Permitting Decisions- Variation

We have decided to grant the variation for BOC Hydrogen Plant operated by BOC Limited.

The variation number is EPR/BJ7522IJ/V005.

The permit was issued on 05/01/2026.

The variation is for adding a carbon dioxide recovery and liquefaction plant (the LIC Plant) to capture carbon dioxide from the existing hydrogen production plant (the H_2 Plant). The LIC Plant will capture up to 144 tonnes per day of carbon dioxide which will be liquefied and exported from the site by road tanker for use in other industrial activities such as food and drink production. Adding the LIC Plant will lead to additional emissions to water whilst facilitating a reduction in energy usage and carbon dioxide emissions.

We consider in reaching that decision we have taken into account all relevant considerations and legal requirements and that the permit will ensure that the appropriate level of environmental protection is provided.

Purpose of this document

This decision document provides a record of the decision-making process. It

- highlights key issues in the determination
- summarises the decision making process in the decision considerations section to show how the main relevant factors have been taken into account
- shows how we have considered the consultation responses

Unless the decision document specifies otherwise we have accepted the applicant's proposals.

Read the permitting decisions in conjunction with the environmental permit and the variation notice.

Key issues of the decision

Operating techniques and Best Available Techniques (BAT) assessment

The assessment of the operating techniques proposed for the LIC Plant against Best Available Techniques (BAT) is set out in the application document titled 'BAT Compliance Assessment – CO_2 Recovery and Liquefaction Plant'.

We have included the relevant application documents and responses to a request for additional information in table S1.2 of the environmental permit, as operating techniques that the operator will need to follow, according to condition 2.3.1 of the permit.

It should be noted that, although the production of hydrogen by thermal conversion of hydrocarbons is a well-established process and this aspect of the site is already permitted, the thermal production of hydrogen coupled with carbon capture is a novel concept that has not yet seen many commercial applications at an industrial scale. Hence, we consider the application to consist of emerging technologies.

Our BAT determination is therefore based on our current understanding of these emerging technologies. Our position on the determination of BAT for hydrogen production with carbon capture is subject to change and development as we receive more applications for similar plants, and we develop and consolidate our positions on specific BAT issues. This may also happen as the result of the continuous exchange of information and engagement with industry and other key stakeholders, the review of received applications and the regulation of the permitted sites brought into operation.

We have determined BAT for the proposed installation with reference to the following guidance: 'Emerging techniques for hydrogen production with carbon capture'. This is published on our website. The BAT criteria referred to in the guidance are those set out in Annex III of the Industrial Emissions Directive (IED), as read in accordance with Schedule 1A to the Environmental Permitting (England and Wales) Regulations 2016. We have taken into account the fact that this application relates to an existing hydrogen production site and the carbon capture is not for storage but is partial carbon capture for utilisation instead.

In addition to the above, the operator has also assessed their proposal against the European BAT Conclusions for Common Waste Gas Management and Treatment Systems in the Chemical Sector, Commission Implementing Decision (EU) 2022/2427 of 6 December 2022 (WGC BAT Conclusions). Although this set of BAT Conclusions is not strictly applicable in England, awaiting for the publication of an equivalent set of UK BAT, we have referred to these BAT conclusions, where relevant, under the provisions of Article 14(6) of the Industrial Emissions Directive, as relevant to the criteria set out in Annex III of the same Directive, namely 'information published by public international organisations'. Our review of the operator's assessment of their proposal against the WGC BAT Conclusions has focussed on the proposed LIC Plant, and has not extended to existing activities that are unchanged as a result of this variation. These existing activities will be reviewed against the WGC UK BAT Conclusions as part of a future permit review process, which will be initiated by the publication of this set of UK BAT Conclusions.

We have also reviewed the operator's proposal against the BAT conclusions for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector, Commission Implementing Decision (EU) 2016/902 of 30 May 2016 (CWW BAT Conclusions). Our review has focussed on the proposed LIC Plant, and has not extended to existing activities that are unchanged as a result of this variation. These existing activities will be reviewed against the CWW BAT Conclusions during the permit review process initiated by the publication of the WGC UK BAT Conclusions (see above paragraph).

Review of application against the Guidance on Emerging Techniques for Hydrogen Production with Carbon Capture

The application is discussed in the following table against the key requirements set out in the guidance on emerging techniques (GET) 'Emerging techniques for hydrogen production with carbon capture'. Only the requirements relevant to the LIC Plant are reviewed in detail, since the hydrogen plant (H_2 Plant) is existing and not changing as part of this variation.

Permitting Decisions- Variation

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
2.	**Technique selection**		
	When choosing hydrogen production and CC plant configuration, you should consider its overall environmental performance, including: • energy efficiency • resource efficiency • CO_2 capture efficiency • emissions to the environment These are the hydrogen production methods the regulators considered when producing this guidance: • steam methane reforming (SMR) • autothermal reforming (ATR) • gas heated reforming (GHR) • partial oxidation (POX) They also considered combinations of these such as GHR plus ATR and GHR plus SMR. All of these methods will need to separate out, capture and prepare hydrogen and CO_2 ready for: • using hydrogen product within the installation	N/A	The proposal is for a carbon dioxide capture for utilisation plant, retrofitted to an existing steam methane reforming (SMR) plant. The carbon dioxide is captured from the syngas, with the SMR plant and hydrogen production process remaining substantially unchanged as a result of this variation. We therefore consider this part of the guidance is not applicable to the proposal in that the scope of the proposal does not cover the selection of the technology to produce hydrogen, and the configuration of the carbon dioxide capture plant has been constrained by the process configuration of the existing activities.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• transporting hydrogen product for use off-site • transporting CO_2 for permanent geological storage off site These activities are outside the scope of this guidance.		
3.	**Plant design and operation**		
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 CO_2 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		Yes	The H_2 Plant operates flexibly in line with hydrogen demand, and this remains the primary purpose of the installation. The operator has stated that the LIC Plant has been designed to accommodate the flexible operation of the H_2 Plant with little impact on the CO_2 removal efficiency. If the H_2 Plant is running at minimum turndown, the LIC Plant may need to be shut down, due to limited steam availability. This will involve venting the recovered CO_2 to atmosphere, and overall CO_2 emissions would therefore revert to the existing permitted scenario. We are satisfied the application meets the relevant requirements of our Guidance on

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
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			Emerging Techniques with regard to flexible operation.
3.2	**Reliability and availability**		
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. You should implement a risk-based other than normal operating conditions (OTNOC) management plan, which identifies potential scenarios, mitigation measures, monitoring and periodic assessment.		Yes, subject to improvement condition	In relation to the LIC Plant, the operator has provided a list of key equipment that is critical to preventing and avoiding emissions during both normal and other than normal operating conditions (OTNOC). A SCADA system controls the plant within the expected limits of operation and there is an established programme for pre-planned maintenance. The operator has stated that inspection and maintenance tasks will be scheduled in line with designer/manufacturer recommendations, with condition monitoring undertaken where appropriate to inform the inspection frequency. The operator has identified potential triggers for OTNOC scenarios, including those that would lead to venting of CO_2, and the preventative/design measures in place to avoid these. Monitoring of key process parameters are linked to data

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
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			trending and system alarms that warn of potential OTNOC scenarios so that appropriate action can be taken to avoid these. We consider that the proposed amount of CO_2 storage alongside the expected frequency of road tanker loading is reasonable for avoiding venting of CO_2 due to full storage capacity. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to reliability and availability, subject to improvement condition IC6 requiring the operator to submit an OTNOC management plan for assessment and approval.
3.3	**Overall CO_2 capture efficiency**		
You should design plant to maximise the carbon capture efficiency. As a 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).		N/A	The LIC Plant is designed to capture 144 tonnes per day of carbon dioxide, which corresponds to a 16% capture rate. The purpose of the proposal is to capture this carbon dioxide for utilisation. Since this carbon dioxide is a product of the process

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
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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. You should note that any carbon-containing compounds as allowed by the hydrogen product specification will be emitted to the environment in downstream uses, such as combustion. You should aim to minimise these where feasible.			and the driver for its capture is of a commercial nature as opposed to aimed at attaining a specified decarbonisation target, we consider that the requirement of our guidance to attain 95% capture efficiency is not applicable to the proposal.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
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. This could include, for example: • maximising absorption for CO_2 capture • optimising solvent regeneration to provide CO_2 at high pressure, but avoiding excessive degradation of solvent • maximising heat exchange between lean and rich solvent streams • minimising solvent carryover to minimise the need for downstream removal • minimising wastes and effluent streams, while removing contaminant build-up in solvent		Yes	We consider that the operator has provided sufficient justification of their choice of solvent, which includes factors such as low electric power consumption, low steam consumption, options for energy and heat integration, emissions control technology, and a high CO_2 capture rate. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to process CO_2 capture from hydrogen product.
3.5	**CO2 capture for steam methane reforming**		
In SMR, heat for the reformer reaction is provided by external combustion in a furnace.		N/A	The existing hydrogen production plant consists of SMR technology, however post-

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
The fuel gas can be either: • methane (usually from natural gas feed) • refinery fuel gas • hydrogen product • a combination of these All require post combustion capture to remove the CO_2 produced from the flue gas, except where pure hydrogen product is used as the fuel. Following consultation with industry, the regulators expect that more than 95% of CO_2 can be removed from the reformer flue gases. The plant could be designed in such a way that no post combustion capture is needed if both of these apply: • hydrogen is used as the fuel gas for the reformer • there is in-process CO_2 removal prior to hydrogen purification You will need to justify the best overall approach, considering all environmental impacts. If post-combustion CO_2 capture is needed, you should use the guidance post-combustion carbon dioxide capture: emerging techniques (referred to as PCC guidance). You should take account of any differences between the flue gases considered in the PCC guidance and the flue gases from the SMR reformer furnace. These differences could be, for example, oxygen and nitrogen content, potential for formation of nitrogen oxides (NO_x) and impact of requirement for flexible operation.			combustion carbon capture is not included in the scope of the proposal and we therefore consider that the associated requirements of our guidance are not applicable. The aim of the proposal is to capture carbon dioxide for utilisation, and the proposed capture configuration consists of carbon dioxide separation from the syngas. As explained above in item 3.3, the carbon dioxide capture rate is dictated in these conditions by considerations of a commercial nature, which pertain to only the operator and are beyond our regulatory remit, as opposed to the requirement to attain an acceptable decarbonisation performance. As such, we consider that the 95% capture rate specified in our guidance does not apply to this proposal and, therefore, there is no need to use a post-combustion carbon capture process to capture the carbon dioxide associated with the combustion of natural gas necessary to run the SMR furnace.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
When optimising for environmental performance, you should consider: • selecting appropriate solvents • emissions to air of solvent and associated degradation products • energy requirements • effluents and wastes • cooling requirements • pump and fan noise • flue gas pre-treatment • treated flue gas dispersion			
3.6	**CO_2 capture from residual gas from hydrogen purification**		
	You should consider how to capture CO_2 produced by the combustion of residual gas, which results when hydrogen is purified. You should aim to remove this CO_2 to maximise the overall carbon capture efficiency and to make sure you achieve at least 95%. The residual gas may contain methane, carbon monoxide (CO) and CO_2 as well as hydrogen, nitrogen and argon. This is normally used as a fuel gas and any carbon containing compounds will be converted to CO_2.	N/A	Not applicable, as the proposal is not aimed at decarbonising the activities. Refer to item 3.3 above.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	The amount of carbon-containing compounds depends on the efficiency of conversion and removal before the hydrogen purification stage.		
3.7	**Energy efficiency, process efficiency, 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. Main energy users will include: • air separation unit (ASU) – for oxygen supply to ATR and POX • hydrogen compressors • CO_2 compressors • hydrogen and CO_2 purification		Yes	In relation to the LIC Plant, the operator has stated that the addition of this plant will lead to an overall improvement in energy efficiency. For example, existing steam will be used in the plant as opposed to condensed using fans, compressors will be powered using process steam as opposed to electrical drivers, and less heat input to the Hydrogen Plant will be required, reducing the usage of natural gas. Cooling water will be provided by a recirculating cooling water system with an associated air-cooled evaporative cooling tower, which has been justified as the optimum balance between cooling water availability, energy use and cooling efficiency. We are satisfied the application meets the relevant requirements of our Guidance on

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• solvent recovery system • pumping or fan systems You should consider: • electrical power needs and whether you will import or generate on site • high pressure steam need and availability • 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, CO_2 and hydrogen compression for power generation or drives • medium temperatures for solvent recovery • lower temperatures for boiler feed pre-heat See also section 3.9 Water supply and use. You should reference the BREF documents: • Industrial Cooling Systems • Energy Efficiency		Emerging Techniques with regard to energy efficiency, process efficiency and cooling.
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. You must consider heat recovery from the heat generated by the air compression system and whether you can use it within	N/A	Not applicable, as the proposal does not include ATR/POX processes.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
the rest of the hydrogen production process to maximise energy efficiency. We expect you to explore all opportunities for waste heat recovery as the ASU will be considered part of the installation. You should take the following into account when designing the oxygen production plant and optimise to show you are using BAT: • overall energy consumption depends on the design of the ASU and its air compressor • energy required will be a balance between oxygen purity, oxygen pressure needed to supply the hydrogen production process and energy needed to purify the hydrogen • higher oxygen purity will increase the energy required for oxygen production, but reduce the amount needed for hydrogen purification to remove residual argon and nitrogen • co-production of argon and nitrogen can be used for export or on site • heat energy needed to dry and purify the compressed air • options to increase the compressor exit temperature to improve options for heat recovery should be explored, balanced with compressor design and higher power requirement. • safe and reliable operation of both the ASU and hydrogen production plant where heat integration is used			

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator’s proposal**
	• high availability of oxygen supply and backup supply or liquid storage is important to avoid potential environmental impacts of emergency or frequent shutdown and start-up of the plant		
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: • 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	Yes	Water usage specific to the LIC Plant is related to the evaporative cooling water system. This will be a recirculating system with continuous purge and make-up of the water required to ensure suitable quality. The operator has confirmed that the system is sized to match the process heat demand needs and hence minimise water usage. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to water supply and use.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	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.		
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.	Yes, subject to improvement conditions	See 'Key Issues – Emissions to water' section below.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	You should use the following references to choose the most appropriate treatments: • BREF and BATC for common waste water 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.		
3.11	**Feed gas quality and treatment**		
	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	N/A	Requirements are not applicable, as there are no changes to the hydrogen production process, other than to the extent concerning the separation of carbon dioxide from the syngas.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• 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 NO_x 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		

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
overall CO_2 balance and capture efficiency monitoring and reporting.			
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.		N/A	Requirements are not applicable, as there are no changes to the hydrogen production process, other than to the extent concerning the separation of carbon dioxide from the syngas.
3.13	**Reforming**		
You should select, design and operate the reformer reaction in order to: • 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.		N/A	Requirements are not applicable, as there are no changes to the hydrogen production process, other than to the extent concerning the separation of carbon dioxide from the syngas.
3.14	**CO shift**		
You should select, design and operate CO shift reaction in order to:		N/A	Requirements are not applicable, as there are no changes to the hydrogen production

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• 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 You should consider a single step CO shift process rather than a more conventional high temperature or low temperature shift process, with isothermal conditions achieved through reactor cooling with recovery of heat. By using this option, it may allow you to: • increase overall heat integration and efficient use of recovered heat, as long as sufficient conversion of CO to CO_2 is achieved • avoid using chromium catalyst needed for high temperature shift, therefore minimising hazardous waste • reduce the potential for catalyst damage, methanation reactions, and Fischer-Tropsch reactions • reduce the potential for the production of methanol which would condense out with water downstream and need to be treated by effluent treatment • consider the cost and environmental benefits of an isothermal reactor against a more complex multi-tube boiling water-cooled reactor		process, other than to the extent concerning the separation of carbon dioxide from the syngas.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
Refer to BREF for large volume inorganic chemicals – ammonia, acids and fertilisers – section 2.4.14 Isothermal Shift Conversion.			
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		N/A	Requirements are not applicable, as there are no changes to the hydrogen production process, other than to the extent concerning the separation of carbon dioxide from the syngas.
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:		N/A	Requirements are not applicable, as there are no changes to the hydrogen production process, other than to the extent concerning the separation of carbon dioxide from the syngas.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	Summary of guidance on emerging techniques requirements	Status Compliant with GET?	Our review of the operator's proposal
- 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. 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.			

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
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.		N/A	Requirements to specify the CO_2 for geological storage are not applicable to the scope of this application. The process has been designed to meet the required CO_2 quality specification, temperature and pressure as required by the end users.
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.		Yes	See 'Key Issues – Emissions to air' section below.
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.		Yes	We consider that the only applicability of this section is in relation to any impact of the LIC Plant on the existing combustion processes. See 'Key Issues – Emissions to air' section below.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
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 NO_x 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 NO_x. 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			

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	pre-treatment of combustion gases needed see the PCC guidance • 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 NO_x formation. Fuel NO_x 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		

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• 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		
4.2	**Post combustion capture plant**		
	Refer to the PCC guidance – section 3.3 Features to control and minimise atmospheric and other emissions.	N/A	Not applicable as there is no post combustion capture plant in the scope of this application.
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	Yes, subject to improvement condition	See 'Key Issues – Emissions to air' section below.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
• 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 (see section 3.2 Reliability and availability) • 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 • 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			

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• 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		

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
• 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			
5.	**Emissions to water**		
You must identify and eliminate, minimise, recycle or treat any emissions to water that could cause pollution. You should carry out a risk assessment, including detailed modelling, where appropriate, to assess the impact of these emissions. For discharges to water, you should refer to the guidance Surface water pollution: risk assessment for your environmental permit.		Yes, subject to improvement conditions	See 'Key Issues – Emissions to water' section below.
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: • methanol		Yes, subject to improvement conditions	See 'Key Issues – Emissions to water' section below.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• ammonia • CO_2 • amines • degradation products You should treat water for reuse as far as possible. See section 3.10 Water treatment. 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: • Refining of Mineral Oil and Gas • Common Waste Gas Management and Treatment 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. You should consider how to deal with the following wastes that may be generated.	Yes	The wastes specific to the LIC Plant will arise from the infrequent replacement of the amine solution and routine maintenance. The handling, storage and disposal of these wastes will be managed in accordance with existing waste handling and management protocols, with recycling and recovery prioritised where possible in line with the principals of the waste hierarchy. Process monitoring will be used to minimise the

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
			degradation of the amine solution. A waste minimisation plan is in place. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to waste.
6.1	**Liquid wastes**		
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		Yes	See section 6 above.
6.2	**Solid wastes**		
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)		Yes	See section 6 above.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
7.	**Monitoring**		
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 the 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.		Yes, subject to pre-operational and improvement conditions	We have included a pre-operational measure for the operator to provide a commissioning plan which will include a commissioning monitoring plan. We have also included an improvement condition for the operator to provide a report on the results of commissioning. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to monitoring.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
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.			
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 • NO_x • 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: • NO_x and CO emissions from combustion		Yes	There are no routine emissions to air from the LIC Plant other than nitrogen venting associated with plant inertisation. Emissions to air from the LIC Plant would solely comprise venting of carbon dioxide during OTNOC or when the LIC Plant is not available and it is not proposed to sample and analyse these. The addition of the LIC Plant will not significantly change the environmental risk of the emissions to air from the H_2 Plant, and the configuration of process carbon dioxide capture is such that amine and amine degradation products are within a

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
	• SO_2 emissions from combustion where the fuel source contains sulphur • ammonia emissions where SCR or SNCR is used • 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 described in section 4.1 Combustion processes. 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.		sealed system and will not vent to atmosphere under normal operation conditions. See also 'Key Issues – Emissions to air' section below.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
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 waste water and waste gas treatment/management system in the chemical sector • BATC for the refining of mineral oil and gas		Yes, subject to improvement condition	See 'Key Issues – Emissions to water' section below.
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.		Yes	We have included new monitoring requirements in relation to emissions to water. The operator has confirmed that all monitoring will be in line with MCERTS as required. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to monitoring standards.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
You should also refer to the JRC Reference Report on Monitoring for IED Installations.			
7.4	**Monitoring CO_2 capture performance**		
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		Yes, subject to pre-operational condition	The application proposes partial carbon capture for utilisation and, under normal operation, 16% of CO_2 will be captured. We have included a pre-operational condition for the operator to provide a commissioning plan which shall include a methodology for approval to demonstrate the carbon dioxide capture efficiency of the LIC Plant. The permit also includes an annual reporting requirement for the carbon dioxide capture efficiency. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to monitoring CO_2 capture performance.

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
7.5	**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.		Yes, subject to pre-operational condition	The operator has stated that the control and operating procedures for the LIC Plant are still underway as part of detailed design, but that the LIC Plant has been designed to ensure that all key process parameters required to ensure the effective and efficient operation of the plant have appropriate monitoring systems in place, and that additional monitoring requirements will be developed as part of the pre-planned maintenance programme for the site to ensure that required periodic monitoring of process conditions is undertaken. We have included a pre-operational condition for the operator to provide a commissioning plan which shall include the established operational envelope and associated process controls including appropriate parameters.
8.	**Unplanned emissions and accidents**		
You should propose a leak detection and repair (LDAR) programme that is appropriate for the fluids and their		Yes	The existing hydrogen production plant incorporates leak detection and repair through a pre-planned inspection and

Table 1 – Assessment of emerging techniques for hydrogen production with carbon capture			
Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
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.			maintenance programme and daily routines. This will be extended to include the LIC Plant. The operator has stated that detailed safety and risk assessments have been carried out, including HAZID and HAZOP. We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to unplanned emissions and accidents.
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		Yes	We do not consider that this application will increase the noise or odour risk of the site, based on the proposed changes and the distances to the closest human receptors (over 2000 metres). We are satisfied the application meets the relevant requirements of our Guidance on Emerging Techniques with regard to noise and odour.

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Ref. (Note 1)	**Summary of guidance on emerging techniques requirements**	**Status Compliant with GET?**	**Our review of the operator's proposal**
• orientation and location of noise-emitting machinery • changing the frequency of the sound Please refer to Noise and vibration management: environmental permits. 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. In England, Wales and Northern Ireland please refer to Environmental permitting: H4 odour management. In Scotland refer to Odour guidance 2010.			
Note 1: the reference numbers throughout the table reflect the numbering of the relevant sections of the online GET.			

Permitting Decisions- Variation

Emissions to surface water

All effluent from the installation is directed to the SABIC North Tees Site drainage system, which passes through an oil-water separator pit before being pumped to a lagoon with an approximate capacity of 2,000 m^3. The effluent is then discharged via a weir to the River Tees, which is classified as estuarine and lies within the designated Teesmouth & Cleveland Coast SSSI/SPA/Ramsar habitat.

The operator has undertaken a risk assessment of parameters and substances relevant to the various effluent streams and assessed the risk of the combined effluent leaving the installation. Our focus when reviewing the operator's risk assessment has been on the changes introduced by the scope of this variation, i.e., the addition of the LIC Plant.

As the final discharge is direct to a SSSI/SPA/Ramsar, modelling was required for any substances that did not screen out at Test 1 of the estuarine screening tests, i.e. substances present at concentrations exceeding the relevant Environmental Quality Standard (EQS) limit or Predicted No Effect Concentration (PNEC) value. Where modelling was required, the operator used a spreading disc plume model spreadsheet tool with conservative assumptions throughout. We have reviewed the operator's assessment as follows.

The operator's assessment was based on sampling data for existing sources:

- 10 samples of the H_2 Plant process effluent, discharged on a batch basis via emission point E1.
- 10 samples of the demineralisation plant effluent, discharged on a batch basis via emission point E2.
- 12 samples of the H_2 Plant cooling water blowdown, discharged on a continuous basis via emission point E3.

The composition of the effluents arising from the proposed variation to add the LIC Plant has been determined as follows:

- The LIC Plant cooling water blowdown is assumed to have the same composition as the H_2 Plant cooling water blowdown and will be continuously discharged via emission point E4.
- The LIC Plant process effluent composition is based on complex process modelling conducted as part of the detailed plant design. This stream will be discharged via emission point E1 along with the H_2 Plant process effluent.

We have included improvement condition IC8 requiring the operator to validate their risk assessment (in relation to parameters relevant to the addition of the LIC Plant) once the LIC Plant is operational using at least 12 samples of their effluent discharges.

In relation to the parameters and substances that have been evaluated, we have concluded the following:

Substance / parameter	Decision
Temperature and pH	Process effluent from the H_2 Plant and LIC Plant will be neutralised prior to discharge from emission point E1, which already has established limits for pH and temperature. Cooling waters are pH controlled, and the cooling system of air-cooled evaporative cooling towers with recirculation means that cooling water blowdown is not expected to be significantly above ambient temperature. We consider that, by the time the effluent leaves the lagoon, its temperature will be at ambient levels. On this basis, neither the temperature nor the pH of the effluents is considered to pose a risk to the receiving environment.
Total suspended solids	Total suspended solids originate solely from existing sources and are therefore not relevant to the variation proposals. We note that the mass emission rate for total suspended solids does not exceed the threshold above which the BAT-AEL in the CWW BAT Conclusions applies.
BOD and dissolved oxygen	BOD was evaluated in relation to existing sources and compared to a river BOD standard. As the discharge is to an estuary, we requested that the operator instead consider the dissolved oxygen standards applicable to transitional and coastal (TraC) waters. The operator provided a qualitative assessment, demonstrating that the additional effluent resulting from the variation proposals will not significantly impact dissolved oxygen levels in the receiving environment, given the opportunities for aeration and mixing in SABIC's drainage system, in the lagoon, and when discharging over the weir onto a spillway. We accept the operator's conclusions but have included improvement condition IC8 in the permit, requiring the operator to monitor dissolved oxygen in their effluent streams and update their surface water risk assessment accordingly.
Phosphorus and orthophosphate	The total phosphorus concentration in the combined effluent from the installation does not exceed the BAT-AEL range in the CWW BAT Conclusions and there are no standards for phosphorus in TraC waters. Orthophosphate will be present in the LIC Plant cooling water blowdown, and the operator has modelled the mixing zone for this substance to

	demonstrate rapid mixing and dilution. We have audited the operator's modelling methodology and included improvement condition IC8 in the permit, requiring the operator to monitor orthophosphate in the installation's effluent once the LIC Plant is operational, to validate their expected emissions.
Chlorine	The operator assessed the expected maximum free chlorine concentration in the combined effluent, originating from the cooling water blowdowns, against the relevant MAC-EQS for chlorine. We note that the MAC-EQS is for chlorine as total residual oxidant but that the only oxidant dosed into the cooling water is chlorine-based, hence we consider that in this case free available chlorine is also a likely indicator of total residual oxidant. As the concentration did not screen out at Test 1, the operator modelled the mixing zone to demonstrate that dilution would be sufficient. We have audited the operator's modelling methodology and included improvement condition IC8 in the permit, requiring the operator to monitor chlorine and total residual oxidant in the installation's effluent once the LIC Plant is operational, to validate their expected emissions. We have also included a limit of 1.6 mg/l as an instantaneous maximum concentration limit for chlorine in the LIC Plant cooling water blowdown discharge, since this is the expected absolute maximum concentration used by the operator in their modelling, alongside a monthly monitoring requirement (with the potential for a future reduction to quarterly) to be reported on a six monthly basis, as proposed by the operator. The operator also assessed against the CWW BAT Conclusions BAT-AEL for adsorbable organically bound halogens (AOX) using the expected concentration of free chlorine, however the BAT-AEL is for AOX expressed as chloride. As referenced in the CWW Bref, AOX is mainly associated with the production of organic chemicals and silicones, and we consider it unlikely that AOX would exceed the emission threshold above which the BAT-AEL would apply. We have included monitoring of AOX in IC8, to validate this.
Amine	The operator reviewed the Material Safety Data Sheet for the selected amine and assessed it against the lowest No Observed Effect Concentration (NOEC) value of any of its constituents, concluding it screened out at Test 1. However, we consider that the lowest PNEC value should be used for assessment and have derived PNECs following the approach in the European Commission's 'Technical Guidance Document on Risk Assessment'. Our assessment confirms that the lowest derived PNEC for any amine constituent still results in screening out at Test 1.

	We have included improvement condition IC8 in the permit, requiring the operator to monitor amine associated with the carbon dioxide capture solvent in the installation’s effluent once the LIC Plant is operational, to validate the expected emissions.
Nitrogen	The operator initially included nitrate from existing sources and ammonia from the LIC Plant in their assessment. Subsequently, it was clarified that the presence of ammonia in the LIC Plant effluent was assumed based on its presence in the syngas, but syngas testing showed ammonia was not detected. The limit of detection was however taken forward in the LIC Plant design. We have assessed the syngas testing report as sufficiently reliable and therefore consider that ammonia is not in fact expected in the effluent discharge. We have also included improvement condition IC8 in the permit, requiring the operator to monitor ammoniacal nitrogen in the installation’s effluent once the LIC Plant is operational and confirm that there is no increase in emissions of this substance as a result of the LIC Plant being operational. Consequently, there is no additional source of nitrogen proposed. We note however that the combined effluent discharge concentration of nitrogen from existing sources complies with the BAT-AEL range as stated in the CWW BAT Conclusions.
Methanol	The operator revised their assessment to include methanol after updated design modelling identified its potential presence in the LIC Plant process effluent. Methanol was initially assessed against a NOEC value of 122 mg/l (from an European Chemicals Agency dossier) and was considered to screen out at Test 1. We consider, however, that methanol should be assessed using a PNEC value. Using the European Commission’s ‘Technical Guidance Document on Risk Assessment’, we derived a PNEC of 1.54 mg/l. The operator’s estimated worst-case methanol concentration is 2.81 mg/l in the effluent, which does not screen out at Test 1 when compared with our derived PNEC. However, given that the expected concentration is close to the derived PNEC, that methanol is readily biodegradable with no environmental hazard classifications, and that the effluent will reside in a lagoon before discharge, we consider that the risk of environmental impact is sufficiently low and no further assessment as part of the application’s determination is required. We have included improvement condition IC8 in the permit, requiring the operator to monitor methanol in the installation’s effluent once the LIC Plant is operational, to validate the expected emissions.

Dosing chemical	The operator assessed the impact of a proposed dosing chemical by considering the lowest NOEC value of any constituent substance. We consider that assessment should instead be against the lowest PNEC value, however the overall risk is expected to be low as the concentrations are based on a worst-case scenario from operational and expected future use data, and the lagoon is likely to further reduce any potential impact. We do not therefore consider any further assessment is required as part of the application's determination. We have included a process monitoring requirement for the operator to record the quantity used of the proposed dosing chemical, as well as improvement condition IC8, requiring the operator to validate their expected emissions once the LIC Plant is operational, informed by this process monitoring.

The operator also assessed acetaldehyde within the LIC Plant process effluent, but subsequently confirmed after updated design modelling that acetaldehyde would not be present.

In accordance with BAT requirements, it is expected that suitable effluent treatment measures are in place. There is however no effluent treatment on-site other than neutralisation where necessary, nor is there any active treatment once the discharge leaves the installation. Considering the conclusions of the operator's risk assessment, we are satisfied that the proposed changes in effluent discharge arising from the addition of the LIC Plant are not expected to adversely affect the receiving water environment. Furthermore, substances present in the effluent discharge do not exceed any thresholds above which CWW BAT Conclusions BAT-AELs would apply. We note that existing and proposed effluents will be combined prior to discharge, and that effluent treatment would therefore be relevant to the wider installation and not just the changes proposed by this variation. In this case, we have therefore included improvement condition IC9 in the permit, requiring the operator to review and identify opportunities for on-site effluent treatment, with the aim of further minimising the presence of potentially polluting substances in the effluent discharge, in line with BAT requirements.

Emissions to air

Under normal operation, the only emissions to air from the LIC Plant will be nitrogen from plant inerting systems. The operation of the LIC Plant will however lead to a reduction in the carbon dioxide content of the Pressure Swing Adsorption tail gas used to fire the existing Steam Methane Reformer (SMR) furnace. The operator has carried out testing which demonstrates that this will lead to only a slight increase in emissions of oxides of nitrogen (NO_x) from the SMR stack, with the concentration remaining well below the 150 mg/m^3 used within the air dispersion modelling submitted as part of the original permit application, and stated that there will be no increase in the discharge flow rate. The operator has also set out the measures that will be used to minimise amine carry over to the tail gas, which include passing the tail gas through a knockout drum prior to its combustion, and hence any impact on emissions of NO_x from amine carry over are expected to be negligible. In summary, we consider that updated air dispersion modelling is not required and there is no increase in environmental risk in relation to emissions of NO_x from the SMR stack.

The operator has also identified the key equipment, systems and monitoring that will be in place to ensure only very minor amine vapour losses in gas streams are possible, whilst any liquid entrainment in gas streams will trigger alarms and, if necessary, shutdown of the LIC Plant.

The operator has identified 'other than normal operating conditions' (OTNOC) scenarios that will require venting of carbon dioxide and carried out dispersion modelling to support that there will be no significant risk to human health. At the time of the application submission, our regulatory approach was to request modelling of carbon dioxide venting associated with carbon capture, however since the application's submission, we have reviewed our approach and do not now require this. We do however require a vent management plan to be in place prior to operation. In this case, we have reviewed and provided comments on the modelling, to support any additional modelling that may be carried out, and we have included improvement condition IC7 in the permit for the operator to provide a vent management plan, as opposed to a pre-operational measure. This accounts for the change in regulatory approach since the application's submission and also the fact that the risk to receptors is very low since the nearest receptors are over 2km away.

Updating to modern conditions

The following updates have been made as a result of the operator's request for the permit to be updated to modern conditions:

- All references to specific application responses in the original permit have been referenced in the Operating Techniques table.
- Requirements relating to the storage of solid wastes, as set out by condition 2.5.2 and Table 2.5.2 in the original permit, have been included within the description and limits of the directly associated activity for the storage of solid waste.
- The requirement for an annual report on energy consumption, as set out by condition 2.7.2 in the original permit, has been replaced by the standard annual reporting requirement for energy usage.
- The requirement for an energy management plan and its annual update, as set out by condition 2.7.3 in the original permit, is no longer applicable, however the operator may choose to continue maintaining an energy management plan as part of their Environmental Management System.

- The requirement for a six monthly report on the reasons for all occasions when steam is deliberately vented to atmosphere at rates in excess of 10 tonnes/hour for periods in excess of one hour, as set out by condition 6.5.1 in the original permit, has been included as a performance parameter.
- The requirement for no transfer from emission point E1 of any substance for which no limit has been specified except in a concentration which is no greater than the background concentration, as set out by condition 7.1.2, is no longer applicable since we do not include this requirement when evaporative cooling towers are used.

Decision considerations

Confidential information

A claim for commercial or industrial confidentiality has not been made.

Identifying confidential information

We have not identified information provided as part of the application that we consider to be confidential.

Consultation

The consultation requirements were identified in accordance with the Environmental Permitting (England and Wales) Regulations (2016) and our public participation statement.

The comments and our responses are summarised in the consultation responses section.

The application was publicised on the GOV.UK website.

We consulted the following organisations:

- Environmental Protection Department, Stockton Borough Council
- Health and Safety Executive
- North Eastern Inshore Fisheries and Conservation Authority
- PD Ports Harbour Authority

The comments and our responses are summarised in the consultation responses section.

The regulated facility

We considered the extent and nature of the facility at the site in accordance with RGN2 'Understanding the meaning of regulated facility', Appendix 2 of RGN2 'Defining the scope of the installation' and Appendix 1 of RGN 2 'Interpretation of Schedule 1'. Carbon dioxide capture for utilisation is not regulated as a Schedule 1 activity in its own right, but is considered a directly associated activity.

The extent of the facility is defined in the site plan and in the permit. The activities are defined in table S1.1 of the permit.

The site

The operator has provided plans which we consider to be satisfactory.

These show the extent of the site of the facility.

The plan is included in the permit.

Site condition report

The operator has provided a description of the condition of the site, which we consider is not satisfactory. The decision was taken in accordance with our guidance on site condition reports and baseline reporting under the Industrial Emissions Directive.

In relation to the area of land being added to the installation boundary as part of this variation, we consider that the pollution of land and water is unlikely, with no relevant hazardous substances proposed to be stored or used in this area. Whilst we do not therefore require baseline reference data to be provided, we also note that historical contamination is present and hence the collection of baseline reference data may be appropriate. The operator has submitted baseline reference data, however we are unable to accept this as representing the baseline for the condition of this area of land, since it does not include soil or groundwater data for all potential contaminants identified in the application.

We have advised the operator in writing what measures they need to take to improve the site condition report. We have advised that they may wish to carry out further soil and groundwater sampling prior to operation and that we recommend at least three rounds of groundwater sampling when establishing a baseline, to account for the potential variation and seasonality in groundwater. We have also highlighted this aspect to the installation’s Regulatory Officer, since maintaining the site condition report is relevant to ongoing regulation and compliance.

Nature conservation, landscape, heritage and protected species and habitat designations

We have checked the location of the application to assess if it is within the screening distances we consider relevant for impacts on nature conservation, landscape, heritage and protected species and habitat designations. The application is within our screening distances for these designations.

We have assessed the application and its potential to affect sites of nature conservation, landscape, heritage and protected species and habitat designations identified in the nature conservation screening report as part of the permitting process.

We consider that the application will not affect any site of nature conservation, landscape and heritage, and/or protected species or habitats identified.

The following site was considered:

- Teesmouth and Cleveland Coast (SPA, Ramsar & SSSI)

See ‘Key issues of the decision – Emissions to surface water’ section above for further details.

We have not consulted Natural England, however we have sent them a copy of our Habitats Risk Assessment for their information.

The decision was taken in accordance with our guidance.

Environmental risk

We have reviewed the operator's assessment of the environmental risk from the facility.

The operator’s risk assessment is satisfactory.

See ‘Key issues of the decision’ section above for further details.

General operating techniques

We have reviewed the techniques used by the operator and compared these with the relevant guidance notes and we consider them to represent appropriate techniques for the facility.

See ‘Key issues of the decision – Best Available Techniques (BAT) assessment’ section above for further details.

The operating techniques that the applicant must use are specified in table S1.2 in the environmental permit.

Operating techniques for emissions that do not screen out as insignificant

Emissions of chlorine and methanol to water cannot be screened out as insignificant. We have assessed whether the proposed techniques are Best Available Techniques (BAT). See ‘Key issues of the decision – Emissions to surface water’ section above for further details.

Operating techniques for emissions that screen out as insignificant

Emissions of amine to water (associated with the carbon dioxide capture solvent) have been screened out as insignificant.

See ‘Key issues of the decision – Emissions to surface water’ section above for further details.

Updating permit conditions during consolidation

We have updated permit conditions to those in the current generic permit template as part of permit consolidation. The conditions will provide the same level of protection as those in the previous permit.

Pre-operational conditions

Based on the information in the application, we consider that we need to include pre-operational conditions.

We have included pre-operational condition PO1 requiring the submission of a written commissioning plan for the LIC Plant, to include:

- Timelines.
- Operational envelope and process controls.
- Expected emissions and an associated risk assessment.
- Commissioning Monitoring Plan.
- Methodology for demonstrating the carbon dioxide capture efficiency.
- Methodology for quantifying the total mass of carbon dioxide emissions vented during start-up and OTNOC.

See ‘Key issues of the decision – Best Available Techniques (BAT) assessment’ section above for further details.

Improvement programme

Based on the information on the application, we consider that we need to include an improvement programme.

We have included an improvement programme to ensure that:

- The environmental performance of the LIC Plant during commissioning is reviewed (IC5).
- An approved OTNOC management plan is in place (IC6).
- Venting of carbon dioxide is appropriately managed (IC7).

- Emissions to water once the LIC Plant is operational are within the risk envelope assessed by the application (IC8).
- Opportunities for additional on-site effluent treatment are considered, and existing treatment is reviewed (IC9).

See ‘Key issues of the decision’ section above for further details.

Emission limits

An Emission Limit Value (ELV) has been added for emissions of chlorine to water from emission point E4.

See ‘Key issues of the decision – Emissions to surface water’ section above for further details.

Monitoring

We have decided that monitoring should be added for emissions of chlorine to water from emission point E4, using the methods detailed and to the frequencies specified.

See ‘Key issues of the decision – Emissions to surface water’ section above for further details.

Based on the information in the application we are satisfied that the operator’s techniques, personnel and equipment have either MCERTS certification or MCERTS accreditation as appropriate.

Reporting

We have added reporting in the permit for emissions of chlorine to water from emission point E4.

See ‘Key issues of the decision – Emissions to surface water’ section above for further details.

Management system

We are not aware of any reason to consider that the operator will not have the management system to enable it to comply with the permit conditions.

The decision was taken in accordance with the guidance on operator competence and how to develop a management system for environmental permits.

Growth duty

We have considered our duty to have regard to the desirability of promoting economic growth set out in section 108(1) of the Deregulation Act 2015 and the guidance issued under section 110 of that Act in deciding whether to grant this permit variation.

Paragraph 1.3 of the guidance says:

"The primary role of regulators, in delivering regulation, is to achieve the regulatory outcomes for which they are responsible. For a number of regulators, these regulatory outcomes include an explicit reference to development or growth. The growth duty establishes economic growth as a factor that all specified regulators should have regard to, alongside the delivery of the protections set out in the relevant legislation."

We have addressed the legislative requirements and environmental standards to be set for this operation in the body of the decision document above. The guidance is clear at paragraph 1.5 that the growth duty does not legitimise non-compliance and its purpose is not to achieve or pursue economic growth at the expense of necessary protections.

We consider the requirements and standards we have set in this permit are reasonable and necessary to avoid a risk of an unacceptable level of pollution. This also promotes growth amongst legitimate operators because the standards applied to the operator are consistent across businesses in this sector and have been set to achieve the required legislative standards.

Consultation Responses

The following summarises the responses to consultation with other organisations, and the way in which we have considered these in the determination process.

Responses from organisations listed in the consultation section

Response received from:

Environmental Protection Department, Stockton Borough Council.

Brief summary of issues raised:

No issues raised. Consultee stated they were satisfied that appropriate environmental risk and impact assessments had been provided showing that the plant will not lead to any significant environmental impacts.

Summary of actions taken:

No further actions required.