# Written Evidence Submitted by The British Geological Survey (BGS)

# (HNZ0026)

1. The suitability of the Government's announced plans for 'Driving the Growth of Low Carbon Hydrogen', including:
   - the focus, scale and timescales of the proposed measures
   - how the proposed measures—and any other recommended measures—could best be co-ordinated
   - 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
   - potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel

## How can hydrogen contribute to Net Zero?

Many forward-looking scenarios and projections that develop pathways for the UK to meet emissions targets and achieve Net Zero (most notably the Committee on Climate Change's Sixth Carbon Budget and National Grid's Future Energy Scenarios report for 2020) include some amount of hydrogen in future energy mixes. There is an anticipated requirement for an increase in subsurface storage for hydrogen (e.g. to help meet seasonal demand) to support some of the large-scale hydrogen trials planned for the 2020s (e.g. Leeds H21 Citygate and HyNet-North-west England initiatives). The plans for 'Driving the Growth of Low Carbon Hydrogen' propose the development of industrial 'SuperPlaces' in which renewable energy, carbon capture, utilisation and storage (CCUS) and hydrogen production will be co-located. These could also be seen as a contributor to the government's levelling-up agenda, because most industrial clusters are located outside south east England.

Due to technology availability and maturity, initially the production of hydrogen is likely to be from the conversion of natural gas to hydrogen via steam methane reforming (SMR) or auto-thermal reforming (ATR). This process produces so-called 'blue hydrogen' and, to prevent the $CO_2$ by-product being emitted to atmosphere, it can only take place in conjunction with CCUS. The rate at which $H_2$ production via renewable energy, primarily excess wind power, will displace blue $H_2$ production remains an open question and is unlikely to occur until excess renewable energy generating capacity becomes available. As a result, the low carbon hydrogen plan should be very closely integrated with other aspects of the Prime Minister's Ten Point Plan, and the plans outlined in the 2020 Energy White Paper. Specifically, the development of low-carbon hydrogen is closely linked to the increase in offshore wind capacity; the development of $H_2$ powered freight and train transport; green ship development; development of greener buildings; investing in carbon capture, usage and storage; and green finance and innovation.

In anticipation of these policy announcements industry has been developing a number of projects that could initiate the development of these low-carbon technologies. BGS has been working with several of these groups to determine the potential future requirements for $CO_2$ storage. Results from two research projects funded by the BEIS Accelerating CCUS Technologies programme, ALIGN and Elegancy, have provided initial estimates of the amount of $CO_2$ storage capacity that might be required to serve the decarbonisation of two future proposed “SuperPlaces”: Grangemouth and Teesside. This includes estimates of future $CO_2$ storage capacities that might be needed to support $H_2$ production from methane, and an initial preliminary estimate of theoretical $H_2$ storage capacities in salt caverns.

## 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

Although some locations that may be suitable for subsurface hydrogen storage are known and quantified (e.g. Cheshire and Teesside saltfields), the character of sites elsewhere is not well understood. BGS recommend that a systematic survey programme is completed that maps out potential UK sites for subsurface hydrogen storage. This will support planning and upscaling of hydrogen storage nationally, and allow routes to decarbonisation using hydrogen to be integrated with subsurface hydrogen storage. The survey should consider onshore and offshore opportunities in solution-mined cavern and porous rock formations.

## 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

### Production

Increasing the volume of hydrogen produced over the short term (e.g. 2020-2030 – AAPG, 2020) will likely occur via steam methane reformation associated with CCS (‘blue hydrogen’). Whilst the natural gas feedstock required for this is likely to come from domestic offshore production (unlikely from onshore sources), there needs to be subsurface space defined to accommodate $CO_2$. Over the longer term (e.g. 2030-50 – AAPG, 2020) the proportion of hydrogen produced via electrolysis utilising electricity from renewables (‘green hydrogen’) is likely to increase. One option is for production of hydrogen to be associated with wind power generation (production of hydrogen is therefore one route by which the proportion of renewable, intermittent energy can be increased). The scale-up of offshore wind will likely require the development of floating wind farms, allowing wind generation in parts of the North Sea with water depths in excess of 50-60 m (Kan, 2020). Hydrogen produced by offshore wind has export potential to European Member States that have little option for hydrogen production at scales required.

### Research

In order to enhance the UK’s leading position in underground gas storage, hydrogen storage and associated CCUS, research is required to understand the implications of a national-scale hydrogen economy and build on previous research (e.g. research projects such as Elegancy, IMAGES or HyPorstor). This know-how will be a valuable exportable asset, allowing the UK to further its leadership role in helping other nations successfully decarbonise and meet climate change targets.

A systematic survey of natural geological and hydrographical assets that may represent potential subsurface hydrogen storage sites is required to allow planning for the upscaling of hydrogen use across the country. This could be completed by a range of public and private sector organisations (including BGS and the Crown Estate) given access to relevant data describing the subsurface, including, but not limited to seismic reflection data (2D and 3D), down-hole borehole geophysical logs and geological data describing rock behaviour (e.g. porosity-permeability, geochemistry and engineering geological properties). The spatial distribution of natural geological and hydrographical assets of the North Sea required to support hydrogen production and storage is not well known. Research is needed to allow the distribution of halite (rock salt) at suitable depths for offshore cavern storage, the bathymetry of the North Sea defining areas where fixed vs. floating wind farms could be viable, and the existing platform and pipeline infrastructure to be understood in the context of offshore hydrogen production from wind. Future offshore hydrogen production, whilst not currently technologically mature, may provide an opportunity to re-use existing oil and gas pipelines to transport $H_2$ ashore. The opportunities, barriers and challenges to this re-use should be investigated further. Initial studies by BGS (ALIGN) and others indicate that some of this infrastructure may also be suitable for re-purposing for $CO_2$ transport to offshore $CO_2$ storage sites.

The development of offshore wind that might support future local $H_2$ production, should be undertaken in careful consideration of the underlying geological resources for future storage of both $H_2$ and $CO_2$. Careful consideration should be given to the opportunities and challenges which might be presented by the co-location of wind farms, hydrogen and $CO_2$ storage in specific location of the southern and central North Sea.

If hydrogen storage in porous rocks is required, then the performance of these reservoirs in terms of hydrogen containment and hydrogen-bedrock geochemical reactions need to be understood. The potential locations in the UK and volumes that could be stored in this type of reservoir must also be determined. These activities will build on the findings of existing research projects.

At present, the environmental impacts of a major upscaling of hydrogen storage are poorly understood. A UK national baseline environmental study of hydrogen would allow the industry to develop with the minimal environmental impact (e.g. leak detection, local environmental impact of hydrogen should a leak occur in a large subsurface facility). Relevant aspects of existing and proposed initiatives such as the UKRI/NERC Long-Term Science Multi-Centre programme (LTSM), should be brought together to support the improved understanding of potential environmental harm resulting from large-scale hydrogen storage in the subsurface.

Studies evaluating how hydrogen storage would operate (e.g. required storage pressures and cavern/storage unit cycling) will allow optimal operating strategies to be developed, feeding into operating practices supporting large-scale uptake of hydrogen in sectors such as industry, transport and domestic heating. This will support the understanding of where storage will be needed nationally, and how much storage volume is required in order to support a large-scale transition to hydrogen and ensure energy system flexibility.

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

### Hydrogen Storage

An increase in hydrogen production will result in a requirement for increased capacity for hydrogen storage, allowing for the decarbonisation of peak electricity generation. Although hydrogen storage in solution-mined caverns in halite (rock salt) has been successfully deployed at a commercial scale in the UK (e.g. storage in three caverns at Teesside – Stone et al, 2009), a national survey/inventory of suitable subsurface storage locations is required to underpin effective planning for the uptake of hydrogen at scale. Additionally, the behaviour of hydrogen in solution-mined caverns located elsewhere in the UK is not well understood, especially if operational parameters need to change in response to a greater demand for the product. There is also the potential that there could be difficulties in achieving optimal use of the subsurface if there is to be a greater use storage space for hydrogen in future. Initial mapping by BGS (Williams et al., 2020) indicates that there is likely to be sufficient theoretical UK capacity if additional solution-mined caverns were constructed in the halite beds in Cheshire and Teesside. Similar development in the Wessex Basin would enhance this capacity further, although theoretical storage capacities in this area are less well-known. However, it is not clear if these locations will be appropriate to store hydrogen for nationwide use. Other uncertainties surrounding this option include planning constraints on cavern development and the options for disposal of excess brine generated by the solution-mining process. Techno-economic modelling is required to establish whether cavern storage in Cheshire and Teesside will be appropriate to support a national hydrogen economy, or if alternate storage solutions in the subsurface (e.g. storage in porous rocks) will be required in areas with no natural resource of halite that is suitable for the development of solution-mined storage caverns. Hydrogen produced by offshore wind power could also be stored for later use in solution-mined caverns in offshore rock salt domes in the North Sea.

### $CO_2$ storage

As well as enabling decarbonisation of industrial processes, and possible future carbon removal options that result in negative emissions (such as Bio-Energy with Carbon Capture and Storage and Direct Air Carbon Capture and Storage), $CO_2$ storage will be needed to allow $H_2$ development via methane reformation. BGS owns and operates the $CO_2$ stored online database (www.co2stored.co.uk) on behalf of the UK, providing access to detailed information on nearly 600 individual potential storage sites. This database indicates that the estimated ***theoretical*** storage capacity of the UKCS is more than enough to meet likely future storage requirements. Furthermore, initial research by BGS indicates that for some scenarios of future $CO_2$ capture rates, including those associated with $H_2$ production, for the Grangemouth and Teesside industrial clusters, sufficient practical storage is available and is likely to be able to store the $CO_2$ at the rates that can be projected to 2050 and beyond. However, more research is needed to consider the implications of further $H_2$ production via methane reforming, on a greater scale at other industrial clusters such as Humber, northwest England and elsewhere.

## 5. Cost-benefit analysis of using hydrogen to meet Net Zero as well as the potential environmental impact of technologies required for its widespread use

No comments

## 6. The relative advantages and disadvantages of hydrogen compared to other low-carbon options (such as electrification or heat networks), the applications for which hydrogen should be prioritised and why, and how any uncertainty in the optimal technology should be managed.

In this context, the BGS focus is primarily on large-scale hydrogen storage and the associated storage of $CO_2$ as hydrogen production is likely to be from methane reforming at least initially (say to 2050). As $CO_2$ storage is central to much of the UK's planning to achieve net zero by 2050, development of $CO_2$ transport and storage infrastructure will be developed in any case and can be seen as a 'no regrets' policy regardless of the eventual scale of $H_2$ use. We recommend that the development of this $CO_2$ transport and storage infrastructure is undertaken to allow future widescale hydrogen production as we expect this to achieve lower costs in the long-run, compared to developing additional $CO_2$ transport and storage infrastructure specifically for $H_2$ production.

## References

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