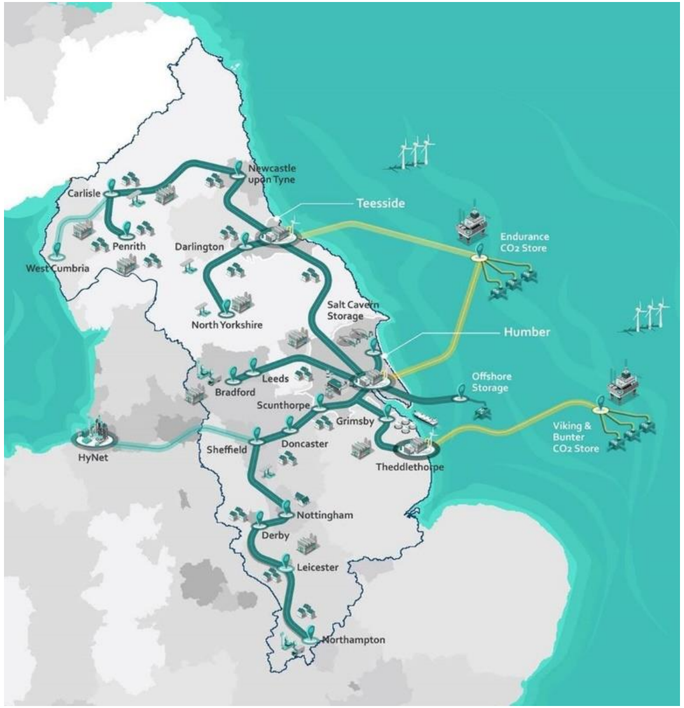
17th April, UKES and HSiSC 2025

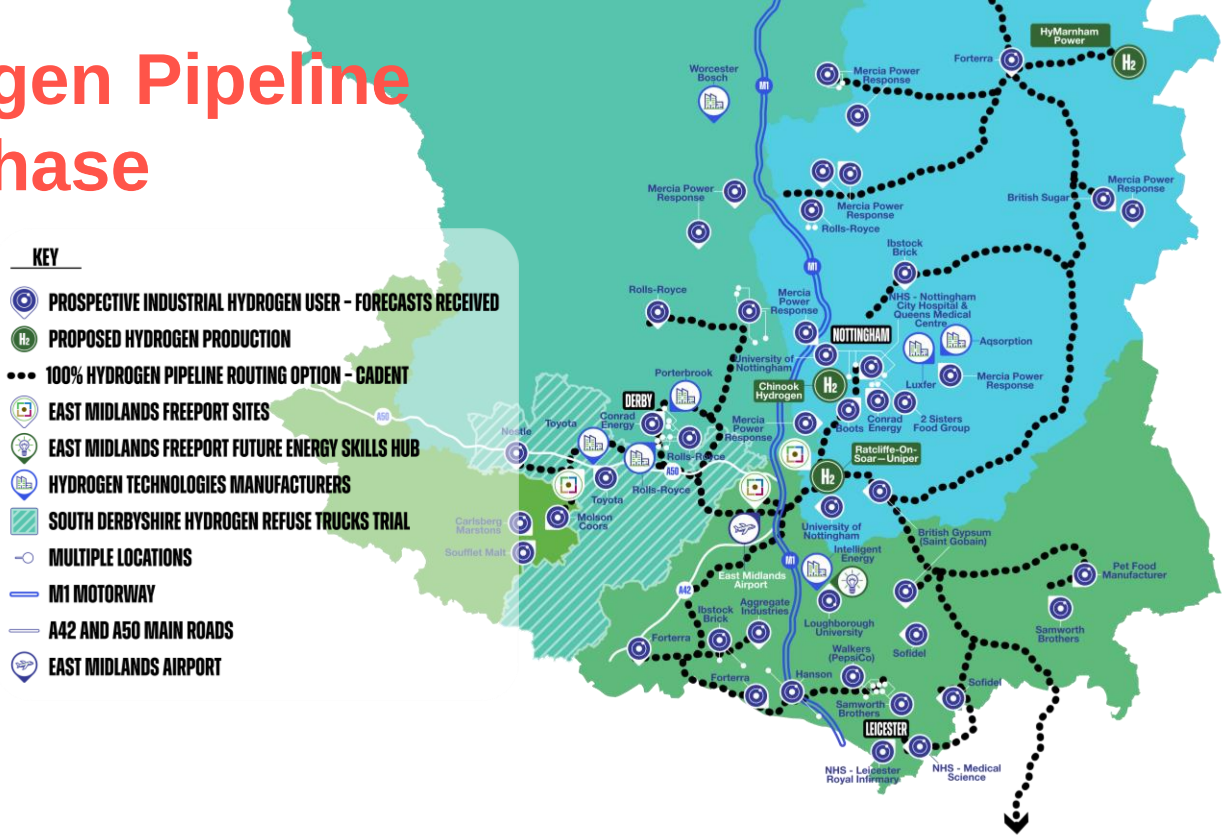
East Midlands Storage (EMStor): Alpha Phase

Tim Armitage, Energy Storage Geoscientist
British Geological Survey

Cadent Your Gas Network · British Geological Survey · Star Energy · The University of Edinburgh · centrica energy storage+ · national gas · uniper · Supported by HyDEX

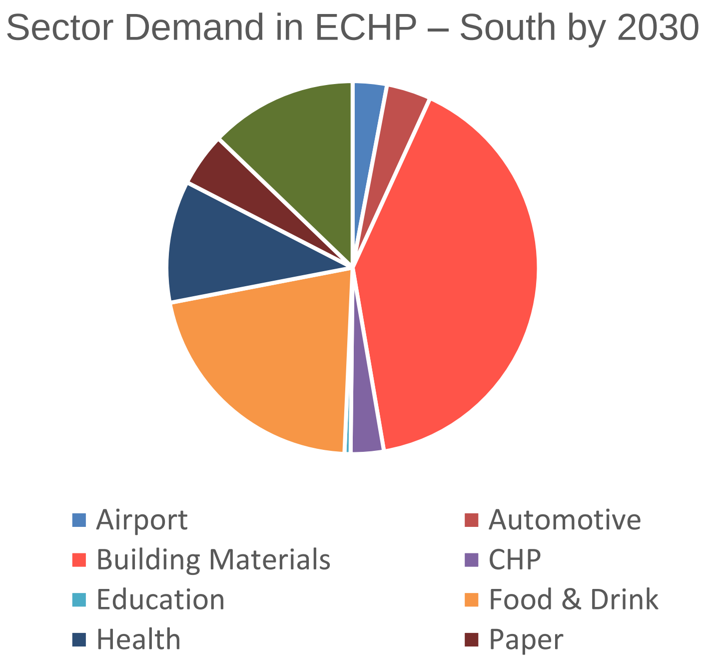
East Coast Hydrogen Pipeline (ECHP) – South Phase

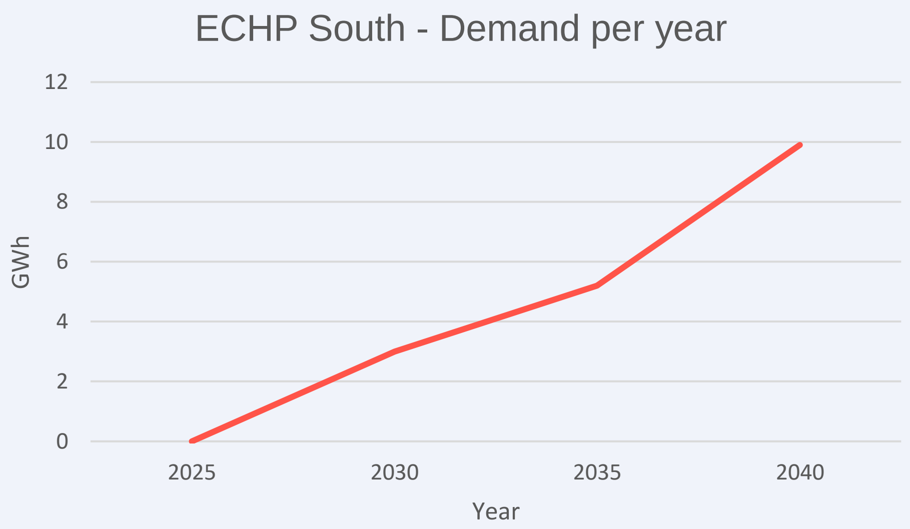




The pipeline routing remains unchanged, connecting hydrogen demand and enabling 1.9Mt/CO2 per annum to be saved once fully developed

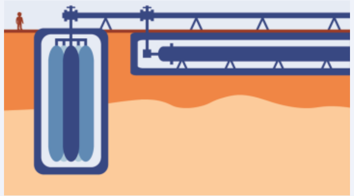
East Midlands Hydrogen Pipeline – has significant demand starting in 2030. GWh-scale storage initial estimate



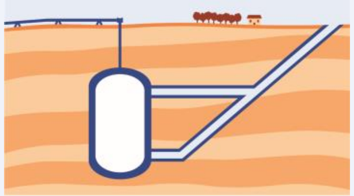


Hydrogen demand increases from 3TWh to near 10TWh by end of the 2030s, across a large range of sectors that exist in the East Midlands today

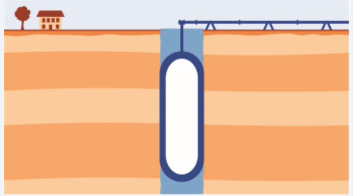
SIF Discovery Phase a quick recap: Multiple storage technologies were evaluated based on identical parameters



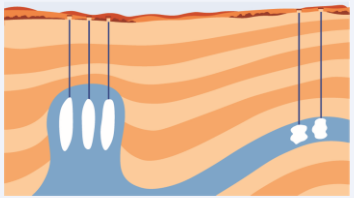
Clustered silos and dedicated pipelines



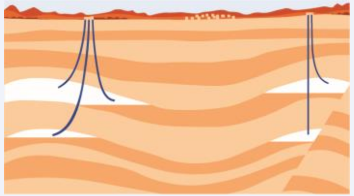
Lined rock caverns



Lined rock shafts



Salt caverns



Porous rock

- Saline aquifers
- **Depleted hydrocarbon fields**

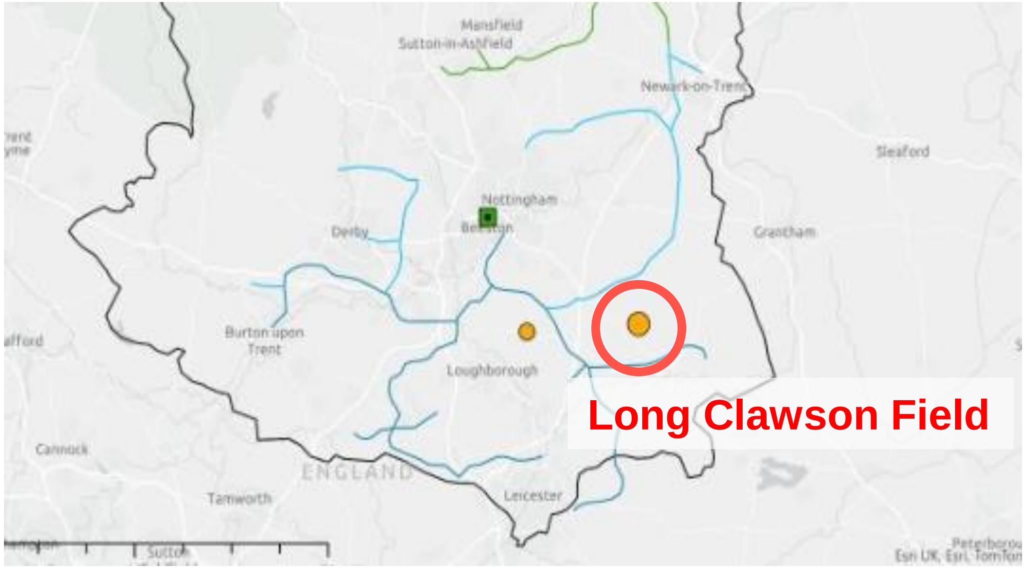
Parameters assessed

- **Storage capacity**
- **Injection and withdrawal rate**
- **Potential for upscaling**
- **Implementation time**
- **Technology readiness level**
- **Cost per GWh**
- Cost of development
- Life cycle cost savings
- Hydrogen deployment
- Gas treatment requirements
- Cushion gas requirements

EMSTor Alpha Phase focuses on the Long Clawson Field

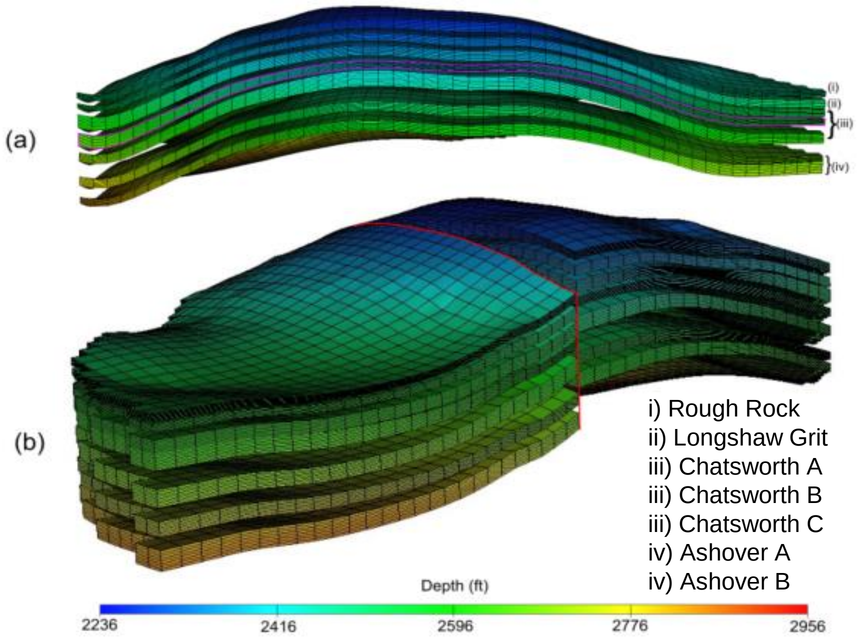
In total the Alpha Phase project has 9 work packages:

- WP1 – Public Perception, stakeholder consultation and feedback – Cadent (lead) with University of Portsmouth
- WP2 – Geological Feasibility – Edinburgh/BGS
- WP3 – Well Integrity Evaluation – Edinburgh/Star
- WP4 – Planning Pre-App – Star
- WP5 – Regulatory Permitting & Compliance – Star
- WP6 – Risk Assessment – Star
- WP7 – Business Case – Uniper
- WP8 – Project Consolidation, decision making & dissemination – Cadent
- WP9 – Project Management – Cadent



Focus on the Long Clawson field due to a number of technical considerations assessed by the project team

Long Clawson field:
An aging Carboniferous oilfield



- Discovered 1986, first production 1990
- Made of 7 reservoirs divided by impermeable strata, *c.* 800 m bgl
- Rollover anticline bounded by a **NE-SW trending normal fault**
- 8 wells drilled 1987 -1997

Rough Rock

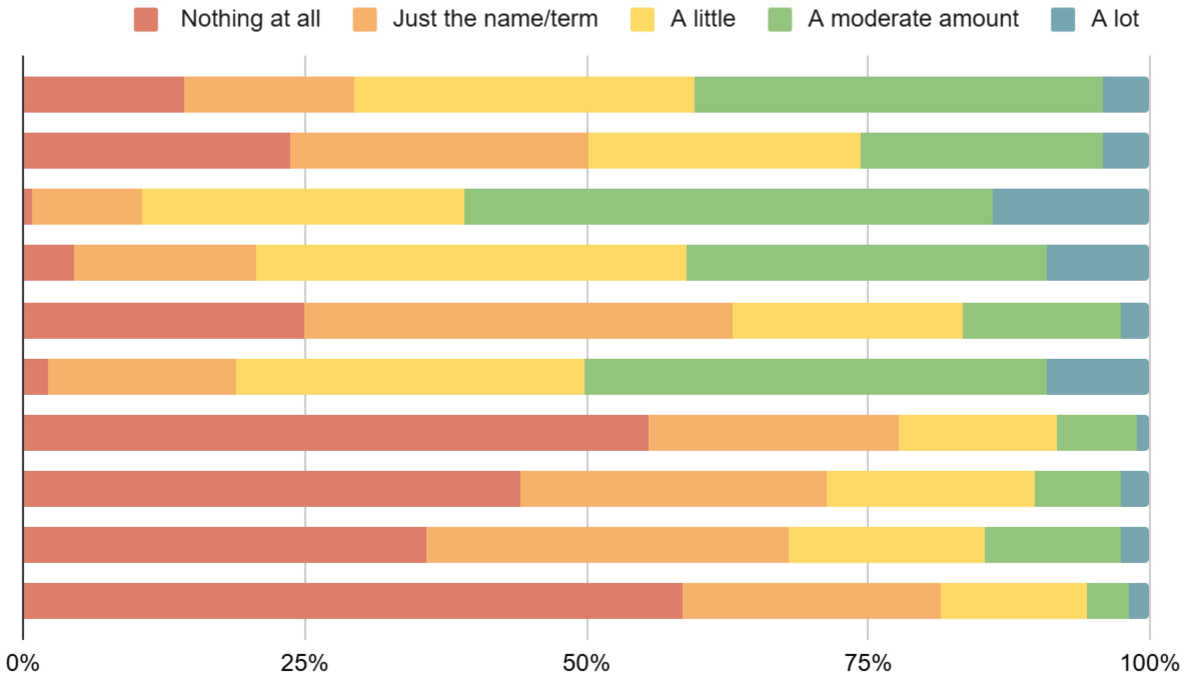
Cross- bedded coarse grained sandstone

Chatsworth Grit

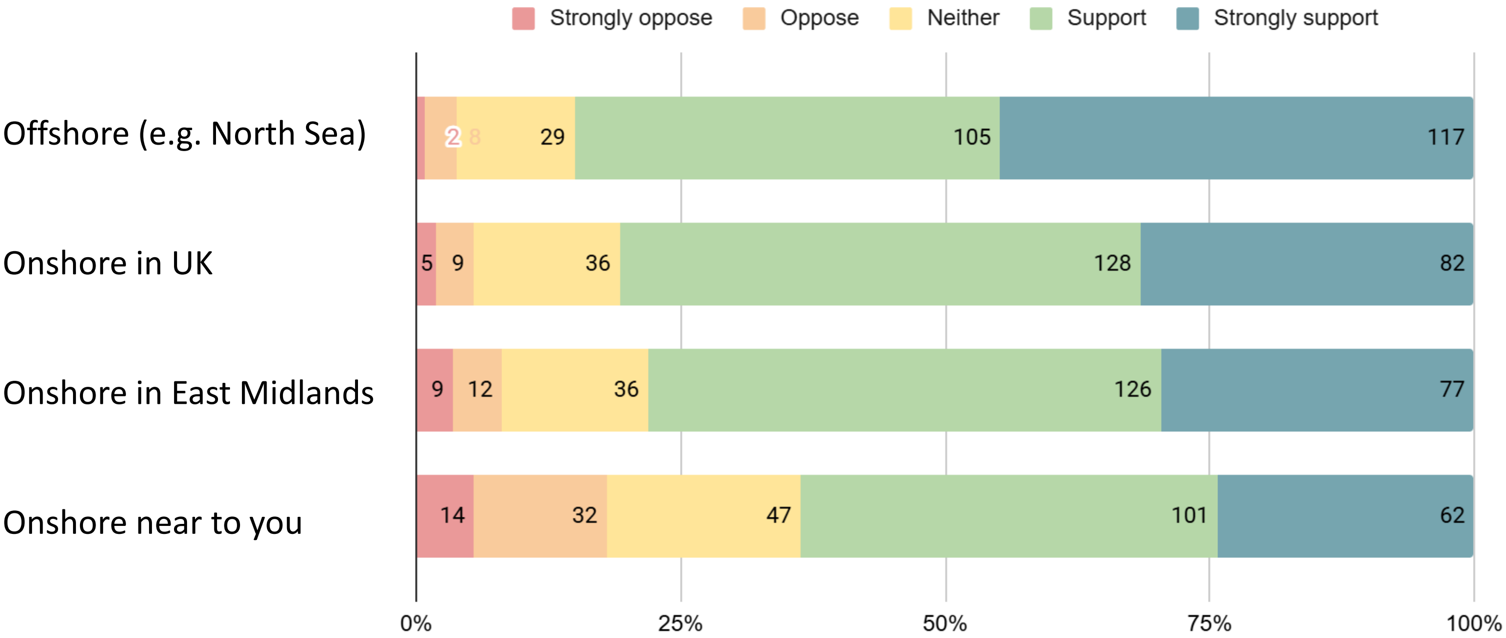
Fine to coarse grained, cross bedded, locally pebbly sandstones with minor interbedded mudstones and siltstone

Awareness of is low. Attitudes towards GHS likely to be changeable

- Net zero
- Energy security
- Climate change
- Renewable ETs
- **Hydrogen**
- Carbon footprint
- **Geological H_2 storage**
- CCS
- Decarbonisation
- **Hydrogen economy**

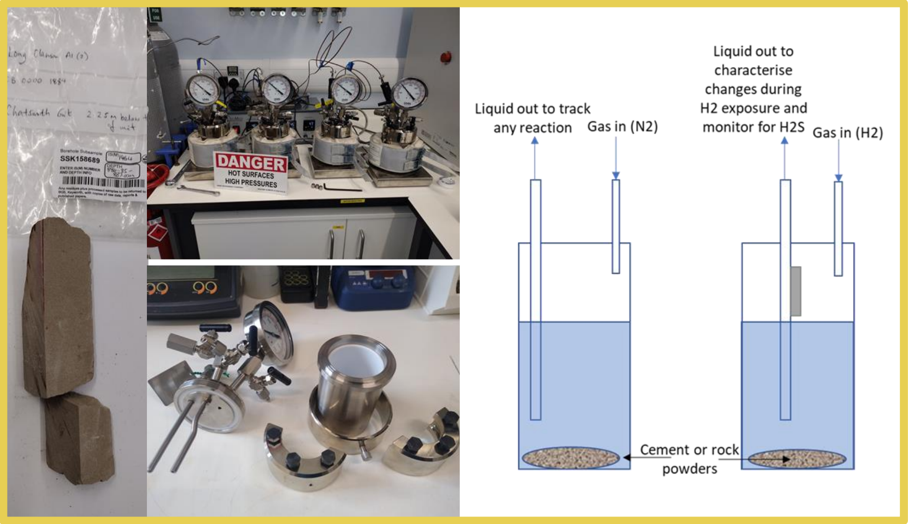


Some NIMBYism but majority support storage. These attitudes can change if a specific project is announced



Geochemical experiments:
Reservoir rocks and well cements

Aim to assess the potential for reactions between reservoir rocks, well cements, formation fluids and hydrogen



$$CO_3^{2-} + 2H^+ = CO_2 + H_2O$$

$$FeS_2 + H_2 = FeS + H_2S$$

$$2Fe_3O_4 + H_2 = 3Fe + 4H_2O$$

Microbiology experiments and methods

Formation fluids were collected from the Long Clawson field

Microorganisms have the potential to:

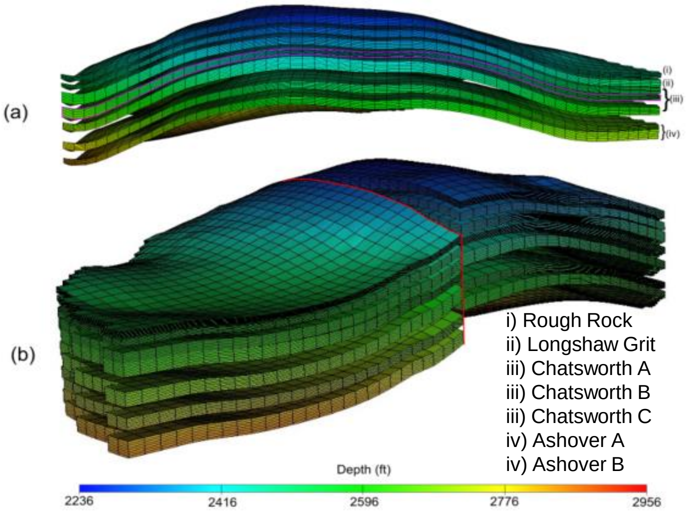
- Consume hydrogen
- Produce methane and hydrogen sulphide
- Precipitate minerals or produce biomass that could block flow paths
- Cause corrosion of metal infrastructure

Results

- Images show runs of DNA after PCR of **bacteria, archaea, sulphate reducers and methanogens**.
- Communities were found in both fields. Long Clawson sees presence of all types, including **sulphur reducers and methanogens.**
- This only shows likely presence. Need to know absolute numbers, growth rate and interaction with potential hydrogen…

Reservoir modelling of Long Clawson

The Long Clawson Field



Software: Eclipse (Schlumberger)

Reservoir Layer Selection Study

Reservoir	Pressure (2025) (bar)	Pore Volume (m^3)	Oil Pore volume (m^3) (2025)	Average Porosity	Average Permeability (mD)	Water Production (million liters)	Oil in Place : Oil Prod	Perforating wells
Rough Rock	26.7	5.6×10^6	716,653	0.18	42.2	2.0	0.101	6
Longshaw Grit	34.8	5.5×10^6	566,529	0.18	1.5	0.2	0.000	3
Chatsworth A	27.0	9.8×10^6	1,165,719	0.17	33	49.8	0.097	6
Chatsworth B	27.8	1.1×10^7	294,300	0.21	84.4	13.5	0.212	2
Chatsworth C	31.8	5.5×10^6	41,187	0.16	4.3	0.0	0.000	0
Ashworth A	64.9	8.2×10^6	709,489	0.21	7.2	9.1	0.000	2
Ashworth B	73.5	6.5×10^6	2,997	0.15	0.6	1.1	0.000	1

Suitability for H_2 storage
Poor
Medium
Good

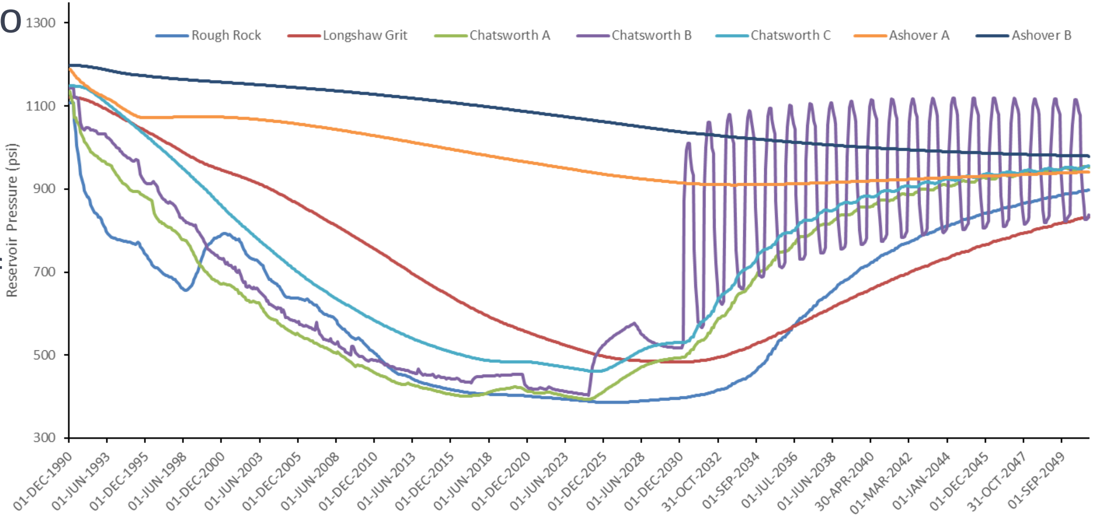
Chatsworth B has the most suitable reservoir characteristics for H_2 storage

Hydrogen capacity estimation summary

- GWh's of storage is possible within Chatsworth B.
- Connectivity between layers due to fault – more cushion gas is therefore required with larger working gas volumes.
- Maximum working gas capacity of up to 10 GWh over the long term (20 years).

Capacity estimation for Simulation 1a

	1st Cycle	10th Cycle	20th Cycle
CG Injection (GWh)	2.0	27.8	43.9
WG injection (GWh)	6.3	12.2	10.7
WG production (GWh)	4.0	10.1	9.3



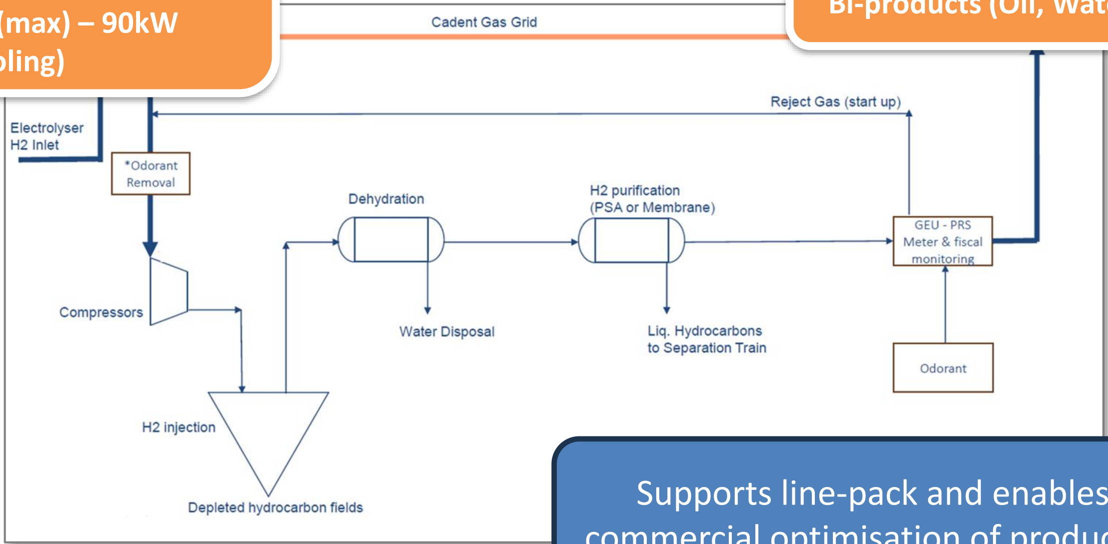
Topside facility - What do H2 storage facilities look like?

The current Long Clawson A Site

An existing H2 storage pilot plant in Austria

Basis of design

Injection Rate – 10,000 scm/h
Injection pressure (grid) >50 barg
Reservoir pressure (max) – 86barg
Compressor power (max) – 90kW
(+30kW cooling)



Production Rate (H2) – 5,000 scm/h
Bi-products (Oil, Water, traces) < 200bbl/d

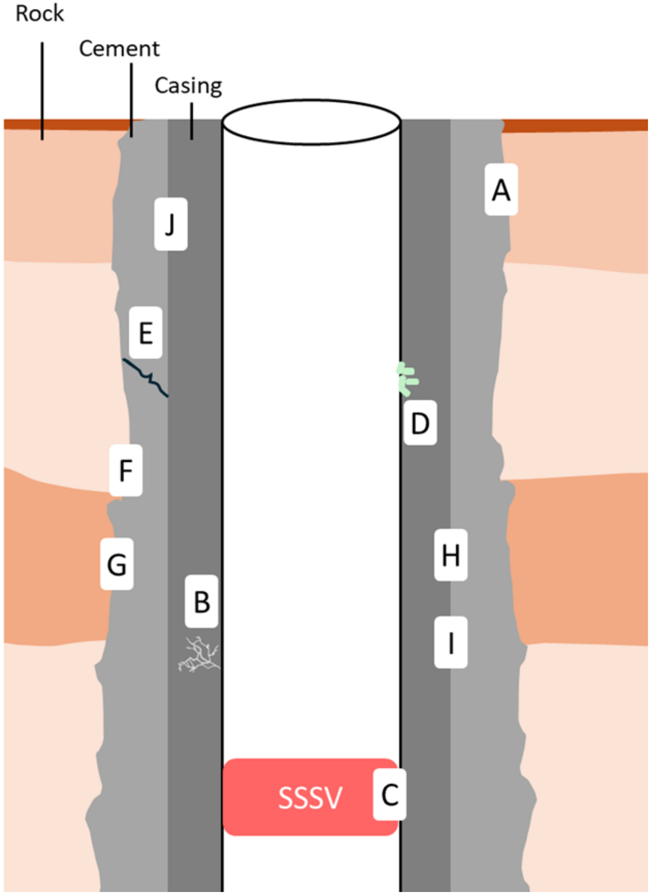
Supports line-pack and enables commercial optimisation of producers

Well Integrity and Hydrogen Readiness

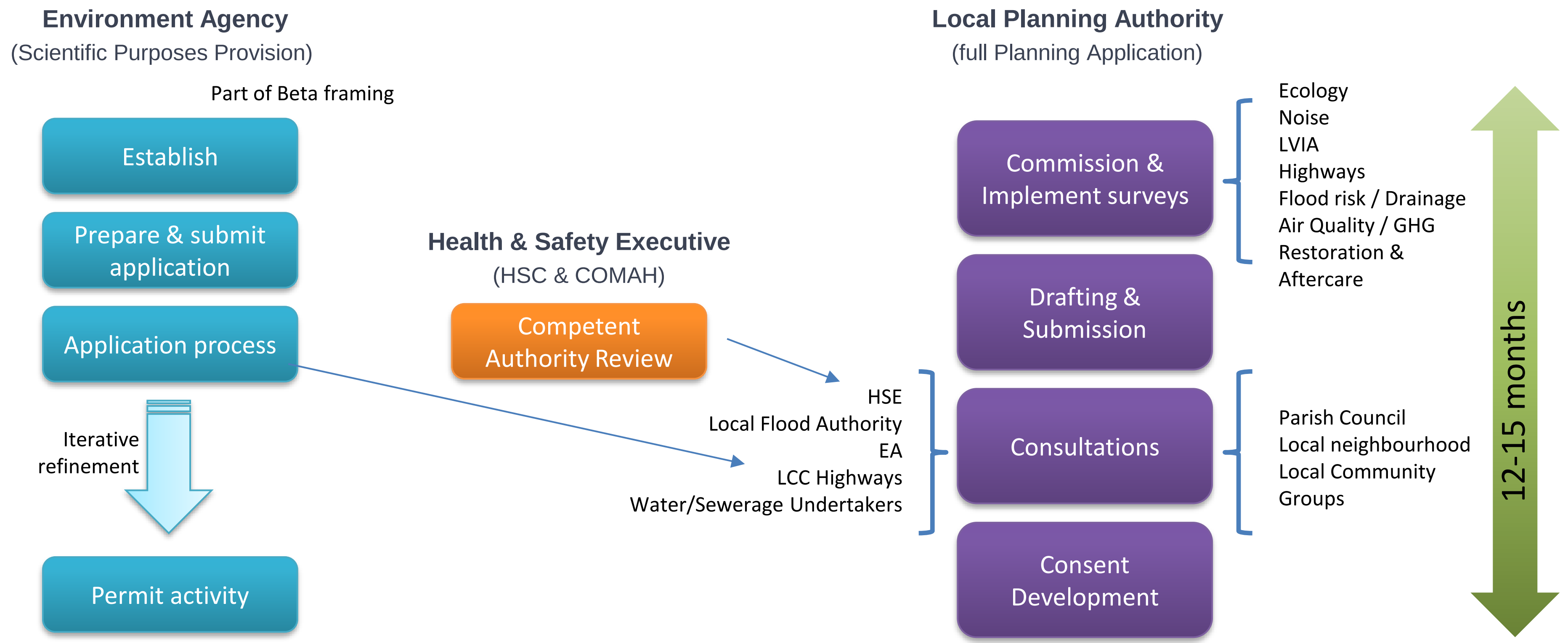
To evaluate the suitability of repurposing the existing wells for use in a hydrogen storage facility

1) Assess the risk of geochemical reactions
2) Assess well integrity
   (since construction and through well life)
3) Evaluate the readiness for repurposing

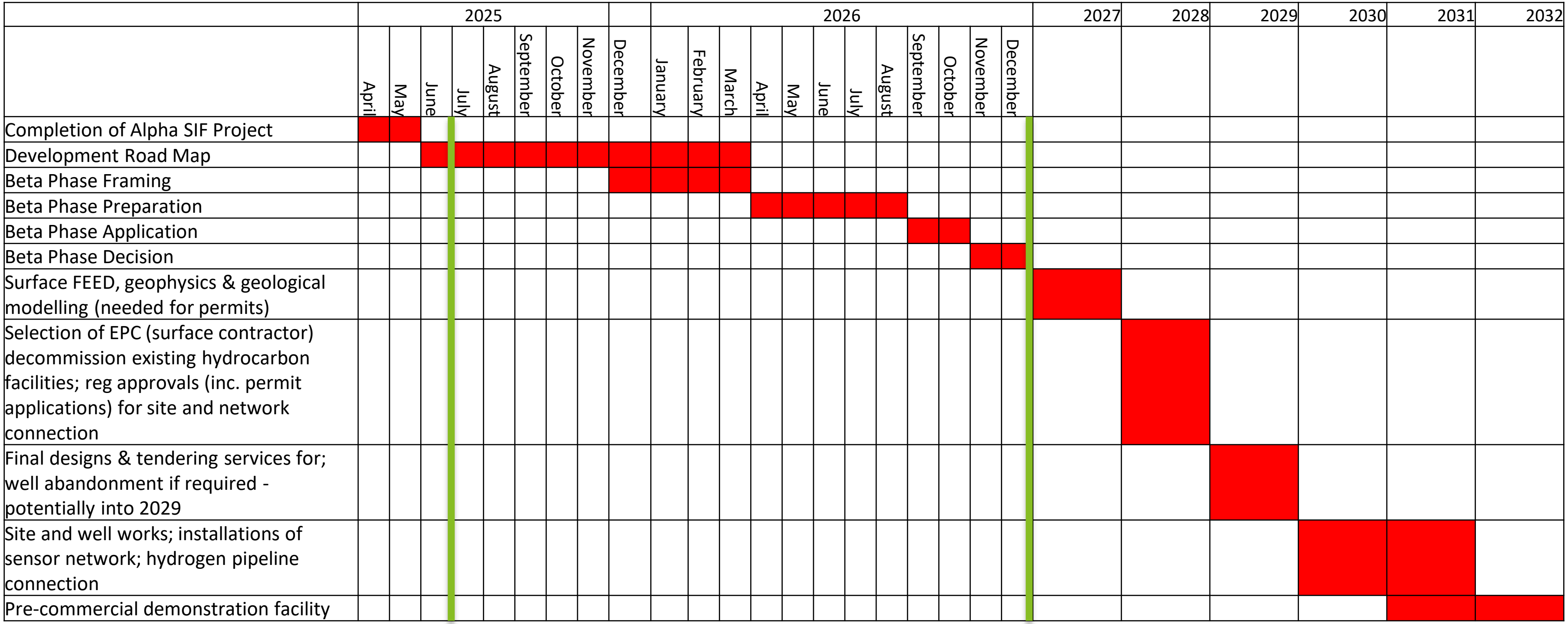
Hydrogen behaves differently from Oil or Gas



Regulatory and Permitting Route for a pilot



Provisional Roadmap moving forward to a demonstration



Opening of the Hydrogen Transport Business Model

Hydrogen Storage Business Model Contracts allocated

Tim Armitage
timarm@bgs.ac.uk

Thank you

Supported by