Meeting the UK's Underground Hydrogen Storage Requirements – An Assessment of Timescales

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DEEP.KBB

UKES2025
UK Energy Storage Conference

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Experience

Approx. **120**
Employees

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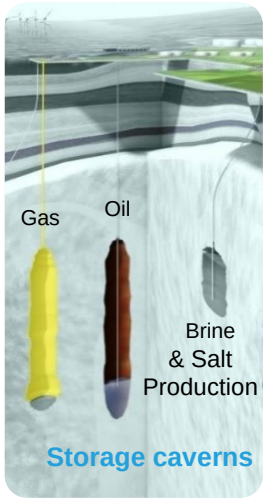
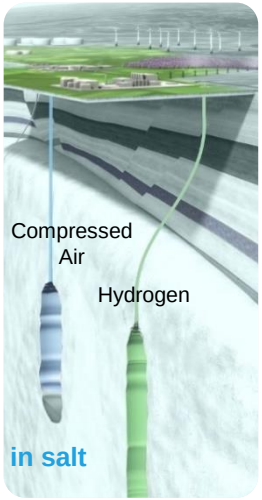




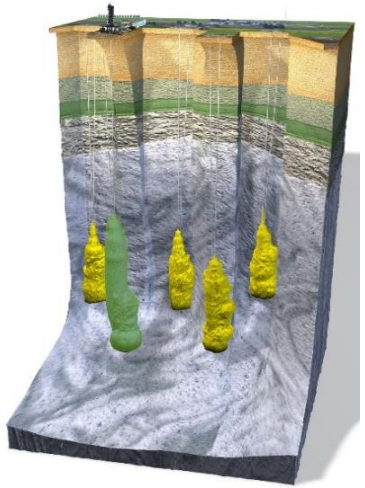
- Consulting
- Engineering
- Project Management
- Rock Mechanical Expertise
- Salt Geology & 3D Modelling
- Construction

DIN EN ISO 9001:2015 | DIN EN ISO 14001:2015 | SCC** Job Safety

HYDROGEN FOCUS

- Long-term Involvement in Theoretical Aspects & papers
- Concept and Feasibility Studies
- Potential Studies / Site Screening
- Basic & Detailed Engineering
- Pre-FEED & FEED Studies
- Active Involvement in different Hydrogen Pilot Projects / R&D

uniper · hystock power to hydrogen · Green Hydrogen Hub DENMARK · H_2CAST Etzel

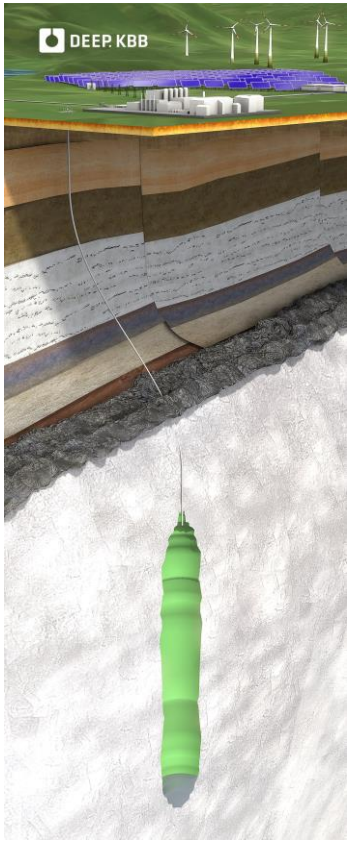


UK’s Hydrogen Storage Requirements

UK’s Hydrogen Storage Requirements
Hydrogens Storage Scenarios

- Different studies forecast a hydrogen storage demand for the UK ranging between **5 TWh** and **100 TWh** by **2050**
- Some studies already forecast a storage demand of **3.4 TWh** by **2030** increasing to **9.8 TWh** by **2035**
- The realisation involves **significant challenges** and includes logistical and geological constraints

Scenario	Min (TWh)	Max (TWh)
The Royal Society	60	100
National Energy System Operator	14	49
Imperial College and AFRY	5	20
Mean	27	56



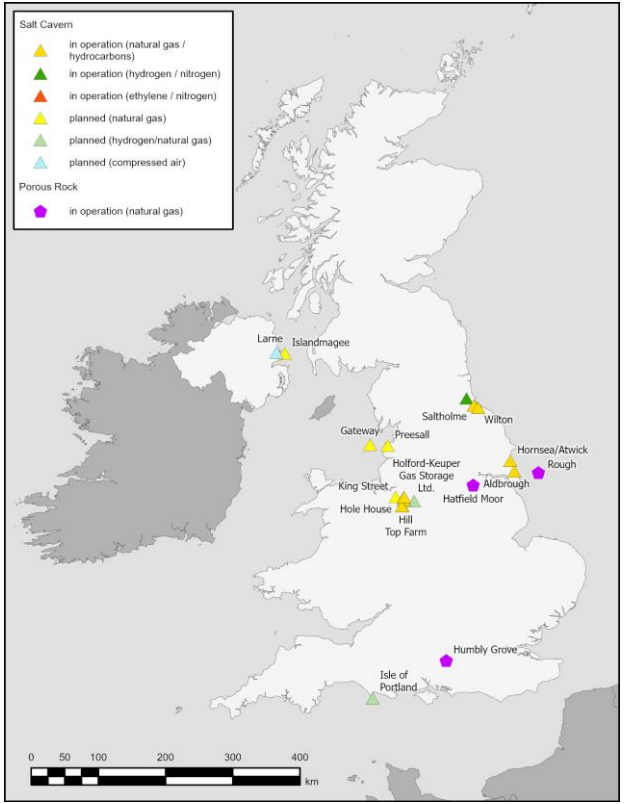
UK’s Hydrogen Storage Requirements

UK’s Current Storage Capacities for Natural Gas

- A total storage capacity of **28.7 TWh** for **natural gas** (salt cavern and porous rock)
- By converting all existing storage sites (if suitable) this would result in an estimated storage capacity of **~ 10 TWh**

Facility	Type	Estimated Working Gas Volume (TWh)	Start date	Owner
Hornsea (Atwick)	cavern	2.83	1979	SSE Hornsea Limited
Hatfield Moor	porous rock	0.64	2000	Scottish Power
Humbly Grove	porous rock	2.34	2005	Humbly Grove Energy
Aldbrough	cavern	2.59	2009	SSE Hornsea Limited/ Equinor
Holford	cavern	2.23	2011	Uniper UK Ltd
Hill Top Farm	cavern	0.54	2011	EDF Energy
Stublach	cavern	3.68	2014	Storengy
Rough	porous rock	13.80	2022	Centrica Storage Limited

Based on Ofgem GB Gas Storage Facilities (2023), converted with factor 9.2 kWh/m³ for natural gas



UK’s Hydrogen Storage Requirements

UK’s Hydrogen Storage Potential

- Various studies have demonstrated that the UK has a **storage potential** far **exceeding** the required **forecasts**

- The potential may decrease when considering a **detailed site analysis** but it is still expected that the potential remains **> 100 TWh**

Study	Potential TWh	Included Basins
Caglayan et al. (2020) (on- & offshore)	10,400 TWh	N/A , incl. area 50 km offshore
Williams et al. (2022) (onshore)	2,151 TWh	Cheshire, Yorkshire, Wessex

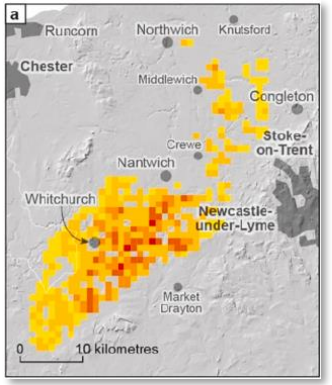
Assessment of Cavern Number

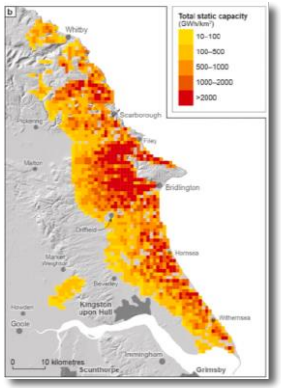
Assessment of Cavern Number
Assumptions for the High Level Analysis

- The **Cheshire** and **Yorkshire Basin** have favourable underground conditions for cavern construction having **existing** operational **cavern storage sites**

- Both basins **exceed** the hydrogen storage potential of **100 TWh** according to Williams et al. (2022):
  - **129 TWh** for the Cheshire
  - **557 TWh** for Yorkshire Basin

- Due to the **available data**, this assessment is limited to these two basins



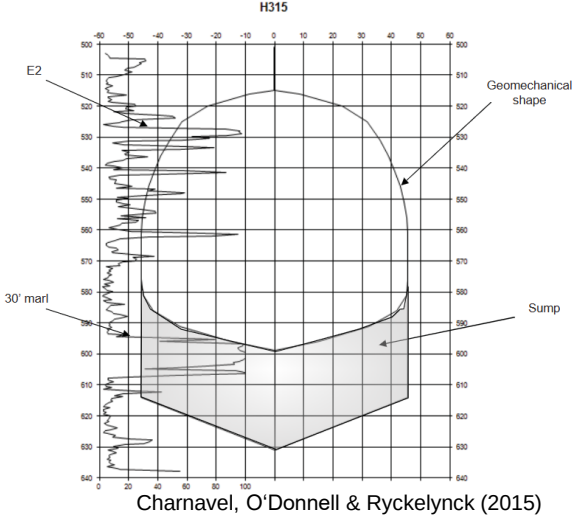


Williams et al. (2022)

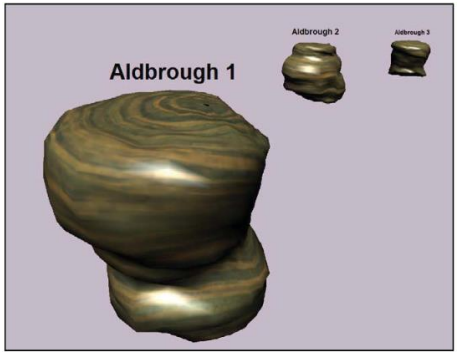
Please note: Other basins (e.g. Wessex or Larne Basin) also indicate favourable hydrogen storage conditions (previous potential analyses)

Assessment of Cavern Number
Input Parameters for the High Level Analysis

- Target of **60 TWh** (mean of studies) by **2050**
- Applied cavern sizes (limited to two volumes)
  - Cheshire Basin: **370,000 m³** (acc. to Stublach[1])
  - Yorkshire Basin: **300,000 m³** (assumed, acc. to Atwick/ Aldbrough)
- Cavern depths (limited to two depths)
  - Cheshire Basin: **300 m** and **500 m**
  - Yorkshire Basin: **1,500 m** and **1,700 m**
- Storage capacity of **30 TWh per basin**
- **Cyclic seasonal** storage operation (~1/3 cushion gas)
- **No repurposing** of existing storage sites considered



Charnavel, O'Donnell & Ryckelynck (2015)



Passaris et al. (2015)

[1] Charnavel, O'Donnell & Ryckelynck (2015)

Assessment of Cavern Number
Energy Content per Generic Cavern Design

- Caverns in Cheshire Basin show a **lower energy content** per cavern due to **shallow depth** compared to Yorkshire Basin

- It can be assumed that **construction** and **operation costs** might be higher in deeper depths (e.g. drilling, pumps, compressors, energy, etc.)

Basin	Depth LCCS (m)	Geometric Volume	WGC (Nm^3)	CGC (Nm^3)	Energy content per cavern (GWh)[1]
Cheshire	340	370,000	13 million	7 million	**~50**
	540	370,000	20 million	11 million	**~70**
Yorkshire	1,540	300,000	37 million	22 million	**~130**
	1,740	300,000	40 million	24 million	**~140**

[1] calorific factor of 39.4 kwh/kg

Assessment of Cavern Number
Required Number of Caverns

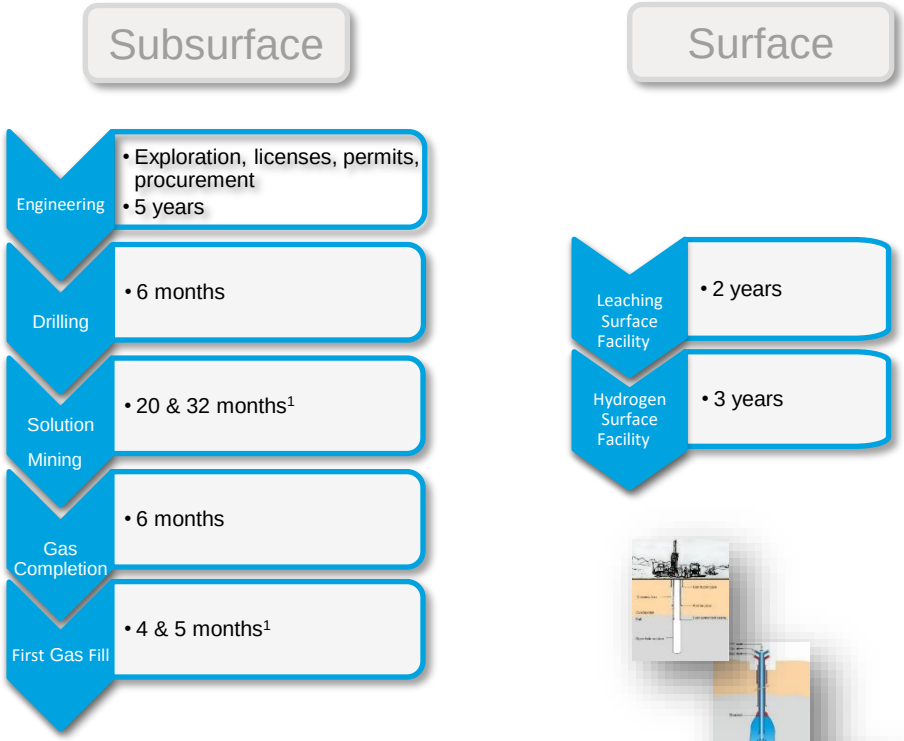
- Assumption that the target value of 60 TWh is **evenly distributed** over both basins
- A **higher number of caverns** is required in the Cheshire Basin in order to store 30 TWh
- A total number of **~700 caverns** are required in order to store 60 TWh in the Cheshire and Yorkshire Basin

Basin	Depth LCCS (m)	Geometric Volume (m^3)	Total Storage Capacity (TWh)	Number of Caverns
Cheshire	340	370,000	15	~300
	540	370,000	15	~200
Yorkshire	1,540	300,000	15	~100
	1,740	300,000	15	~100
Total			**60**	**~700**

High Level Assessment of Timescale

High Level Assessment of Timescale
Estimated Construction Time

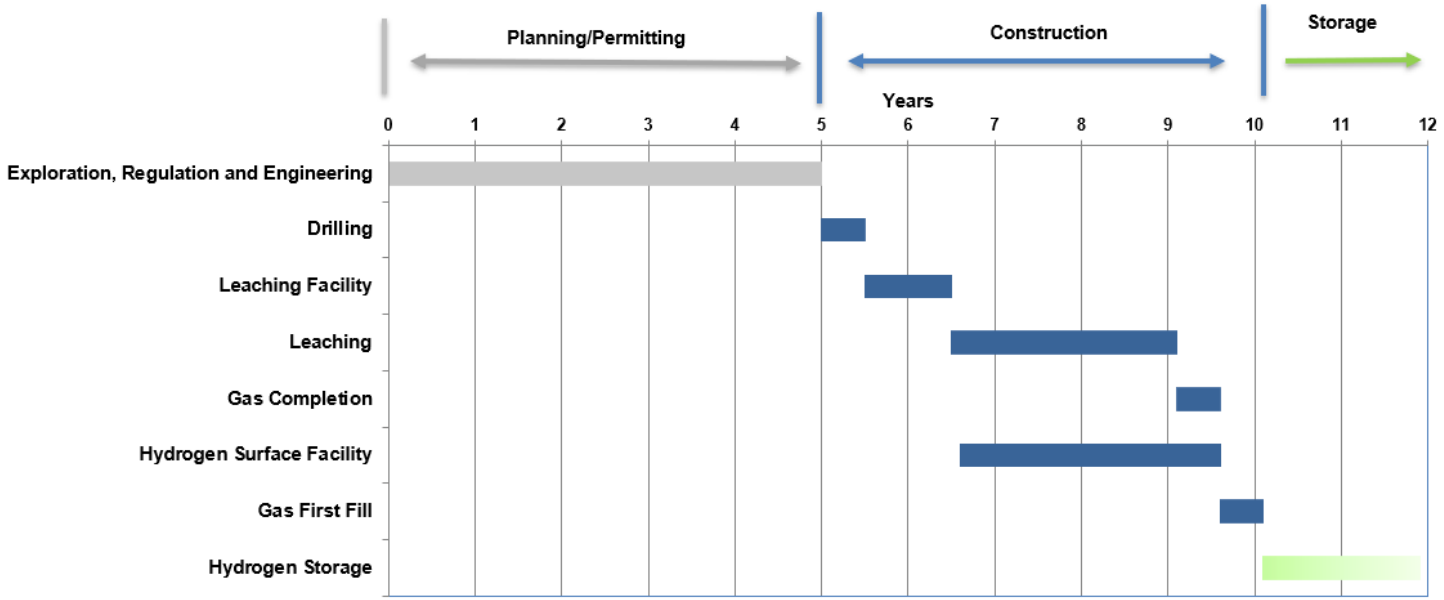
- Rough time estimation **per cavern**
- Depending on **cavern volume** the cavern engineering and construction will take about **10 years** per cavern
- Cavern construction typically in **parallel**
- Engineering time is expected to **decrease over time** through **accumulated knowledge** and the **replication of existing designs**



[1]depending on cavern volume

High Level Assessment of Timescale

Generic Flow Chart for the Cheshire Basin



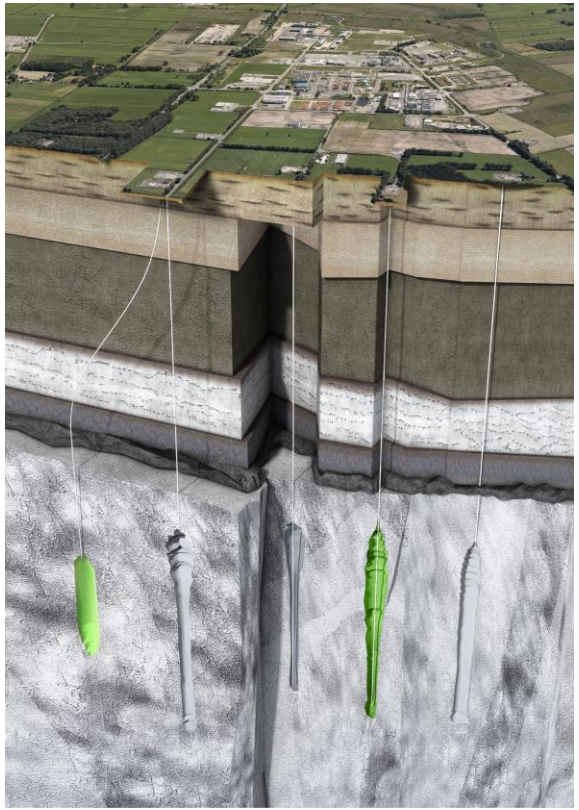
- Hydrogen storage anticipated to be available after **~10 years**
- Long durations of the **planning** and **leaching phase**

High Level Assessment of Timescale

Results of the Considered Scenario

- About **47 caverns per year** need to be newly developed (between 2025 and 2039) in order to achieve the target value of **60 TWh** by **2050**

- An amount of **~33 TWh** of **cushion gas** is required to store 60 TWh (in total an amount of 93 TWh of hydrogen have to be stored)



Please note: A different cavern design (→ energy content per cavern) might lead to a different number of caverns (per year)

Summary and Conclusions

Summary and Conclusions

In total **700 caverns** are required (applied scenario) to store 60 TWh

About **47 caverns per year** need to be newly developed in order to achieve the target value

To store **60 TWh** of (working gas), an amount of **33 TWh** of **cushion gas** is required (scenario)






Summary and Conclusions
Further Aspects / Constraints

Availability of **equipment and services**:

- Drilling rigs, services
- Casings and well heads
- Surface facilities (pipelines, pumps, compressors, treatment, gas first fill units, valves etc.)
- W/O rigs (leaching, gas completion , testing)
- Snubbing units
- Gas completion equipment: packer, SSSV, gas and debrining well heads
- Etc.

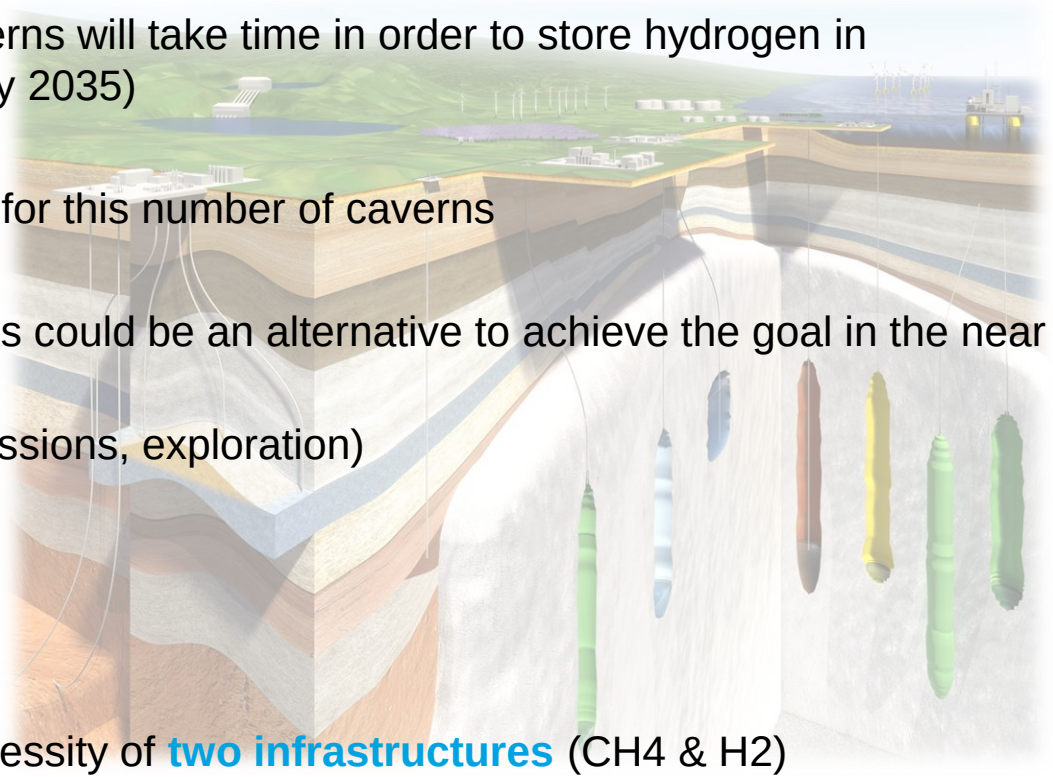
Permits, licenses, exploration

Land use

Fresh water sources and **brine** disposal / use

Summary and Conclusions
Repurposing of Existing Salt Caverns

- Construction of **new hydrogen** caverns will take time in order to store hydrogen in significant quantities (e.g. 10 TWh by 2035)
- **Infrastructure** needs to be build up for this number of caverns
- **Repurposing** of existing salt caverns could be an alternative to achieve the goal in the near future
  - Planning phase (licences, permissions, exploration)
  - Leaching phase
  - Etc.



➢ **But: Transition period** with the necessity of **two infrastructures** (CH4 & H2)

Thank you for your ATTENTION!

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