



SNC • LAVALIN

ATKINS

Member of the SNC-Lavalin Group

Utilising public data for
identifying offshore salt strata
and developing salt caverns for
storing hydrogen

Dr. Georgios Yfantis

Acknowledgments

Part of this work was extracted from the **soon to be published** study:

“Assessing the potential of developing offshore salt caverns for hydrogen storage, UK Continental Shelf”

@ the GSL Special Publication "Enabling secure subsurface storage in future energy systems"

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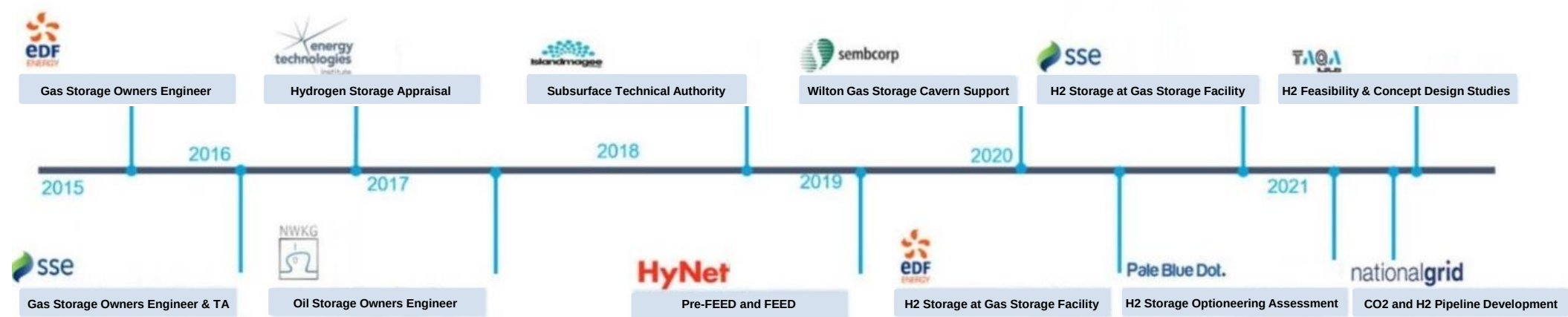
(and myself)



Hydrogen Storage and Atkins

A Net Zero marriage

Atkins Selected Experience



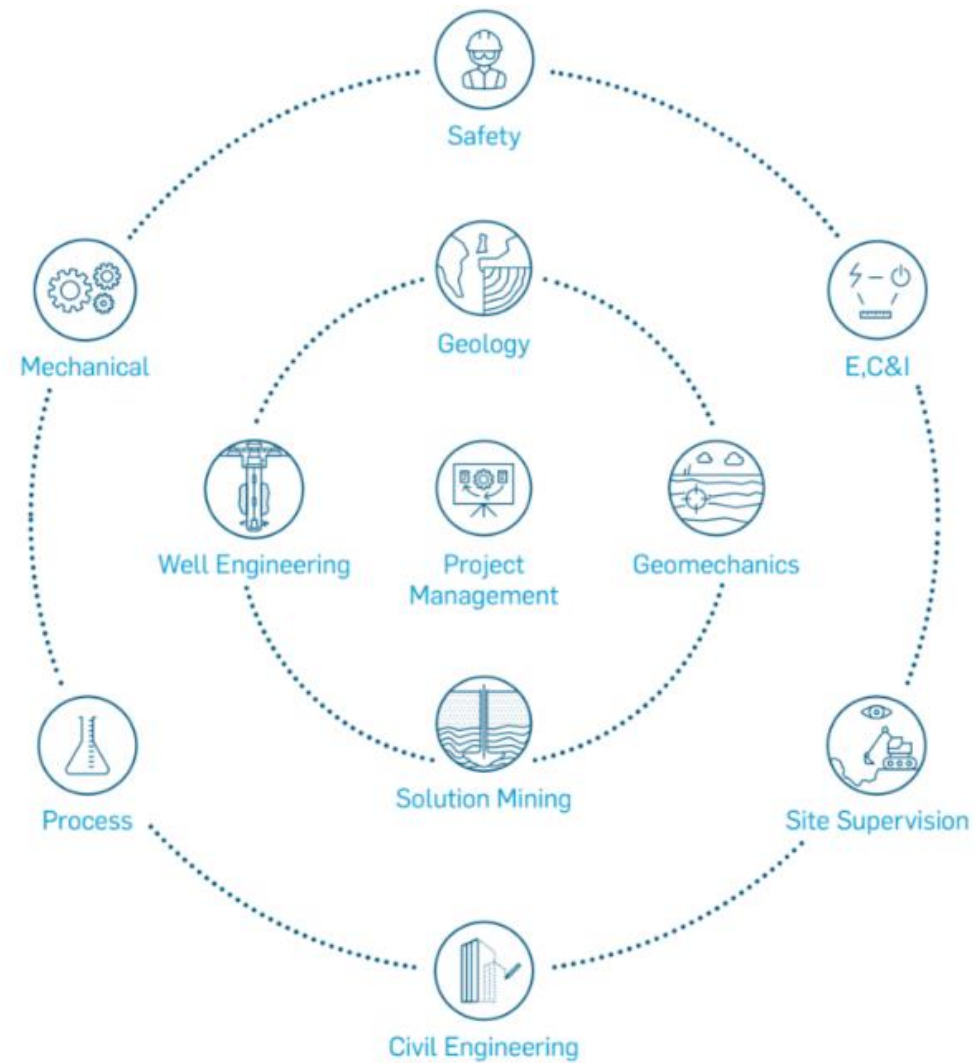
2021 / 2022  &  Feasibility and Pre-FEED top-to bottom study of a new Hydrogen Storage salt cavern storage site.



Atkins – What we do

The dedicated underground energy storage team can be considered as a:

“One stop shop”



Why Hydrogen? And why hydrogen storage?

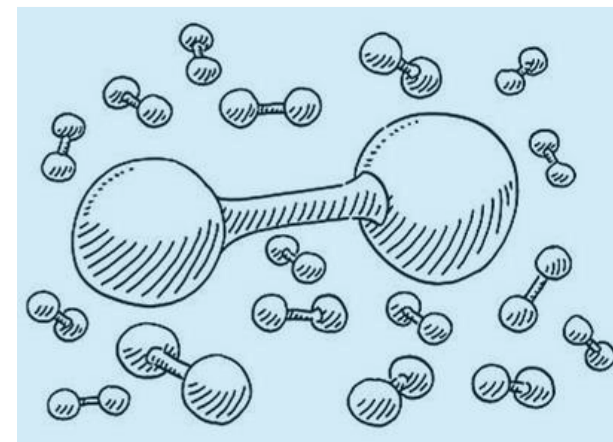
Why Hydrogen?

Hydrogen could provide a decarbonisation vector for many sectors.

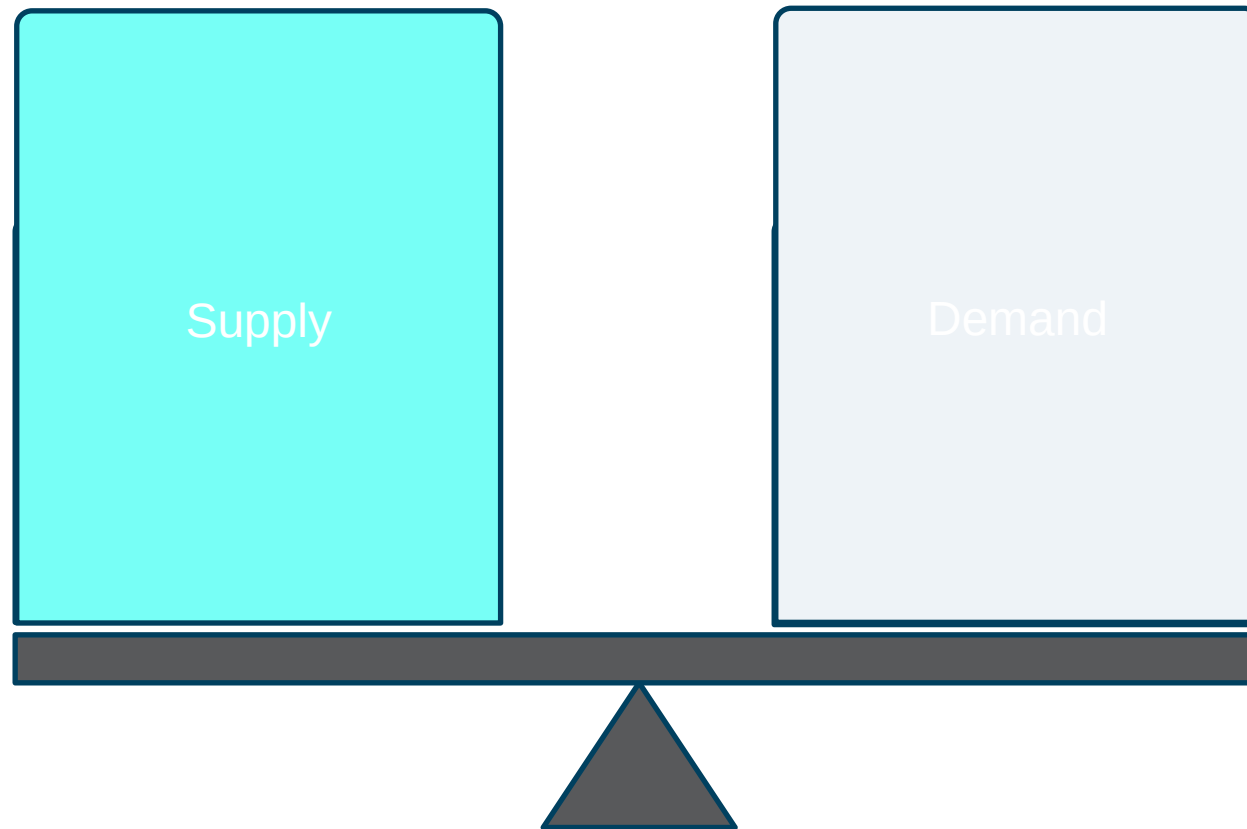
Assumption is Hydrogen produced using Electrolysis from excess electrical generation (supply > demand)

Renewables have load factors between 25-50%.

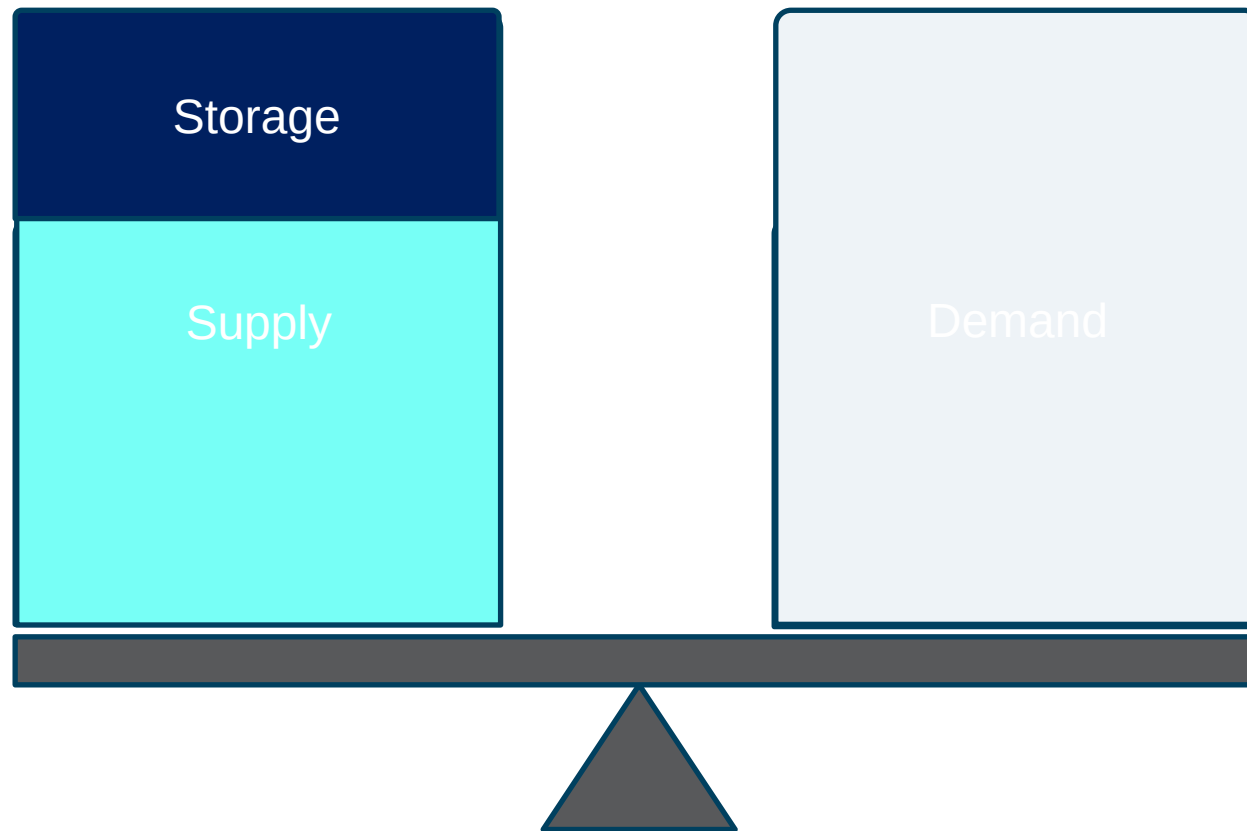
Hydrogen is envisioned to offset renewable energy generation.



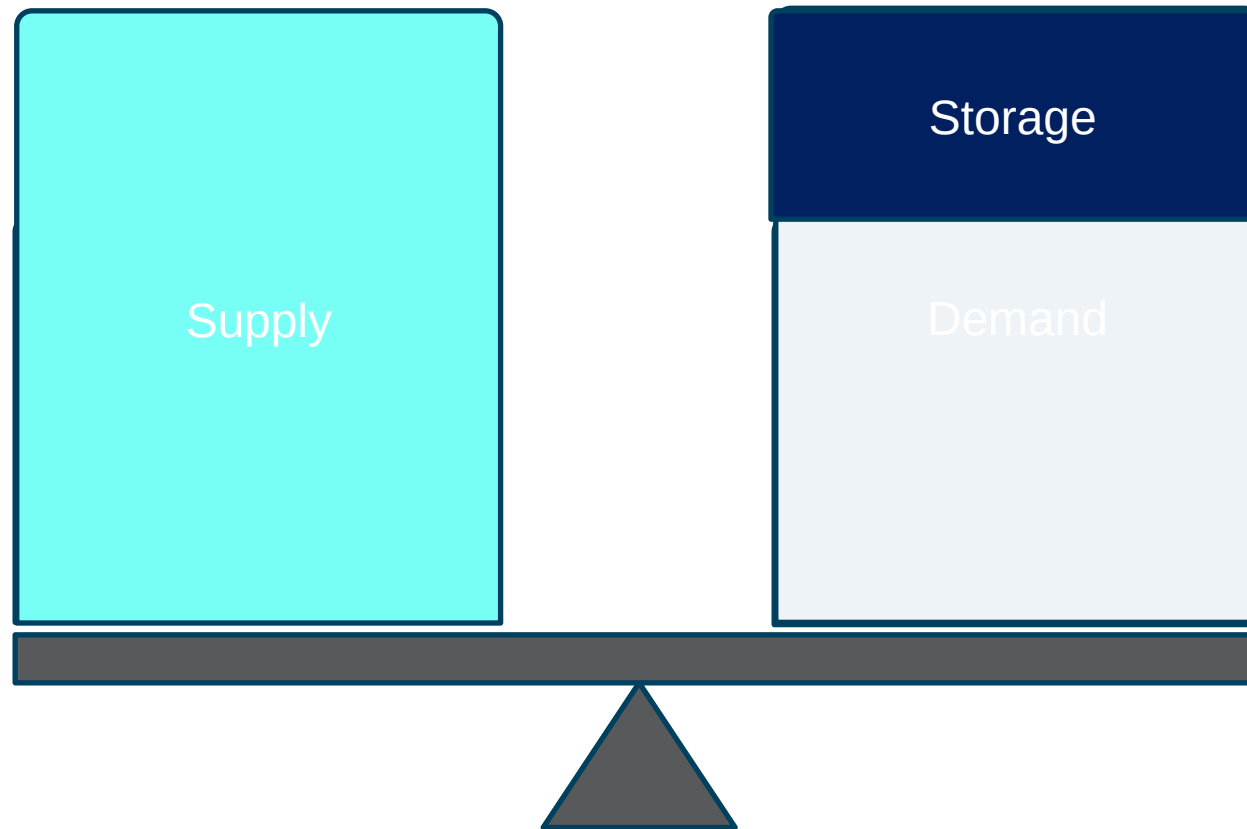
Why Hydrogen Storage?



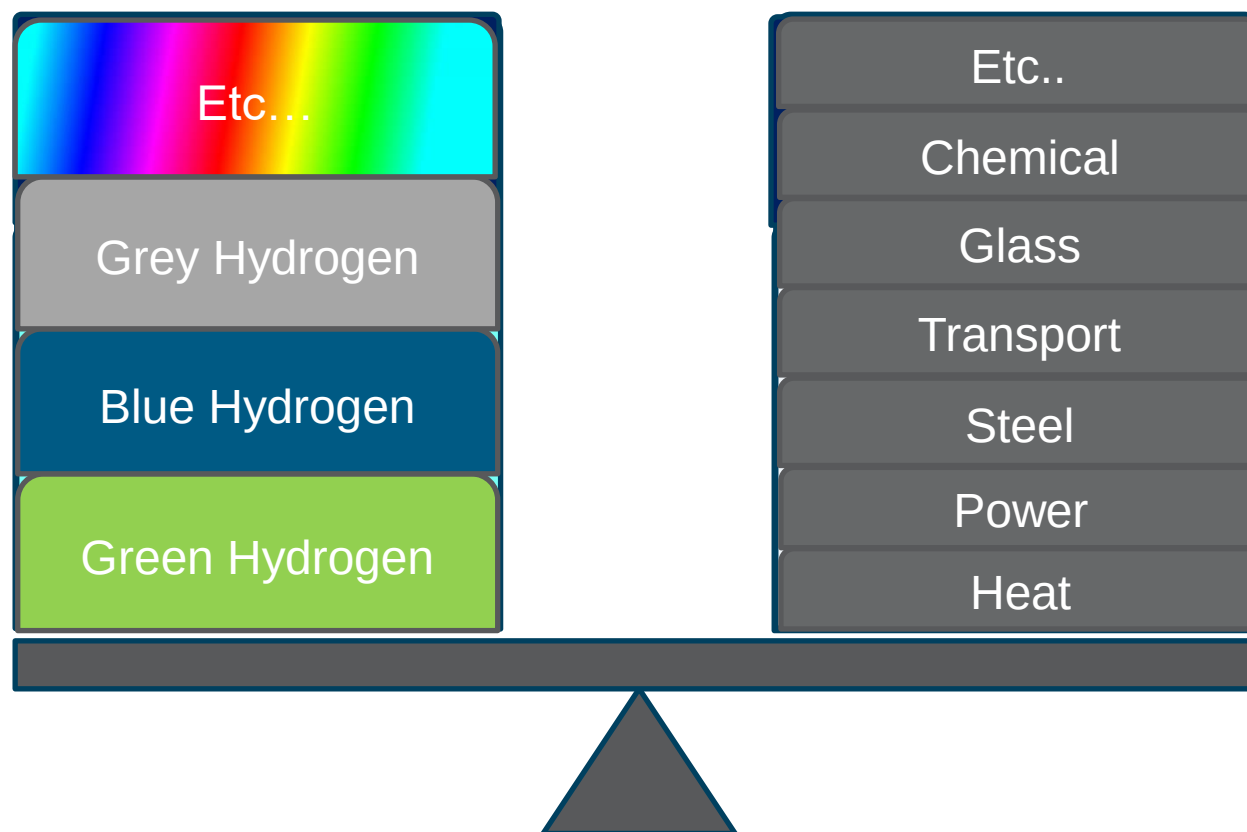
Why Hydrogen Storage?



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Why Hydrogen Storage?

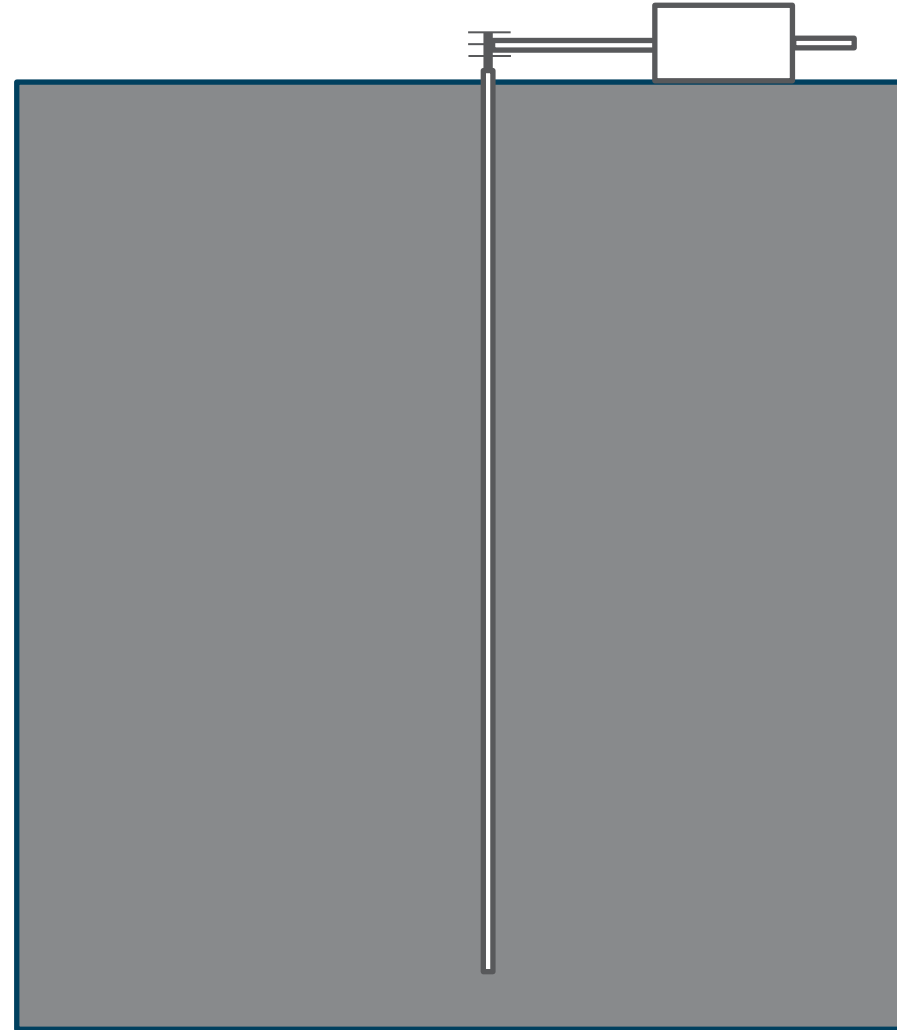


Why Salt Caverns? Why not something else?

What are Salt Caverns?

They are an engineered underground space that is characterised by high tightness.

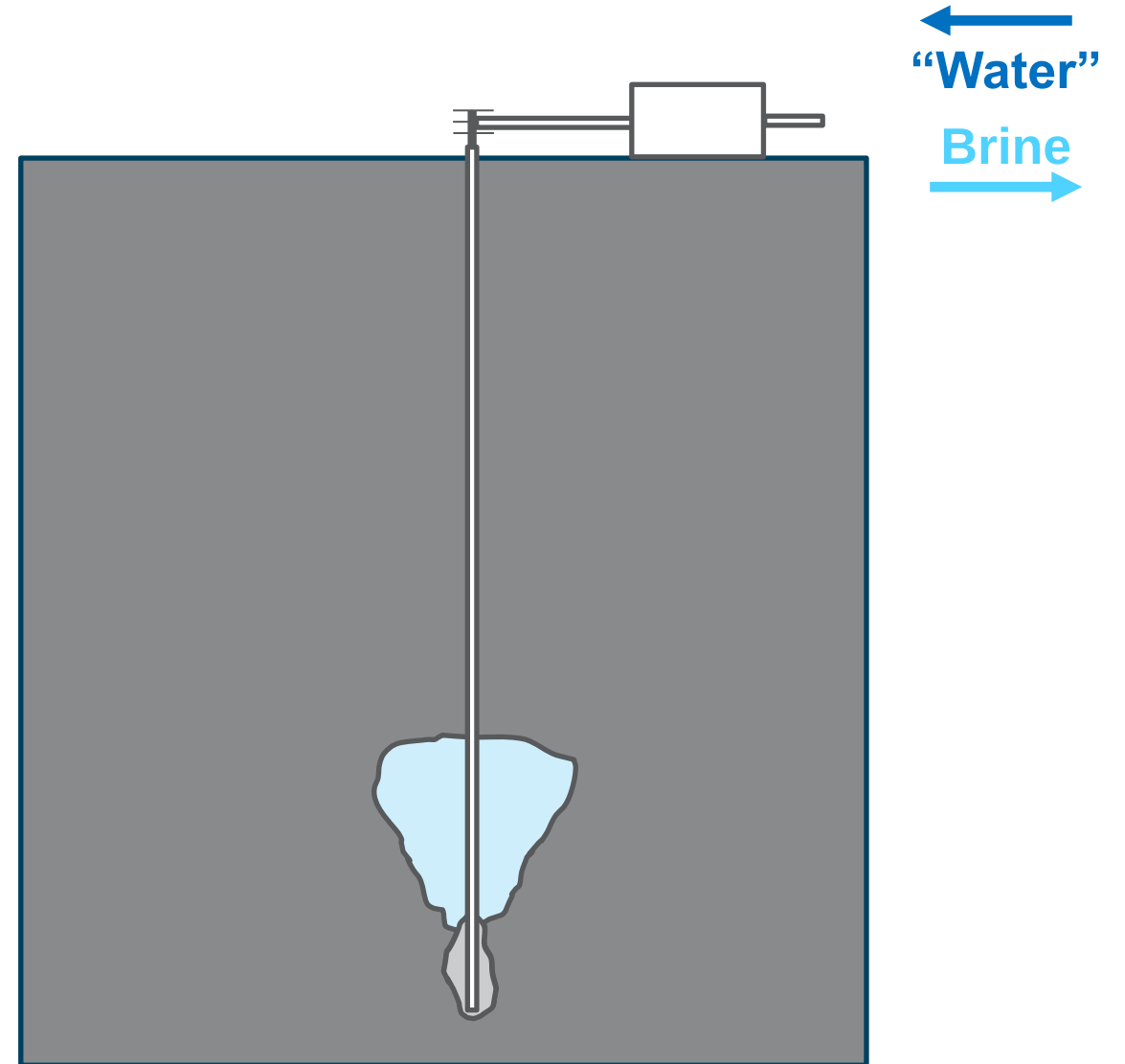
- › Drill a well
- › Install a wellhead
- › Surface plant in place
- › Start leaching
- › De-brine / First H₂ fill
- › Cavern commercial operations



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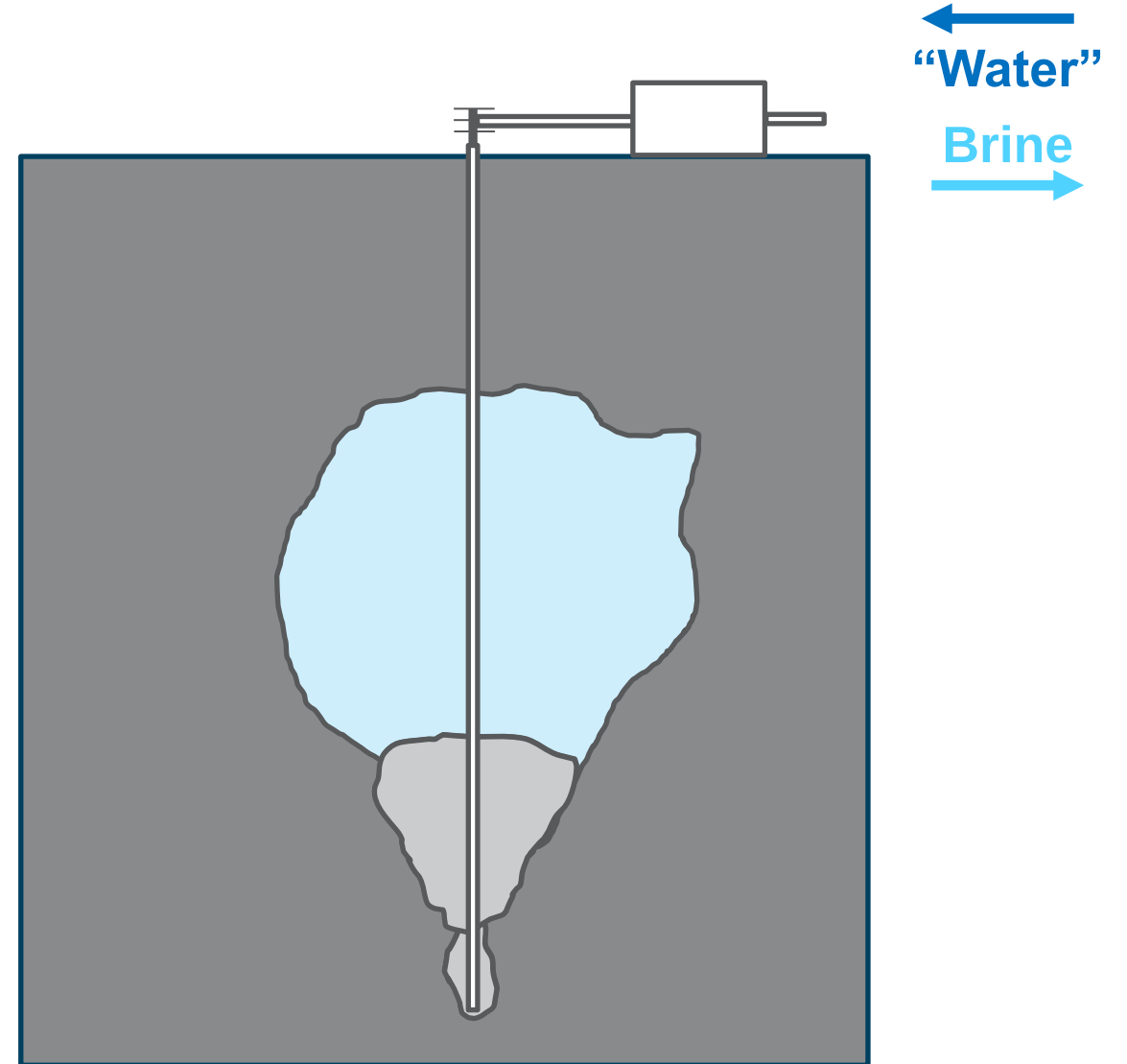
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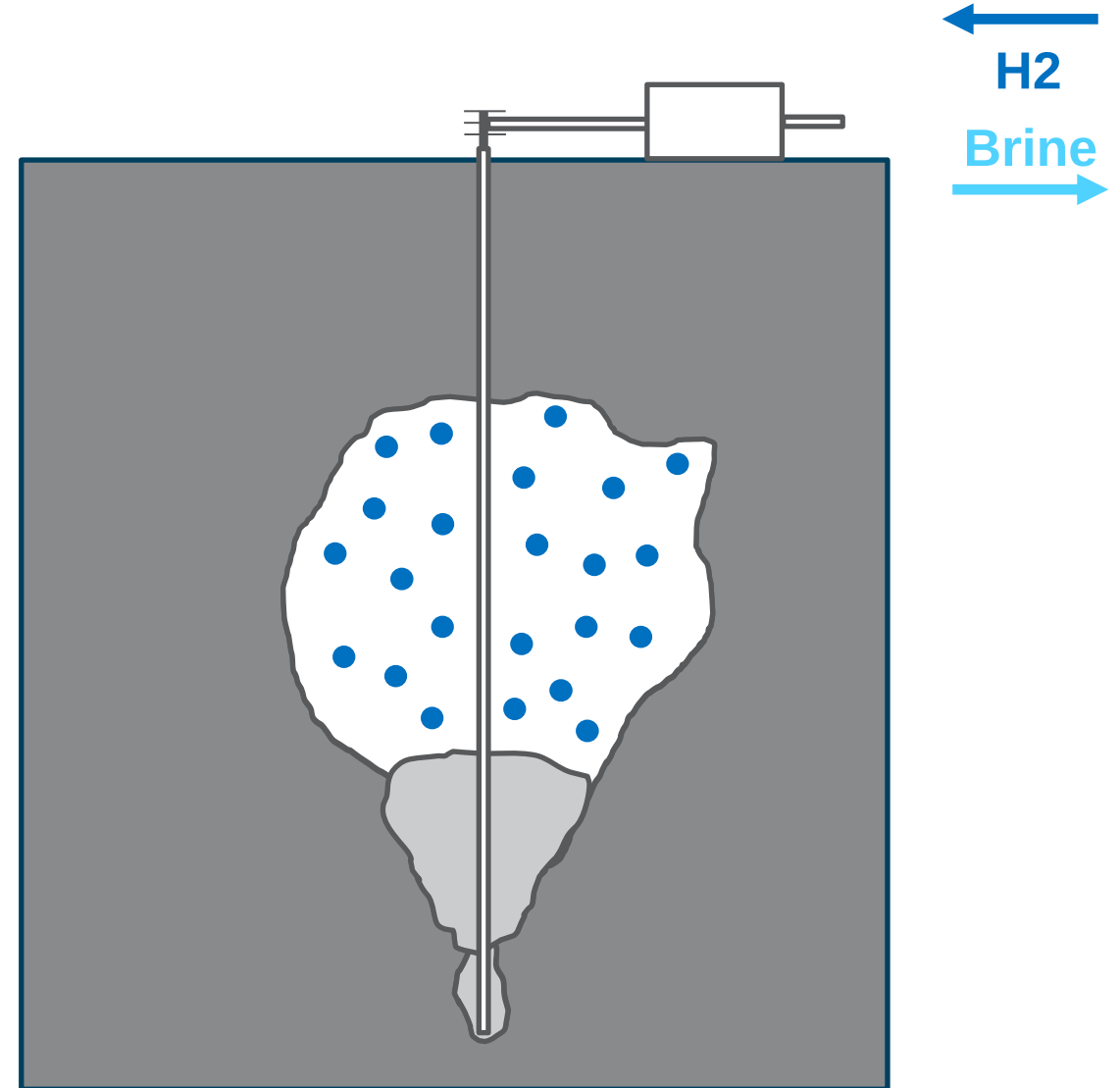
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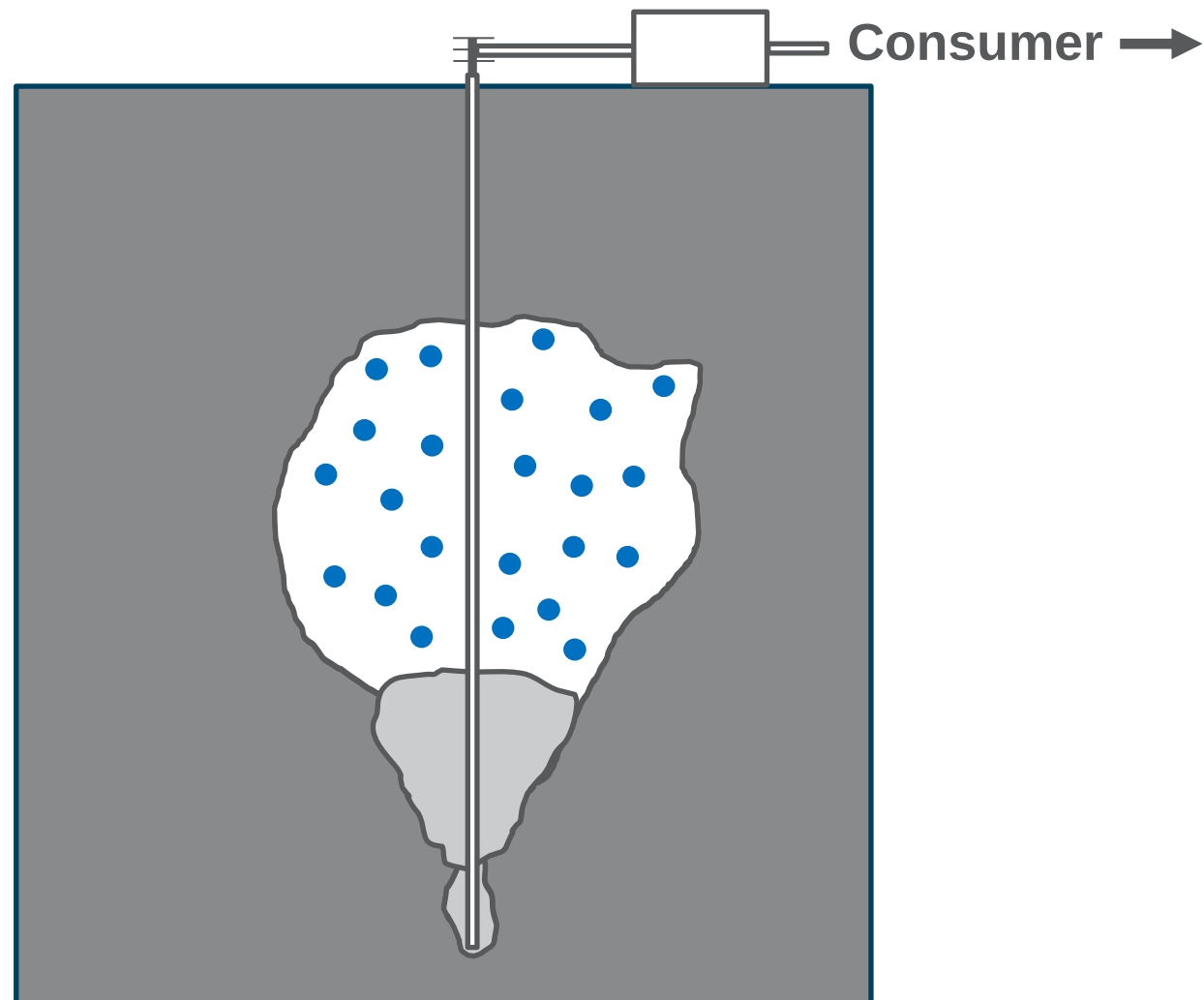
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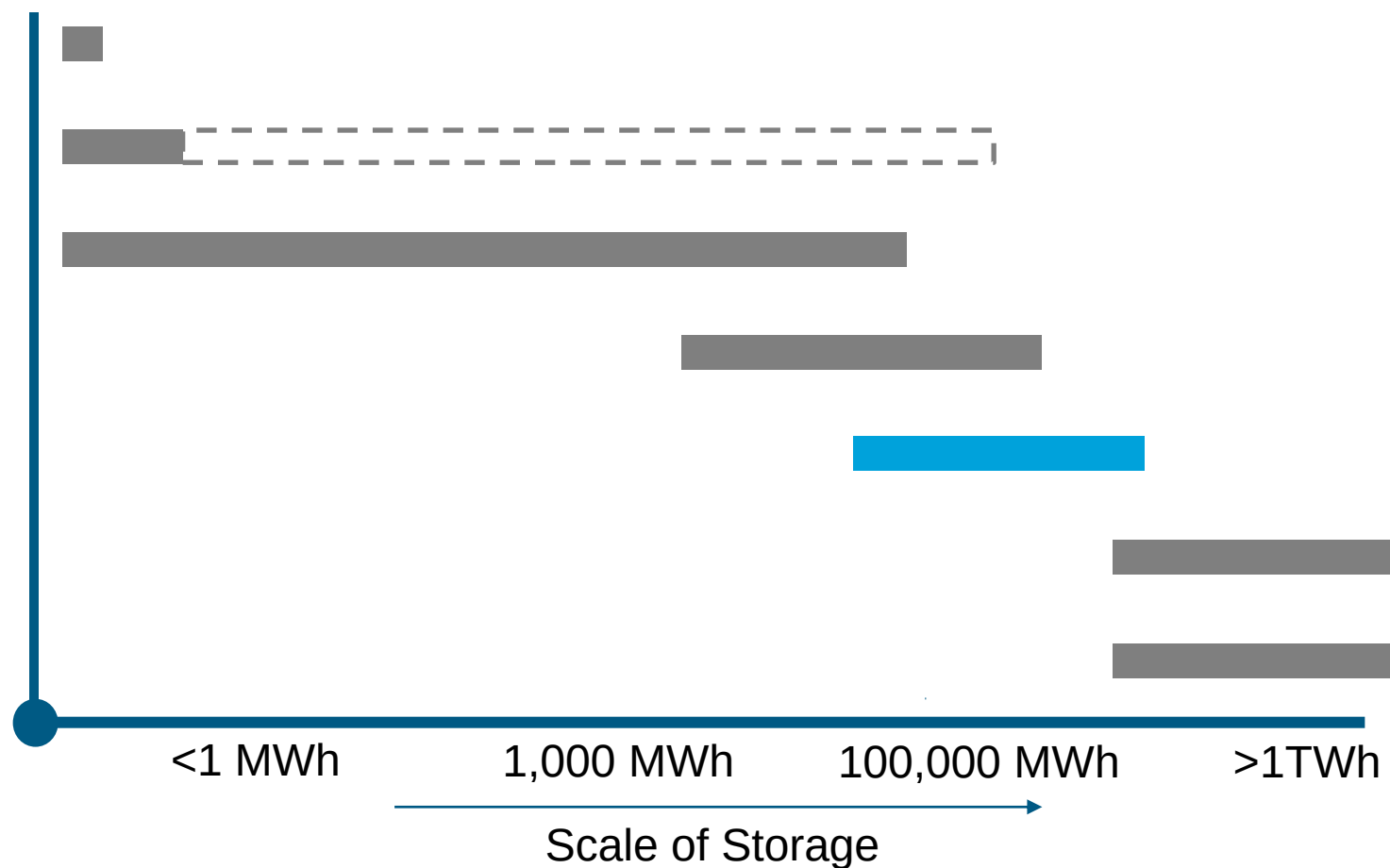
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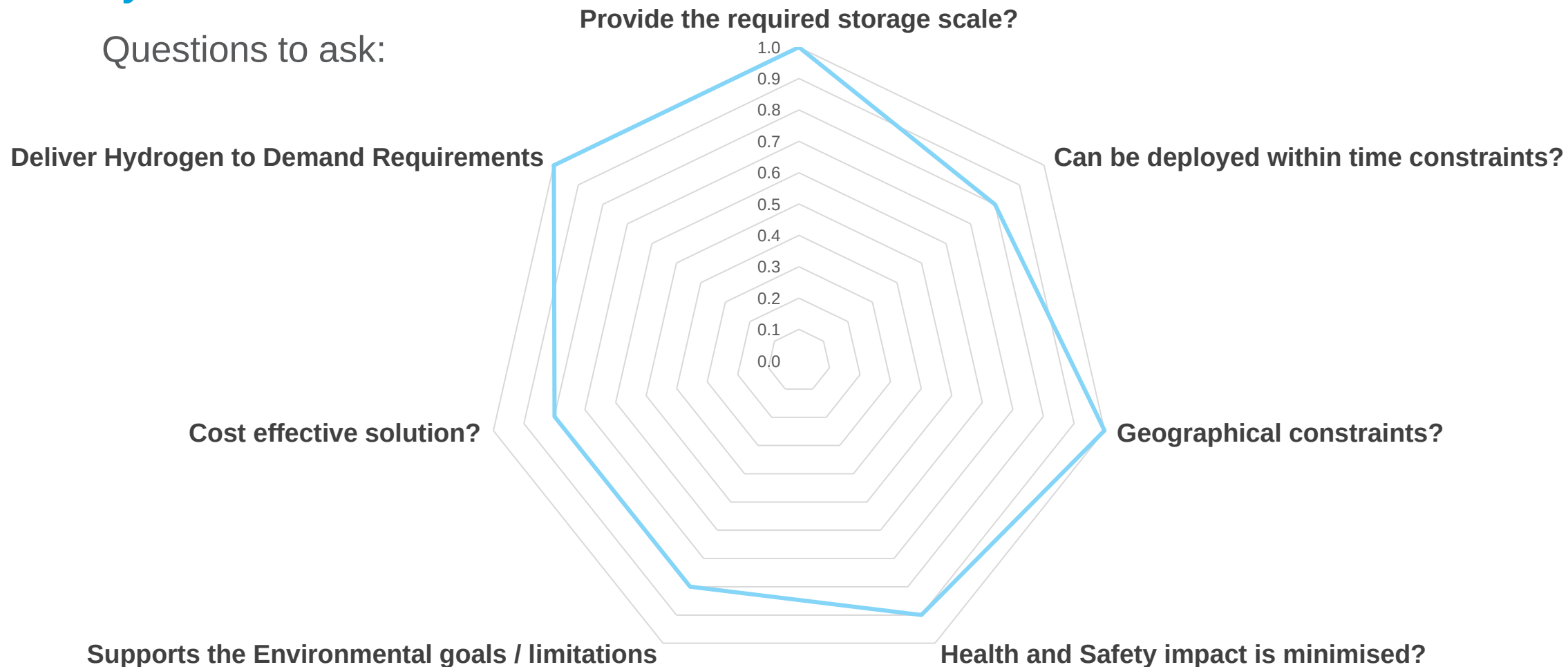
Why Salt Caverns?

1. Solid State
2. Pipelines
3. Vessels
4. Liquid Carriers
5. Salt Caverns
6. Reservoirs
7. Aquifers



Why Salt Caverns?

Questions to ask:



Why Salt Caverns?

In summary salt caverns have:

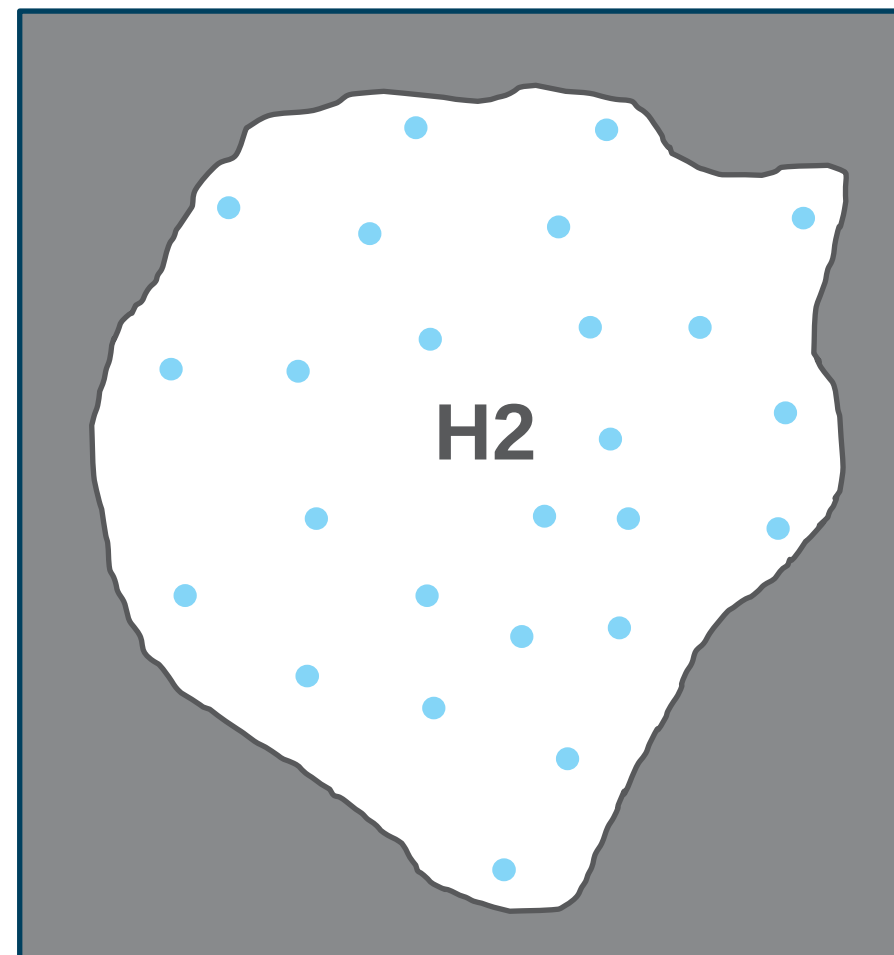
- › a high H₂ sealing potential,
- › large injection/withdrawal flow rates, and
- › a capacity for storing large H₂ volumes.

Bonus: the potential to endure fast cyclic loading.

Existing examples: Teesside, UK

Moss Bluff dome, USA

Clements dome, USA



Offshore salt caverns

Offshore Salt Cavern Projects

The “Gateway” Gas Storage Facility, East Irish Sea, UK

Approval in 2008. A total of 20 offshore caverns envisioned.

Did not mature for commercial reasons.

Larne Lough, Northern Ireland

Wellheads positioned onshore.

7 Caverns leached offshore using directional drilling (up to 500 million m³).

dCarbonX & ESB, announcement (26/05/2021)

Investigating whether H₂ offshore salt caverns can be developed at the Poolbeg peninsula (Dublin).

Tractebel et al., announcement (17/12/2021)

World’s 1st offshore H₂ storage concept in offshore caverns. Up to 1.2 million m³ of H₂.

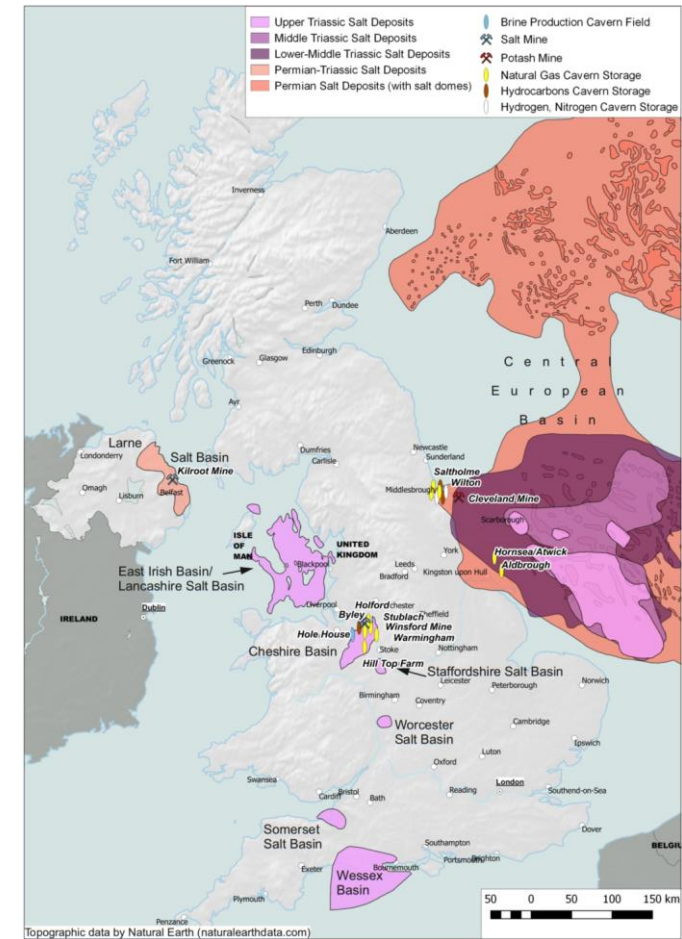


Offshore Salt Cavern Projects

Why all this interest?

Because there is salt out there.

And because the hydrogen economy demands a place to store its valued commodity.



Horváth P. et al., (2018). Update of SMRI's Compilation of Worldwide Salt Deposits and Salt Cavern Fields, SMRI

Utilising Public Data

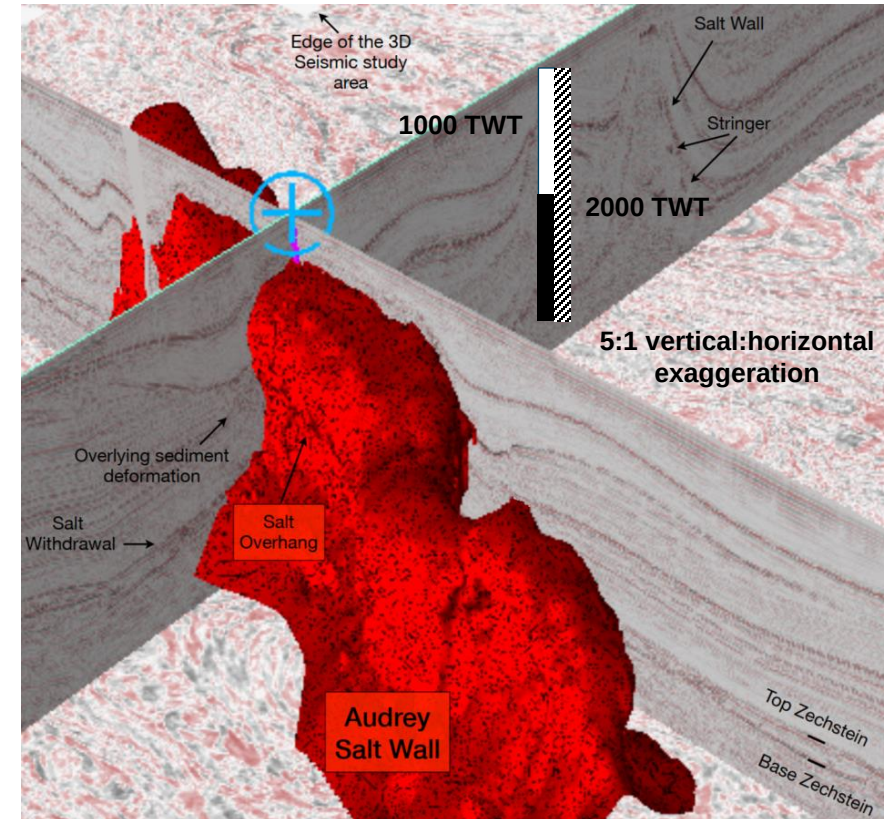
Existing geological maps

Seismic lines / images

Borehole data

Probably collected for the needs of the oil & gas industry

Salt could be bedded or domal.



Offshore site selection

Site Selection Methodology

Geological & Geophysical Investigation



Geomechanical Investigation



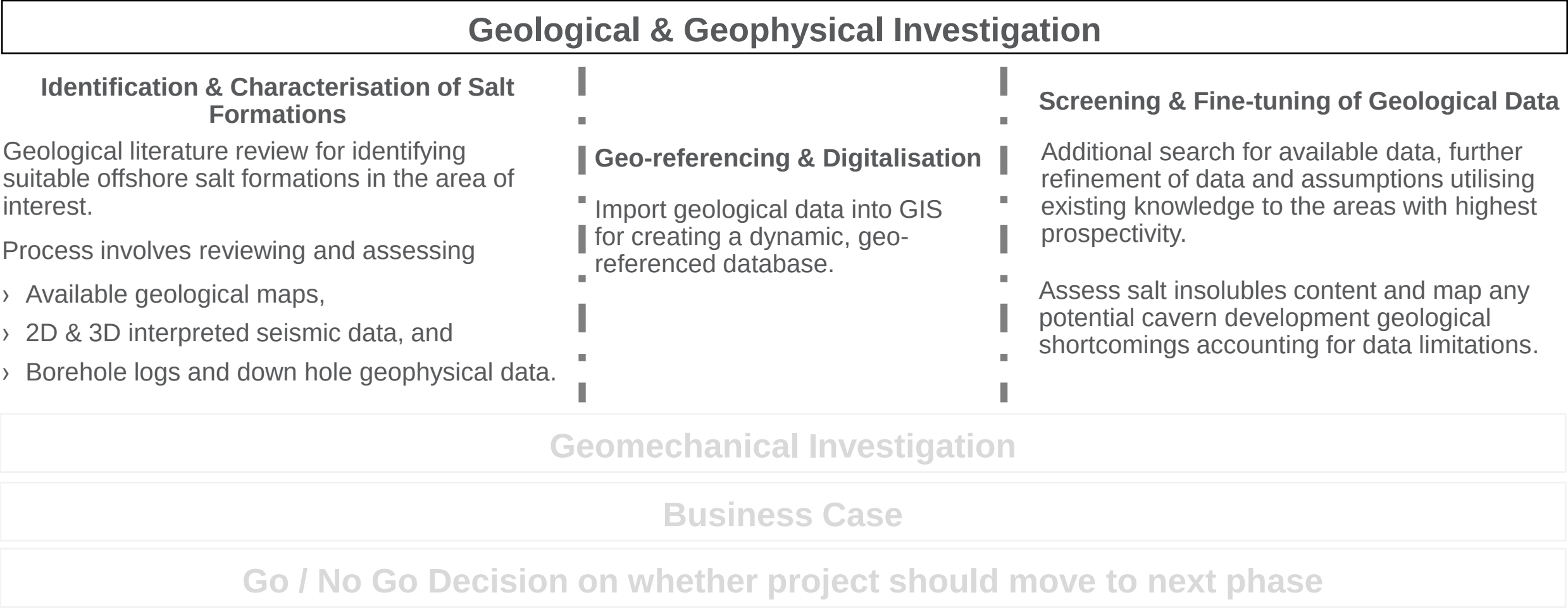
Business Case



Go / No Go Decision on whether project should move to next phase



Site Selection Methodology



Site Selection Methodology

Geological & Geophysical Investigation

Geomechanical Investigation

Suitability Assessment of Salt Deposits

Gap analysis regarding information and risk identification/mitigation.

Selection of potential underground salt cavern storage site location based on the derived geological model.

Cavern Placement

- Determination of cavern placement and numbers based upon:
 - › the derived geological model, and
 - › geomechanical rule of thumbs
- accounting for the limitations of utilized data

Geomechanical Assessment

- › Cavern shape & volume
- › Height and maximum diameter of cavern
- › Geometrical configuration of LCCS from top of salt and cavern roof
- › Cavern distance from adjacent caverns & perturbing geological features
- › Cavern operating pressures & flow rate limits

Business Case

Go / No Go Decision on whether project should move to next phase



Site Selection Methodology

Geological & Geophysical Investigation

Geomechanical Investigation

Business Case

Storage Capacity Estimation

Storage potential derived from thermostatic calculations. Calculation of required cushion gas quantities.

Conversion of storage capacity into available stored energy (MWh).

Utilisation of Existing & Future Infrastructure

- Identification of existing infrastructure that could be repurposed both too and from the storage facility, i.e. pipelines.

- Identification of onshore industrial clusters which are/will be involved in the H2 economy.

Financial / Risk Estimations

- Derive at a high level:

- › CAPEX

- › OPEX

- › Other relevant KPIs

- Conduct GAP and SWOT analysis, derive risk matrix.

Go / No Go Decision on whether project should move to next phase

i.e, site investigation, Pre-FEED design etc.



Site Specific Criteria

Parameter

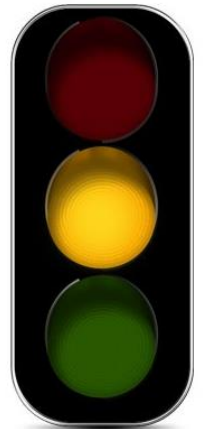
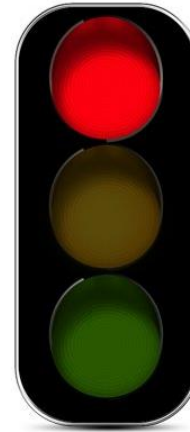
Criteria

Host salt formation

- › Depth [m] (from seabed)
- › Thickness [m]
- › Purity [%]
- › In situ stress state

Load bearing rock formation (hanging- and foot-wall)

- › Lithology
- › Thickness [m]
- › Structural features



Site Specific Criteria

Parameter

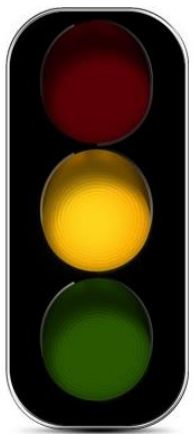
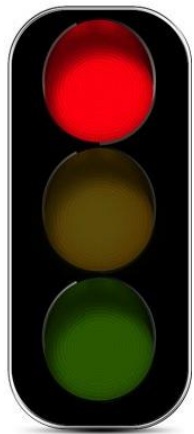
Criteria

Lithological
interlayers

- › Lithology
- › Thickness [m] (non-salt)
- › Thickness [m] (K-Mg salts)
- › Location
- › Number of interlayers

Industrial

- › Pipeline infrastructure [km]
- › Dist. from coastline [km]



Geomechanical analysis

Geomechanical Analysis

Cavern geometry?

Local Geology?

Proximity to other structures?

Roof to LCCS distance?

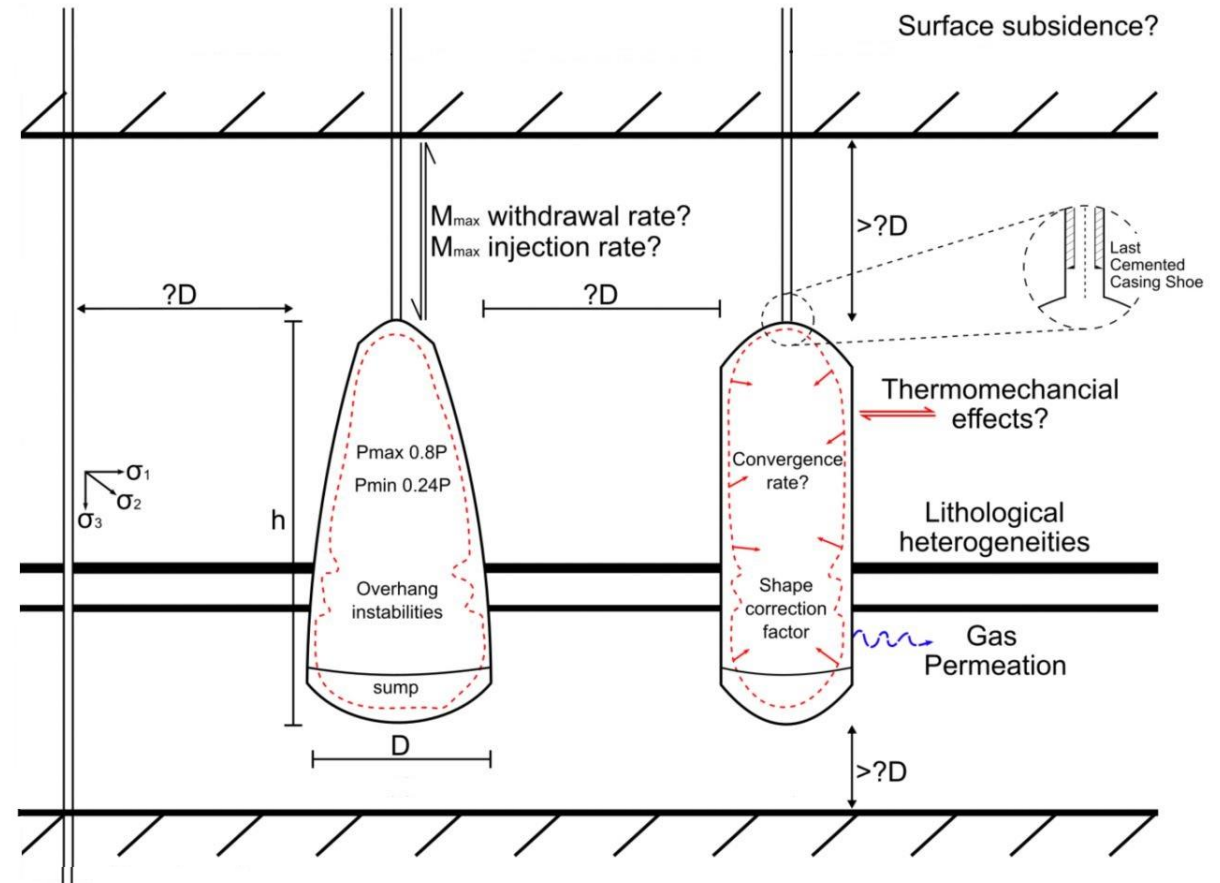
Roof to top of salt distance?

Sump to bottom of salt distance?

Cavern operations?

Convergence?

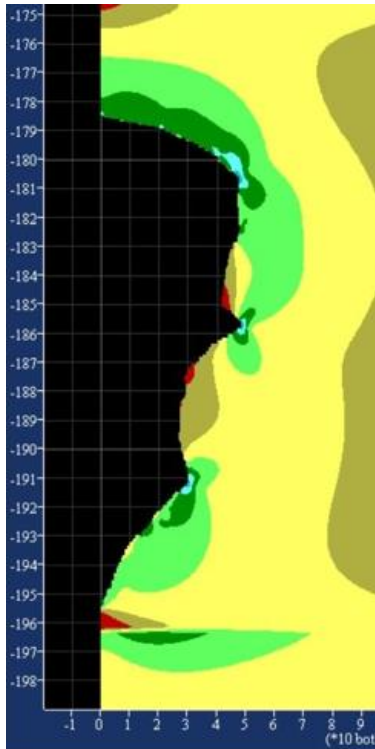
Surface subsidence?



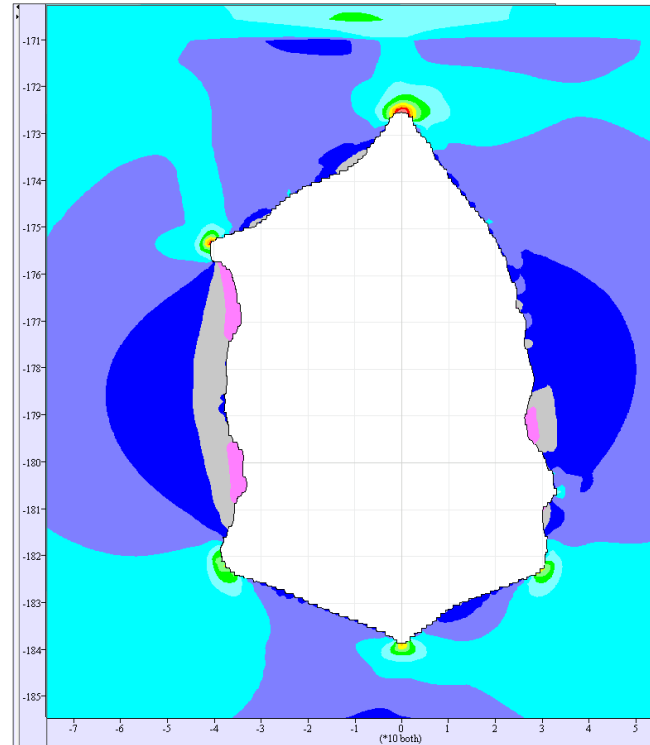
Geomechanical Analysis

Each has a role to play depending on the question and the available data

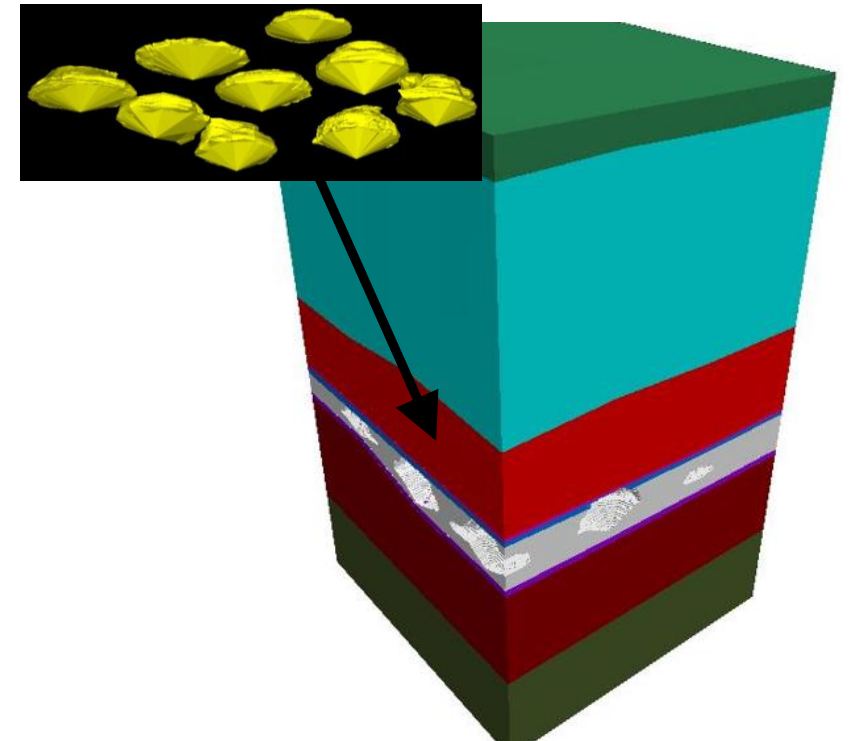
2D Axisymmetric



2D plain strain



3D



In a nutshell

In a nutshell

There is salt out there offshore. Data support it.

At cases, higher granularity would have been beneficial.

Recent project announcements indicate the presence of interest.

H2 storage caverns can be developed.

Let's make Net Zero a reality.



Thank you for your time & attention.



Questions?