Written Evidence Submitted by the Geological Society (HNZ0060)

I. The Geological Society is the UK's learned and professional body for Earth science and a major international publisher with around 12,000 Fellows (members) worldwide. The Fellowship encompasses those working in industry, academia, regulatory agencies and government with a broad range of perspectives on policy-relevant Earth science. The Society is a leading communicator of this science to government bodies, those in education, and other non-technical audiences.

II. We have recently launched a new strategic science programme, with a focus on 'The Energy and Materials Transition'. Bringing together key stakeholders and subject experts on topics such as hydrogen, geothermal, carbon capture and storage, materials and minerals for clean growth, this focus will see us raise awareness of the contribution of the Earth sciences to the major challenges facing society today and tomorrow.

III. We have responded to questions in this Call for Evidence as and where they relate to Earth science research and industry.

1. The suitability of the government's announced plans for "Driving the growth of low carbon hydrogen", including:

- **The dependency of the government's proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated;**

IV. The limitations of current technology mean that commercial hydrogen must be generated by a process called steam methane reformation. The major drawback of this method is that it produces CO_2 as a by-product, which needs to be captured and stored to ensure carbon neutrality. Technologies to produce commercial hydrogen by hydrolysis are not currently viable. For this reason, sustainable use of commercial hydrogen requires co-development of the UK's carbon capture and storage industry, including investment into demonstration and pilot schemes around the UK.

V. Hydrogen produced via steam methane reformation (sometimes referred to as 'blue hydrogen') produces CO_2 as a by-product. At present, the majority of hydrogen is produced by this method. Growth of low carbon hydrogen therefore requires suitable CO_2 storage locations to be identified to ensure schemes are CO_2-neutral.

VI. It is important to note that, irrespective of the production method, the storage of hydrogen in the subsurface will be required to support any transition to a hydrogen economy.

VII. Although hydrogen technology may be applied across a number of sectors, national-scale deployment could be limited by the availability of suitable subsurface sites for hydrogen storage. Hydrogen storage is proven in halite (salt) rock caverns, in which large volumes of storage space can be created through solution mining.

2. The progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps to most effectively build on this progress;

VIII. The UK should appraise the adoption of hydrogen into low-carbon initiatives exemplified in China and the US. However, in both countries, there has been significant surface storage of hydrogen rather than subsurface geological storage, which has impacted land availability and use. The use of halite caverns to store hydrogen removes any competition for land at the surface when developing hydrogen technology.

3. The engineering and commercial challenges associated with using hydrogen as a fuel, including production, storage, distribution and metrology, and how the government could best address these;

IX. The geological storage of hydrogen enables a more consistent supply that can accommodate fluctuation in seasonal, and annual demand[1].

X. Hydrogen storage in salt caverns is 'proven, inexpensive, and reliable technology'[2]. The geological storage of hydrogen in the UK - and elsewhere - takes place in salt caverns, excavated by solution mining. Worldwide, this is not yet commonplace, and in the UK, underground storage of hydrogen has only taken place in one location (Teesside)[3].

XI. The suitability of salt deposits for hydrogen storage elsewhere in the UK is poorly understood, and more information regarding the properties of these rock formations (specifically, halite and interspersed mudstones) would de-risk proposals to store hydrogen in other similar geological units across the UK.

XII. Halite deposits are only thick enough for gas storage in some regions of the UK e.g., Cheshire, Teesside, west Lancashire, and Dorset[4]. Outside of these areas, other options for hydrogen storage need to be identified. These could include storage in porous geological media such as depleted hydrocarbon reservoirs and aquifers, which

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[1] https://hydrogeneurope.eu/hydrogen-storage
[2] https://medium.com/@cH2ange/louis-londe-technical-director-at-geostock-hydrogen-caverns-are-a-proven-inexpensive-and-346dde79c460
[3] CROTOGINO, F., DONADEI, S., BÜNGER, U. AND LANDINGER, H., 2010, May. Large-scale hydrogen underground storage for securing future energy supplies. In 18th World hydrogen energy conference (Vol. 78, pp. 37-45).
[4] EVANS, D. J. & CHADWICK, R. A. (eds) Underground Gas Storage: Worldwide Experiences and Future Development in the UK and Europe. The Geological Society, London, Special Publications, 313, 217–226. DOI: 10.1144/SP313.13 0305-8719/09/$15.00 # The Geological Society of London 2009.

are plentiful across the UK continental shelf, namely inthe North and Irish Seas where petroleum production is prevalent. Understanding the response of these rocks to the presence of hydrogen is essential to ensure that these deposits can safely store the required gas. This includes understanding the suitability of sealing rock units in relation to hydrogen. As the hydrogen molecule is smaller than methane, it is possible that natural gas reservoirs may not be gas tight for hydrogen. Geoscientists can test the properties of rocks with respect to hydrogen in the laboratory. Additionally, the potential impact of hydrogen on microbial communities that exist in the subsurface needs to be better understood in order to understand how geological reservoirs may react to the presence of hydrogen.

XIII. Recent estimates, from January 2021, suggest there is ample geological space in offshore gas fields to store enough hydrogen to meet the UK's seasonal demand fluctuations, with 40 times the volume needed in place[5]. Additionally, depleted gas fields offer the opportunity to reuse and repurpose existing infrastructure in place to extract natural gas, therefore reducing implementation costs. However, the only *proven* geological storage of hydrogen is in salt caverns.

4. The infrastructure that hydrogen as a Net Zero fuel will require in the short- and longer-term, and any associated risks and opportunities;

XIV. For hydrogen to be a viable decarbonised energy source ample seasonal and annual storage is required for both hydrogen and carbon dioxide. The required volume of storage is unlikely to be met by surface storage infrastructure.

XV. Hydrogen fuel cells and production of hydrogen are an essential part of clean growth, particularly for transport, infrastructure and industry[6,7,8]. Electrolysis for hydrogen production and fuel cells require electrolysers. Electrolysers contain mined platinum-group metals (PGM) catalysts in higher concentrations than in the catalytic converters on combustion engine vehicles (the chief use of PGM currently)[9]. However, uncertainties around the balance between hydrogen and battery-based technologies in 'The Fourth Industrial Revolution' means that forecasting future demand for raw materials is difficult. PGM are classified as critical raw materials due to the security of supply and being produced from only a handful of deposits in a few countries (chiefly South Africa and Russia)[10,11,12].

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[5] https://www.sciencedirect.com/science/article/pii/S0360319920347005?dgcid=author
[6] http://www.fch.europa.eu/sites/default/files/2017_FCH%20Book_webVersion%20%28ID%202910546%29.pdf
[7] Agency for Natural Resources and Energy (2016). Strategic Roadmap for Hydrogen and Fuel Cells. Japan. (online) Available at: http://www.meti.go.jp/
[8] U.S. Department of Energy (2011). The Department of Energy Hydrogen and Fuel Cells Program Plan. (online) Available at: https://www.hydrogen.energy.gov/roadmaps_vision.html
[9] Fuel Cell & Hydrogen Energy Association (2018). Fuel Cell Basics. (online) Available at: http://www.fchea.org/
[10] European Commission (2020). Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability.

[11] European Commission (2020). Critical Raw Materials Factsheets
[12] European Commission (2020). Study on the EU's list of Critical Raw Materials (2020).

XVI. The storage of hydrogen is contingent on the research, skills, knowledge and experience of geologists and ground engineers. Availability of skilled workers in these professions relies on commitment to, and investment in, geoscience training and education from Primary through to Higher Education and beyond. Additionally, a number of these professions are currently on the UK Shortage Occupation List[13] (Standard Occupation Codes: 2113 Physical Scientists & 2129 Engineers) and the resulting regulations around immigration of workers with these skills should be considered accordingly.

Further comments:

XVII. The long term uncertainty of energy markets as well as the permitting and planning processes, are greater hurdles to the development of a fully decarbonised hydrogen economy than the geological availability and suitability of hydrogen storage.

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[13] https://www.gov.uk/guidance/immigration-rules/immigration-rules-appendix-k-shortage-occupation-list