# Northfleet HPF EP Application

## Environmental Permit Application Pack

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| Client: | Green Hydrogen Three Ltd |
| Project/Proposal No: | 6551 |
| Version: | 1.0 |
| Date: | 25/01/2024 |

# Document Information

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| Project Name: | Northfleet HPF EP Application |
| Document Title: | Environmental Permit Application Pack |
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| Reviewed: | G M Bollan |
| Approved: | G M Bollan |
| Date: | 25/01/2024 |
| Version: | 1.0 |
| Project/Proposal Number: | 6551 |

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## Revision History

| Version | Date | Authored | Reviewed | Approved | Notes |
|---|---|---|---|---|---|
| 0.2 | 21/11/2023 | T Hatch | G M Bollan | | Draft for Client Review |
| 0.3 | 30/11/2023 | T Hatch | G M Bollan | | Post Client Review |
| 0.4 | 18/12/2023 | T Hatch | G M Bollan | | Final snagging to Client |
| 0.7 | 11/01/2024 | T Hatch | G M Bollan | | Final Draft |
| 1.0 | 25/01/2024 | T Hatch | G M Bollan | G M Bollan | First Issue |

# Contents

# Abbreviations

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|---|---|
| BAT | Best Available Techniques |
| BREF | BAT Reference |
| °C | Degree Celsius |
| $CO_2$ | Carbon dioxide |
| COMAH | Control Of Major Accident Hazards |
| DAA | Directly Associated Activity |
| EIA | Environmental Impact Assessment |
| EMS | Environmental Management System |
| ENVID | Environmental impact identification |
| EP | Environmental Permit |
| ERA | Environmental Risk Assessment |
| FEED | Front End Engineering Design |
| GHG | Greenhouse Gas |
| GW | Gigawatt |
| HAZID | Hazard identification |
| HAZOP | Hazard and operability (study) |
| HPF | Hydrogen Production Facility |
| HRS | Hydrogen Refuelling Station |
| HSE | Health & Safety Executive |
| LDAR | Leak Detection And Reporting |
| LOPA | Layers of Protection Analysis |
| $m^3$/hr | cubic metres per hour |
| MW | Megawatt |
| OEM | Original Equipment Manufacturer |
| PEM | Proton Exchange Membrane |
| PPA | Power Purchase Agreement |
| RO | Reverse Osmosis |
| VOC | Volatile Organic Compound |

# 1. Non-Technical Summary

1.1.1 HYRO Limited (”HYRO”) provides green hydrogen solutions for energy intensive business, supporting hard-to-electrify processes to reach their decarbonisation goals. HYRO is a joint venture between Octopus Energy Generation and RES. RES is the world's largest independent renewable energy developer, having delivered 23GW of generation capacity in 11 countries. Octopus Energy Generation is one of Europe's largest investors in renewable energy. The Octopus team manages over 3 gigawatts (GW) of green power assets worth £5 billion across 11 countries. It is the generation arm of Octopus Energy Group, the global energy technology pioneer.

1.1.2 The applicant for this permit will be special purpose vehicle Green Hydrogen Three Limited (Companies House Number 14314761) which is a fully owned subsidiary of HYRO.

1.1.3 HYRO proposes to install a green hydrogen production facility (HPF) (“the HPF Installation”) on land owned by international paper product company Kimberly-Clark (KC) and immediately adjacent to KC’s Northfleet Paper Mill in Northfleet, Kent. The HPF Installation would be developed on land owned by KC on a vacant part of their site currently given over to hardstanding for wood pulp storage.

1.1.4 HYRO will develop a 15 megawatt (MW) (electrical) electrolytic hydrogen plant with ancillary gas handling, purification and storage which will send hydrogen via dedicated pipe run to the paper mill’s boiler plant at the southern end of the KC site.

1.1.5 KC is planning to upgrade their natural gas-fired boiler to a dual-fuel natural gas and hydrogen-fired boiler, capable of firing up to 100% hydrogen.

1.1.6 Feedstock water will be ordinary towns water and will be provided by agreement with Southern Water.

1.1.7 Waste water from the feedstock water demineralisation process is proposed to be discharged to sewer subject to agreement of a Consent to Discharge by Southern Water.

1.1.8 The HPF installation at the Northfleet site is expected to be considered an industrial hydrogen (inorganic chemical) production facility by the regulator Environment Agency (EA), under Schedule 1, Section 4.2A(1)a(i) of the Environmental Permitting Regulations.

1.1.9 The HPF Installation will produce green hydrogen through electrolysis of purified water, using electricity supplied from renewable sources to split water into its component molecules of oxygen and hydrogen. If the hydrogen gas is not required immediately at the paper mill, it will be stored temporarily at the site within dedicated storage tanks. A maximum of 1800 kg storage capacity is proposed.

1.1.10 A small quantity of hydrogen at low concentrations is vented from the electrolysers during normal operation, and waste water is generated by the feedstock purification process. Oxygen is a by-product of hydrogen production and will be vented directly to atmosphere. There are no other material routine emissions from the HPF Installation aside from a continuous nitrogen purge of the hydrogen vent required to maintain safe operation.

1.1.11 An Environmental Risk Assessment has been carried out according to Environment Agency requirements and residual risks to the environment assessed as either low or negligible.

1.1.12 The proposed design of the HPF Installation is considered in general to represent Best Available Techniques (BAT) for pollution prevention and control for the inorganic chemical sector, in the absence of specific BAT for the electrolytic hydrogen industry.

# 2. Introduction

## 2.1 Structure of this document

2.1.1 This document forms part of the Environmental Permit (EP) application materials for the HPF Installation. It includes material which does not practically fit in the current Environment Agency Application Form templates for ease of reading. The main sections are as follows:

- Introduction to the application, the operator, the proposed HPF Installation and relevant guidance;
- Process description, covering the regulated and ancillary parts of the green hydrogen production process;
- Management system summary;
- Environmental risk assessments, which identify where more detailed assessments have been undertaken;
- Energy and resource efficiency measures; and
- Best Available Techniques (BAT) assessment.

Also included with the application are the following documents:

- Application forms A, B2, B3, B6 and F;
- Application Document Key for Form F;
- Permit Application Drawings (Drawings 1 to 3: 6551-1 Site Location Plan, 6551-2 Installation Boundary and Emission Points, 6551-3 Proposed Pipeline Routes, 6551-4 Site context on KC installation boundary)
- Site Condition Report with H5 appended (Site Condition Report);
- Climate_Change_Adaptation_Risk_Assessment (Climate Change Risk Assessment); and
- H1 Environmental Risk Assessment (effluent discharge).

The environmental impact assessment reports produced in support of the concurrent planning application for the Installation;

- Noise assessment report R01_2023-07-27_Acoustic-Impact-Assessment-of-Northfleet-Green-Hydrogen Development_V03 (approved); and
- Flood Risk Assessment 681775-R1(4)-FRA.

2.1.2 It should be noted that the geo-environmental report and flood risk assessment’s scope of coverage are the location of the proposed HPF installation and the surrounding KC installation (see Drawing 6551-4).

## 2.2 Background to the Application

2.2.1 National decarbonisation targets to reach net zero by 2050 will require a diverse package of measures including green hydrogen, which is a carbon-free thermal fuel intended to partly or fully replace natural gas. Current government aspirations are for 10GW of green (electrolytic) hydrogen production by 2030. The HPF Installation will represent a step towards that 10GW target, with the introduction of 15MW of electrolyser capacity.

2.2.2 The scale of the HPF Installation will mean the development can provide a reliable source of green hydrogen, powered by renewables in accordance with the requirements of DESNZ's Low Carbon Hydrogen Standard.

2.2.3 A long-term Power Purchase Agreement (PPA) will be in place to provide energy to the Installation from renewable generating assets developed by HYRO constituent company Octopus. The HPF Installation will consume electrical energy from these ring-fenced amounts of renewable energy on a matched settlement period basis (after accounting for grid losses).

2.2.4 Hydrogen production by the Installation will be driven primarily by the demand profile of the hydrogen off-taker (the Northfleet Papermill). No significant seasonality in demand is anticipated.

2.2.5 Storage will primarily be used to take advantage of periods of low-cost green energy during a period in which the installation will overproduce.

2.2.6 Energy used at the site will be sourced from renewable energy producers onshore wind and solar photovoltaic projects. Since these technologies have complementary seasonality behaviours, no significant seasonality in the generation profile of the mixture of ring-fenced asset generation output is therefore expected.

2.2.7 It will save up to 10,600 tonnes of $CO_2e$ per year once operational, which represents a significant saving on the paper mill's current greenhouse gas emissions.

2.2.8 The site address is Northfleet Mill, Crete Hall Road, Gravesend, DA11 9AD and the co-ordinates for the centre of the site are TQ 62672 74590. The site location is shown in 6551-Drawing 1. and the layout (and emission points) in 6551-Drawing 2. The site process and surface water drainage plan is shown in 6551-Drawing 3.

## 2.3 The Operator

2.3.1 The Operator and the applicant will be Green Hydrogen Three Limited, an entity set up specifically to develop this specific green hydrogen Installation which is 100% owned by HYRO.

2.3.2 Founded in 2022, HYRO provides green hydrogen solutions for energy-intensive businesses, supporting hard-to-electrify processes to reach their decarbonisation goals.

2.3.3 HYRO is a joint venture between Octopus Energy Generation and RES. RES is the world's largest independent renewable energy developer – having delivered 23GW of generation in 11 countries.

2.3.4 Octopus Energy Generation is one of Europe's largest investors in renewable energy. The Octopus team manages over 3GW of green power assets worth £5 billion across 11 countries. Octopus Energy Generation is the generation arm of Octopus Energy Group, the global energy technology pioneer.

2.3.5 This aligns with the UK's wider decarbonisation ambitions as HM Government is targeting 10 GW of low hydrogen capacity built by 2030, with at least 5GW of that target being green i.e. electrolytic and renewably powered.

## 2.4 Pre-Application Advice

2.4.1 The Environment Agency (EA) was approached in October 2023 and provided pre application advice and a reference number (EPR/MP3624ST/P001). A Nature and Heritage Conservation report was also undertaken by the EA the results of which are below:

Sites and Features within Screening Distance

- Special Protection Area (pSPA or SPA) – Thames Estuary & Marshes (Screening distance 5km)
- Ramsar - Thames Estuary & Marshes - Marshes (Screening distance 5km)
- Sites Special Scientific Interest (SSSI) – Swanscombe Peninsula (Screening distance 5km)

- ➢ Local Wildlife Sites (LWS) – Ebbsfleet Marshes (Northfleet) and Botany Marshes (Screening distance 2km)

Protecting Species within Screening Distance (up to 2km)

- ➢ European Eel migratory route
- ➢ Atlantic Salmon migratory route
- ➢ Twaite Shad migratory route
- ➢ Allis Shad migratory route
- ➢ River Lamprey migratory route
- ➢ Sea Lamprey migratory route
- ➢ Smelt migratory route

2.4.2 The plans showing the above screenings confirm that none of these receptors are located within the site. As subsequent sections discuss, there is no expected interaction between the HPF Installation and the habitat and species receptors identified.

2.4.3 A further detailed pre-application meeting was held on 12 January 2024. HYRO took advice on a number of issues including the scope of the requisite environmental risk assessments.

## 2.5 The Proposed Installation and classification

Overview

2.5.1 The HPF Installation will consist of six Proton Exchange Membrane (PEM) electrolysers. Each electrolyser will be rated at 2.5 megawatt (MW) (as new) electrical input each with a nominal design production capacity of 46.7kg of hydrogen gas per hour. The electrolysers will be housed in container modules in which ancillary equipment including water treatment and hydrogen gas conditioning / purification units are also housed.

2.5.2 The HPF Installation boundary will cover an area of approximately 2.2 hectares (ha).

2.5.3 The main components will include:

- ➢ Main electrolyser machinery;
- ➢ Water treatment packages;
- ➢ Gas purification treatment and drying packages;
- ➢ Hydrogen storage facilities; and
- ➢ Electrical Substation(s).

2.5.4 The 15 MW unit will produce hydrogen at a maximum rate of approximately 280 kg/hr. The exact rate of production will be confirmed when electrolyser supplier confirmed based on electrolyser efficiency; it will not be so different from the assumed rate to affect the conclusions drawn in this permit application.

2.5.5 The maximum quantity of water required when the electrolysers are operating at full output will be 5.64 cubic metres per hour ($m^3$/hr) and a mean flow rate of 2.9 ($m^3$/hr).

2.5.6 Waste water is proposed to be discharged to the public sewer via emission point S1. The peak flow of process waste water expected is 4.0 $m^3$/hr and the mean flow is expected to be 1.44 $m^3$/hr.

2.5.7 Surface water is proposed to be discharged to the Thames at the existing outfall W1 using the existing site drainage infrastructure (see 6551-Drawing 3). W1 currently discharges storm water from the section of the KC site to be used by the HPF Installation. Waste process water (or Trade Effluent) will be discharged to the Southern Water sewer network via a new connection, S1. As is common with all electrolytic hydrogen installations, the process effluent will consist of brine rejected from a reverse osmosis treatment system. The volume is expected to be in the order of 96 $m^3$ per day peak (35$m^3$ per day mean); the composition will be similar to the towns water in terms of dissolved species present, at a higher concentration due to the nature of the water purification process necessary to supply the electrolysers. The process waste water (i.e. non-storm water) arising will be collected in a buffer tank and the rate of discharge monitored using MCERTS compliant equipment as conditioned.

2.5.8 The hydrogen production facility will include hydrogen storage, metering, a pressure let down station and a distribution pipeline. The stored hydrogen will be kept at around 30 Bar and distributed to the offtaker at 3 barg. A maximum 1.8 tonnes of hydrogen will be stored at any one time.

2.5.9 The hydrogen-ready boiler at the KC paper mill will be the sole user of the hydrogen produced at the Installation.

<u>Classification</u>

2.5.10 The green hydrogen electrolysis process is understood to represent an Installation under the definitions in the Environmental Permitting (England) Regulations Schedule 1 Part 2 Chapter 4 Section 4.2 Part A(1)(a)(i) as hydrogen gas will be produced:

*"Producing inorganic chemicals such as— (i) gases (for example ammonia, hydrogen chloride, hydrogen fluoride, hydrogen cyanide, hydrogen sulphide, oxides of carbon, sulphur compounds, oxides of nitrogen, hydrogen, oxides of sulphur, phosgene)."*

2.5.11 The scale of production is expected to meet the definitions of "industrial scale" provided in Environment Agency Regulatory Guidance Note RGN2 which sets a lower threshold of 100 kg per annum for site producing single products. Oxygen is also generated as part of the process but not captured for use as a commercial product.

<u>Directly Associated Activities (DAAs)</u>

2.5.12 The integrated hydrogen production and conditioning modules and their water treatment units will represent the core Permitted activities. Directly associated activities (DAAs) included on the grounds of associated emissions will include:

- Water treatment packages (waste arisings) and
- Emergency vent and flare system (air emissions of combustion by-products).

2.5.13 The Environment Agency has suggested that the Kimberly-Clark boilers and the main hydrogen production facility will be mutual DAAs. Any variation to KC's existing permit EPR/BJ7379IZ to reflect this change will be made in due course subject to the EA's confirmation.

2.5.14 There is a slight overlap of the proposed installation boundary and the existing KC installation boundary. The KC boundary is shown in green on Drawing 6551-4. The hydrogen production facility boundary does not coincide with any actual scheduled activities within the KC boundary, the shared land is part of the current KC pulp storage area, the location of site drainage and KC effluent pipe runs and part of the KC effluent treatment plant curtilage.

Other Non-Directly Associated Activities

2.5.15 Activities also included within the Installation boundary which are not believed to represent DAAs on grounds of lack of environmental emissions are included for completeness:

- Associated infrastructure including converter substations; and
- Stormwater drainage infrastructure.

Site drainage

2.5.16 Surface water drains at the site that are owned by KC are present across the site and run adjacent to the Installation area on all sides arising from the east. These drains are served by gullies that intercept surface water in and around the development site area, joining the KC trunk drain running along the west of the site. KC's surface water drains also occupy and serve the road to the south east of the site and partially along Crete Hall Road. Surface water will be vastly predominated by storm water. Some minimal quantities expected to be generated from process uses such as wash downs (minimal domestic cleaning). No process water will be combined with the surface water and surface water will not be used for cleaning.

## 2.6 Guidance and legislation consulted

2.6.1 Legislation consulted as part of the permit application process consists of:

- The Environmental Permitting (England and Wales) Regulations 2016; and
- The Environmental Permitting (England and Wales) (Amendment) Regulations 2018.

2.6.2 Reference has also been made, *inter alia*, to the following guidance:

- Permitting guidance from the UK Government landing page (https://www.gov.uk/topic/environmental-management/environmental-permits);
- Directive 2010/75/EU (The Industrial Emissions Directive);
- Environment Agency Regulatory Guidance Note 2;
- Sector Guidance Note EPR4.03 for the Inorganic Chemicals Sector;
- Reference Document on Best Available Techniques for Energy Efficiency (the Energy Efficiency BREF), 2009 version as amended in 2021;
- Reference Document on Best Available Techniques on Emissions from Storage (the Storage BREF), 2006 version; and
- Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (the Industrial Cooling Systems BREF), 2001 version.

# 3. Process Description

## 3.1 Overview

3.1.1 The proposed HPF Installation will be built around an electrolyser for hydrogen production using Proton Exchange Membrane (PEM) electrolyser technology. This type of electrolyser operates at a high efficiency across a wide range of electrical loads, making it the ideal technology to produce hydrogen from potentially intermittent or variable renewable energy sources. The electrolyser splits water molecules into hydrogen and oxygen using electrical energy.

3.1.2 PEM electrolysers require two sources of feedstock, namely electrical energy, and high purity water. The Installation primarily using an energy supply agreement with a generating supplier to ensure there is a supply of renewable energy for the site and green hydrogen GHG intensity criteria for electrical inputs are met.

3.1.3 A Process Flow Diagram is included as Figure 3-1.

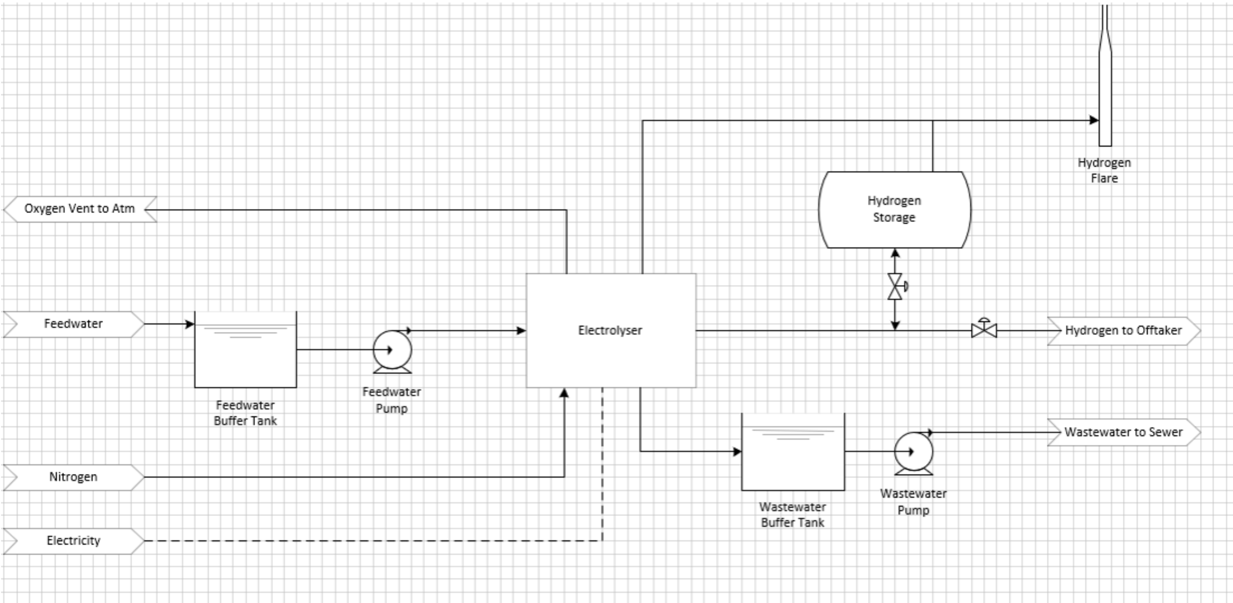


*Figure 3-1 Hydrogen Production Installation Block Diagram*

## 3.2 Detailed Process Description

3.2.1 Hydrogen production will be based on the electrolysis of purified water by a containerised 15MW (6 x 2.5MW) PEM electrolysers. The associated nominal hydrogen output capacity of the combined electrolysis packages will be approximately 280 kg per hour.

3.2.2 KC as the sole offtaker will have a hydrogen demand of approximately 210kg/hr at 99.9% purity required at 0.4 barg pressure. The 15 MW unit will be able to provide a maximum of approximately 270kg/hr. There will be a maximum of 1800 kg of hydrogen on site to meet hydrogen demand during periods of low production.

3.2.3 Delivery to KC at this low outlet pressure from the HPF means no compression is required.

3.2.4 The electrical distribution systems will be developed to provide a safe, reliable, operable, and economic system meeting the requirements of the hydrogen plant. HYRO have opted for a firm grid feed from the Distribution Network Operator (DNO) providing 16MVA import connection from the grid supply to the plant.

3.2.5 Raw water from Southern Water will be stored in a raw water tank sufficient to provide around one hour of production capacity at full electrolyser loads. The raw water will be treated to remove dissolved salts using ion exchange and reverse osmosis (RO) treatment to achieve a low concentration of dissolved salts equivalent to a conductivity of less than 1 microSiemens per centimetre (µS/cm). The system will require approximately 4.2 cubic metres per hour ($m^3$/hr) of demineralised water. To achieve this, a raw water consumption rate of 5.64 $m^3$/hr is required.

3.2.6 Rejected water (brine, with an increased concentration of dissolved salts) is sent to the drainage system and purified water is sent to the electrolyser stack at a rate in proportion to the prevailing electrical load. Brine is produced at a maximum rate of 1.44 $m^3$/hr – the balance of the raw and process water described above.

3.2.7 Hydrogen and oxygen are produced at opposite electrodes within the electrolyser. Hydrogen will be introduced to a header system via dedicated gas / water separator units; oxygen will be vented to atmosphere.

Hydrogen processing

3.2.8 Figure 3-1 shows the hydrogen treatment process. The hydrogen produced by the electrolysers is treated to remove traces of oxygen and water vapour before transmission to the offtaker.

3.2.9 It is first passed to a DeOxo unit, where trace oxygen is removed from the hydrogen through catalytic reaction, producing small amounts of water which is routed to the waste water stream.

3.2.10 It is then passed to the hydrogen drier, where the water content is reduced through a molecular sieve adsorption process, again producing trace quantities of water which is routed to the waste water stream.

Oxygen

3.2.11 Oxygen will be emitted from the electrolyser at a rate of approximately 2,200 kg per hour. There is no anticipated demand for oxygen at the KC Papermill and hence this will all be vented to atmosphere. This is unlikely to be revisited given the space constraints at the site and a future offtaker for oxygen will not be sought.

Operations

3.2.12 The HPF Installation is being designed to operate on a generally autonomous basis. All relevant process parameters (e.g. electrolyser load, storage tank pressure, gas treatment temperature etc.) will be subject to instrumental control and generate telemetry collated by a SCADA system. The SCADA system will be continuously monitored by a machine system which will provide where necessary alerts (following unplanned depressurisation, out of range alarms, low water level etc.) to a human operative of Green Hydrogen Three. The operative can manually instigate process adjustments and shutdowns as required, and attend site as required.

3.2.13 Periodic planned and precautionary inspection and maintenance visits will complement the above.

# 4. Emissions and Monitoring

4.1.1 Direct monitoring of hydrogen is not proposed due to the nature of the expected releases and lack of available monitoring technology, as is discussed further in this section. Electricity and water intakes will be subject to fiscally-compatible metering if low overall measurement uncertainty.

## 4.2 Routine emissions

Hydrogen

4.2.1 Process venting of hydrogen which cannot be recovered for further use will be emitted from the electrolyser packages to atmosphere at a combined rate of around 1 kilogram per hour under normal operation. It is also expected that there will be a very small continuous flow of hydrogen from the safety valves on the balance of plant, connecting into the main vent header. These small emissions have been quantified based on OEM data on calculated rates of release and this will be the proposed monitoring approach during operation of the installation. All other produced hydrogen will either be exported directly to KC's paper mill boiler or stored under pressure for ultimate use by KC.

4.2.2 The process facilities will be designed to minimise the probability for accidental release of hydrogen, by:

- Rating all piping, vessels, pipelines, and equipment in accordance with maximum foreseeable operating pressures and temperatures.
- Ensuring that material selection is fully compatible with process fluids and conditions, and the wall thickness take account of corrosion and erosion potential for the expected operating life, with cathodic protection and coatings where applicable.
- Minimising potential leak sources (including joints, valves, instrument fittings and flanges) as far as is practicable, whilst allowing for safe operation and maintenance. This includes fully welded piping where practical.

4.2.3 Hydrogen emissions during commissioning will be quantified by calculation rather than direct measurement, there are no known instruments meeting MCERTs standards available for monitoring hydrogen emissions. These calculations will be based on calculated hydrogen production rates from electrolyser load and water consumption for the relatively large-scale venting during commissioning.

4.2.4 Hydrogen emission points are labelled as A1, A3, A4, A6, A7, A9, A10, A12, A13, A15, A16 and A18 on Drawing 6551-2 Sheet 2.

Oxygen

4.2.5 There is no demand for oxygen at the paper mill and hence any oxygen generated will all be vented. No monitoring of oxygen is proposed. For normal operation the expected emissions rates to air for oxygen is around 2,200 kg/h.

4.2.6 Oxygen emission points are labelled as A2, A5, A8, A11, A14 and A17 on Drawing 6551-2 Sheet 2.

Nitrogen

4.2.7 Nitrogen is used inside the electrolyser package and to inert vent lines and flare. After being used, nitrogen will be vented to atmosphere. It will be produced on or delivered to site.

4.2.8 There will also be a continuous vent of nitrogen (routed to a safe location) to prevent a flammable atmosphere forming in the blowdown system. For normal operation the expected emissions rates to air for nitrogen is 135 kg/hr from routine purging.

4.2.9 Emission points from the Installation are either process vents installed to vent low pressure gas during commissioning or pressure relief valves for emergency venting. The emergency vent stack is also an emission point, A19.

4.2.10 Both nitrogen and oxygen will be vented through the individual electrolyser vents. Hydrogen will be purged using nitrogen through the main emergency vent/flare.

Oxides of nitrogen

4.2.11 There are no routine emission of oxides of nitrogen (NOx) from the installation under normal operating conditions. Some NOx formation is likely in the event that the emergency flare is activated. The mass of hydrogen to be flared is in the order of 900 kg This value is to be finalised once the FEED stage has been completed. The quantity of NOx formed is expected to be a small fraction of the combustion gas make-up.

4.2.12 The location of the flare stack is shown as emission point A19 on Drawing 6551-2 Sheet 2.

Waste water

4.2.13 Waste water is proposed to be discharged to the sewer network. As is common with all electrolytic hydrogen installations, the effluent will consist of brine rejected from a reverse osmosis treatment system. The volume is expected to be in the order of 96 cubic metres per day maximum and 35 cubic metres per day mean and the composition will be similar to the abstracted water in terms of dissolved elements present, at a higher concentration due to the nature of the water purification process necessary to supply the electrolysers. Waste water will be collected in a buffer tank and discharges metered before onward flow to S1 via the public sewer.

4.2.14 The composition of the effluent is included in Section 9.

4.2.15 Waste water emissions at peak flow will be approximately 4 $m^3$/hr and the mean flow will be approximately 1.44 $m^3$/hr.

4.2.16 Measurement of effluent flow and composition will be in accordance with conditions agreed with the discharge permit. It is expected that temperature and volumetric flow rate will be monitored continuously. Process effluent will be sampled and monitored as required. Effluent discharge will be measured in accordance with the MCERTS performance standard for the self-monitoring of flow.

4.2.17 Process waste water arisings will predominantly be from the water treatment packages with minimal other uses such as washdowns.

4.2.18 The point at which process effluent joins the public sewer is shown as S1 on Drawing 6551-2 Sheet 1.

Visible Emissions

4.2.19 Emissions from the vent will be relatively dry and no visible water vapour plume is anticipated.

Other Than Normal Operating Conditions

4.2.20 The proposed HPF Installation has a wide envelope of normal operating conditions, as the intention is for the PEM electrolyser to operate near continuously under as wide a range of electrical loads as possible. Operations under Other Than Normal Operating Conditions would generally be restricted to infrequent start up and shutdown events. Some minimal release of hydrogen may occur during the nitrogen line purges which would be required for these events.

4.2.21 Emergency purging of hydrogen will be at a rate of 155kg/minute for a maximum of 15 minutes during an emergency event.

4.2.22 Nitrogen is used inside the electrolyser package and to inert vent lines and flare. After being used, nitrogen will be sent to a flare. Nitrogen will be produced on, or delivered to, site.

4.2.23 An emergency flare will be installed to combust large volumes of purged hydrogen in the event of inventory loss. This flare will act as a cold process vent during normal operation, with automatic pilot ignition during emergency events. The flare will combust hydrogen to water vapour to prevent large amounts of elemental hydrogen being released to atmosphere. According to API 521, high volume storage should be depressurized from operating pressure to 7 barg in 15 minutes. The depressurising calculation for the hydrogen tank capacity leads to a maximum flowrate near 2.7 kg/s in case of storage at 30 barg. A maximum of 50% of the inventory would be flared. Please note that routine flaring is not expected, and it is only to be used in emergency situations.

4.2.24 The flare system will have the following:

- ➢ a pilot ignition (but no pilot flame);
- ➢ flameout warning systems; and
- ➢ a means to purge the vent line.

4.2.25 Testing and maintenance may see lifting of relief valves or control valves to vent. This is expected to occur infrequently for a matter of minutes. A conservative estimate for this would be 30 minutes per month. Please note that routine flaring is not expected, and it is only to be used in emergency situations.

4.2.26 For the six 2.5MW PEM electrolysers, this equates to an annual average of 50 kilograms of hydrogen gas per year.

4.2.27 Periodic depressurisation will be required for vessel inspection and general maintenance. The system inventory will be reduced through offloading to offtakers (or worst case to flare) prior to any system depressurisation. For a facility that has approximately 1.8 tonnes of hydrogen storage approximately 10% of this total (180 kg) may be vented annually to enable intrusive maintenance.

4.2.28 Events which may necessitate venting of hydrogen to reach the above-mentioned totals are as follows:

- ➢ Purging of equipment to ensure safe for entry;
- ➢ Testing of safety critical equipment; and
- ➢ Calibration of metering systems.

<u>Commissioning</u>

4.2.29 The facilities are considered to be fully commissioned three months after the main grid has been made available, and an uninterrupted stable operation has been demonstrated.

4.2.30 Venting of hydrogen will be required during the commissioning phase. While the commissioning plan has yet to be fully developed, the following commissioning steps are anticipated:

- ➢ Electrolyser commissioning tests - ~2.5tonnes over one week
- ➢ Nitrogen-free process equipment - ~1.5tonnes over four days
- ➢ Hydrogen metering calibration - ~2.5tonnes over four days
- ➢ LCHS performance test - ~3.5tonnes over one day

4.2.31 This is a single operation and will only occur during first commissioning. The use of the flare system to combust the vented hydrogen during commissioning has been considered but the high-pressure design of the flare system, which is intended to quickly combust a large and relatively pure hydrogen inventory in the event of an emergency, is incompatible with these release types so a stable flare would not be achievable.

## 4.3 Climate effects

4.3.1 Operation of the HPF Installation is expected have a negligible effect on climate change. Hydrogen is understood, most recently in "Atmospheric Implications of Increased Hydrogen Use" (Warwick et all, via gov.uk, 2022) to have a Global Warming Potential of around 11. The effects of the release of one tonne of hydrogen would be equivalent to the emission of 11 tonnes of carbon dioxide.

4.3.2 Routine emissions are estimated at around 8.8 tonnes of hydrogen per year from process venting and hence around 96 tonnes of carbon dioxide equivalent This is a much less than the estimated 10,600 tonnes of $CO_2$ releases which will be saved by the paper mill switching to the hydrogen fuel produced by the Installation.

# 5. Management system

## 5.1 General management system

5.1.1 The Northfleet Hydrogen Production Facility Installation will benefit from the existing Business Management System developed by RES, one of the two joint venture parties forming the HYRO joint venture which in turn is the parent of the applicant Green Hydrogen Three Ltd. RES carries out all of the project development work on behalf of HYRO and it is anticipated that RES will oversee the construction stage and provide asset management and operation and maintenance (O&M) services to the project in collaboration with specialist subcontractors. RES are a renewable energy developer by background and their BMS will provide a robust platform for development at Northfleet.

5.1.2 RES has an integrated BMS which is third party accredited to ISO 9001, ISO 14001, ISO 45001 & ISO 55001. This provides a framework for all corporate polices, processes and systems covering project development, construction, and operation.

5.1.3 The RES integrated HSQE policy is a key document available to all employees, visitors, subcontractors, and others with an interest in how RES approaches and manages safety, quality and environment issues. The HSQE policy is communicated to staff via RES intranet and during business updates. The policy demonstrates how RES will operate and identifies key elements to achieve this, encouraging everyone working for, or on behalf of RES, to feel empowered to stop work and avoid taking risks (safe behaviours), and sets out the organisational commitment to being a good custodian of the environment in which we work and operate.

5.1.4 RES has a competent HSQE team who provide guidance and support to the business and ensure that RES senior management are actively involved in developing the HSQE Business Management System (BMS), strategy, issuing HSQE bulletins, undertaking safety stand down days and carrying out site visits. Managers develop departmental HSQE objectives and actively monitor progress on these through monthly and quarterly HSQE reporting.

5.1.5 RES uses a dedicated electronic incident recording system, Velocity, comprising of a global dashboard that records incidents, accidents, near misses and 'good catches' where observations of potential issues are recorded, and improved processes implemented using this information. Environmental improvements and initiatives are captured in a similar fashion and included as part of ongoing continuous improvement.

5.1.6 Commitment to HSQE is achieved via objectives, targets and engagement, focusing on minimising RES and its client's impact on environment and setting quality standards that reflect the needs of the business and getting it right first time for customers. An environmental impact register has been established which details environmental risks throughout the business and includes risk management measures associated with materials procurement, waste management and energy management.

5.1.7 The RES Sustainability group policy details the core of RES's business activity and reinforcing the vision of a future where everyone has access to affordable zero carbon energy. The RES sustainability agenda is to power positive change by ensuring that operations, products and services make a net positive contribution to society and the environment and commitments to Environmental, Social and Governance factors.

5.1.8 The integrated business management system (BMS) includes specific and integrated environmental requirements. This includes but is not limited to:

5.1.9 Commitment to being a good custodian to the environment in which we work and operate. This incorporates the commitment to the provision of the necessary resources, competencies, awareness, communication, and documentation needed to implement and maintain the policy and requirements of ISO 14001.

- Waste Management procedure (BMS-4172592)
- Risk Assessment Procedure (RSOP-014)
- Emergency Response Procedure (IMS-3163747)
- Safety & Environmental Requirements for Contractors on all activities (RSWP 005)
- Incident Investigation (IMS-3446709)
- Environmental Aspects, Impacts & Significance Evaluation Procedure (IMS-023).

5.1.10 RES has a HSQE assurance plan which monitors and ensures the effectiveness of the management system and safeguards and sets out a cycle of plan-do-check-act (PDCA) that enables continual improvement.

5.1.11 As the Northfleet hydrogen project development continues, more specific management systems relating to these developments will form an additional part of the BMS. This will include operational planning and process control, maintenance programmes, emergency planning and response protocols, specific competency and training programmes for staff whose work may affect environmental performance, monitoring requirements including KPIs that reflect the environmental performance of the facility and outlines the roles and responsibilities needed to achieve this.

5.1.12 HYRO is developing the operational part of the management system which will be applied to the Northfleet project ahead of commissioning. The installation-specific management system is not fully developed at the time of making the EP application and will be predicated on the final detailed engineering design, as many procedures will relate closely to the operability of what will be a unique industrial facility.

5.1.13 The expected outline structure for the environmental management system is presented below.

- Definition of the scope and boundaries of the EMS;
- Statement of commitment, leadership, and accountability of the management, including senior management, to the implementation of an effective EMS;
- An environmental policy that includes the continuous improvement of the environmental performance of the installation;
- Register of environmental risk and opportunities from the installation as well as of the applicable legal requirements relating to environment compliance;
- Objectives and performance indicators in relation to relevant environmental aspects;
- Procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;

- Details of structures, roles, and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
- Procedures to manage the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g., by providing information and training);
- Internal and external communication, and encouraging employee involvement;
- Producing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
- Operational planning and process control;
- Implementation of appropriate maintenance programmes;
- Emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
- Other Than Normal Operating Conditions procedures;
- Implementation of a monitoring and measurement programme;
- Measures for benchmarking environmental performance;
- Commitment to horizon scanning for emerging best practice;
- Periodic independent (as far as practicable), internal auditing and periodic, independent external auditing of the EMS;
- Evaluation of causes for nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;
- Periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
- Sectoral benchmarking for environmental performance, where sectoral data exists;
- Waste management plan; and
- Considerations for decommissioning of the installation.

Accident management

5.1.14 Extensive work has already been carried out to minimise the risk of harm to human health and safety, and environmental damage, from accidents at the proposed Installation to As Low As Reasonably Practicable (ALARP). This work will continue to be developed during the progression of the Installation design through the Front End Engineering Design (FEED) and subsequent final detailed design iterations (during the commencement of the EPC phase).

5.1.15 The maximum storage quantity for hydrogen at the Installation will be 1.8 tonnes. Under the Planning (Hazardous Substances) Regulations 2015, this storage capacity does not require a Hazardous Substances Consent from the local planning authority as it is under 2 tonnes.

5.1.16 Site layout has been designed and optimised through a predictive risk assessment process undertaken by the Installation engineering designer, which considers a number of plausible major accident events including:

- Vapour cloud explosions;
- Flammable gas dispersion for flash fires; and

- Jet fires and their associated thermal radiation levels.

5.1.17 The principal engineering designer has produced a Health Safety and Environmental Philosophy for the equipment at the Installation which will be the basis of the more detailed design philosophy as the project moves through the FEED stage.

5.1.18 Accident prevention measures will include the design of the Installation through to minimise opportunities for hydrogen gas to leak, with a presumption to minimise flanged connections in favour of welded pipe joints.

5.1.19 Instrumentation and control equipment including gas detection and alarm systems will be ATEX rated (where required) to minimise the risk of ignition in the event of loss of hydrogen.

5.1.20 The integrated site SCADA system will monitor overall site operation, including production rates, quality and pressure, storage and waste water generation rates. Data on all process parameters will be logged.

5.1.21 Procedures will be developed for the following accidental release scenarios where environmental impacts are possible:

- Loss of containment for hazardous chemicals and oils
- Loss of containment of hydrogen inventory: cold venting
- Loss of containment of hydrogen inventory: flaring

5.1.22 These scenarios are considered in the Environmental Risk Assessment in this document.

<u>Climate resilience</u>

5.1.23 Risks to the installation from climate change over the remainder of the 21$^{st}$ century have been assessed in the accompanying Climate Change Risk Assessment document. Actions and responsibilities will be documented in the EMS.

<u>Chemical inventory</u>

5.1.24 Relatively little chemical inventory will be stored on site at the HPF Installation as the main throughputs are water and electrical energy; there will be no bulk storage of any substance apart from the product (gaseous hydrogen).

5.1.25 The containment and drainage systems are to provide measure for containment of spilled materials, provide means for proper disposal of liquids, prevent escalation of incidents to adjacent areas of plant and allow for incident response and control.

5.1.26 Small quantities of cooling water dosing reagents, and water treatment reagent will be stored in dedicated storage areas with drip trays. The total inventory is expected to be as follows:

- Lubrication Oils;
- Glycol/Water;
- Non-Flammable Refrigerant; and
- Transformer Oil.

The expected volumes for each inventory are in the order of 25 litres.

5.1.27 The volumes stored on site will be kept to a minimum, generally in drums with pallet bunding. The exact arrangements will be confirmed at the detailed design stage.

# 6. Environmental Risk Assessment

## 6.1 ERA

6.1.1 EP application guidance from gov.uk was consulted to develop an Environmental Risk Assessment (ERA) based on a reasonable set of environmental hazards and associated risks. The ERA is presented in Table 6.1.

*Table 6-1 Environmental Risk Assessment*

| Hazard | Receptor | Pathway | Risk management | Probability | Consequence | Overall risk |
|---|---|---|---|---|---|---|
| Routine emissions to air | The closest dwellings are located c400m southwest of the site to the north and south of the B2175 (High St/London Rd).<br><br>Closest habitat designation Swanscombe Peninsula SSSI (1.4 km west of site)<br><br>Global atmosphere as a GHG receptor. | Air | No measures considered necessary for oxygen. Minimisation of hydrogen venting by design and operational procedures.<br><br>Human and habitat receptors are not considered sensitive to hydrogen gas. | High | No consequences of emissions to oxygen, plume may have a moisture content which could under certain meteorological conditions be visible. Mitigation measures to minimise routine venting of hydrogen are being discussed with the electrolyser OEM.<br><br>Increase of atmospheric GHG burden by around 1440 tonnes of $CO_2$ equivalent per year. | Low |
| One-off emissions to air during commissioning | Global atmosphere | Air | Some hydrogen produced during commissioning which will be vented unburned via the flare stack or similar temporary arrangement.<br><br>Human and habitat receptors are not considered sensitive to hydrogen gas. | High | Increase of atmospheric GHG burden. Commissioning will last for around five days and the average duration of venting three hours per day. | Low |
| Non-routine emissions to air from flaring | | Air | The process is designed and will be operated to maximise utilisation of hydrogen by the end client and unplanned releases will only occur in extreme | Low | Temporary increase of short-term NO and $NO_2$ concentrations in vicinity of | Low |

| Hazard | Receptor | Pathway | Risk management | Probability | Consequence | Overall risk |
|---|---|---|---|---|---|---|
| | | | emergencies when loss of inventory is necessary for safe and rapid shutdown of the plant. | | flare – no routine NOx emissions | |
| Routine emissions to watercourse | Groundwater | Water | Surface water drainage will run to the Thames via the KC surface water drainage network as is currently the case. Overloading and percolation through the site slab area to groundwater are considered unlikely – no specific substances are present in any case. Slab integrity to be confirmed. | Very low | Uncontrolled loss of storm and process water to watercourse would cause a temporary elevation in the concentration of naturally occurring salts (carbonates) with little consequence to groundwater or river quality. | Not significant |
| Emissions to land | Site infrastructure | None | Non-domestic type solid waste arisings will occur only from routine and breakdown maintenance and be disposed of off-site | Very low | Minor build-up of waste material | Not significant |
| Unplanned emissions to air: loss of hydrogen | Nearby residential, commercial, habitat sites | Air | Operating systems, instrumentation and control systems, hydrogen detection sensors. Production ceases in the event that a particular concentration of hydrogen is detected as per the shutdown cause and effect chart. Isolation of affected component (e.g., valve). Intrinsically safe electrical equipment specified to reduce probability of spark ignition. | Low | Temporary loss of hydrogen which will rapidly disperse. Concentrations where health effects to humans or wildlife are possible will never be reached. Greenhouse gas effect of hydrogen gas will add to overall atmospheric GHG burden. Build up to lower explosive level in air highly unlikely due to outdoor location and highly buoyant nature of the release. | Low |
| Unplanned emissions to surface water: loss of chemical inventory | River Thames | Water | Liquid reagents will be stored with drip trays, and small quantities of lubricating oils will be stored indoors and provided with spill response kits. Operating procedures for clearing spillages for | Low | Small quantities of oil / lubricant to surface water (River Thames) possible if all mitigation measures fail. | Low |

| Hazard | Receptor | Pathway | Risk management | Probability | Consequence | Overall risk |
|---|---|---|---|---|---|---|
| | | | off-site disposal by appropriately qualified and licensed waste carrier. | | | |
| Unplanned emission to watercourse | Groundwater | Water | Site drainage system will be tested for integrity. Overloading and percolation through the site slab area to groundwater are hence unlikely. Interaction with site chemical inventory not considered likely given contained storage of chemicals and oils. | Very low | Loss of chemical inventory into flood water could have local water quality effects but the probability of the two events taking place at once is remote. | Not significant |
| Dust, bioaerosols, odour, litter | Nearby residential, commercial, habitat sites | Air | No inherent source of process dust, odour or bioaerosols nor use of any bulk materials which could give rise to any of them. Incidental dust and litter within the site parameter will be controlled through general housekeeping measures. | Very low | Nothing material. | Not significant |
| Noise | Nearby residential, commercial sites. | Air | Relatively low sound power levels for rotating equipment will be specified as a procurement policy.<br><br>An acoustic impact assessment of the Northfleet Green Hydrogen Development has been undertaken in consultation with Gravesham Borough Council and with reference to relevant planning policy and sound/noise guidance.<br><br>This assessment determined that the development is not expected to be significant in terms of the requirements of BS 4142, BS 8233, ProPG, WHO guidelines and overarching policy in respect of sound emitted by industrial developments. It determined that specific mitigation is not required. | Low | Night time disturbance | Not significant |

## 6.2 Summary of impacts

6.2.1 All environmental hazards considered were assessed as presenting a “low” or “not significant” risk after suitable management measures were considered.

## 6.3 Further detailed assessments

6.3.1 Assessment work has been undertaken using the proposed equipment specifications, Installation layout and locations of nearby (residential) receptors to determine noise levels and assess their significance. This assessment in full accompanies this application.

6.3.2 A screening of the effluent discharge to S1 was undertaken using the H1 screening tool, on the robust assumption that emissions would eventually be to the River Thames albeit via waste water treatment works. The only pollutant identified in the effluent which was applicable to the assessment was chloride. The assessment confirmed that no more detailed assessment was required: the emission screened out at Test 1.

# 7. Energy and Resource Efficiency

## 7.1 Energy Efficiency

7.1.1 Energy efficiency considerations will be integrated into the final design of the HPF Installation. At the time of application, the design is still undergoing the FEED stage and subject to further refinement.

7.1.2 The purpose of the HPF Installation is to produce green hydrogen in the most economical way possible from the renewable electrical energy supply, supplied by the associated renewable energy development. Reducing the parasitic load of the HPF Installation itself is therefore of paramount importance to the economic viability of the Installation.

7.1.3 An exhaustive plant and equipment list has been generated as part of the FEED engineering process, and electrical loads will be modelled for each consumer. Below is the list of key plant and equipment:

- Electrolysis package;
- Feed Water Buffer Tank;
- Feed Water Centrifugal Pump;
- Hydrogen Storage Tank;
- Nitrogen Filter;
- Nitrogen Supply Package;
- Feed Water Treatment;
- Waste Water Buffer Tank;
- Waste Water Transfer Pump; and
- Electrical Substation(s).

7.1.4 The major consumers of electrical energy at the HPF Installation will be the electrolysers. PEM electrolysers have been selected for their flexibility in generating gases at a high percentage of energy efficiency (in terms of electrical energy in and useful hydrogen out) over most of their operating load range. The efficiency of the electrolyser supplier is quoted as being 75.3% (Year 1), 73.6% (Year 2) and 71.8% (Year 3).

7.1.5 The electrolyser will only be operating if the green energy supply meets the agreements of the Low Carbon Hydrogen Standard.

7.1.6 The gas treatment and purification system packages will include heat recovery of treated gas to minimise electrical heating requirements.

7.1.7 Energy efficiency will be a consideration when purchasing balance of plant items, particularly pumps and gas heaters.

## 7.2 Raw Materials

7.2.1 The raw materials used at the Installation will be limited to just feedstock water. A small quantity of oils and lubricants will be stored at the site.

## 7.3 Resource Efficiency

7.3.1 The principal physical resource consumed by the Installation will be water, which is used as a process feedstock.

7.3.2 An agreement is in place with Southern Water to use the Towns Water supply for feedstock water. The hydrogen Installation will be a different pump to KCs supply pump for the water.

7.3.3 The maximum quantity of water required when the electrolysers are operating at full output will be 5640 litres/hour.

7.3.4 Process water arising from the hydrogen and oxygen purification will have few dissolved contaminants.

7.3.5 A closed loop water cooling system will be used and blast air cooling to minimise water consumption for cooling.

7.3.6 Brine (i.e., the rejected effluent from the reverse water treatment plant) will be relatively good quality albeit with an increased concentration of dissolved ions such as calcium, magnesium, carbonate, and chloride which have been removed by the RO plant. No viable means of re-using brine on site have been identified.

## 7.4 Waste Management

7.4.1 Waste arisings from the Installation will be minimal. Policies will be developed in the EMS for the legal and responsible disposal of domestic-type and packaging wastes according to the traditional waste hierarchy.

7.4.2 Rotating equipment will require lubricating oil which will undergo periodic replacement. Quantities arising from the full build are not expected to be greater than a few cubic metres per year and will be removed from site by a suitably licensed and qualified waste haulier for reprocessing where possible and energy recovery where not.

7.4.3 Advice will be taken from the OEM on the optimum route for disposal of any consumable or replaceable parts arising from the electrolysers, gas treatment systems and RO units. Arisings are expected to be minimal and include spent catalysts (on a very infrequent basis), seals, RO membranes, etc.

# 8. BAT assessment

8.1.1 In preparing the Best Available Technique (BAT) Assessment for the Installation, guidance documents on BAT for pollution control and environmental management were consulted, including the following:

- Sector Guidance for the Inorganic Chemicals Industry, which is still promulgated by the Environment Agency and hence used as the primary BAT reference (BREF);
- Common Waste Water and Waste Gas Treatment / Management Systems for the Chemical Industry BREF;
- Energy Efficiency BREF; and
- Storage BREF.

8.1.2 The latter three documents have not been used in a comparative assessment as the relevant BAT are considered to be already substantially covered by the Sector Guidance Note. The scope of the Storage BREF does not include gas storage.

*Table 8-2 BAT assessment*

| BAT theme | Document Reference | BAT clause | Response | BAT? |
|---|---|---|---|---|
| Performance Indicators | 1.1 | Monitor and benchmark environmental performance develop KPIs per tonne hydrogen produced | KPIs will be developed and monitored for water use and electrical energy import per quantity of saleable hydrogen produced. | |
| Energy Efficiency | 1.3 | Select process with lowest environmental impact | The fundamental choice to produce green (rather than fossil-derived) hydrogen means the process has by far the lowest overall impact of all viable hydrogen production methods. The choice of PEM electrolyser, which can operate at high production efficiency over variable loads, means production can continue at low loads minimising production outages, and can adapt to changing loads placed on the system.<br>No material amounts of chemicals are used, other than for pH correction and biocide / scale control in the cooling water system. | |
| Resource Efficiency | 1.4.1 | Heat transfer and rejection of waste heat by cooling tower rather than once-through | The electrolyser cooling system will be a closed loop and waste heat rejected via heat exchanger to ambient air. | |
| | 1.4.2 | Water reuse | Drain water from the gas purification, dryers can be reused as electrolyser feed (subject to water specifications and design constraints); the volumes produced will be examined to determine whether or not this is worthwhile. Intake water treatment system effluent is not suitable for reuse in the process as the dissolved species content would quickly degrade the efficiency of the treatment plant. | |
| | 1.4.3 | Minimal cleaning use | There will be little requirement for cleaning of vessels; the electrolysers will be in mostly continuous use and cleaned only on occasional shutdown. The site will be running mostly continuously 24/7 to meet demand. A regular filter flushing process will take place every two to three weeks. | |
| | 1.4.4 | Reuse options | The "brine" which is rejected from the wastewater treatment plant has a relatively high concentration of carbonate salts, which are typically the dissolved salt species with the highest concentration in potable / towns water, commonly known as hardness salts. The effects of water hardness on | |

| BAT theme | Document Reference | BAT clause | Response | BAT? |
| --- | --- | --- | --- | --- |
| | | | plant and pipework are well known, and it is considered that reuse of effluent will cause rapid degradation to both. | |
| Waste avoidance and management | 1.5.1 | Demonstrate opportunities for reuse or recycling of waste | Lubricating oils and greases will be replaced according to Original Equipment Manufacturer (OEM) maintenance recommendations, opportunities for reuse will be very limited but all waste oil and grease will be sent for recycling where possible. Other wastes will include worn or failed machinery components which will be returned for refurbishment or specialist disposal where take-back arrangements are offered by the OEM. Packaging will be returned to the supplier or recycled as domestic type waste. | |
| | 1.5.2 | Demonstrate that the disposal routes selected represent the BPEO | Solid waste arisings are minimal and as noted will be removed by licensed haulier to a suitable recycling facility, or for energy recovery where this is not possible. No landfilling of waste is expected. | |
| Design | 2.1.1 | Consider all environmental impacts | The proposed installation has been subject to a Preliminary Environmental Assessment and an Environmental Impact Assessment (EIA) Screening consultation with the local planning authority which has identified and agreed with stakeholders whether there will be significant impacts to be assessed. The screening has considered all likely environmental effects and subject specific assessments have been undertaken rather than a full EIA. No significant adverse effects are expected | |
| | 2.1.2 | Undertake formal HAZOP as design progresses | HAZOP workshops to identify safety and environmental risk and hazard areas have been undertaken as part of FEED. A further End-to-End HAZOP will be carried out once the vendors are selected in detailed engineering. The associated actions will be incorporated into the plant design. | |
| Storage and handling | 2.2.1 | Stable storage of reactive chemicals | Hydrogen is stored in appropriate pressurised vessels and oxygen directly vented to atmosphere. No other bulk chemicals are used on site. | |
| | 2.2.2 | Vent storage tanks to a safe location | All process venting is to ambient air. Exclusion zones around the vent are being considered as part of safe design. | |

| BAT theme | Document Reference | BAT clause | Response | BAT? |
|---|---|---|---|---|
| | 2.2.3 | Minimise contamination from failures of storage (bunding, leak detection) | Storage tank pressure is continuously monitored, and pressure drops will raise the alarm. There will be a network of gas sensors in the vicinity of the storage tanks and around upstream pipework connections. Pipe runs will be welded where possible to minimise the number of flanges. | |
| | 2.2.4 | HAZOP to identify environmental risks | Environmental risks continue to be in the scope of the HAZOP workstream (see 2.1.2). | |
| Plant systems and equipment | 2.3.1 | Improvement plan for any plant with emissions including noise | Noise assessment (R01_2023-07-27_Acoustic-Impact-Assessment -of-Northfleet-Green-Hydrogen-Development_V03(approved)) concluded that residual noise not considered to require further improvements. Compressors removed from balance of plant – fewer noise sources. | |
| | 2.3.2 | HAZOP on plant | See 2.1.2 | |
| | 2.3.3 | Vacuum systems | None present. | |
| | 2.3.4 | HAZOP for pressure relief systems (env risks) | See 2.1.2 | |
| | 2.3.5 | Measures to prevent over pressurisation (if relevant) | The plant is design to include necessary pressure gauges, pressure control valves, blow down valves and pressure release safety valves to prevent over pressurisation events. All the equipment and pipelines will be equipped with appropriate materials and the pressure rating as per the operating pressure of each system. Layers of Protection Analysis (LOPA) has been conducted after HAZOP to ensure appropriate instrument and controls are incorporated in the plant safety and control systems. | |
| | 2.3.6 | Venting system to be maintained in state of readiness | The vent will be continuously purged with nitrogen for safety and would be ready to purge as required by the project. Availability requirements of nitrogen vent system were assessed during the FEED HAZOP and will be further defined during the project Reliability, Availability and Maintainability study. | |

| BAT theme | Document Reference | BAT clause | Response | BAT? |
|---|---|---|---|---|
| | 2.3.7 | Leak detection and corrosion monitoring (gas / water) | Periodic corrosion assessments will be performed to mitigate leaks from cooling water system. Fugitive hydrogen leak detection discussed under 3.4.1. | |
| | 2.3.8 | Likelihood of damage by corrosion ($H_2$ embrittlement) and how mitigated by design | Equipment and pipework will be specified as resistant to hydrogen embrittlement as a mandatory procurement consideration. Where possible, pipe connections will be welded, and the pipe work will be designed with appropriate corrosion thickness. | |
| | 2.3.9 | Cooling water BAT (if relevant) | Water will be recirculated rather than a once-through system. | |
| | 2.3.10 | Management of VOCs / other purge gases | No VOCs will be associated with the production process; purge gases are pure nitrogen which will be used in quantities of around, 800$m^3$ per year during for shutdowns. We have a continual purge of the vent with nitrogen at a rate of 135kg/hr. | |
| Reaction stage | 2.4.1 | Evaluate options for reactor types | Not applicable – no reactor | |
| | 2.4.2 | Selection of reactor | Not applicable | |
| | 2.4.3 | Review reactor design where existing | Not applicable | |
| | 2.4.4 | Demonstrate maximum yield from process control and management | Yield will be determined by electrical load; the electrolyser specified can operate at a high efficiency over a wide load range. | |
| | 2.4.5 | Minimise releases from pressure relief | As 2.3.5 and 2.3.6 | |
| | 2.4.6 | Waste reduction from reactor cleanouts | Not applicable | |
| | 2.4.7 | Management of vapour losses | Not applicable | |
| Separation stage: Liquid -vapour | 2.5.1 | Separation techniques following HAZOP, design to minimise losses | Only applicable to the removal of water vapour from the hydrogen stream, uses gravimetric separation and absorption. | |
| | 2.5.2 | Instrumentation for control and alarm | To be included as part of the general process instrumentation and control system. | |
| Liquid-liquid separations | | N/A | No such separations are part of the process | |

| BAT theme | Document Reference | BAT clause | Response | BAT? |
|---|---|---|---|---|
| Liquid-solid separations | | N/A | No such separations are part of the process | |
| Purification | 2.7 | Process controls with alarms in range | Instrumentation and controls to be specified during FEED. | |
| Analysis | 2.8 | Analyse by products and waste streams | By-product from gas treatment is water which will not require analysis and be routed to the waste water stream. Wastewater streams will be equipped with continuous monitoring to ensure compliance with environmental permit conditions. | |
| Emissions to air | 3.1 | N/A | Vents from purges, pressure relief and oxygen from the electrolyser will all be routed to a local safe location. No local air quality effects which would be influenced by stack height. Emergency flaring may lead to NOx emissions as with any flare. | |
| Emissions to water | 3.2.1 | Control emissions to the specified water quality standards (Consent to Discharge) | No effluent treatment is expected to be necessary. Risk assessment work demonstrates no adverse effect. Water quality will be regulated by permit conditions set by the EA, if any. | |
| | 3.2.2 | Heat transfer between process streams | No heat transfer between process streams. | |
| | 3.2.3 | Recirculating cooling systems with cooling tower not once through | Heat will be rejected via heat exchanger; no cooling tower is required. | |
| | 3.2.4 | Design to keep cooling water free from process impurities | Cooling water will be closed loop with no interface with the process. | |
| | 3.2.5 | Reduce water for cleaning | Minimal cleaning requirements. A “backflush” of the electrolysers will take place every 2-3 weeks (using 13,200 litres of water in total). This number of “backflushes” will be no more than recommended by the Original Equipment Manufacturers (OEM). | |
| | | Remainder of 3.2 BAT N/A | | |
| Emissions to land | 3.3 | Measures to minimise solid waste - specific to process | Minimal waste arisings – consumables and worn components only. | |

| BAT theme | Document Reference | BAT clause | Response | BAT? |
|---|---|---|---|---|
| Fugitive emissions | 3.4.1 | LDAR programme | Networked and alarmed hydrogen detection will be installed. Fugitive emissions testing plans will be developed in compliance with the requirements of the Low Carbon Hydrogen Standard. | |
| | 3.4.2 | Minimal breathing vents | No breathing vents on storage as this will cause the loss of inventory. | |
| | 3.4.3 | Storage tank maintenance, solar absorbency, temperature control, insulation, inventory management | Maintenance will be as per OEM requirements. Gas storage will be outdoors in ambient conditions. Tanks will be coated and finished to minimise solar gain. | |
| | 3.4.4 | Impermeable surfaces under pumps etc and oil-containing equipment | Site underlain by impermeable slab; secondary containment will be incorporated into the final design. | |
| | 3.4.5 | Interceptors - catch pits | No catch pit considered necessary given the pallet-bund containment proposed for chemicals and oils. Transformers will similarly be bunded. | |
| | 3.4.6 | Spill kits | To be kept on hand in the event of lube oil loss. | |
| | 3.4.7 | Groundwater protection | The part of the Installation where lubricants are to be stored is to be constructed on an impermeable concrete slab drip trays. Site drainage will be of high confirmed integrity; no viable route to groundwater. | |
| | 3.4.8 | Integrity tests etc. | Drain CCTV surveys will be programmed at multi-year intervals once the site is operational. | |
| Odour | 3.5 | N/A | No odourant will be added to the hydrogen supply; there will be no other material sources of odour on site. | |
| Noise | 3.6.1 | Encapsulation / containment of noisy plant. | An acoustic impact assessment was undertaken that determined the noise effects of the current design are not considered significant and no specific mitigation is required. | |
| | 3.6.2 | Silencers on safety valves | To be considered as part of detailed design. | |
| | 3.6.3 | Minimise blow-off from compressors, silencers | Compressor not used at the installation. | |

| BAT theme | Document Reference | BAT clause | Response | BAT? |
|---|---|---|---|---|
| Monitoring | 3.7.1 | Air Emissions | No monitoring of hydrogen is considered viable, no MCERTs methods or equipment. | |
| | 3.7.2 | Waste records and precautions | Records will form part of reportable data to the Environment Agency and be controlled under the site EMS. | |
| | 3.7.3 | Monitoring methods and EMS integration (effluent only) | To be confirmed once permit is granted, expected to cover flow rate, temperature and pH which will all be measured in accordance with the regulator's stipulations. | |

# 9. Effluent Composition

| | |
|---|---|
| Carbonate | 40 |
| Bicarbonate | 517 |
| Silicate | 30.5 |
| Chloride | 52.9 |
| NaCl | 70.1 |
| Magnesium | 3.24 |
| Calcium | 21.9 |
| Conductivity | 972µS/cm |

All chemical concentrations are in mg/l.

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