Immingham Green Energy Terminal
Green Hydrogen Production Facility

EPR/VP3425SV/A001

Environmental Permit Application

Appendix D2 – Assessment of Best Available Techniques for Energy Efficiency

Environmental Permitting (England and Wales) Regulations 2016

Applicant: Air Products BR Ltd

May 2024

Environmental Permitting (England and Wales) Regulations 2016

Immingham Green Energy Terminal Green Hydrogen Production Facility

Environmental Permit Application

Appendix D2 – Assessment of Best Available Techniques for Energy Efficiency

---

Regulation Reference	EPR Regulations, Part 2, Chapter 1 R12
Environmental Permit Reference	EPR/VP3425SV/A001
Application Document Reference	VP3425SV/APP/BAT02
Author	Air Products (BR) Limited

Version	Date	Status of Version
Revision 1	28 March 2024	For Client Review
Revision 2	02 May	Final Review
Issue 1	17 May 2024	Issue to Regulator

Table of contents

Chapter **Pages**

Tables

1.0 INTRODUCTION

1.1. Purpose of the Report

1.1.1 This document 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 energy efficiency. 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:

- EU Best Available Techniques Reference (BRef) Document for Energy Efficiency

1.1.4 The Main Supporting Document provides an overall view of the Permit application being made for the proposed installation. In addition to this energy efficiency BAT assessment, additional BAT assessments have been prepared for emissions (Appendix D1), process and technology (Appendix D3) 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 NH_3 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 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.

2.0 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 hydrogen 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:

- The technology licensors requiring commercial confidentiality of their process cycle and catalysis;
- 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.

2.2.4 A number of BAT reference documents were confirmed as applicable during pre-application discussions with the Environment Agency covering the process and technology related to H_2 production at the Immingham Green Energy Terminal. This section provides an overview of the relevant BAT guidance document, followed by the BAT conclusions in tabulated form in the subsequent sections.

2.2.5 This assessment addresses energy efficiency aspects proposed for the installation and the EU BRef Document for Energy Efficiency is the appropriate BAT standard detailing how to achieve energy efficient operation of the proposed installation. BAT standards from the BRef document are presented and approaches justified in section 4 below.

2.2.6 The approach to BAT has been agreed with the Environment Agency (EA) during the pre-application discussions.

2.3. Conclusions

2.3.1 On the basis of the assessment against the required BAT Standards in BRef for Energy Efficiency, as shown in section 3, it is considered that the proposed installation will be designed and operated in compliance with and in accordance with BAT.

3.0 ENERGY EFFICIENCY FOR THE INSTALLATION

3.1. Design Basis for Energy Efficiency

3.1.1 The overall performance of the H_2 production plant for optimised energy efficiency is dependent on, as far as practical, of electrical, and water circuits along with optimised integration of utilities.

3.1.2 Thermal modelling will be undertaken during each design phase to identify the key plant areas for energy performance management including consideration of:

- Optimised design of the H2 production process to provide for the most efficient operation of the plant;
- Optimised recovery or reuse of low heat streams.

3.1.3 The pressure swing adsorption (PSA) unit design will be optimised to remove traces of impurities to purify the hydrogen to >98 vol % H_2. The tail gas will be used as a fuel.

3.1.4 As design progresses through FEED consideration of further energy efficiency optimisations where practicable such as:

- Insulation of relevant areas of the plant to reduce heat loss during shutdown; and
- Heat recovery from compression systems.

3.2. Cooling System

3.2.1 The cooling systems will be designed for optimised energy efficiency.

3.2.2 The plant will be cooled by open loop cooling water system using evaporative cooling towers cooling water towers, with raw water feed from Anglian Water Limited as described in the BAT assessment for cooling water. The selection of the primary cooling systems is considered to represent BAT for the installation.

3.2.3 The cooling system designs will be refined during FEED and optimised during commissioning to maximise energy efficiency of the installation as a whole.

3.3. Maintenance Philosophy

3.3.1 The operator will minimise the number of planned shutdowns as far as is practicable by harmonising and scheduling the maintenance of major equipment within the installation, and by implementing an appropriate design, maintenance philosophy and spares strategy.

3.3.2 Maintenance routines will follow a cycle as shutdowns are required after a set number of operating hours or start-ups (whichever comes earliest).

3.3.3 All equipment for use in the proposed plant will be selected to maximise energy efficiency in the proposed duties, whilst considering the reliability, part load efficiency and other operating parameters.

3.3.4 Elements of the plant's design that help achieve the high energy efficiency include the following.

- Design following current best practices in optimising efficiency;
- The use of wet cooling instead of air cooling or direct once through cooling for cooling water system;
- High efficiency motors and drives to reduce parasitic loads;
- The use of plant components sized appropriately for the design capacity of the plant, so that each element is operating optimally and efficiently;
- Where needed variable speed drives (VSDs) will be included on all sizeable motors to optimise process control; and
- The effective insulation of hot surfaces and cold surfaces such as vacuum jacketed for critical liquid hydrogen lines.

3.3.5 The plant will also be subject to regular planned maintenance in order to optimise the efficiency of the equipment on site, including (but not limited to):

- Continuous and intermittent water quality maintenance activities, such as blowdown of the steam drum and injection of chemicals, to maintain the cycle water quality and optimum working medium;
- Boiler chemical cleaning;
- Optimised lubrication schedules in accordance with OEM specifications;
- Performance monitoring for motors, pumps, blowers and compressors;
- Production plant minor inspection regime; and
- Production major plant inspection/overhaul.

4.0 BAT ASSESSMENT FOR ENERGY EFFICIENCY

Table 3.1 Assessment Against BRef for Energy Efficiency

BAT No.	BATC Requirement	Demonstration of BAT-Operator Response	Indicative BAT?
1	**Energy efficiency management** BAT is to implement and adhere to an energy efficiency management system (ENEMS) that incorporates, as appropriate to the local circumstances, all of the following features (see Section 2.1. The letters (a), (b), etc. below, correspond those in Section 2.1):		
	a. commitment of top management (commitment of the top management is regarded as a precondition for the successful application of energy efficiency management)	As described in Management Techniques, Section 4 of the Supporting Statement (Document ref: VP3425SV/APP/SS) AP will operate the installation in accordance with their own Environmental Management System (EMS), which will include operational and commercial management of the operations and covers the BAT elements detailed. Air Products' EMS will be consistent with various national and international management system standards and the facility will be accredited with the most relevant standard; BS EN ISO14001:2015. Procedures for the management and monitoring of energy will sit within the EMS. The operator will maintain an energy efficiency policy within the EMS.	Yes
	b. definition of an energy efficiency policy for the installation by top management		
	c. planning and establishing objectives and targets (see BAT 2, 3 and 8)	The EMS will include the annual establishment of objectives and targets including those associated with energy and performance is monitored in accordance with defined Key Performance Indicators (KPIs). The site will maintain an Energy Efficiency Plan as part of the EMS and will report on its energy performance as defined in the Environmental Permit	
	d. implementation and operation of procedures paying particular attention to: i. structure and responsibility ii. training, awareness and competence (see BAT 13) iii. communication iv. employee involvement v. documentation vi. effective control of processes (see BAT 14) vii. maintenance (see BAT 15) viii. emergency preparedness and response ix. safeguarding compliance with energy efficiency-related legislation and agreements (where such agreements exist).	The policies and procedures within the EMS will be site specific and address the following: • Management organisation and responsibilities • Workforce (and contractor) competence, training and support • Systematic identification of hazards and risk assessment • Legal and other requirements • Plant integrity and maintenance • Safe systems of work • Controls for the safe operation of processes • Emergency planning - SHE (including energy) performance indicators and continuous improvement • Document & record control • Communications	Yes
	e. Benchmarking: the identification and assessment of energy efficiency indicators over time (see BAT 8), and the systematic and regular comparisons with sector, national or regional benchmarks for energy efficiency, where verified data are available (see Sections 2.1(e), 2.16 and BAT 9)	As a first-of-a-kind project, there are no defined benchmarks for the proposed installation as a whole. It is expected that benchmarks for operational parameters will be developed during commissioning and ongoing operation in consultation and agreement with the Regulator.	Yes
	f. checking performance and taking corrective action paying particular attention to: i. monitoring and measurement (see BAT 16)	• Monitoring of performance in relation to energy and energy efficiency requirements will be defined in the EMS and will be undertaken in accordance with the requirements of	Yes

BAT No.	BATC Requirement	Demonstration of BAT-Operator Response	Indicative BAT?
	ii. corrective and preventive action iii. maintenance of records iv. independent (where practicable) internal auditing in order to determine whether or not the energy efficiency management system conforms to planned arrangements and has been properly implemented and maintained (see BAT 4 and 5)	the environmental permit which will require the operator to report energy consumption annually to the Environment Agency. • The Installation will be controlled and operated via a BPCS to continuously monitor the operation of the plant and equipment at the site. 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. • Records of plant operation, maintenance and corrective action will be maintained in accordance with document/record management arrangements defined within the EMS • The IMS is subject to periodic review and update and will be subject to internal audits as well as external certification audits.	
	g. review of the ENEMS and its continuing suitability, adequacy and effectiveness by top management	As a certified management system the EMS including energy management will be reviewed at least annually by senior management.	Yes
	h. preparation and publication (and possibly external validation) of a regular energy efficiency statement describing all the significant environmental aspects of the installation, allowing for year-by-year comparison against environmental objectives and targets as well as with sector benchmarks as appropriate	Air Products will produce a summary as part of our corporate environmental report.	Yes
	i. having the management system and audit procedure examined and validated by an accredited certification body or an external ENEMS verifier	The EMS will be subject to periodic review and update and will be subject to external certification audits against BS EN ISO 14001:2015	Yes
	j. when designing a new unit, taking into account the environmental impact from the eventual decommissioning of the unit	The installation will be constructed in such a manner to ensure: • Fuels and cooling fluids are stored in above ground tanks with appropriate containment • Process areas are constructed on impermeable concrete surfaces that minimise the potential for ingress of pollutants to groundwater or land during the operation and decommissioning of the installation and facilitates ease of decontamination. • Biodegradable and recyclable materials will be used where possible • The chemicals being processed at this facility are gases at ambient conditions and therefore inherently will vaporise and disperse to the atmosphere - minimising concerns for ground contamination. Details of the approach to decommissioning are provided in Section 8 of the Supporting Statement (Document ref: VP3425SV/APP/SS)	Yes
	k. development of energy efficient technologies, and to follow developments in energy efficiency techniques	Relevant developments in energy efficient technologies will be captured if appropriate in the annual EMS review.	Yes
2	**Planning and establishing objectives and targets - Continuous environmental improvement** BAT is to continuously minimise the environmental impact of an installation by planning actions and investments on an integrated basis and for the short, medium and long term, considering the cost-benefits and cross-media effects	The proposed installation will be designed to current compliance and design standards. It will be operated in accordance with the EMS, with regular appraisal of the equipment in use at the installation. The EMS will set periodic objectives and targets to control and minimise the impact of operations, including energy consumption (considering the cost benefits).	Yes
3	**Identification of energy efficiency aspects of an installation and opportunities for energy savings**	The proposed installation will be designed to current compliance and design standards. It will be operated in accordance with the EMS, with regular appraisal of equipment in use at	Yes

BAT No.	BATC Requirement	Demonstration of BAT-Operator Response	Indicative BAT?
	BAT is to identify the aspects of an installation that influence energy efficiency by carrying out an audit. It is important that an audit is coherent with a systems approach (see BAT 7).	the installation. Periodic energy efficiency assessments will be conducted to identify opportunities for energy savings	
4	**Identification of energy efficiency aspects of an installation and opportunities for energy savings** When carrying out an audit, BAT is to ensure that the audit identifies the following aspects (see Section 2.11): a. energy use and type in the installation and its component systems and processes b. energy-using equipment, and the type and quantity of energy used in the installation c. possibilities to minimise energy use, such as: • controlling/reducing operating times, e.g. switching off when not in use (e.g. see Sections 3.6, 3.7, 3.8, 3.9, 3.11) • ensuring insulation is optimised, e.g. see Sections 3.1.7, 3.2.11 and 3.11.3.7 • optimising utilities, associated systems, processes and equipment (see Chapter 3) d. possibilities to use alternative sources or use of energy that is more efficient, in particular energy surplus from other processes and/or systems, see Section 3.3 e. possibilities to apply energy surplus to other processes and/or systems, see Section 3.3 f. possibilities to upgrade heat quality (see Section 3.3.2	The EMS will include a process for regular energy efficiency auditing as part of the performance evaluation. The BAT requirements (a-f) will be considerations during the assessments where applicable. The operator is currently looking into alternative sources of energy to increase efficiency of the installation in the future. Currently the installation is designed to run on natural gas so there will be no energy surplus to apply elsewhere.	Yes
5	**Identification of energy efficiency aspects of an installation and opportunities for energy savings** BAT is to use appropriate tools or methodologies to assist with identifying and quantifying energy optimisation, such as: • energy models, databases and balances (see Section 2.15) • a technique such as pinch methodology (see Section 2.12) exergy or enthalpy analysis (see Section 2.13), or thermo-economics (see Section 2.14) • estimates and calculations (see Sections 1.5 and 2.10.2)	The FEED design for the proposed installation, and its ongoing optimisation will include the use of industry standard energy model tools, to identify energy efficiency optimisation measures.	Yes
6	Identification of energy efficiency aspects of an installation and opportunities for energy savings BAT is to identify opportunities to optimise energy recovery within the installation, between systems within the installation (see BAT 7) and/or with a third party (or parties), such as those described in Sections 3.2, 3.3 and 3.4	As described in Section 3.2 of the Supporting Statement (Document ref: VP3425SV/APP/SS) the proposed installation will be designed to maximise systems integration. Once operating, some H2 tail gas from the process will be fed back as fuel within the HPU. Water reduction and reuse measures have been incorporated into design of the H2 production process. This includes use of a recirculating water system reuse and segregation of water streams and process control of chemical dosing and cooling water and boiler blow down systems.	Yes
7	**A systems approach to energy management** BAT is to optimise energy efficiency by taking a systems approach to energy management in the installation. Systems to be considered for optimising as a whole are - process units (see sector BREFs) - heating systems such as: steam (see Section 3.2) hot water - cooling and vacuum (see the ICS BREF) - motor driven systems such as: compressed air (see Section 3.7) pumping (see Section 3.8) - lighting (see Section 3.10) - drying, separation and concentration (see Section 3.11).	See response to BAT 5 – the use of energy models considers the system as a whole. See Section 3 for further detail.	Yes
8	**Establishing and reviewing energy efficiency objectives and indicators** BAT is to establish energy efficiency indicators by carrying out all of the following:	Energy efficiency indicators, boundaries and variables will be developed during the design of the installation and will be maintained via the EMS. Initial indicators for the new plant will be established during commissioning of the plant	Yes

BAT No.	BATC Requirement	Demonstration of BAT-Operator Response	Indicative BAT?
	a. identifying suitable energy efficiency indicators for the installation, and where necessary, individual processes, systems and/or units, and measure their change over time or after the implementation of energy efficiency measures (see Sections 1.3 and 1.3.4) b. identifying and recording appropriate boundaries associated with the indicators (see Sections 1.3.5 and 1.5.1) c. identifying and recording factors that can cause variation in the energy efficiency of the relevant process, systems and/or units (see Sections 1.3.6 and 1.5.2).		
9	**Benchmarking** BAT is to carry out systematic and regular comparisons with sector, national or regional benchmarks, where validated data are available.	The plant performance guarantees will be developed through the FEED process and benchmarked against performance information published from other developing H2 production projects as well as performance data from test and on current operation of other facilities including those run by AP. However as a first-of-a-kind project, there are no defined benchmarks for the proposed facility as a whole. It is expected that benchmarks for operational parameters will be developed during commissioning and ongoing operation in consultation and agreement with the Regulator.	Yes
10	**Energy efficient design (EED)** BAT is to optimise energy efficiency when planning a new installation, unit or system or a significant upgrade (see Section 2.3) by considering all of the following: a. the energy efficient design (EED) should be initiated at the early stages of the conceptual design/basic design phase, even though the planned investments may not be well-defined. The EED should also be taken into account in the tendering process b. the development and/ or selection of energy efficient technologies (see Sections 2.1(k) and 2.3.1) c. additional data collection may need to be carried out as part of the design project or separately to supplement existing data or fill gaps in knowledge d. the EED work should be carried out by an energy expert e. the initial mapping of energy consumption should also address which parties in the project organisations influence the future energy consumption and should optimise the energy efficiency design of the future plant with them. For example, the staff in the (existing) installation who may be responsible for specifying design parameters.	Energy efficiency will be embedded at all stages of design – see section 3 for further detail.	Yes
11	**Increased process integration** BAT is to seek to optimise the use of energy between more than one process or system (see Section 2.4), within the installation or with a third party	The proposed installation will be designed to maximise systems integration. See section 3.1 of this document for further detail.	Yes
12	**Maintaining the impetus of energy efficiency initiatives** BAT is to maintain the impetus of the energy efficiency programme by using a variety of techniques, such as: a. implementing a specific energy efficiency management system (see Section 2.1 and BAT 1) b. accounting for energy usage based on real (metered) values, which places both the obligation and credit for energy efficiency on the user/bill payer (see Sections 2.5, 2.10.3 and 2.15.2) c. the creation of financial profit centres for energy efficiency (see Section 2.5) d. benchmarking (see Section 2.16 and BAT 9) e. a fresh look at existing management systems, such as using operational excellence (see Section 2.5) f. using change management techniques (also a feature of operational excellence, see Section 2.5).	See response to BAT 1 -The efficient use of energy is embedded in the management system and performance requirements of the proposed installation. Energy reporting will take place in line with the Environmental Permit. The installation will be subject to regular preventative maintenance cycles to ensure the efficiency of plant and equipment is maintained.	Yes

BAT No.	BATC Requirement	Demonstration of BAT-Operator Response	Indicative BAT?
13	**Maintaining expertise** BAT is to maintain expertise in energy efficiency and energy-using systems by using techniques such as: a. recruitment of skilled staff and/or training of staff. Training can be delivered by in-house staff, by external experts, by formal courses or by self-study/ development (see Section 2.6) b. taking staff off-line periodically to perform fixed term/specific investigations (in their original installation or in others, see Section 2.5) c. sharing in-house resources between sites (see Section 2.5) d. use of appropriately skilled consultants for fixed term investigations (e.g. see Section 2.11) e. outsourcing specialist systems and/or functions (e.g. see Annex 7.12)	The proposed installation will be operated by suitable personnel with required skills and training. Maintenance activities associated with the installation will be undertaken by appropriately skilled and trained staff and contractors. Specific training given to contractors coming to the site specific to their role and responsibilities.	Yes
14	**Effective control of processes** BAT is to ensure that the effective control of processes is implemented by techniques such as: a. having systems in place to ensure that procedures are known, understood and complied with (see Sections 2.1(d)(vi) and 2.5) b. ensuring that the key performance parameters are identified, optimised for energy efficiency and monitored (see Sections 2.8 and 2.10) **c.** documenting or recording these parameters (see Sections 2.1(d)(vi), 2.5, 2.10 and 2.15).	The operation of the installation will be automated, with a BPCS providing continuous monitoring and control. The design philosophy of the BPCS is to provide the maximum possible level of automation for all systems installed and the plant will, in general, operate automatically under operator supervision during normal operation. Semi-automatic sequences and manually requested actions will also be available via the BPCS when required. The monitoring and control of the installation will be in accordance with the systems and procedures documented within the EMS. Procedural requirements will be included in the operator training to ensure they are known, understood and implemented at the installation. This will include contractors working at the site. Performance will be monitored through regular review and auditing processes. Staff will undergo both general training and role specific training. Records of training will be retained to document the training and the competencies achieved, with refresher training every 5 years unless mandated by legislation or corporate requirements. The Operator will have an energy policy which includes energy efficiency targets as part of the installations key performance indicators. Periodic energy assessments will be conducted to identify opportunities for energy saving	Yes
15	**Maintenance** BAT is to carry out maintenance at installations to optimise energy efficiency by applying all of the following: a. clearly allocating responsibility for the planning and execution of maintenance b. establishing a structured programme for maintenance based on technical descriptions of the equipment, norms, etc. as well as any equipment failures and consequences. Some maintenance activities may be best scheduled for plant shutdown periods c. supporting the maintenance programme by appropriate record keeping systems and diagnostic testing d. identifying from routine maintenance, breakdowns and/or abnormalities possible losses in energy efficiency, or where energy efficiency could be improved e. identifying leaks, broken equipment, worn bearings, etc. that affect or control energy usage, and rectifying them at the earliest opportunity	Roles and responsibilities on site will be clearly defined for the maintenance of the proposed installation. The proposed installation will be subject to regular preventative maintenance cycles to ensure the efficiency of plant and equipment is maintained. Reactive maintenance will be implemented as appropriate to rectify issues that may impact on plant efficiency after poor performance or breakdown is observed. Asset management techniques will use plant and breakdown data to enhance and adjust maintenance programmes. Yearly planned outages of about a week will be scheduled for inspections and minor maintenance. The H_2 production unit maintenance is anticipated every 2 years for catalyst replenishment & every 4 years for a major turnaround.	Yes

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
			All maintenance, breakdowns and other abnormal circumstances will be recorded and stored at local level as part of the site BS EN ISO 14001 certification. Documentation management, control and recordkeeping will comply BS EN ISO 14001, or local regulatory requirements, whichever are more stringent. Areas of improvement for energy efficiency will be identified from these circumstances to be improved quickly.	
16	**Monitoring and measurement** BAT is to establish and maintain documented procedures to monitor and measure, on a regular basis, the key characteristics of operations and activities that can have a significant impact on energy efficiency. Some suitable techniques are given in Section 2.10		Monitoring and measurement of key performance parameters that could have an effect on energy efficiency will be integral to the control system and embedded in the EMS. Estimations and calculations of energy consumption will be taken to assist in identifying and achieving energy savings.	Yes
17	**Best available techniques for achieving energy efficiency in energy-using systems, processes, activities or equipment - Combustion** BAT is to optimise the energy efficiency of combustion by relevant techniques such as: - those specific to sectors given in vertical BREFs		The operation of the installation will be automated, with a BPCS providing continuous monitoring and control. The design philosophy of the BPCS is to provide the maximum possible level of automation for all systems installed and the plant will, in general, operate automatically under operator supervision during normal operation. Fuel choice for the installation is currently natural gas with waste H_2 gas reuse . The operator is currently reviewing alternative sources of energy to increase efficiency in the future including the possibility of using H_2 product that is fed back to power the installation.	Yes
18	**Steam systems** BAT for steam systems is to optimise the energy efficiency by using techniques such as: - those specific to sectors given in vertical BREFs		The Steam is used at the installation for maintenance purposes only (e.g. when valves are frozen over) and will be generated by a separate electric steam boiler. Efficiency of the electric steam boiler will be achieved by: • energy efficient design to include optimised distribution pipework; • operational control via the BPCS system to optimise performance; • minimising blowdown through effective water quality control; • use of insulation on the distribution network where appropriate; and • effective maintenance including prevention and removal of scale and maintenance of refractory • multi-heater facility for electric boiler system to achieve required turndown in steam generation when full capacity steam generation is not needed.	Yes
19	**Heat recovery** BAT is to maintain the efficiency of heat exchangers by both: - monitoring the efficiency periodically, and - preventing or removing fouling.		Heat exchanger efficiency and maintenance will be included within the preventative maintenance cycle.	Yes
20	BAT is to seek possibilities for cogeneration, inside and/or outside the installation (with a third party).		Not currently viable	N/A
21	BAT is to increase the power factor according to the requirements of the local electricity distributor by using techniques such as those in Table 4.3, according to applicability (see Section 3.5.1)			
	Technique	**Applicability**		

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	Installing capacitors in the AC circuits to decrease the magnitude of reactive power.	All cases. Low cost and long lasting, but requires skilled application	The need to increase the power factor is subject to detailed design at FEED stage and use of capacitors will be reviewed at that time. In terms of operational control: • the plant will optimise motor selection to the required load and will avoid motor idling; • plant will be designed to the appropriate voltage and operation above rated voltage will be avoided; and • over the life of the installation, the energy efficiency of plant/motors will be a factor in the selection of plant replacement. .	Yes
	Minimising the operation of idling or lightly loaded motors	All cases		
	Avoiding the operation of equipment above its rated voltage	All cases		
	When replacing motors, using energy-efficient motors (see Section 3.6.1)	At time of replacement		
22	BAT is to check the power supply for harmonics and apply filters if required (see Section 3.5.2).		not required.	N/A
23	BAT is to optimise the power supply efficiency by using techniques such as those in Table 4.4, according to applicability:			
	Technique	**Applicability**		
	Ensure power cables have the correct dimensions for the power demand	When the equipment is not in use, e.g. at shutdown or when locating or relocating equipment	Cable schedule shall ensure that correct cable sizing will be optimised and adopted.	Yes
	Keep online transformer(s) operating at a load above 40 - 50 % of the rated power	• for existing plants: when the present load factor is below 40 %, and there is more than one transformer • on replacement, use a low loss transformer and with a loading of 40 - 75 %	Load List will confirm that adequate contingencies & growth factors been used while sizing the transformers.	Yes
	Use high efficiency/low loss transformers	At time of replacement, or where there is a lifetime cost benefit	Is a FEED deliverable and transformer efficiency and loss factors will be optimised.	Yes
	Place equipment with a high current demand as close as possible to the power source (e.g. transformer)	When locating or relocating equipment	Cable routing layout is a FEED deliverable, and design shall ensure that all the electrical consumers will be fed from respective substations in a way which avoids any large voltage drops at motor terminals .	Yes
24	BAT is to optimise electric motors in the following order: 1. optimise the entire system the motor(s) is part of (e.g. cooling system,) 2. then optimise the motor(s) in the system according to the newly determined load requirements, by applying one or more of the techniques in Table 4.5, according to applicability			
	Technique	**Applicability**		
	SYSTEM INSTALLATION or REFURBISHMENT			
	Using energy-efficient motors (EEM)	Lifetime cost benefit	Use and design of electric motors will be determined during FEED and will be optimised to the system the motors will serve.	Yes
	Proper motor sizing	Lifetime cost benefit		
	Installing variable speed drives (VSD)	Use of VSDs may be limited by security and safety requirements. According to load. Note in multi-machine systems with variable load systems (e.g. CAS) it may be optimal to use only one VSD motor		

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	Installing high-efficiency transmission/ reducers	Lifetime cost benefit		
	Use: • direct coupling where possible • synchronous belts or cogged V-belts in place of V belts • helical gears in place of worm gears	All		
	Energy-efficient motor repair (EEMR) or replacement with an EEM	At time of repair	N/A New Installation	Yes
	Rewinding: avoid rewinding and replace with an EEM, or use a certified rewinding contractor (EEMR)	At time of repair	N/A New Installation	Yes
	Power quality control	Lifetime cost benefit	To be determined during FEED	
	SYSTEM OPERATION and MAINTENANCE			
	Lubrication, adjustments, tuning	All cases	The site will implement a planned preventative maintenance, and this will include defect monitoring, reporting and investigation as appropriate.	Yes
25	BAT is to optimise compressed air systems (CAS) using the techniques such as those in Table 4.6, according to applicability			
	Technique	**Applicability**		
	SYSTEM DESIGN, INSTALLATION or REFURBISHMENT			
	Overall system design, including multi-pressure systems	New or significant upgrade	No compressed air systems.	N/A
	Upgrade compressor	New or significant upgrade		
	Improve cooling, drying and filtering	This does not include more frequent filter replacement (see below)		
	Reduce frictional pressure losses (for example by increasing pipe diameter)	New or significant upgrade		
	Improvement of drives (high-efficiency motors)	Most cost effective in small (<10 kW) systems		
	Improvement of drives (speed control)	Applicable to variable load systems. In multi-machine installations, only one machine should be fitted with a variable speed drive		
	Use of sophisticated control systems			
	Recover waste heat for use in other functions	Note that the gain is in terms of energy, not of electricity consumption, since electricity is converted to useful heat		
	Use external cool air as intake	Where access exists		
	Storage of compressed air near	All cases		

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	highly fluctuating uses			
	SYSTEM OPERATION and MAINTENANCE			
	Optimise certain end use devices	All cases	No compressed air systems.	N/A
	Reduce air leaks	All cases – largest potential gain		
	More frequent filter replacement	Review in all cases		
	Optimise working pressure	All cases		
26	BAT is to optimise pumping systems by using the techniques in Table 4.7, according to applicability (see Section 3.8):			
	Technique	**Applicability**		
	DESIGN			
	Avoid oversizing when selecting pumps and replace oversized pumps	For new pumps: all cases For existing pumps: lifetime cost benefit	Pump selection will be optimised during FEED to ensure correct pump selection in terms of sizing, duty of motors and distribution system	Yes
	Match the correct choice of pump to the correct motor for the duty	For new pumps: all cases For existing pumps: lifetime cost benefit		
	Design of pipework system (see Distribution system, below)			
	CONTROL and MAINTENANCE			
	Control and regulation system	All cases	Pump selection and associated control systems will be optimised during FEED. The site will implement a planned preventative maintenance, and this will include defect monitoring, reporting and investigation as appropriate. Pumps will be maintained to check for excessive wear and will be repaired and replaced if necessary.	Yes
	Shut down unnecessary pumps	All cases		
	Use of variable speed drives (VSDs)	Lifetime cost benefit. Not applicable where flows are constant		
	Use of multiple pumps (staged cut in)	When the pumping flow is less than half the maximum single capacity		
	Regular maintenance. Where unplanned maintenance becomes excessive, check for: • cavitation • wear • wrong type of pump	All cases. Repair or replace as necessary		
	DISTRIBUTION SYSTEM			
	Minimise the number of valves and bends commensurate with keeping ease of operation and maintenance	All cases at design and installation (including changes). May need qualified technical advice	Pipework routing and design will be optimised during FEED to ensure diameters are appropriate for their duty and the distribution system will be designed to minimise the number of valves and bends.	Yes
	Avoiding using too many bends (especially tight bends)			

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	Ensuring the pipework diameter is not too small (correct pipework diameter)			
27	BAT is to optimise heating, ventilation and air conditioning (HVAC) systems by using techniques such as: • for ventilation, space heating and cooling, techniques in Table 4.8 according to applicability • for heating, see Sections 3.2 and 3.3.1, and BAT 18 and 19 • for pumping, see Section 3.8 and BAT 26 • for cooling, chilling and heat exchangers, see the ICS BREF, as well as Section 3.3 and BAT 19 (in this document).			
	Energy Saving Measure	**Applicability**		
	DESIGN and CONTROL			
	Overall system design. Identify and equip areas separately for: • general ventilation • specific ventilation • process ventilation	New or significant upgrade. Consider for retrofit on lifetime cost benefit	HVAC requirements for general and process needs will be optimised during FEED to ensure correct sizing, duty of system components and distribution systems.	Yes
	Optimise the number, shape and size of intakes	New or upgrade		
	Use fans: • of high efficiency • designed to operate at optimal rate	Cost effective in all cases		
	Manage airflow, including considering dual flow ventilation	New or significant upgrade		
	Air system design: • ducts are of a sufficient size • circular ducts • avoid long runs and obstacles such as bends, narrow sections	New or significant upgrade		
	Optimise electric motors, and consider installing a VSD	All cases. Cost effective retrofit		
	Use automatic control systems. Integrate with centralised technical management systems	All new and significant upgrades. Cost effective and easy upgrade in all cases		
	Integration of air filters into air duct system and heat recovery from exhaust air (heat exchangers)	New or significant upgrade. Consider for retrofit on lifetime cost benefit. The following issues need to be taken into account: the thermal efficiency, the pressure loss, and the need for regular cleaning.		
	Reduce heating/cooling needs by: • building insulation • efficient glazing • air infiltration reduction	Consider in all cases and implement according to cost benefit		

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	• automatic closure of doors • destratification • lowering of temperature set point • during non-production period (programmable regulation) • reduction of the set point for heating and raising it for cooling			
	Improve the efficiency of heating systems through: • recovery or use of wasted heat (Section 3.3.1) • heat pumps • radiative and local heating systems coupled with reduced temperature set points in the non-occupied areas of buildings	Consider in all cases and implement according to cost benefit		
	Improve the efficiency of cooling systems through the use of free cooling	Applicable in specific circumstances		
	MAINTENANCE			
	Stop or reduce ventilation where possible	All cases	The site will implement a planned preventative maintenance, and this will include checks on system integrity, balancing of systems for optimisation, defect monitoring, reporting and investigation as appropriate.	Yes
	Ensure system is airtight, check joints			
	Check system is balanced			
	Manage airflow: optimise			
	Air filtering, optimise: • recycling efficiency • pressure loss • regular filter cleaning/replacement • regular cleaning of system			
28	BAT is to optimise artificial lighting systems by using the techniques such as those in Table 4.9 according to applicability (see Section 3.10):			
	Technique	**Applicability**		
	ANALYSIS and DESIGN OF LIGHTING REQUIREMENTS			
	Identify illumination requirements in terms of both intensity and spectral content required for the intended task	All cases	Illumination requirements will be optimised during FEED and will consider these three aspects.	Yes
	Plan space and activities in order to optimise the use of natural light	Where this can be achieved by normal operational or maintenance rearrangements, consider in all cases. If structural changes, e.g. building work, is required, new or upgraded installations	Lighting will be designed depending on task within the area, considering the brightness/placement and energy efficient bulbs where possible. Natural light will also be optimised where possible and decided in the design stages.	

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	Selection of fixtures and lamps according to specific requirements for the intended use	Cost benefit on lifetime basis		
	OPERATION, CONTROL, and MAINTENANCE			
	Use of lighting management control systems including occupancy sensors, timers, etc.	All cases	Lighting management control systems will be reviewed during FEED stage. For areas where lighting does not need to be consistent, timers or sensors will be installed.	Yes
	Train building occupants to utilise lighting equipment in the most efficient manner	All cases	EMS training for all workers will cover lighting efficiency.	
29	BAT is to optimise drying, separation and concentration processes by using techniques such as those in Table 4.10 according to applicability, and to seek opportunities to use mechanical separation in conjunction with thermal processes:			
	Technique	**Applicability**		
	DESIGN		No drying, separation or concentration processes at the installation.	N/A
	Select the optimum separation technology or combination of techniques (below) to meet the specific process equipment.	All cases		
	OPERATION			
	Use of surplus heat from other processes	Depends on the availability of surplus heat in the installation (or from third party)		
	Use a combination of techniques	Consider in all cases		
	Mechanical processes, e.g. filtration, membrane filtration	Process dependent. To achieve high dryness at lowest energy consumption, consider these in combination with other techniques		
	Thermal processes, e.g. • directly heated dryers • indirectly heated dryers • multiple effect	Widely used, but efficiency can be improved by considering other options in this table		
	Direct drying	See thermal and radiant techniques, and superheated steam		
	Superheated steam	Any direct dryers can be retrofitted with superheated steam. High cost needs lifetime cost benefit assessment. High temperature may damage product		
	Heat recovery (including MVR and heat pumps)	Consider for almost any continuous hot air convective dryers		
	Optimise insulation of the drying system	Consider for all systems. Can be retrofitted		
	Radiation processes e.g. • infrared (IR) • high frequency (HF) • microwave (MW)	Can be easily retrofitted. Direct application of energy to component to be dried. They are compact and Reduce the need for air extraction. IR limited by substrate dimensions. High cost, needs lifetime cost benefit assessment		

BAT No.	BATC Requirement		Demonstration of BAT-Operator Response	Indicative BAT?
	CONTROL			
	Process automation in thermal drying processes	All cases		