Keuper Gas Storage Project

Preliminary Environmental Information Report - Alternatives

PREPARED FOR
Keuper Gas Storage Limited

DATE
September 2025

REFERENCE
EN0310001

DOCUMENT DETAILS

DOCUMENT TITLE	**Keuper Gas Storage Project**
DOCUMENT SUBTITLE	Preliminary Environmental Information Report - Alternatives
PROJECT NUMBER	EN0310001
DATE	September 2025
VERSION	1.0
AUTHOR	ERM
CLIENT NAME	Keuper Gas Storage Limited

CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

Acronym	Description
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
ES	Environmental Statement
GPP	Gas Processing Plant
KGSL	Keuper Gas Storage Limited
KGSP	Keuper Gas Storage Project
MC	Material Change
PEIR	Preliminary Environmental Information Report
PSA	Pressure Swing Adsorption

Acronym	Description
SMC	Solution Mining Compound
TRL	Technology Readiness Level
TSA	Temperature Swing Adsorption

3. ALTERNATIVES

3.1 INTRODUCTION

3.1.1.1 Schedule 4 (paragraph 2) of the Infrastructure Planning Environmental Impact Assessment (EIA) Regulations 2017[1] (hereafter referred to as the 'EIA Regulations') require all applicants to identify how preferred options have been selected and the rationale behind all of the alternatives considered by the developer. For example, this includes any design, technology, location, size and scale alternatives studied by the developer which are relevant to the Proposed Development and its specific characteristics.

3.1.1.2 This Preliminary Environmental Impact Report (PEIR) and the subsequent Environmental Statement (ES) will outline the options considered for the Proposed Development, and justify the reasons for selecting specific options.

3.1.1.3 Environmental, social and economic effects, technical and commercial feasibility, and the overall objectives of the Proposed Development have all been considered. The EIA will also consider a 'Do Nothing' option, which will identify the expected evolution of the baseline scenario without implementation of the Proposed Development.

3.1.1.4 Whilst the Proposed Development design is well-advanced for the PEIR, it remains preliminary, and will continue to evolve throughout the EIA process, in consideration of best practice engineering advice and stakeholder feedback. However, it is expected that any changes in design will be preferential from an environmental perspective e.g., to lower building, infrastructure heights etc to reduce the anticipated significance of effects.

3.1.1.5 This Chapter summarises the decision-making process followed to date to consider alternatives for the Material Changes being brought forward to the Consented Development. Further detail regarding the consideration of alternative and design evolution will be included in the ES.

3.2 THE 'DO NOTHING' ALTERNATIVE

3.2.1.1 The 'Do Nothing' alternative would mean that the Proposed Development would continue to be progressed as per the Consented Development. This would be the development of an underground storage facility for natural gas only and not hydrogen storage.

3.2.1.2 The National Policy Statement NPS for Natural Gas Supply Infrastructure (NPS EN-4)[2] highlights the need for efficient import,

[1] HM Government (2017). *The Infrastructure Planning (EIA) Regulations 2017*. Available at: https://www.legislation.gov.uk/uksi/2017/571/contents/made.

[2] Department for Energy Security & Net Zero (2023). Overarching National Policy Statement for Natural Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4). Available online at: https://www.gov.uk/government/publications/national-policy-statement-for-natural-gas-supply-infrastructure-and-gas-and-oil-pipelines-en-4.

storage, and transmission of natural gas to meet current energy demands whilst developing low carbon alternatives.

3.2.1.3 However, the UK is actively phasing out natural gas in preference of hydrogen, as part of its strategy to reduce carbon emissions and achieve its Net Zero target by 2050. The UK Hydrogen Strategy outlines a comprehensive plan to develop a low-carbon hydrogen sector which includes replacing natural gas with hydrogen in various sectors, with the government investing in hydrogen infrastructure, such as pipelines and storage facilities, and supporting innovation to reduce costs and enhance efficiency. By leveraging hydrogen's potential, the UK aims to decarbonise its energy system, reduce reliance on fossil fuels, and enhance energy security.

3.2.1.4 UK Government policy specifies that *'there is an urgent need for all types of low carbon hydrogen infrastructure to allow hydrogen to play its role in the transition to Net Zero'*. Storage capacity will be an integral component in a hydrogen economy, balancing supply from production facilities with demand by consumers. Hydrogen storage, therefore, will play a critical role in supporting the delivery of the UK Government's legally binding Net Zero targets.

3.2.1.5 The Proposed Development is one of many projects working to deliver a Net Zero future as well as decarbonising the North West region, as part of the HyNet North West cluster to reduce carbon dioxide emissions by millions of tonnes every year.

3.2.1.6 Although the Consented Development for a 50-year natural gas only storage facility has been accepted, and remains to be a viable storage capacity option, for the reasons outlined above, the 'Do Nothing' alternative scenario is not considered to be the preferred option.

3.2.1.7 Further information about the need for the Proposed Development will be included in **Chapter 5, Planning and Policy Context**.

3.3 ALTERNATIVE SITE LAYOUTS

3.3.1.1 For the Proposed Development, the decision has been made to keep the Site Boundary the same as the boundary of the Order Limits for the Consented Development.

3.3.1.2 The locations of the underground storage cavities are as per the Consented Development. The change from natural gas to hydrogen gas storage does not impact the cavity design and/or the original engineering and environmental design decisions that drove the cavity location decisions, which are as per Section 15.5 of the Consented Development ES and can be summarised as follows:

- The proposed cavities have been placed in safe and geologically suitable locations, taking into account the below requirements.
- Cavities needed to be sited where the salt is at a suitable depth and of the required thickness, whilst maintaining separation from the salt boundary of the King Street Fault, and other minor faults;

- cavities were selected to minimise the amount of new infrastructure required for both solution mining and gas operation;
- pillars of salt between cavities needed to be of a required width to satisfy design requirements, which in turn influenced the location of wellheads (i.e. 275m minimum distance between each of the KGSP wellheads, and also neighbouring Holford Gas Storage Cavity wellheads);
- The number of properties that are located within the 'inner zone' (as defined by the HSE's Planning Advice near Hazardous Installations methodology) were minimised, and the KGSP cavity wellheads are at least 240m from the nearest occupied buildings which comfortably meets these criteria;
- Wellheads have been located to avoid unnecessary impact on the ecology and archaeology of the area, such that ponds, trees, established hedgerows and Scheduled Monuments have been avoided; and
- Wellheads have been located and orientated to minimise impact on agriculture and farm business, where possible.

3.3.1.3 Given that the underground storage cavity locations are not changing, the associated infrastructure for the cavities, including wellhead compounds, access roads, pipework and electrical connections are not considered further.

3.4 GPP LOCATION ALTERNATIVES

3.4.1.1 Whilst there has been an extension to the footprint of the Gas Processing Plant (GPP) area and changes to the infrastructure within the GPP, which are outlined in **Chapter 2, Proposed Development Description;** the location of the GPP (next to the Drakelow Farm area) remains as per the Consented Development as it is the most appropriate location. This is due to the cavity locations remaining the same and for the reasons noted in Section 15.5 of the Consented Development ES:

- the land is owned by the applicant and there are no occupied properties on the site;
- the plant, while close to King Street, is sufficiently set back to allow for good screening;
- development of this site will not require tenant farmer relocation; and
- HGVs will have relatively easy access to the site from the A530.

3.5 ATMOSPHERIC VENTING AND FLARING

3.5.1.1 This section outlines the venting and flaring options which were considered for the Proposed Development.

3.5.1.2 A safety system to facilitate the release of the hydrogen gas will be required within the GPP when elements of the facility need to be depressurised.

3.5.1.3 Typically, as much hydrogen as possible will be diverted and recovered back to the cavern storage, with only residual levels of hydrogen requiring venting / flaring. This will only occur for short daytime durations during planned maintenance activities throughout the year. However, on very rare occasions, depressurisation may also be required in the event of an emergency.

3.5.1.4 Since the submission of the Scoping Report, further process safety design work has been completed to allow for a decision regarding venting or flaring for the Proposed Development.

3.5.1.5 The decision has been made to select an elevated flare to depressurise and allow safe shutdown of the GPP during emergency situations (1 in 10+ year events), while an enclosed ground flare will be used to depressurise and safely remove residual hydrogen from the GPP equipment so that it can undergo maintenance throughout the year. The enclosed ground flare involves the flaring of low flowrates of hydrogen during normal working hours.

3.5.1.6 Further information on the suitability of each of the venting / flaring options is provided also below.

3.5.2 VENT AND FLARE OPTIONS

3.5.2.1 The disposal of hydrogen from the GPP can be achieved by several methods, either as hydrogen dispersal in the atmosphere, or combusted at the point of release. The technologies which were considered for the disposal of hydrogen for the Proposed Development include a:

- Elevated cold vent;
- Elevated flare;
- Enclosed ground flare; and
- Multi-point ground flare.

Elevated Cold Vent

3.5.2.2 Elevated cold vents are simple, reliable and economical technologies that release hydrogen directly into the atmosphere.

3.5.2.3 An elevated cold vent consists of a vertical vent stack with a vent tip positioned on top of the vent stack. The stack may be self-supporting or supported using a derrick and/or guy-wires.

3.5.2.4 The vent stack height is selected to ensure that the gas is released above the height where an ignited / unignited release could adversely affect any personnel or equipment including elevated platforms and members of the public.

3.5.2.5 Given the very low density of hydrogen, it rises rapidly and disperses upwards into the atmosphere and the stack would be designed to ensure that there would be no risk of the gas accumulating in locations across the facility.

3.5.2.6 A sterile zone and hazardous area classification is required around the vent stack to allow for adequate dispersion of the gas to below lower flammability limits and to restrict access to personnel to limit exposure to thermal radiation.

3.5.2.7 The use of atmospheric vents for hydrogen service is generally limited to small scale local releases as opposed to large scale releases via a segregated vent structure as would be required for this application.

Elevated Flare

3.5.2.8 Elevated flares are established technologies for onshore facilities in the UK in hydrogen rich streams, such as refineries and the petrochemical industry.

3.5.2.9 An elevated flare consists of a vertical stack (similar to an elevated vent stack) with a flare tip positioned on top of the stack.

3.5.2.10 Th hydrogen released is sent to the flare and combusted, producing a flame, not visible to the naked eye, which protrudes from the flare tip.

3.5.2.11 The height of the flare stack and sterile area surrounding the stack is set to ensure that the flame does not impact on the public, operational personnel, or equipment.

3.5.2.12 An elevated flare would only be used for emergency releases, so could operate without a permanent pilot flame and would be ignited during use.

Enclosed Ground Flare

3.5.2.13 Enclosed ground flares are established technology and have been used for similar fluids in the oil and gas industry and used in hydrogen rich streams in the UK. However, even in non-hydrogen applications, there are few examples of large capacity units.

3.5.2.14 An enclosed ground flare consists of a series of burners located within a refractory lined cylinder, with an open wind fence beneath. Burners are arranged at the base of the lined cylinder and consist of several stages to ensure good combustion efficiency over a range of flows.

3.5.2.15 An enclosed ground flare will combust the hydrogen within the height of the enclosed chamber to minimise the visual impact of the flare when it is firing.

Enclosed Multi-Point Ground Flare

3.5.2.16 Multi-point ground flares are established technology typically used for high pressure, heavy hydrocarbon service.

3.5.2.17 A multi-point enclosed ground flare consists of a field of burner towers at ground level, all enclosed by a solid steel perimeter fence set back from the burners to shield the exterior from the flame radiation. The burners are arranged in stages to ensure good combustion efficiency over a range of flows.

3.5.2.18 There are few to no examples of multi-point ground flares in hydrogen service, but they have track record at capacity equal to this application.

Selected Vent / Flare Technology

3.5.2.19 A comparison of each of the venting and flaring options was conducted via a technology selection assessment, which included the scoring of different criteria and a workshop to agree criteria weightings.

3.5.2.20 A summary of the different criteria used and general technology preference is presented below.

TABLE 3.1 – VENT / FLARE COMPARISION SUMMARY

Criteria		Preferred Technology
Proven Technology	Flaring is generally the more established technology, particularly for the larger releases of hydrogen that the project could require in an emergency depressurisation. The Elevated Flare has been recommended by vendors for emergency depressurisation of this project. Enclosed Ground Flare examples at smaller scale e.g. the types of maintenance depressurisations that the project could require. Multi-point Ground Flare has no examples of hydrogen service, but has capacity examples for natural gas far above the demands of the project. Elevated Vents are well established but generally limited and/or	Flare

Criteria		Preferred Technology
	segregated to smaller capacities of hydrogen.	
Process Safety – Hydrogen accumulation + delayed ignition risk	Hydrogen has a low density and generally disperses quickly once released into the atmosphere, therefore Elevated Vents are an acceptable technology. However, flares are designed to burn hydrogen safely, not allowing the formation of uncombusted hydrogen and thus minimising the risk of any delayed ignition of cloud formation.	Flare
Process Safety – Thermal Radiation	Elevated Vents and Elevated Flares require a sterile area, generally the elevated vent will require a smaller sterile area for a comparative stack height. Enclosed Ground Flares and Multi-Point Ground Flares have thermal shielding and therefore do not require large sterile areas. However, refer to plot space criteria below, for this project the advantage is minor due to the proximity of the GPP equipment and requirement for separation.	Vent
Environmental – Emissions	The flaring of hydrogen will produce emissions of nitrogen oxides (NOx) and by association nitrogen dioxide (NO2) which can have negative effects on human health and ecological receptors. While the venting of hydrogen will lead to uncombusted hydrogen entering the atmosphere, which is an indirect GHG that would impact climate change. The amount of venting/flaring is relatively small and therefore both options would be considered acceptable, however it is thought	Flare

Criteria		**Preferred Technology**
	that flaring would be the preferred option and flaring design can be optimised to reduce NOx emissions.	
Environmental – Noise	No comparable difference in normal operations as the systems should be offline. Depending on the duty i.e. if being used for an emergency or maintenance, the Enclosed Ground Flare and Multi-Point Ground Flares could require permanent pilot lights which would make them noisier than the other options, but well within industry standards. In emergency situations the Elevated Vent and Elevated Flare would generate more noise than the shielded flaring options, however these are 1 in 10+ year events.	Both
Environmental – Light	The Elevated Vent will not produce a flame as the hydrogen is not being combusted. The Enclosed Ground Flare and Multi-point Ground Flares will have shielding to minimise any impacts. The Elevated Flare will produce a flame, however it will generally not be visible to the naked eye.	Vent
Visual Impact	The site location has great landscape coverage and potential for additional shielding, therefore all options are considered acceptable. Generally the Elevated Vent would have the lowest impact as it is shorter than the Elevated Flare, a similar height to the Enclosed Ground Flare, and while taller than the Multi-point Ground Flare, it is a	Vent

Criteria		Preferred Technology
	much less substantial structure (only 1-2m diameter stack).	
Plot Space	The Enclosed Ground Flare would have the smallest plot space overall, however this is cancelled out by requiring separation space from the GPP equipment (which is near equivalent to the sterile areas of the Elevated Vent and Elevated Flare options)	Both
Reliability, availability, maintainability	The Elevated Vent requires very little maintenance in comparison to the flaring technologies as it is a simpler technology.	Vent

3.5.2.21 As stated at the start of this section,

- Emergency Events: Elevated Flare
- Maintenance Events: Enclosed Ground Flare

3.5.2.22 The key factors that have influenced the selection of flaring technologies are:

- Proven technology / best track record
- Lowest risk of delayed ignition
- Lowest greenhouse gas impact

3.5.2.23 Realistic worst-case parameters for both flare arrangements have been used for the PEIR and are detailed in **Chapter 2, Proposed Development**. Further refinement of the dimensions / elevations of both flares will be provided as part of the ES.

3.6 GPP TECHNOLOGY ALTERNATIVES

3.6.1 COMPRESSOR TRAINS

3.6.1.1 Various types of dynamic and positive displacement compressors have been considered as part of a technology assessment for the Proposed Development. Reciprocating compressors and centrifugal compressors were taken forwards for consideration in more detail.

3.6.1.2 Whilst centrifugal compressors are a well-established technology in gas service and the Applicant has notable experience with this technology in the Holford Brinefields area; the technology is not currently at the required Technology Readiness Level (TRL) for the Proposed Development. This is due to the low density of hydrogen requiring high tip speeds and thus there is a lack of track record in large scale hydrogen applications.

3.6.1.3 Reciprocating compressors are the technical standard for petrochemical applications using hydrogen to break long chain hydrocarbons e.g. refineries. Therefore, on this basis, reciprocating compressors are currently the technology selected for the Proposed Development.

3.6.1.4 The Applicant will continue to monitor the progression of centrifugal compression technology and if it does reach the adequate TRL ahead of detailed design and construction, then the Applicant will reconsider selection as the technology will be preferential from an environmental perspective i.e. there will be no increase/adverse impact in safety, footprint, elevation, energy usage, noise or maintenance requirements compared to reciprocating compressors.

3.6.1.5 As per the Consented Development, Section 15.5.9, electric driven motors for the compressor drives as opposed to gas turbines remain the most suitable choice due to the following key factors:

- avoiding local emissions of carbon dioxide, nitrogen oxides and sulphur oxides from gas combustion where possible;
- selecting a drive with low noise emissions;
- minimising the visual impact of the facility by having the lowest overall height possible; and
- safeguarding health in the workplace.

3.6.2 GAS DEHYDRATION

3.6.2.1 Absorption, Condensation and Membrane systems have all been considered as part of a technology assessment for the Proposed Development.

3.6.2.2 Condensation and Membrane systems were discounted based on performance and reliability to achieve the required dehydration specification, as well as a lack of track record in hydrogen applications.

3.6.2.3 Absorption systems (glycol based) are the most commonly used dehydration processes in the natural gas industry, however there are currently a lack of industrial applications in hydrogen service when compared with adsorption dehydration systems.

3.6.2.4 Adsorption dehydration systems using a solid bed of alumina, silica or molecular sieve and which are regenerated either by Temperature Swing Adsorption (TSA) or Pressure Swing Adsorption (PSA) are well established in hydrogen service, notably hydrogen electrolyser processes and particularly in refineries. The systems also offer other flexibility in being able to remove other potential contaminants e.g. hydrogen sulphide and generally offer faster start-up times than absorption systems.

3.6.2.5 TSA is the technology currently proposed for KGSP.

3.6.3 HYDROGEN COMPRESSION COOLING

3.6.3.1 Both closed loop systems (i.e. heat exchangers) and simpler direct air cooling were considered for the Consented Development. For the Consented Development, direct air cooling was selected since it is simpler, modular, and would provide sufficient cooling; closed loop systems were discounted as they are more complex, and the level of cooling that they provide was not required for the Consented Development.

3.6.3.2 Following a review of the hydrogen compression cooling systems for the Proposed Development, it was decided there would be no change and that direct air cooling would be selected as the preferred cooling system option.

3.7 SMC DESIGN EVOLUTION

3.7.1.1 Within the Consented Development design, a new Solution Mining Compound (SMC3) was included to enable the solution mining process for cavity creation. SMC3 was to be situated outside of the GPP Area to the south-east of the site, within the main site red line boundary.

3.7.1.2 As part of a review of the Proposed Development design, an existing SMC at a neighbouring gas storage facility, Stublach, was considered. When the Development Consent Order (DCO) was in the pre-application phases, the existing SMC was being operated by the Stublach Gas Storage Project (SGSP), and still would have been in operation when the Consented Development was due to start cavity construction.

3.7.1.3 Due to the Applicants strategy to provide support to the UK Government's Net Zero targets, further design work and planning requirements has resulted in a delay to underground cavity construction. The existing SMC has completed the required operation for SGSP, which has allowed for the opportunity to use the existing infrastructure to create the Consented Development underground cavities.

3.7.1.4 After a feasibility study, the decision has been made to use the existing SMC at Stublach, for the solution mining of the Consented Development underground cavities.

3.7.1.5 The consented SMC3 compound will still be constructed and contain equipment required to support solution mining, however a significant portion of the consented infrastructure will not be constructed. The consented elements that will be constructed, as described in the Consented Development approved plan, includes the electrical switchroom and control equipment, nitrogen storage and distribution. The key elements of SMC3 that will not be constructed under the

Consented Development are the pumphouse, pumps, degassing tanks and the coolant system.

3.7.1.6 The existing SMC at Stublach has been noted in this PEIR for completeness, however, it does not form part of this MC application as it is an operational asset to be utilised off-site and does not need to be constructed or materially altered.

3.8 SUMMARY

3.8.1.1 To conclude, whilst this alternatives chapter outlines the key options considered for the Proposed Development in terms of the 'Do Nothing' Alternative, flaring and venting, GPP alternatives, GPP location and SMC design evolution; the Proposed Development design is on-going and will be refined for the ES.

3.8.1.2 If the Proposed Development design evolves any further through other statutory and non-statutory consultation feedback or new engineering recommendations this will be reported in the ES.

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ERM's London Office

2nd Floor, Exchequer Court

33 St Mary Axe

London

EC3A 8AA

T: 020 3206 5200

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