes in capacity, or start-up following enforced shutdown. You should describe measures you would take to minimise the environmental impact of these scenarios, which could result in, for example: • reduced CO2 capture rates. • reduced energy efficiency. • increased emissions to air, venting and flaring. • increased effluent or wastes produced. • increased risk of accidents in non-steady state conditions.	The plant has been designed to be flexible to fluctuations in demand for hydrogen from users. Liquid hydrogen tanks are available, which can be filled & emptied according to demand. The overall plant has a master controller which will ramp both the HPU and the hydrogen liquefier in order to manage the hydrogen demand. This has been described in the process control philosophy document. Additionally the technology can produce H_2 at a minimum 99.9 mol% purity. Immingham H_2 installation will be equipped with a BPCS (Basic Process Control System) with appropriate control loops, set points, alarms and shutdown initiators. The role of the BPCS is to dynamically control the system within its' operating envelope or regime. This will minimise the occurrence of any unsafe deviations. A well designed BPCS will make the incidence of plant trips rare. The alarm and trip summary shall include a record of the setpoint for every alarm, trip and permissive shown on the P&ID	

BAT No.	BATC Requirements	Operators Response	Operating to BAT
3.2	**Reliability and Maintenance** You will need to identify equipment and systems that are critical in avoiding emissions. You will need to design, operate and maintain these to make sure they are reliable and available, including providing installed back-up equipment, where necessary.	A planned maintenance programme will be implemented that specifies how plant / equipment will be assessed to determine their maintenance criticality and the nature and frequency of maintenance requirements. Regular checks and formal inspections of static items such as tanks, pipework, retaining walls, bunds and ducts will be undertaken. The Planned Inspection and Maintenance procedure will be in place and require that all EHS&Q critical items are covered. The maintenance objectives for the plant are as follows: to maintain the integrity and efficiency of the facility so as to prevent or, where not possible, minimise emissions, incidents, accidents and process upsets; and, to undertake all maintenance tasks safely, economically and with no, or minimum, environmental impact. The European wide reliability-based maintenance management system (SAP) will be used for controlling the maintenance of the IGET H2 Production Facility, and will be controlled centrally by the European Maintenance Manager to ensure an appropriate maintenance programme is developed and applied to each asset. The objective of this approach is to avoid breakdown maintenance and avoid unnecessary preventative maintenance. At a local level, the Plant Supervisor will be responsible for the maintenance of the facility under his control. The maintenance philosophy will be embodied in a computerised preventive maintenance system that requires each plant to perform a programme of tasks at predetermined frequencies and submit feedback reports at regular intervals. The preventive maintenance system incorporates and schedules the following activities: • equipment condition monitoring; • periodic inspection and testing of systems; • functional testing of all safety devices; • inspection and testing of devices according to company standards and the relevant Codes of Practice; and, • relevant Air Products documents for the Periodic Inspection and Test (PI&T) programme relevant to the plant are included in the operational procedures. The following maintenance techniques will be used to provide early detection of impending faults or conditions likely to compromise Safety, Environmental Containment or Production: • a portable vibration data collection and analysis package can be used to collect machine-operating data and to evaluate rotating machinery; • electric motor performance; • leak detection and repair; • ultrasonic testing can be used to monitor valve systems for leakage by detecting stem & flange leakage on gaseous duty, and valve passing on both liquid and gaseous systems; and, • emergency response equipment is serviced and maintained in accordance with requirements defined in the site major emergency procedure. Details of the maintenance tasks and compliance are available on-site via the SAP System. • See maintenance in Management Techniques section (section 4) of Supporting Statement (Document ref: VP3425SV/APP/SS)	Yes
	You should implement a risk-based other than normal operating conditions (OTNOC) management plan, which identifies potential scenarios, mitigation measures, monitoring and periodic assessment.	• The plant and associated BPCS will be designed to minimize the potential for OTNOC events to occur. The plant BPCS will continuously monitor the operation of the plant and equipment at the site. Any non-conformance 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 shall be trained to monitor plant operation and take appropriate action(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	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
		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 system provided to minimise the potential for OTNOC conditions to occur. • The Installation will also have accident management plan (AMP) and emergency response procedures for the management of spills, firewater, and the blocking of any discharge outlet to the river. See section 4 Management Techniques of Supporting Statement (Document ref: VP3425SV/APP/SS).	
3.3	**Overall CO_2 capture efficiency:** You should design plant to maximise the carbon capture efficiency. As minimum, you should achieve an overall CO_2 capture rate of at least 95%, although this may vary depending on the operation of the plant. You can base this on average performance over an extended period (for example, a year). Overall carbon capture rate or efficiency is defined as 'the mass of CO_2 equivalent captured for storage as a percentage of the mass of CO_2 equivalent in all feed gas, including methane or refinery fuel gas (or both) used in combustion plant'. For clarity, this is the same as 'the mass of carbon captured as a percentage of the mass of carbon in all feed gas'. This should be achievable for the hydrogen production and CO_2 capture routes considered for new plant. You will need to provide justification if you are proposing a design CO_2 capture rate of less than 95%. You should consider how you would comply with future requirements for increased CO_2 capture efficiency by making your plant decarbonisation ready. You should plan to allow for space and technical retrofit within the design for additional carbon capture plant. This will allow for the capture of residual emissions of CO_2, for example, from combustion of any hydrogen purification residual gas. This is to future-proof the plant so you can comply with any future requirements for carbon capture ready for emissions of CO_2 and the likely changes to CO_2 capture efficiency required.	The hydrogen produced at the Immingham facility is designed to meet the carbon intensity targets set by the UK government RFNBO criteria of 32.9 gCO2eq/MJ. This includes all emissions from 'well-to-wheel' meaning that the CO_2 emissions produced by the furnace are included in this calculation. The carbon dioxide emission to atmosphere from the HPU (Hydrogen Production Unit) is a result only of the natural gas used to heat the furnace. There is inherently less CO_2 produced in the operation than in a Steam Methane Regenerator (SMR) because the process gas for H_2 production is ammonia, not natural gas. At the outlet of the flue gas stack there will be a stream with 4% mol CO_2 at just above atmospheric pressure. The mass flow per unit of this CO_2 will be just 1.5 tonnes/hour. A 'very small' CO_2 capture project would be 21 tonnes/hour, which is an order of magnitude smaller than a small industrial unit for CO_2 capture. An economy of scale will therefore be needed to successfully deploy CO_2 capture technology, to justify investment in the necessary CO2 transportation and storage infrastructure and the increased complexity. If the site is required to further reduce carbon intensity, the first intention is to use Renewable Natural Gas (RNG) for the installation when available. Alternatively, hydrogen could be used as fuel if there was a need to reduce carbon intensity. This reflects a self-fuelling mode, and is not currently available due to additional testing needed on the burners. This has been confirmed in the DCO Application Environmental Statement Ch19 Section 19.8.14. Carbon capture capacity is not currently being considered for the HPUs/cracker but options for future incorporation into the design including potential uses of the jetty for carbon dioxide imports and exports to facilitate storage which will also assist the transition towards a net zero trajectory are being considerCed. this could be a viable carbon capture option for this operation in the future. The hydrogen is likely to be used locally for industrial uses or sold as a renewable transport fuel. In terms of emission displacement, the emissions factor (i.e. the rate of greenhouse gas emissions) of the green hydrogen produced by the Project if used directly for industrial uses locally (distributed by pipeline) will be compliant with the UK's standard for low carbon hydrogen.	Yes
3.4	**Process CO_2 capture from hydrogen product** Technology for CO_2 capture from hydrogen product will typically be through absorption in a circulating solvent, with regeneration of the solvent through reducing pressure and heating to liberate CO_2. You should select the solvent, process design and operating conditions that maximise energy efficiency, capture performance, and minimise the waste and effluent treatment required. Where you have considered various options, you should provide the reasoning behind this to demonstrate that your chosen option uses overall BAT.	Not currently used the carbon dioxide emission to atmosphere from the HPU (Hydrogen Production Unit) is a result only of the natural gas used to heat the furnace. There is inherently less CO2 produced in the operation than in n Steam Methane Regenerator (SMR) because the process gas for H2 production is ammonia, not natural gas. At the outlet of the flue gas stack there is will be a stream with 4% mol CO2 at just above atmospheric pressure. The mass flow of this CO2 will be just 1.5 tonnes/hour. A 'very small' CO2 capture project would be 21 tonnes/hour, which is an order of magnitude smaller than a small industrial unit for CO2 capture. An economy of scale is will therefore be needed to successfully deploy CO2 capture technology, to justify investment in the necessary CO2 transportation and storage infrastructure and the increased complexity.	N/A
3.5	**CO_2 capture for steam methane reforming**	SMR is not being used. Main feed is green ammonia imported by pipeline from jetty.	N/A

BAT No.	BATC Requirements	Operators Response	Operating to BAT
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3.6	**CO_2 capture from residual gas from hydrogen purification**	No carbon capture taking place; however, tail gas is fed back into the process., which results in: • additional heat recovery from the process; and • a single emission source from the flue gas stack	N/A
3.7	**Energy Efficiency, Process Efficiency and Cooling** You should choose your hydrogen production process and design your plant to maximise: • energy efficiency (minimise the energy needed to produce each tonne of hydrogen) • process efficiency (minimise the raw materials, such as methane and water, needed to produce each tonne of hydrogen) To decide on BAT, you will have to balance how you achieve these efficiencies in order to optimise the environmental and economic requirements. You must explain how you have done this and what your considerations were. This should take into account all of the chemical and physical processes within the installation boundary needed to produce hydrogen and capture carbon. You should consider: • electrical power needs and whether you will import or generate on site • high pressure steam need and availability • maximising any residual waste heat recovery • cooling needs • cooling type and medium You should also consider: • heat integration optimisation, for example, heat recovery at: • higher temperatures from compression systems including the ASU, CO2 and hydrogen compression for power generation or drives • medium temperatures for solvent recovery • lower temperatures for boiler feed pre-heat	There will be no power generation on site, however, during normal operation the process will be operated with tail gas from the PSA as a proportion/component of the fuel used for heating. • There is no requirement for steam within the process, although an electric boiler will be used to generate steam for maintenance & cleaning purposes only. • The proposed installation will be designed to maximise systems integration. • The hydrogen production plant has been designed to maximise both energy and process efficiency. See Energy Efficiency BAT Document (Appendix D2) and Cooling BAT Document (Appendix D4).	Yes
3.8	**Oxygen production** Oxygen is required for the ATR and POX processes. It is usually produced by an ASU, which is a relatively large energy user.	Process does not use ATR or POX processes.	N/A
3.9	**Water Supply and Use** Water supply and its efficient use is an important aspect of BAT in hydrogen production plant. The quality of the water supply will determine the pre-treatment needed before it can be used as a:	• Water reduction and reuse measures have been incorporated into design of the hydrogen production process. This includes use of a recirculating water system, reuse and segregation of water streams, process control of chemical dosing and cooling water boiler blow down systems. • Approximately 3,640m3/day of non-potable water (as make-up water) will be required to support the hydrogen production facility during the operation of the installation. Non-potable water will also be required for periodic use	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	• raw material in hydrogen production • heat transfer medium • cooling medium Water is consumed in the process as part of the hydrogen product. Your choice of hydrogen production method will determine the ratio of hydrogen product that comes from water compared with that which comes from methane, or refinery fuel gas, or both. For further details see Water consumption (process) in Table 20 of the review of emerging techniques. You should: • minimise the amount of water you use • segregate, treat and reuse water where possible • choose a cooling method that takes account of the temperature impact on process performance, energy efficiency and environmental impact on the receiving medium For refineries, you should also comply with BAT conclusion 11 emissions to water from the BAT conclusions (BATC) for refining of mineral oil and gas.	including fire water storage and utility stations, but these will be small quantities and would not impact the overall water demand. A limited supply will be used for offices (including fire sprinkler systems), welfare facilities, steam boiler and site safety showers. The non-potable water will be supplied by Anglian Water through existing mains water supply in various areas around the site. • Water pre-treatment does not take place. See Water Supply Supporting Statement Section 3.4.4 & 3.6	
3.10	**Water Treatment** Water and steam are used in the process. Water is condensed both from steam systems and from process cooling. In most cases, this water can be reused without being treated. However, some water will need to be removed to avoid the build-up of contaminants. You will need to treat it in an effluent treatment system before releasing it into the environment. You should decide how much water to treat and how to treat it before it is: • reused • released to surface water or sewage undertaker • disposed of You should identify how much contaminant, such as methanol and ammonia, needs to be removed and design the treatment process accordingly. You should identify any emissions to air or wastes that may result from the water treatment process, for example, emission of CO_2 from deaeration of boiler feed water. You should use the following references to choose the most appropriate treatments: • BREF and BATC for common wastewater and waste gas treatment/ management systems in the chemical sector • BREF and BATC for refining of mineral oil and gas For discharges to water, you should refer to the guidance Surface water pollution: risk assessment for your environmental permit. For further details on water treatment for re-use, see the review of emerging techniques, section 5.13.	Site uses a recirculating water system, facilitating reuse and segregation of water streams. Water from blowdown circuits that can't be recirculated to minimize build-up of contaminants will be discharged to sewer. Water systems will be segregated into contaminated and non-contaminated, oil will be removed via oil interceptor system. See Water Supply Supporting Statement Section 3.4.4 & 3.6	Yes
3.11	**Feed gas quality and treatment**	The site is not an SMR so does not use a methane containing gas as the feed gas. Green ammonia is used as the feed gas facilitating production of H_2. As such there is no requirements for a pre-reforming stage or a process stage to remove contaminants such as sulphur or trace metals.	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	Your choice of supply of methane-containing feed gas will determine the type of gas treatment processes you will need prior to the main conversion reactions., It will also determine whether you will need to remove inert gases at the hydrogen purification stage. If you use refinery fuel gas as your feed gas supply, where possible, you should remove contaminants such as sulphur and mercury in existing upstream refinery processes, taking account of BAT across the refinery installation. You will need to take account of the possible range of gas composition so that you can design your processes to minimise the overall environmental impact, including substances such as: • sulphur (S), typically as H_2S • nitrogen (N_2) • CO_2 • mercury • other hydrocarbons You will need to design your gas treatment and downstream processes in order to: • minimise solid wastes (for example, catalyst) for recycling or disposal • minimise sulphur dioxide (SO_2) emissions to air where feed gas is combusted • maximise overall process reaction and energy efficiency • minimise emissions to air associated with the removal of nitrogen or other inerts You should consider removing sulphur compounds by hydrogenation and using catalyst adsorbent to avoid SO_2 emissions from combustion and catalyst poisoning. You should consider removing other hydrocarbons by pre-reforming to avoid carbon deposition on catalysts. You should consider the impact a pre-reforming step will have on the downstream reforming stage for an SMR. You may be able to optimise the energy efficiency and minimise NOx emissions to air due to reduced gas fired reformer furnace duty. You will need to consider the impact on steam balance for the plant. You should remove mercury to avoid catalyst poisoning and other downstream contamination. Any CO_2 in the feed gas will be removed along with the CO_2 produced in the process. You should include this in the overall CO_2 balance and capture efficiency monitoring and reporting.	As outlined earlier. the CO_2 emission to atmosphere from the HPU is a result only of the natural gas used to heat the furnace. There is inherently less CO_2 produced in the operation than in a SMR because the process gas for H_2 production is ammonia, not natural gas. At the outlet of the flue gas stack there is will be a stream with 4% mol CO_2 at just above atmospheric pressure. The mass flow of this CO_2 will be just 1.5 tonnes/hour. A 'very small' CO_2 capture project would be 21 tonnes/hour, which is an order of magnitude smaller than a small industrial unit for CO_2 capture. An economy of scale is will therefore be needed to successfully deploy CO_2 capture technology, to justify investment in the necessary CO_2 transportation and storage infrastructure and the increased complexity.	
3.12	**Reforming and CO shift** Hydrogen is produced in the reforming and CO shift stages of the plant. You should convert methane to hydrogen, CO and CO_2 in the reforming stage, while minimising unreacted methane. You should optimise CO conversion to CO_2 considering the overall CO_2 capture requirement and the impact on downstream processing stages to meet the hydrogen product specification.	The process does not use methane-containing gases for H_2 production.	N/A
3.13	**Reforming** You should select, design and operate the reformer reaction in order to:	The reformer for this process converts green NH_3 to H_2 and catalysts are selected for optimum H_2 production and are chromium free. Catalyst activation is done in situ with no waste generation.	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	• reduce the risk of carbon deposition on catalyst, which would result in reduced reaction efficiency • minimise catalyst change frequency and the need for recycling or waste disposal If you choose ATR or POX technologies, carbon formation may be more likely due to the reducing atmosphere. You should choose operating parameters to minimise this risk.		
3.14	**CO Shift** You should select, design and operate CO shift reaction in order to: • maximise energy efficiency through, for example, heat integration with the overall hydrogen production and CO_2 capture processes • minimise the duration of start-up operations and associated emissions to air from flaring • minimise the production of wastes for recycling or disposal	Not used in this process	N/A
3.15	**Catalyst selection** When you choose which catalysts to use, you should consider the overall environmental performance, including, for example: • any required pre-treatment to avoid poisoning, to minimise waste and associated treatment • preventing any dust emissions, where applicable • the ability to recover or recycle the solids or metals from the spent catalyst waste • handling spent catalyst for environmentally safe recovery, recycling or disposal	The reformer for this process converts green NH_3 to H_2 and catalysts are selected for optimum H_2 production and are chromium free. Catalyst activation is done in situ with no waste generation. Catalyst handling and loading will be done in line with AP and manufacturer's recommendations and does not present any particular challenges compared to other catalysts used in industry. Spent catalyst will be recovered and the metal content recycled and reused. Catalyst deactivation, handling and recovery will be done in line with AP and manufacturer's recommendations and does not present any particular challenges compared to other catalysts used in industry. Spent catalyst will be recovered by the manufacturer and the metal content recycled and reused. See Supporting Statement.	
3.16	**Hydrogen product** You will need to purify and compress hydrogen so that it is fit for purpose after it is separated from the CO_2 in the CO_2 capture stage. You should take account of hydrogen purification requirements. These will depend on: • the hydrogen product quality specification • impurities in the hydrogen following reforming, CO shift and CO_2 capture steps The impurities may include: • CO, which is not converted to CO_2 in the reforming or CO shift sections • CO_2, which is not removed in the CO_2 capture section • methane, which is not converted to CO in the reforming section • nitrogen and argon – inert gases present in feed gas or oxygen supply • water – the hydrogen is saturated with water following CO_2 capture You should consider pressure swing adsorption (PSA) to remove impurities from the hydrogen. Treating residual gas containing the impurities is considered in section 3.6 CO_2 capture from residual gas from hydrogen purification. You should consider whether methanation to convert CO into methane is appropriate, depending on the specification of hydrogen, to make sure hydrogen is fit for purpose. You should consider the impact on overall energy efficiency and the need for further treatment of hydrogen purification off-gas streams.	A purification system will be used and is located downstream of the Hydrogen production unit and is designed to produce > 99.97% pure H_2.	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	You should design the overall process to minimise the power required for compression to achieve the pressure required by the user. See section 3.7 energy efficiency, process efficiency, cooling.		
3.17	**CO_2 product** You should design the process to meet the required CO_2 quality specification, temperature and pressure as required for transport to permanent geological storage. You should design the overall process to minimise the power required for compression to achieve the pressure required by the user. You should maximise recovery of waste heat from compression. See section 3.7 energy efficiency, process efficiency, cooling.	No CO2 capture as part of this process.	N/A
4	**Emissions to air** You should eliminate, minimise or reduce any emissions to air that could cause pollution. You should make sure that your process emissions can comply with all ELVs which are required under the relevant BATC. You should carry out a risk assessment, including detailed air quality modelling, to assess the impact of these emissions.	The process is designed to meet BAT AELs. Refer to the BAT for Emissions (Appendix D1). Air quality modeling has been carried out to evaluate the impact of emissions - see Air Quality report DCO ES Ch 6.	Yes
4.1	**Combustion Processes** You should maximise energy efficiency and heat integration so you minimise the need for combustion processes, resultant CO_2 and other combustion products. You should maximise the capture of CO_2 from combustion processes, taking account of the overall carbon capture requirement. If you decide that carbon capture from a combustion process is not appropriate, you must justify your decision based on BAT. You must identify and minimise the continuous and periodic emissions of combustion products to air. You should consider NOx abatement techniques where the combustion of hydrogen-rich gas with the potential for higher flame temperatures will increase thermal NO_x formation, including: • burner design • flue gas recirculation • heat exchange with fuel or air You should consider whether abatement of any of these emissions is required to comply with relevant BAT AELs or local air quality standards, for example, for NOx. Where relevant, you should consider the following abatement techniques: • selective catalytic reduction (SCR) • selective non-catalytic reduction (SNCR) You should consider: • the overall impact of using residual gas from the hydrogen purification process as a supplementary fuel for fired equipment to balance overall heat requirements, while considering the impact of the additional emissions of combustion products to air • for SMR, the requirement for post-combustion carbon capture for the reformer furnace emissions to air and any pre-treatment of combustion gases needed see the PCC guidance	Immingham H_2 installation will be equipped with a BPCS (Basic Process Control System) with appropriate control loops, set points, alarms and shutdown initiators. The role of the BPCS is to dynamically control the system within its' operating envelope or regime. This will minimise the occurrence of any unsafe deviations and will act as second layer of protection. A well designed BPCS will make the incidence of plant trips rare. The alarm and trip summary shall include a record of the setpoint for every alarm, trip and permissive shown on the P&ID The BPCS will provide for efficient operation of the process in term of energy and process efficiency and will facilitate optimisation of the combustion processes. In terms of emissions control, the site will utilise: • Low NOx burners; • Natural gas or H2 rich tail gas as a fuel source therefore minimising the potential for SO_2 and particulate emissions. • Utilise SCR for the minimisation of NOx emissions. The process is designed to meet BAT AELs. Refer to the BAT for Emissions (Appendix D1). A number of burners which processes natural gas, ammonia and hydrogen as a mixed fuel have been tested and has implemented the burner with the lowest NOx emissions. Selective catalytic reduction has been implemented as a two-stage system with a static mixer. This ensures adequate removal of NOx emissions. In terms of CO_2 capture, as outlined earlier. the CO_2 emission to atmosphere from the HPU is a result only of the natural gas used to heat the furnace. There is inherently less CO_2 produced in the operation than in a SMR because the process gas for H_2 production is ammonia, not natural gas. At the outlet of the flue gas stack there is will be a stream with 4% mol CO_2 at just above atmospheric pressure. The mass flow of this CO_2 will be just 1.5 tonnes/hour. A 'very small' CO_2 capture project would be 21 tonnes/hour, which is an order of magnitude smaller than a small industrial unit for CO_2 capture. An economy of scale is will therefore be needed to successfully deploy CO_2 capture technology, to justify investment in the necessary CO_2 transportation and storage infrastructure and the increased complexity.	

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	• for ATR, whether the relatively smaller additional heat need can be supplied by combustion of hydrogen-rich residual gas or combustion of hydrogen product • for POX, the process is usually energy-balanced or produces excess heat and so combustion processes may not be needed • the impact on emissions to air due to variability in fuel gas composition or any need to switch between fuel gas sources, for example, at start-up when residual PSA gas for fuel is not available and some feed gas may need to be combusted. You could consider using excess oxygen, where available, to support oxy-combustion, in order to remove the source of nitrogen and therefore limit thermal NOx formation. Fuel NOx may form from nitrogen in the residual gas from the PSA. There is limited experience of using oxygen, especially for hydrogen-rich gases and any such proposal would need to be fully justified with supporting data. You should design combustion processes to comply with required emissions limit values (ELVs) from the existing sources of statutorily applicable emission limits and BAT AELs, including the following: • Medium Combustion Plant Directive • Industrial Emissions Directive Chapter III Annex V ELVs • BAT AELs identified in the Large combustion plant BREF and BATC • Refining of Mineral Oil and Gas • Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers • Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector You should consider the: • type of combustion equipment • fuels proposed to be combusted • net rated thermal inputs • BAT for control of emissions • conclusions of an environmental risk assessment, considering the dispersion of pollutants into air and the sensitivity of the relevant receptors	Oxy-combustion is not used as there is additional NOx formation because of the presence of ammonia.	
4.2	**Post combustion capture plant** PPC Guidance - Features to control and minimise atmospheric and other emissions	Not used on this process	N/A
4.3	**Flaring and venting** You must design and operate your plant to minimise the need for continuous or intermittent flaring or venting of gases, whether for operational or safety reasons, including: • methane or refinery fuel gas • hydrogen • CO_2 This should include: • flaring rather than venting, where emissions cannot be eliminated and where practicable, to minimise emissions of higher global warming potential gases such as methane and hydrogen • plant design to maximise equipment availability and reliability • avoiding routine flaring for waste gas destruction • managing production of off-gas and balance against requirements for fuel gas using advanced process control, for example	**Process Control** The installation will be equipped with a BPCS (Basic Process Control System) with appropriate control loops, set points, alarms and shutdown initiators. The role of the BPCS is to dynamically control the system within its' operating envelope or regime. This will minimise the occurrence of any unsafe deviations and will act as second layer of protection. A well designed BPCS will make the incidence of plant trips rare. The alarm and trip summary shall include a record of the setpoint for every alarm, trip and permissive shown on the P&ID **Flare Systems** The ammonia storage tank is supported by a flare for safety reasons and flaring will be required to operate in an emergency or during plant start-up to burn off the release of NH_3 emissions. Additionally, each HPU unit is equipped with its own emergency flare which will operate in an emergency to burn off the hydrogen emissions. While the flares will operate on pilot gas, actual flaring of NH_3 or H_2 will occur no more than a few hours per year.	

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	• using procedures to define operations, including start-up and shutdown, maintenance work and cleaning • using commissioning and handover procedures to ensure that the plant is installed in line with the design requirements • using return-to-service procedures to ensure that the plant is recommissioned and handed over in line with the operational requirements • designing flaring devices to enable smokeless and reliable operations, and to ensure an efficient combustion of excess gases when flaring under other than normal operations • monitoring and reporting of gas sent to flaring and associated parameters of combustion You must minimise emissions under start-up, shutdown, and abnormal operations. This can be achieved by: • using a flare gas recovery system with adequate capacity • routing gas that would be flared to alternative users • using high integrity relief valves • other measures to limit flaring to abnormal operation If your activity is part of a refineries installation, you should refer to BAT conclusions 55 and 56 in BATC for the Refining of Mineral Oil and Gas. You should quantify and assess harm from other routine venting and purging requirements, identifying any pollutants that are expected to be present, including, for example: • CO_2 • hydrogen • CO • methane • ammonia vapour • methanol vapour Requirements for continuous venting during normal operations may include, for example: • water vapour from CO_2 dehydration systems using circulating tri-ethylene glycol • deaeration of steam condensate or boiler feed waters • gases from processing waste water streams • purge of tanks, vent or flare headers Requirements for intermittent venting may include, for example: • CO_2 vented in abnormal conditions, such as when the downstream transportation and storage system is not available, or if the CO_2 does not meet the export specification • venting needed as part of purging equipment for maintenance activities.	Flaring events are envisaged only during emergency, process upset, start-up or shutdown and occasionally for changes in operating modes (moving to plant turndown), with no flaring during normal operation of the HPU. The flare ignition system has been specified with built in redundancy and will meet or exceed API 537 requirements for wind speed and rainfall so that the pilot remains lit in adverse environmental conditions. Pilot gas will be supplied from a third-party reliable gas supplier through piped connection and failure of pilot gas from the source is unlikely. HPU safe shutdown will be initiated. Flare flame detection will be through retractable thermocouples with redundancy and indications will be provided on the flare ignition panel show pilot status, with loss of pilot alarms provided to alert operators. Any deviation from the expected flowrate through the flare header would indicate potential flaring and Operator will be expected to take required corrective action immediately. CEMS will be used to continuously monitor the flue gas venting from the flue gas stacks (hydrogen production units), any deviation from the expected emission concentrations would indicate some issue with the fired heater operation and Operator will be expected to take required corrective action immediately. Each HPU will have a dedicated flare and normally flare planned maintenance would be coupled with the HPU turnaround, however in the event of an unplanned maintenance of the flare due to malfunction, the respective HPU will be safely shutdown. Each flare will be designed to relevant design standards with sufficient capacity of the system it is supporting and will be controlled via the BPCS to ensure: • combustion is optimized; • key parameters such as gas flow, temperature and pressures are monitored; and • operation is smokeless. Records will be maintained via the BPCS including recording of flaring events (i.e. combustion of process gases), the estimated gas composition, the volume of gas combusted and the duration of the flaring event. **Venting** Hydrogen would be routed to a vent system for disposal for certain non-routine, infrequent scenarios such as: • High pressure excursion in the compressor area of the liquefier • Contaminated trailer returned from a customer • Conditioning of the trailer for first use • LHY storage tank relief valves or bursting discs which will vent through a vent stack • Storage area overfill The vent system will be designed to safety vent hydrogen in accordance with EIGA 06/19 which permits venting when the vent stack is discharging in a safe place in the open air to prevent impingement of escaping gas on to personnel or any structure. The vent stack height will be ~40 m from ground and will be confirmed at detailed design through dispersion modelling. The hydrogen vent pipework will be purged continuously with high purity nitrogen, this prevents air ingress to the system and any potential solidification of air at valves or PSV outlets. This limits the likelihood of ignition in the vent pipework system itself. Air Products will follow AP standard STD-ENG-MS007 'Venting of Bouyant Flammable Gases' for the design of the venting system..	
5	**Emissions to water** You must identify and eliminate, minimise, recycle or treat any emissions to water that could cause pollution.	**Surface Water**	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	You should carry out a risk assessment, including detailed modelling, where appropriate, to assess the impact of these emissions. For discharges to water, you should refer to the guidance Surface water pollution: risk assessment for your environmental permit.	A new surface water drainage network and management system will be provided for the terrestrial areas of the Site that would provide adequate interception, conveyance and treatment of surface water runoff from buildings and hard standing. The drainage system will be designed to be inherently safe and protect the local environment from urban diffuse pollutants that may be present. The drainage system will segregate clean surface water, oily water and water that may have contamination from liquid chemicals (water treatment chemicals, or NH_3 solution). Clean surface water run-off will be gravity drained into the local sump and pumped out to an external location in the local drainage network via an Oily Water Separator (OWS). Surface water run-off from the NH3 storage non-contaminated areas will be routed to retention pond on the east site via. storm sewer networks. Surface water run-off from areas which could have accidental contamination (e.g., boil-off gas compression system installation area) will be routed through oil/water separator sumps resulting in oil free water routed to the retention pond on the east site. Oil/Water sump will have oil in water analyser and also ammonia analyser or detector (to be confirmed during detailed design) and in case ammonia is detected in the sump (due to accidental contamination) the outflow from the sump is isolated using automated isolation valve to contain ammonia contaminated water in the sump. The ammonia contaminated water will trucked out from the facility for offsite treatment. **Process Water** Equipment/process wastewater (e.g., blow down and condensate) will go through an OWS before being discharged to foul sewer along with sanitary waste. Blowdown waters are recycled back into the process where possible and then treated on site before discharge to sewer. See drainage section within section 3 Process Description of the Supporting Statement (Document ref: VP3425SV/APP/SS). See Management Techniques (section 4) of Supporting Statement (Document ref: VP3425SV/APP/SS).	
5.1	Effluent treatment discharges You should identify continuous and periodic effluent streams from the process and determine whether effluent treatment is required. These streams may include process condensate containing contaminants, which may need treatment before discharge, for example: • ammonia You should treat water for reuse as far as possible. You should refer to the appropriate BREF and BATC (where available) if the installation is considered to be part of a refinery or a chemicals installation: nt Systems in the Chemical Sector • Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers		
6	**Waste** You must eliminate or minimise wastes and treat, where appropriate. Liquid wastes such as: • demineralised water production reject stream • amine solvent – for example, from bleed or feed replacement • dehydration solvent – for example, in case of tri-ethylene glycol dehydration • amine reclaimer residue Solid wastes such as: • depleted catalyst material – hydrogenation, reforming, CO shift • spent adsorbent materials – gas treatment, dehydration, hydrogen purification • solids from amine filtration • soot (POX process)	Wastes produced on site will be minimized, recovered or treated in accordance with the waste hierarchy which will be detailed in the “Operational Waste Management Plan” (OWMP). An OWMP will be produced before the plant is operational. There are no continuous process wastes aside from cooling water blowdown on this site. With specific reference to catalysts, these will be activated in situ with no waste generation. Catalyst handling, loading and deactivation will be done in line with AP and manufacturer’s recommendations and will be recovered and the metal content recycled and reused.	Yes
7.0	**Monitoring**	Monitoring plan will be in place to cover routine monitoring as well as compliance monitoring requirements.	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	The main purpose of monitoring is to demonstrate compliance with the permit and show that emissions from the process are not causing harm to the environment. You must also carry out monitoring to show that resources are being used efficiently. This includes: • energy and resource efficiency • carbon capture efficiency • verifying that the CO_2 product is suitable for safe transport and storage • hydrogen product quality • verifying (when applicable) compliance with low carbon hydrogen standards Your permit application should include a monitoring plan for both a commissioning phase and routine operation. During commissioning phase, you will need to assess monitoring results and optimise the operation of the process. You will need to report on your commissioning phase monitoring results, your assessment of them and any changes you want to make to the operation. It's likely you will need to do more extensive monitoring during the commissioning phase than during routine operation. As these production techniques for hydrogen with CCS are emerging techniques, you will need to develop monitoring methods and standards. You should include proposals for this in your permit application. Complying with ELVs in your permit will provide the necessary protection for the environment, by monitoring emissions at authorised release points. You must also show that you are managing the process to prevent (or minimise) the formation of solvent degradation products. Where degradation products are formed (and may be released), you must reduce these and any solvent emissions to the appropriate level. This process control monitoring will also be part of the permit conditions.	A monitoring plan will be produced before the plant is operational.	
7.1	**Monitoring point source emissions to air** You should provide a monitoring plan for monitoring emissions to air, based on expected pollutants such as: • ammonia • amine compounds • SO_2 • NOx • CO • methane • hydrogen You should do this using appropriate methods and measuring techniques. Emissions of methane and hydrogen should be eliminated or minimised due to their global warming potential. Your monitoring should consider, for example: • NOx and CO emissions from combustion • SO_2 emissions from combustion where the fuel source contains sulphur • ammonia emissions where SCR or SNCR is used	The site will monitor emissions to air as follows: • NH_3 emissions to air monitored against EN 21877 standards every 6 months in accordance with BAT 17. • NO_x emissions monitoring will be monitored against EN 14792 as the emission rate is < 2.5 kg/h and monitoring will take place once every 6 months. • CO emissions will be monitored in accordance with EN 15058 . as the emission is < 2 kg/h and monitoring will be every 6 months. Monitoring plan will be developed in accordance with the permit requirements prior to the plant being commissioned. See Supporting Statement Section 6.3 (Document ref: VP3425SV/APP/SS)	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	• amine or amine degradation products and other volatile solvent emissions, where relevant • methane and hydrogen 'slip' from any combustion processes • any other sources of methane or hydrogen emissions For combustion plant, your monitoring plan should demonstrate compliance with the applicable emission limits. Where you are using post-combustion CO_2 capture, for example, using amine solvent, your plan should include monitoring relevant emissions such as: • ammonia • volatile components of the capture solvent • likely degradation products such as nitrosamines and nitramines Specific pollutants arising from post-combustion capture may be monitored by continuous emissions monitors, if they are available, or by periodic extractive sampling. Where aerosol formation is expected, the sampling must be isokinetic.		
7.2	**Monitoring emissions to water** You must monitor emissions to water based on expected impurities (for example, ammonia, amine compounds, methanol, CO_2) using appropriate methods and measuring techniques. You should use monitoring standards for discharges to water following: • BATC for common wastewater and waste gas treatment/management system in the chemical sector • BATC for the refining of mineral oil and gas	There is potential to contaminate surface-runoff water with either oil, ammonia or glycol in case of accidental spills in the designated contaminated areas. The likelihood of oil contaminated water stream is more in comparison to ammonia and glycol. The high-level plan is to contain ammonia or glycol contaminated water in the sump and truck it outside the facility for further processing and/or disposal. The oil contaminated water will be routed through an oil/water separator system to separate oil from water and then route the oil free water into the retention ponds. Oil/Water separator sumps will have oil in water analyzer to monitor oil content in the oil free water compartment. Basically, waste water streams (except for the blowdown waters form cooling water & boiler system) will end up into the retention pond. The water in the retention pond will be sampled before sending the wastewater into the outfall ditches. With the procedure of holding the water in the retention pond and sampling it, AP will have better control over quality of water that will be routed to the outfall ditches and in event of accidental contamination of the retention pond water, it will be trucked out to third party for further processing and/or disposal. A Monitoring Plan will be in place to monitor discharges to water as per the relevant schedule in the Environmental Permit. A monitoring plan will be produced before the plant is commissioned.	Yes
7.3	**Monitoring standards** The person who carries out your monitoring must be competent and work to recognised standards such as the Environment Agency's monitoring certification scheme (MCERTS). MCERTS sets the monitoring standards you should meet. The Environment Agency recommends that you use the MCERTS scheme, where applicable. You can use another certified monitoring standard, but you must provide evidence that it is equivalent to the MCERTS standards. There are no prescriptive BAT requirements for how to carry out monitoring. Monitoring methods need to be flexible to meet specific site or operational conditions. You must use a laboratory accredited 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	Monitoring will be carried out in line with the scheduled monitoring detailed in the EP using the relevant MCerts or equivalent standards in an accredited laboratory. Monitoring for carbon intensity of the hydrogen product will be aligned with EU RED III and UK Low Carbon Hydrogen Standards	Yes
7.4	**Monitoring CO_2 capture performance**	N/A no carbon capture taking place.	N/A

BAT No.	BATC Requirements	Operators Response	Operating to BAT
	You should clearly identify how you will monitor the CO_2 capture performance of the plant. The regulators expect you to monitor CO_2 capture performance according to standards that are recognised under the UK ETS. Measurements required to monitor CO_2 emissions to atmosphere may, for example, include directly measuring the flow and composition of fuel gas to combustion systems. This, together with measuring the following, will allow monitoring of the CO_2 capture rate and CO_2 quality (considering any impurities that could impact downstream systems): • flow and composition of feed gas • hydrogen product (including methane content where applicable) • CO_2 product streams You will need to include: • CO_2 equivalent mass balance • CO_2 equivalent in feed gas • total capture efficiency (CO_2 equivalent captured as a mass percentage of CO_2 equivalent in feed gas) • CO_2 equivalent released to the environment • CO_2 quality		
7.5	a) Monitoring process performance You should identify the main requirements for monitoring process operations where these ultimately impact on environmental performance, including, for example, for the CO_2 capture system: • amine system performance, including monitoring of amine solvent quality such as amine concentration • pH and presence of degradation or corrosion products • amine temperatures • amine and wash water circulation rates • rich and lean amine CO_2 loading • stripper reboiler steam rates You should monitor energy efficiency in the hydrogen production and CO_2 capture processes by measuring feed and product gas flows and electrical power consumption to calculate overall energy consumption. You should monitor the quality of the hydrogen product to ensure it is fit for purpose. Requirements for process performance monitoring, either online or offline, will also be a condition of the permit.	The Installation will be controlled and operated via a BPCS to continuously monitor the operation of the plant and equipment at the site including key process parameters such as emissions, flue gas flow, flow, temperatures and pressures. Any non-conformance or deviation in normal operating parameters will be identified by the BPCS to allow the operator to take action to avoid a breach of permitted emission levels Process and operational performance will be detailed in Air Products (AP) procedures which will include: • equipment condition monitoring; • periodic inspection and testing of systems; • functional testing of all safety devices; • inspection and testing of devices according to company standards and the relevant Codes of Practice; and, • relevant AP documents for the Periodic Inspection and Test (PI&T) programme relevant to the plant are included in the operational procedures. Supporting Statement section 4.4.10 (Document ref: VP3425SV/APP/SS)	Yes

BAT No.	BATC Requirements	Operators Response	Operating to BAT
8	**Unplanned emissions and accidents** You should propose a leak detection and repair (LDAR) programme that is appropriate for the fluids and their composition. This should use industry best practice to manage releases, including from joints, flanges, seals and glands. You should include how you will use LDAR to eliminate or reduce fugitive emissions of methane and hydrogen due to their global warming potential. Your hazard assessment and mitigation for the plant must consider the risks of accidental releases to the environment. This should also consider the actual composition of the liquids, gases and vapours that could be released from the plant after an extended period of operation.	Leak detection and management systems will be in place and the Operator will develop an appropriate LDAR Plan prior to the plant being commissioned. The Environmental Risk Assessment looks at the risks and impacts of unplanned emissions and accidents, The Supporting Statement also covers the management techniques for such events (Document ref: VP3425SV/APP/SS)	Yes
9	**Noise and odour** You need to consider sources that have high potential for noise and vibration. In, particular, CO_2 and hydrogen compression, pumping and fan noise could be significant additional sources. Once you've identified the main sources and transmission pathways, you should consider using common noise and vibration abatement techniques and mitigation at source, wherever possible. For example: • embankments to screen the source of noise • enclosure of noisy plant or components in sound-absorbing structures • anti-vibration supports and interconnections for equipment • orientation and location of noise-emitting machinery • changing the frequency of the sound. Handling, storing and using some amines may result in odour emissions, so you should always use best practice containment methods. Where there is increased risk that odour from activities will cause pollution beyond the site boundary, you will need to send an odour management plan with your permit application.	A Noise Impact Assessment and Noise Management Plan have been produced to identify and mitigate against potential noise sources. See Noise Impact Assessment and Noise Management Plan (Appendix F and G of the Supporting Statement). An Odour Management Plan has been produced to meet best practice requirements. See Odour Management Plan (Appendix H of Supporting Statement).	Yes

4 BAT Conclusion for Storage of Ammonia and Hydrogen

5.1.1 The BRef document for Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF) was reviewed in respect of the storage and handling of ammonia and hydrogen – this directs that the BAT requirements for storage of such chemicals is defined within European Commission (2005). "BREF on Emissions from Storage". The assessment against the BAT for storage is detailed below.

Table 4.1 BAT Assessment Against BRef For Emissions from Storage – Ammonia and Hydrogen in Tanks

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
1	**Storage of liquids and liquefied gases** Tanks – General Principles to prevent and reduce emissions: a) Tank design b) Inspection and maintenance c) Location and layout d) Tank colour e) Emissions minimisation principle in tank storage f) Monitoring of VOC g) Dedicated systems	**Tank Design** Tank design for ammonia ~~and hydrogen~~ has been developed and a double containment tank is considered most appropriate ~~for both substances~~. Each tank will meet the relevant regulatory standards (i.e., environmental and safety) including CIRIA C736 requirements. Each tank design will be subject to HAZID and HAZOP studies and will consider: • The physico-chemical properties of the substances being stored; • Material of construction is suited to material properties; • The instrumentation and controls required at each tank, specific to the material stored; • The safety devices such as pressure relief devices, interlocks and containment; • The tank monitoring arrangements including alarms and associated control processes; • Access for maintenance and inspections; • Tank colour taking into consideration the liquid/vapour properties of each material; and • Potential emergency scenarios specific to the material being stored. The liquid hydrogen tanks are multiple vacuum insulated pressure vessels, installed horizontally and connected by piping to equalize the level across the tanks. The tanks are equipped with pressure build-up units to maintain pressure whilst liquid is drawn from them, and excess vapour is returned to the liquefier for recovery. See section 4.2. **Inspection and Maintenance** Each tank and its associated pipework will be included in the Planned Preventative Inspection and Maintenance PPIM) programme. PPIM includes a means of tracking the status of maintenance through to completion. Corrective work such as repairs or remediation required as a result of equipment fault, breakdown or degradation shall be recorded and managed in the same system. This will cover all equipment, plant wide. **Location and Layout** Ammonia storage tank will be located on the East site which closest to the incoming ammonia pipeline from the terminal. Hydrogen storage will be located on the west site to facilitate loading of vehicles. Each tank provides for above ground storage and are located in well-ventilated areas. A generic tank design is shown in Drawing H1006281_R5 and is subject to detailed design for each material during FEED. **Tank Colour** Hydrogen tank cryogenic tanks will be painted white to minimize heat leak. **Emissions Minimisation**	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
		Ammonia storage tank has fixed fiberglass blanket at the top which minimizes heat gain from warm dome space above the insulation deck. Ammonia storage tank is equipped with refrigeration system to recover static boil-off from the ammonia storage tank due to heat gain from ambient. Ammonia vapor from tank is compressed, liquefied, chilled and sent back to ammonia tank as part of the recovery system, thus minimizing emissions. Ammonia tank is "Tank in wall," outer concrete wall contains any liquid ammonia leak from the inner tank. Each tank is situated within a containment bund which prevent releases to ground and water. **VOC Monitoring** An LDAR management plan will be developed for the site prior to plant commissioning. **Dedicated Systems** The installation will use dedicated storage systems for ammonia and H2. See Supporting Statement.	
2	Tank specific considerations Fixed roof tanks	**Ammonia Tank** The ammonia will be stored at nearly atmospheric pressure and minus 33°C. Tank design has been considered and a double containment tank has been chosen with the following benefits: • Fixed dome roof, with an insulation deck at the top (fiberglass blanket) few meters above the design liquid level. • Annular space & outside of tank: Not exposed to Ammonia in normal service and access for inspection O&M. • Acoustic Emission monitoring system for warning of stress corrosion cracking. • Outer concrete wall contains any liquid leak and provides protection against blast and external impact. • Elevated tank foundation - Air gap to protect against cold propagation to ground and flood protection. • Insulation - Outside tank shell (not roof) Tank base and TCP - Cellular glass. Suspended deck - Fibreglass. • Annular space of tank provided with ammonia detectors and temperature sensors. **Hydrogen Tank** Liquid hydrogen is stored at 0.5 barg and saturated temperature. The tank is a pressure vessel and placed horizontally. • Double wall, thermally insulated, vacuum jacketed cryogenic tank and surrounding liquid pipework minimizes heat leak and therefore vaporization in the tank. • Sufficient liquid level protection instrumentation and operating pressure regulator system to ensure the tank stable and safe operation. • Pressure buildup system is used to maintain tank pressure to avoid the vacuum in the inner thank. • The tanks have pressure safety valves connected to a vent header which will discharge to atmosphere and a bursting disc as a final layer of protection which will discharge directly to atmosphere. • The structure will be built with gravel underneath, which is graded away from storage. This will encourage the dissipation and vaporization of hydrogen in case of a liquid spill.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
		See Supporting Statement.	
3	Preventing incidents and (major) accidents: • Safety and risk management • Operational procedures and training • Leakage due to corrosion and/or erosion • Operational procedures and instrumentation to prevent overfill • Instrumentation and automation to detect leakage • Flammable areas and ignition sources • Fire protection • Fire-fighting equipment • Containment of contaminated extinguishant	**Safety and Risk Management** The site is subject to COMAH regulation and processes/infrastructure including storage tanks will be subject to HAZID and HAZOP studies, development of a Safety Report and an Emergency Management Plan. The DCO application includes a Major Accidents and Disasters chapter in the Environmental Statement and the production of a COMAH Safety Report. **Operational Procedures and Training** Appropriate documented procedures will be implemented for environmentally critical plant, equipment and operations, whose failure could lead to adverse impact on the environment. These procedures will cover: • Operation of equipment; • Maintenance of equipment; and, • Spill contingency procedures. Site staff will be subject to relevant training in respect of site procedures and operational control. **Leakage Due to Corrosion and/or erosion.** The tanks will be designed with regards to the physico-chemical properties of the materials being stored and will be constructed of an appropriate material (e.g., concrete or steel). Where required each ammonia and glycol tank will be equipped with containment to retain any materials which may have leaked thus minimizing risk to ground or waters. Each tank will be subject to routine inspection and maintenance and the following maintenance techniques are used to provide early detection of impending faults or conditions likely to compromise Safety, Environmental Containment or Production: • a portable vibration data collection and analysis package can be used to collect machine-operating data and to evaluate rotating machinery; • acoustic emission monitoring to detect stress erosion cracking. • electric motor performance is also monitored; • leak detection and repair; - ultrasonic testing can be used to monitor valve systems for leakage by detecting stem & flange leakage on gaseous duty, and valve passing on both liquid and gaseous systems; and • emergency response equipment is serviced and maintained in accordance with requirements defined in the site major emergency procedure. Details of the maintenance tasks and compliance are available on-site via the SAP System. Backup systems will also be subject to regular maintenance as per operations standards. Mandatory tasks must be completed at a defined frequency where they are associated with regulatory, statutory, mechanical integrity or other procedural requirements.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
		Operational procedures and instrumentation to prevent overfill/detect leakage The plant has undergone best practice in the engineering design of process facilities and the specification of SIS Safety Instrumented Functions and safety lifecycle process in accordance with IEC 61511, which are important to prevent overfill, a loss of containment occurring from process systems which could lead to an accident. These standards are a key mitigation measure in the prevention of a number of risk events, such as fire, explosion and toxic release. During Project operation and maintenance activities, detailed risk assessments will be completed, documented and regularly updated to reflect any changes made on site. These risk assessments will demonstrate a robust basis for safe operation of the Site as required by DSEAR. **Fire protection** The site is subject to COMAH regulation and fire protection measures will be developed during the detailed design following HAZID and HAZOP studies. Details will be captured in the Site Safety Report and Site Emergency Plan. **Fire Fighting Equipment** Portable fire extinguishers compliant with BS 5306 will be provided in accordance with installation guidance codes of practice. Staff will be trained in the use of such equipment; all extinguishers will be checked as part of the site inspection programme. A manual system provides firefighting water at strategic positions around the Site which will be specified in the detailed design. **Containment of Contaminated Extinguishant** Firewater will be managed via the site surface water drainage systems which can be isolated in the event of a fire to contain the firewater on site. See Supporting Statement and Environmental Risk Assessment (Appendix I).	
4	<u>Transfer and handling of liquids and liquefied gases</u> • Inspection and maintenance • Leak detection and repair programme • Emissions minimisation principle in tank storage • Safety and risk management • Operational procedures and training	The controls outlined No 3 are also applicable to the transfer and handling of ammonia and hydrogen.	Yes
5	<u>Considerations on transfer and handling techniques</u> **Piping** BAT is to apply aboveground closed piping in new situations.	Above ground pipelines will run from the Terminal to the East Site to the Ammonia Storage area to deliver the offloaded refrigerated liquid ammonia to the 55,000 MT ammonia storage tank. Underground pipework will also connect the East and West sites. The pipeline design will minmise the number of bolted flanges and gasket-sealed joints by replacing them with welded connections. Where bolted flange connections cannot be avoided, the operator will: • fit blind flanges to infrequently used fittings to prevent accidental opening.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
		• 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 • Use of high integrity gaskets, such as spiral wound, kammprofile or ring joints due to toxicity of ammonia. Prevent internal 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. Prevent external corrosion by applying appropriate layers of a coating system where applicable depending on the site-specific conditions. The liquid ammonia Pipeline between the jetty and the ammonia storage tank will be provided with leak detection system. 2 X 16” liquid ammonia pipelines transfer the liquid ammonia from Jetty to Storage and each pipeline will have installed emergency shutdown valves (ESDV’s) at certain intervals along the pipeline run, to isolate and minimize the liquid ammonia volume in event of leaks form pipeline Pressure and temperature instruments are installed on the pipelines to monitor operating conditions of the pipeline while transferring liquid ammonia. The 2 X 16” pipelines will have liquid ammonia inventory only when offloading from Ship is being done or cooldown of the pipelines are to be done before offloading form Ship, thus most of the which would be not frequently done for the Immingham site, most of the times pipelines will be filled only with low pressure ammonia vapor, thus minimizing the risk at site. The liquid ammonia pipeline between the East and West sites will be buried underground and be pipe-in-sleeve design. The pipeline will be provided with the leak detection system. 2 X 8” liquid ammonia pipelines transfer the liquid ammonia from east to west site and have emergency shutdown valves (ESDV’s) installed at each end of the pipeline to isolate the liquid ammonia inventory in event of leaks. Pressure and temperature instruments are installed on the pipelines to monitor operating conditions of the pipeline while transferring liquid ammonia.	
6	<u>Vapour treatment</u> 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.	Flashing & vapour displacement will occur when importing ammonia into the storage tank. The ammonia storage tank has a dedicated compressor and reliquefication system which has been sized adequately to ensure that ammonia will not be flared during the importing operation.	
7	<u>Valves</u> BAT for valves include: • correct selection of the packing material and construction for the process application with monitoring, focusing 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.	Valves will be finalised at FEED following HAZID and HZAOP studies and will be selected and installed to ensure valves are appropriate to the properties of the materials being handled.	Yes
8	<u>Pumps and compressors</u> **Installation and maintenance of pumps and compressors** The design, installation and operation of the pump or compressor heavily influence the life	Pumps and compressors will be finalised at FEED following HAZID and HZAOP studies and will be selected and installed to ensure:	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	potential and reliability of the sealing system. 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 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. **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. **Sealing systems in compressors** BAT for compressors transferring non-toxic gases is to apply gas lubricated mechanical seals. 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. In very high pressure services, BAT is to apply a triple tandem seal system.	• Equipment is fixed to its base plate and/or frame; • Shafts, casings, drives and pumps will be correctly aligned; • Hydraulic and rotatingg systems are correctly balanced; • Equipment is selected to suit its duty and the materials being handled; • Equipment is operated and maintained in accordance with manufacturer's recommendations; and • Seals for pumps and compressors will be suitable for the material being handled.	
9	**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.	No intrusive sampling is required for the products, there are sample lines linked to on line equipment and no operator intervention is required.	

5 Best Available Techniques – Emergency backup diesel engines on installations

Emergency generators at the site are required to meet the requirements in the Environment Agency "BAT Guidance for Emergency Back-up Diesel engines in installations and will be used for

- Start up
- for emergency backup power supply

The generators will have capacity more than or equal to 1 megawatt thermal (MWth) and less than 50MWth burning any fuel.

The assessment of Bat for the generators is presented in the table below.

Table 5.1 BAT Assessment for Emergency Back-up Diesel Engines

Item No.	BAT Standard	Demonstration of BAT – Operator's Response	Operating to BAT
1	**Emission Requirements:** ▪ Engines must be optimised to reduce emissions. ▪ Combustion plant specification sheets that keep to one or more of the former 2g TA Luft and United States Environment Protection Agency (EPA) Tier 2 (or equivalent) standards are acceptable proof of BAT plant. ▪ Approximately 750mg per m^3 NO_x (as NO_2) at 15% O_2 standard temperature and pressure, dry, 273K and 101.3kPa (equivalent to 2,000mg per m^3 at 5% O_2 – commonly termed '2g') at a typical emergency load (usually greater than 67% of standby power rating). A copy of engine specification sheet should be supplied with application. Your stack design should ensure good flue gas dispersion. Stacks should be vertical and emissions should not be obstructed by caps or cowls.	Engines will be maintained optimised and meet the relevant standards, see Appendix A. ▪ stack will ensure good flue gas dispersion: ▪ vertical stacks will be employed unobstructed by caps or cowls. A copy of the engine specifications are provided in the Appendix A	Yes
2	**Operational** Testing and Maintenance plan in place for all site equipment within the installation boundary, including the backup generator diesel engines. To meet standards for operational controls these will include; – diesel engines to be tested one at a time, – they will not be tested for more than 50 hours per annum – or during periods of poor air quality.	Diesel engines will be included in the Operational Maintenance Plan that will be in place before commissioning We can confirm that engines will operate will be tested individually and testing won't exceed 50 hrs/annum.	Yes

Appendix A Engine Specification

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Standby Diesel Generator Specification Data Sheet

Opportunity Number: EN222517 | Last Rev By: BREARLM

Opportunity Name: Immingham NH3 Terminal | Last Rev Date: 28/03/2024

Tag Name/Number: 600-P610

Rev.

BASIC DATA

Quantity Required:	1				
Nameplate Power	1200	kW	at	0.8	PF Lagging
Voltage	400	V			
Frequency:	50	Hz			
Phase:	3				

STANDARDS & SPECIFICATIONS

Industry Standards:

- [ ] NEMA MG-1
- [x] IEC-60034
- [ ] Other ______________________

Air Products Specifications:

- [x] 4WEL-52361
- [ ] Other ______________________

EMISSION STANDARDS

- [ ] Compliance with US EPA NSPS under the applicable provisions of 40 CFR Part 60
- [ ] EPA Compliance Statement Required
- [x] Exhaust Emission Data Sheet Required
- [ ] EPA Certificate of Conformity Required
- [x] European Stage V
- [ ] Other ______________________

Document Number: EN222517-601-ED1-00003 | Release Purpose: For Enquiry | Rev: 02

SITE SPECIFICS

General:

Location:	Immingham, UK			
Altitude:	6	m	20	ft
Seismic Code:	N/A			
Seismic Zone:	N/A			
Units of Measure:	Metric			
Document/Nameplate Language:	English (UK)			

Ambient Conditions:

Ambient Temp.	(5% summer high)	22.8	C	73	F
	(5% winter low)	-3.3	C	26	F

OUTPUT CIRCUIT BREAKER

☐ 3-Pole ☒ 3-Pole + N

OPTIONS

- ☐ Engine Options (4WEL52361 section 3.2.2.1)
- ☒ Generator Insulation Class F with Class B Rise (4WEL52361 section 3.2.2.2.1)
- ☒ Future Paralleling Capability (4WEL52361 section 3.2.2.2.2)
- ☒ Space Heaters 230 VAC (4WEL52361 section 3.2.2.2.3)
- ☒ Termination Pads (4WEL52361 section 3.2.2.2.4)
- ☒ Wiring Diagrams Permanently Attached (4WEL52361 section 3.2.2.2.5)
- ☒ Resistance Temperature Detectors (RTD's) (4WEL52361 section 3.2.2.2.6)
- ☒ Battery Box Heater at 230 VAC (4WEL52361 section 3.2.2.3)
- ☒ Auxiliary Fuel Tank sized for 24 Hours (4WEL52361 section 3.2.2.4)
- ☒ Silencer Type Critical (4WEL52361 section 3.2.2.5)
- ☒ Load Bank, Controller, and Test Circuit Breaker (4WEL52361 section 3.2.2.6)
- ☐ Inspection Points (4WEL52361 section 3.2.3.1)
- ☒ Witness Testing (4WEL52361 section 3.2.3.2)
- ☐ Additional Testing (4WEL52361 section 3.2.3.3)
- ☐ Installation and Commissioning (4WEL52361 section 3.2.4)

Document Number: EN222517-601-ED1-00003 Release Purpose: For Enquiry Rev: 02

MAIN SUPPLY TERMINATIONS

[X] Supplier Furnished Box with: [X] Removable Non-Magnetic Gland Plate for Cables
Quantity: 9 Size: 400mm2

LOAD DATA

Largest Motor to be Started:

186	KW
400	VAC
3	Phase
50	Hz
19.1	FLA
138	LRA

MISCELLANEOUS

1. All RTD's to be grounded at the generator by the generator vendor.