

Aldbrough Hydrogen Storage

14 March 2022



VIDEO:

<https://vimeo.com/580721923/b11039e0c1>

(to be embedded)

About the project partners



SSE, headquartered in Perth, Scotland, is the leading generator of renewable electricity in the UK and Ireland, with over 10,000 employees.



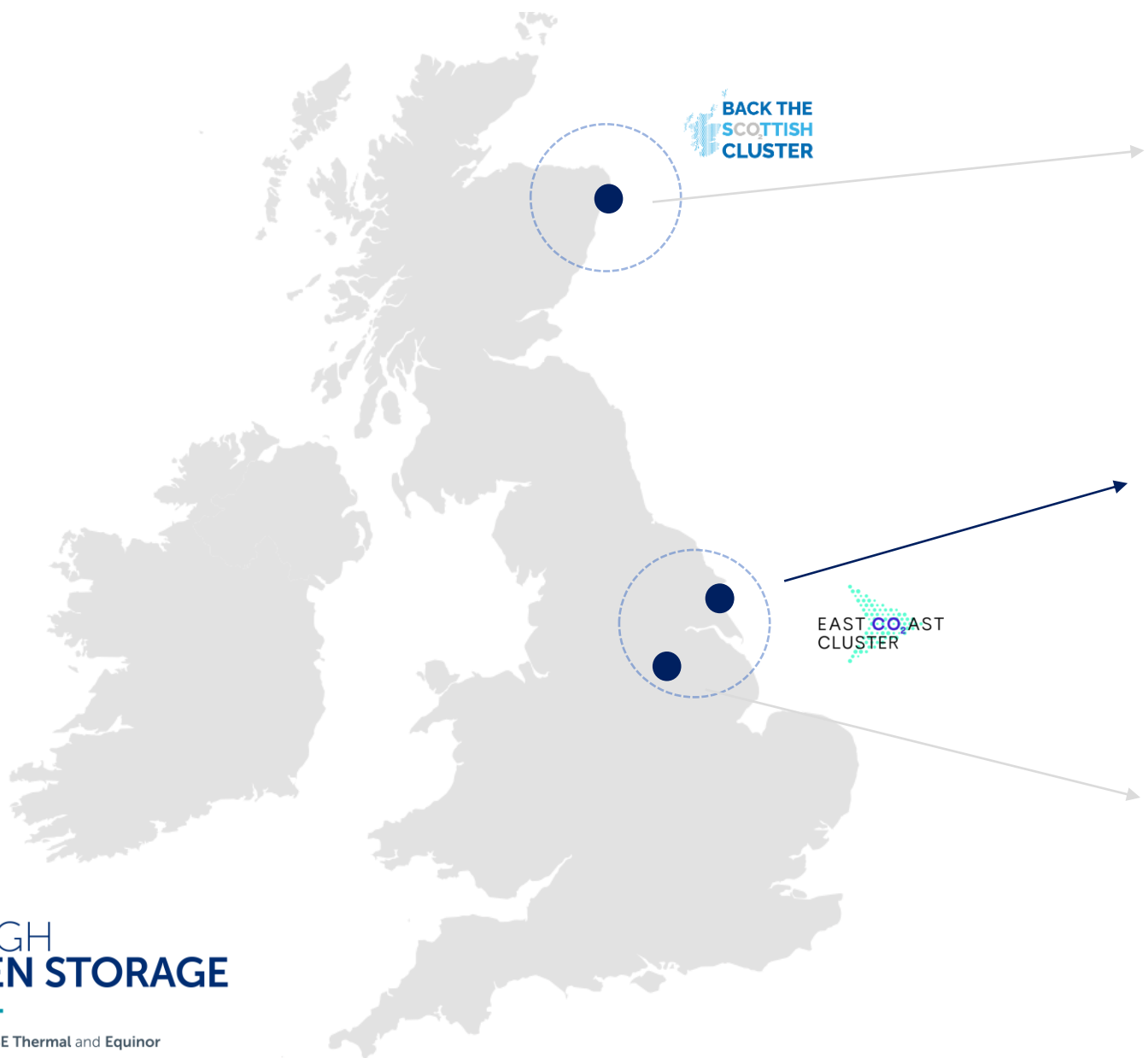
Equinor, headquartered in Stavanger, Norway, is an energy company present in more than 30 countries worldwide, with over 21,000 employees.

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HYDROGEN STORAGE

A collaboration between **SSE Thermal** and **Equinor**



Developing world-leading low-carbon projects



Peterhead Carbon Capture Power Station



Aldbrough Hydrogen Storage

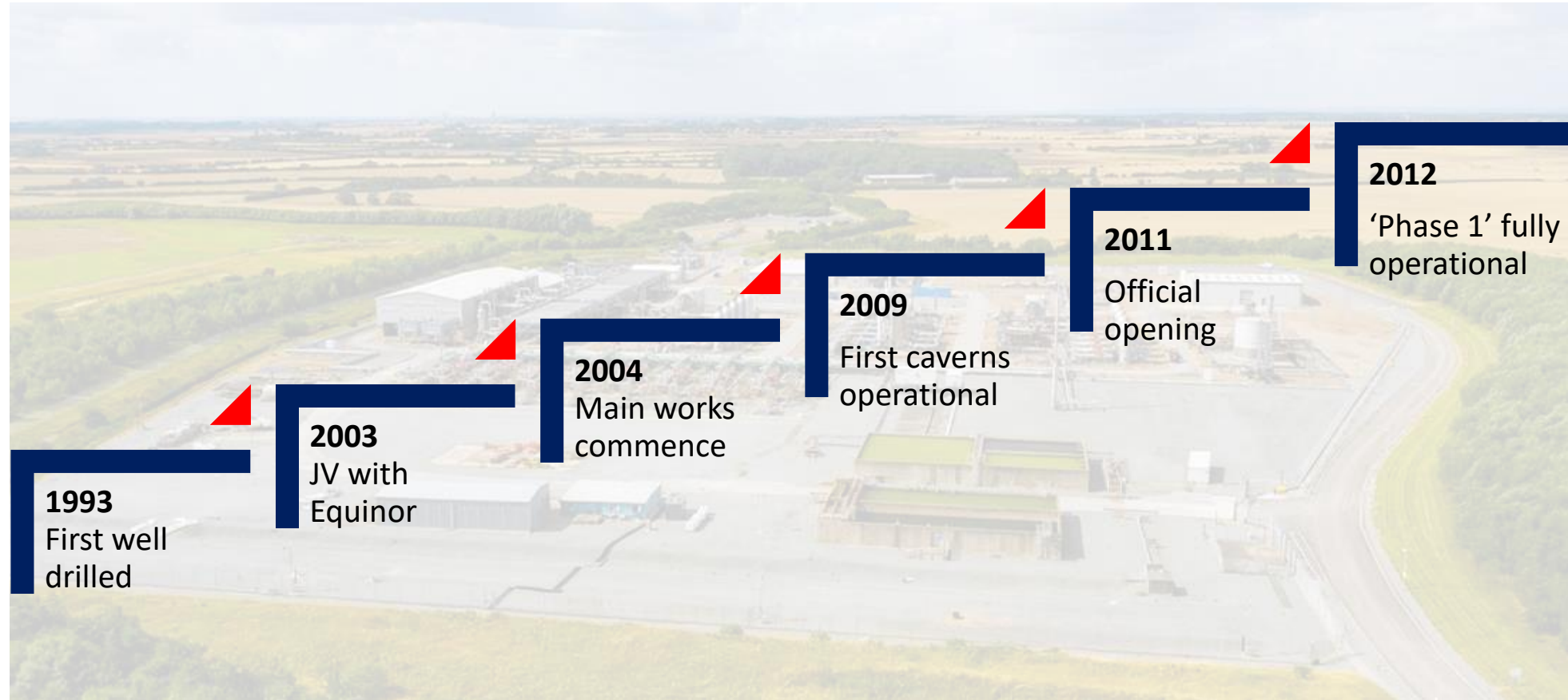


Keadby Carbon Capture and Hydrogen Power Stations

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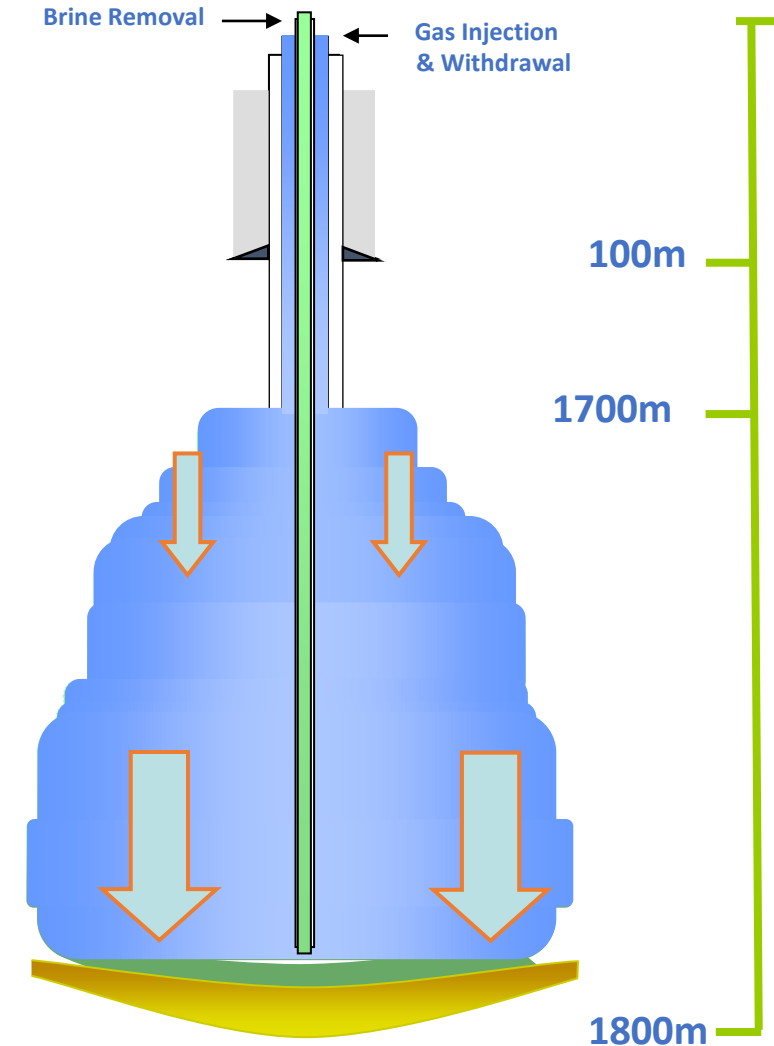
Aldbrough Gas Storage - Timeline



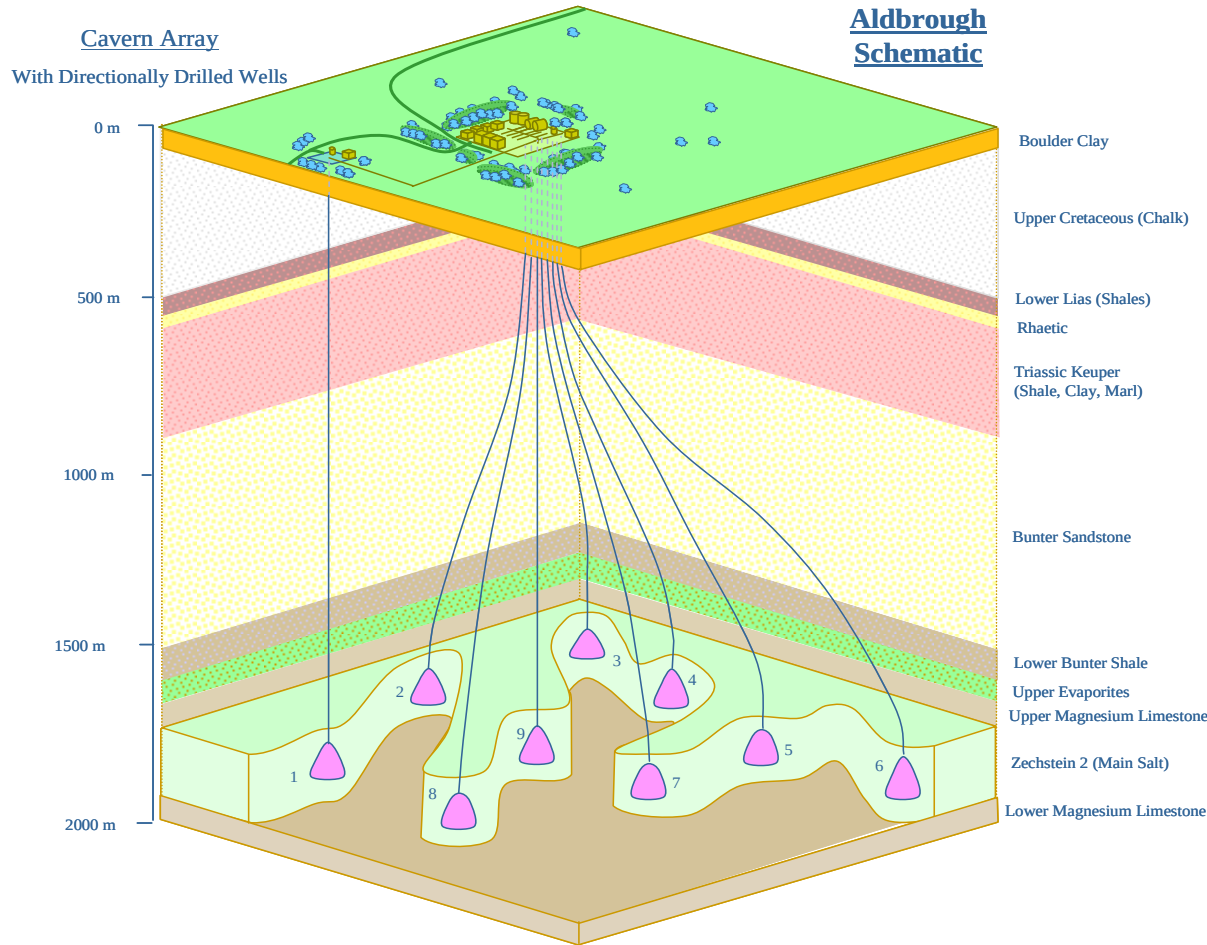
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How a cavern is created

- Seawater is pumped into the well, dissolving the salt and creating a brine solution
- A blanket of nitrogen being progressively raised helps to create the cavern shape
- The brine solution is then pumped from the well
- This 'leaching' process continues for around two years
- Once the cavern is the correct shape and size, it is ready to be filled with gas



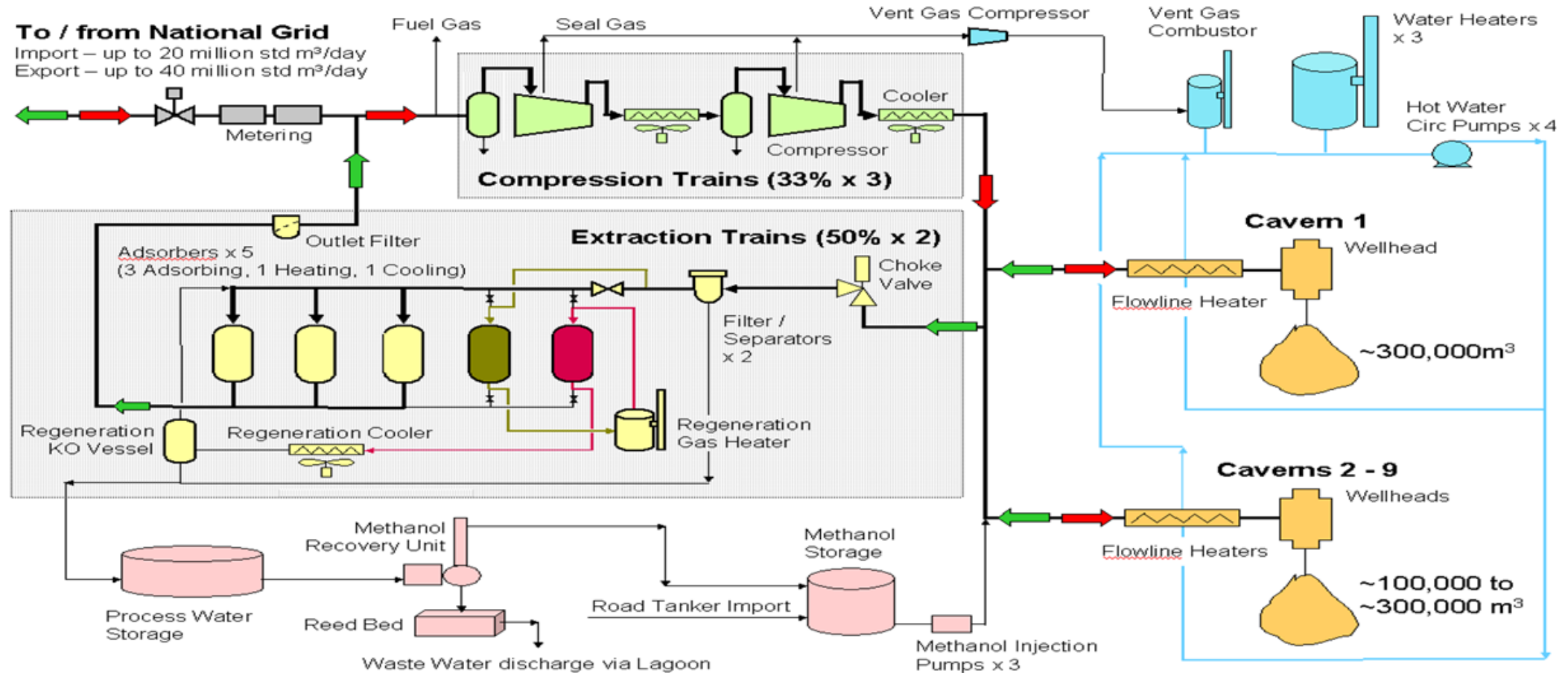
Aldbrough Gas Storage - Today



- Upper Tier COMAH site, regulated by the HSE
- Team of 85 people (across Aldbrough and Atwick)
- Over 82m therms of cavern stored energy
- Injection rate - up to 27 mscm/d (297 GWh/d)
- Withdrawal rate - 23.6 mscm/d (262 GWh/d)
- On-going optimisation works to improve efficiency, cost to inject, and cavern volumes

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Aldbrough Gas Storage – Process Flow



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Aldbrough Hydrogen Storage

Creating one of the world's largest hydrogen storage facilities



Technology: Hydrogen storage

Location: Aldbrough, East Yorkshire

Cluster: East Coast Cluster



Capacity: At least 320GWh

Timescale: Potential to be operational by 2030

Net Zero Impact: Storing the low-carbon hydrogen produced and used in the Humber region, enabling the decarbonisation of power generation, industry, heat, and transport

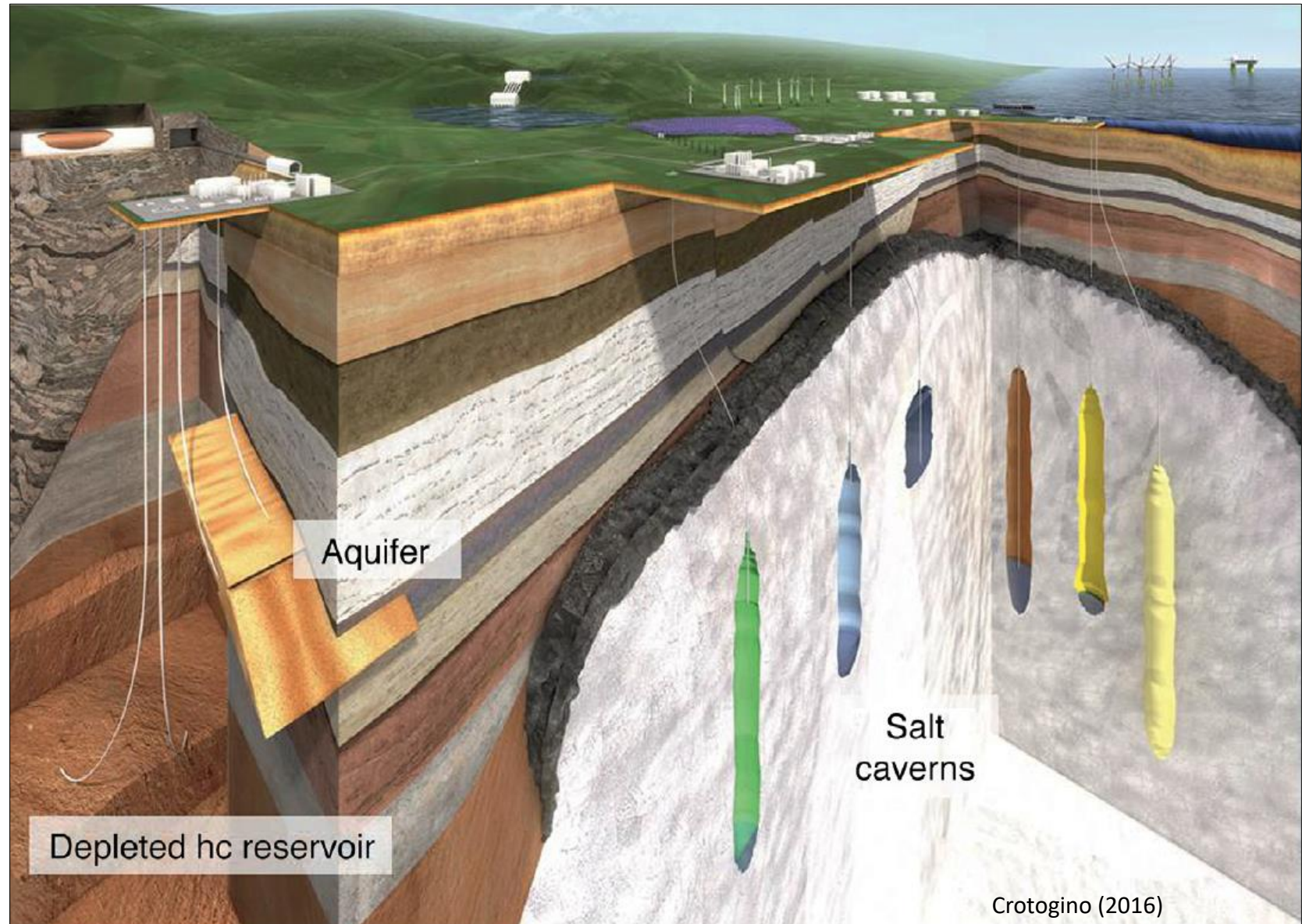
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KEADBY HYDROGEN POWER STATION

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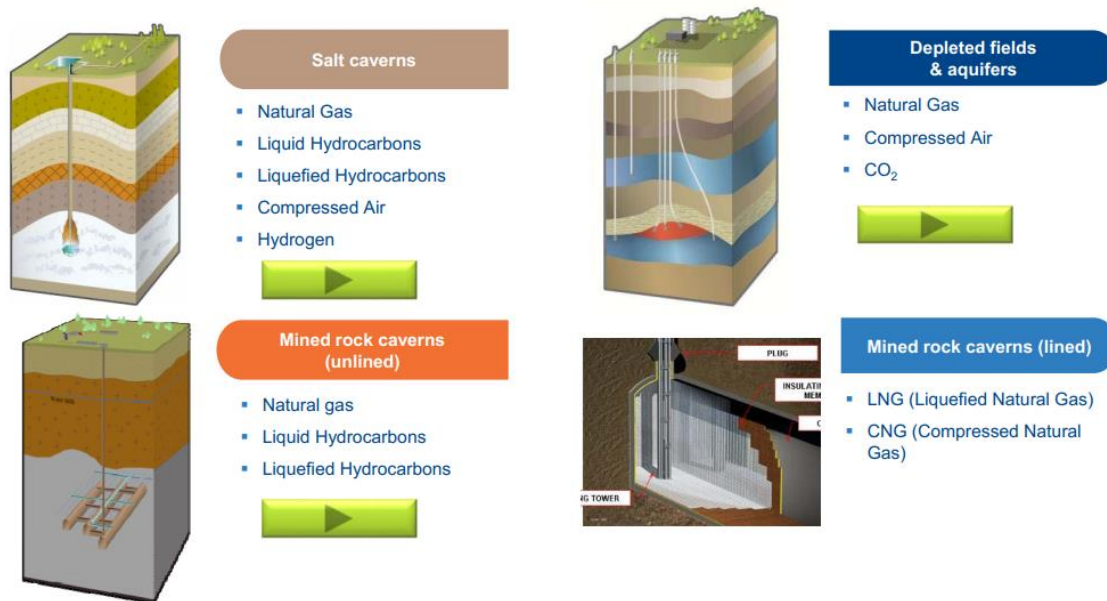
Hydrogen Storage – Salt Caverns

Storage types



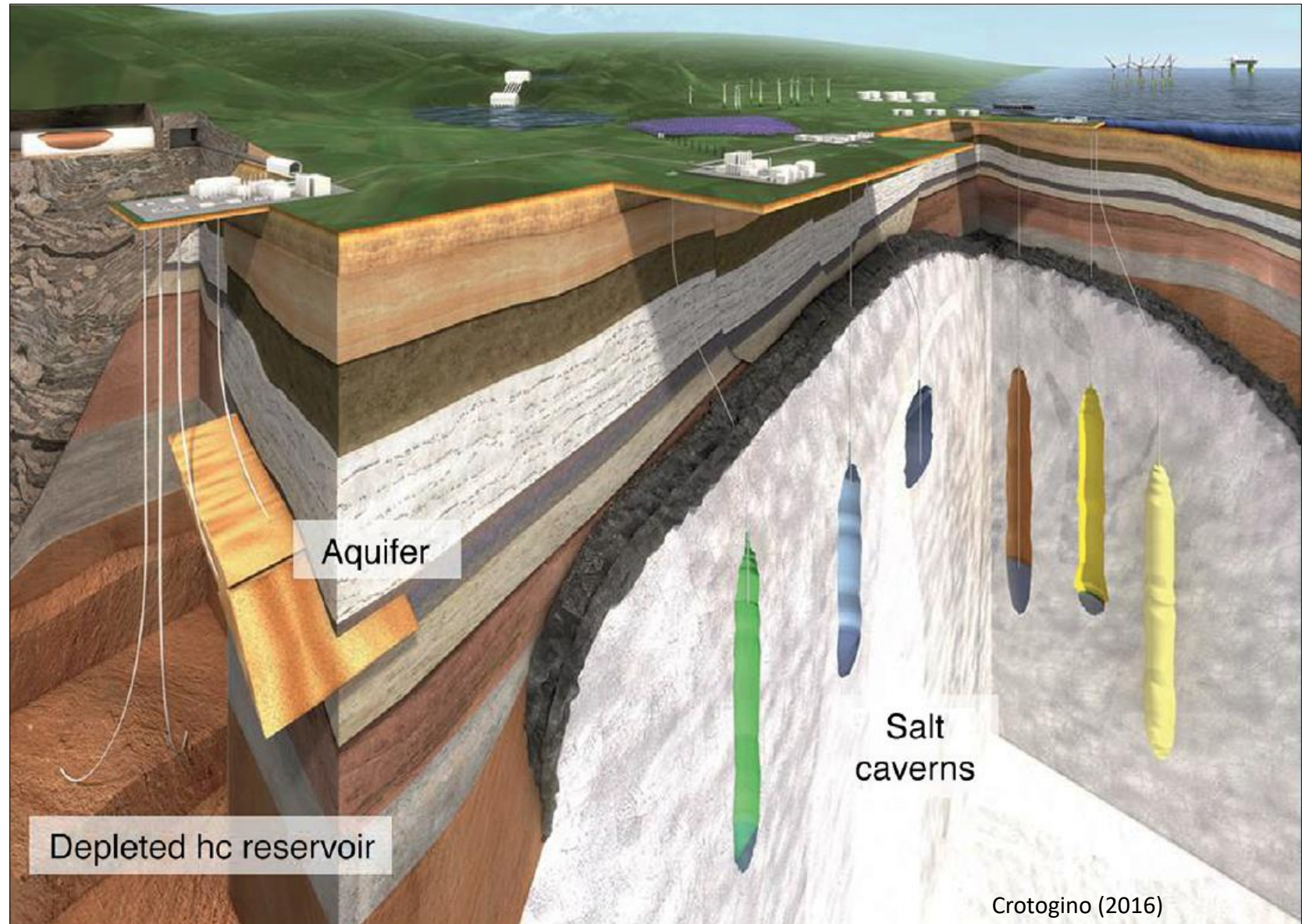
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Comparison of different storage types



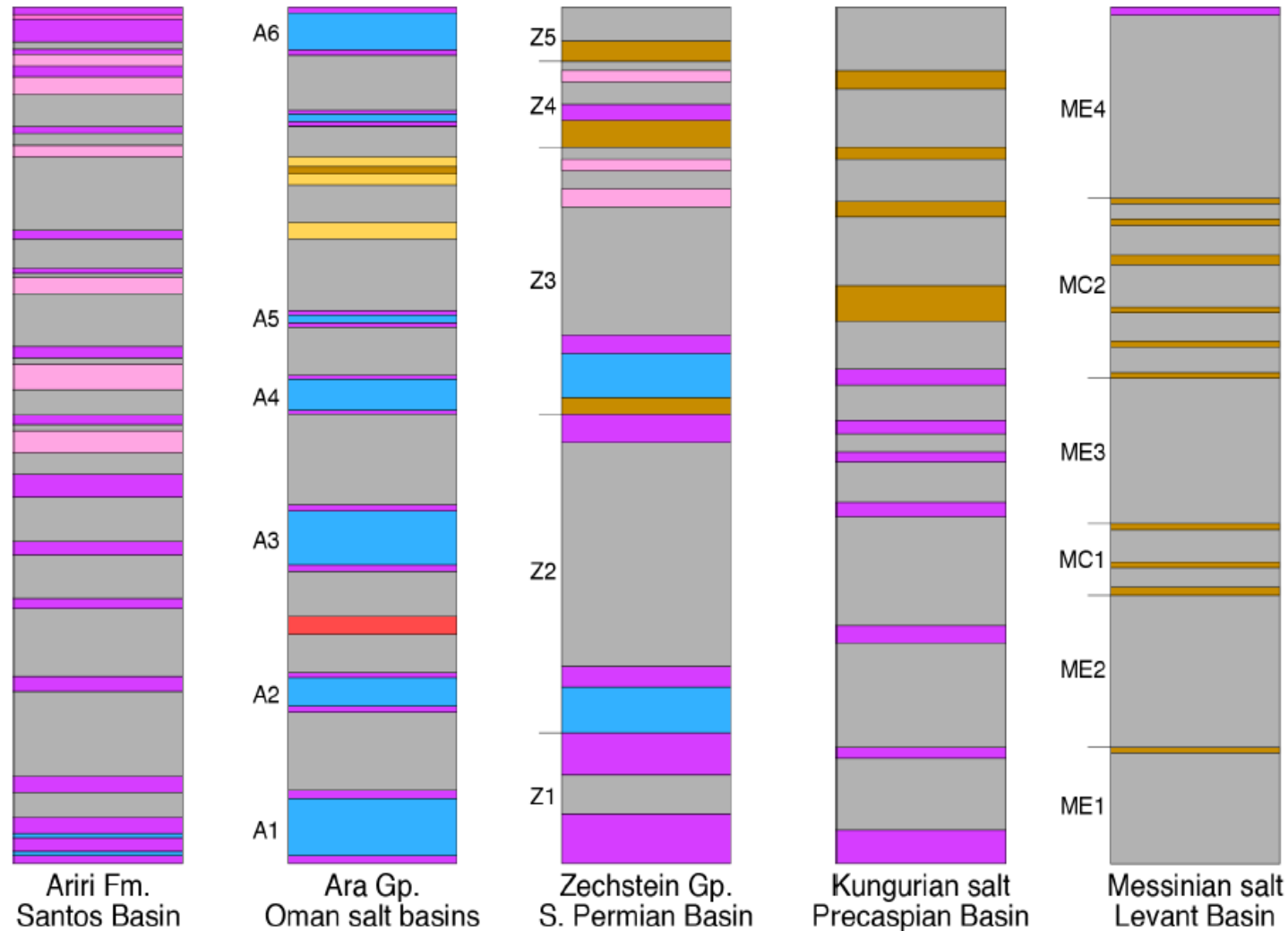
Type	Pros	Cons
Depleted fields	- Geological and reservoir mechanical parameters known - Tightness of reservoir proven - Boreholes already available - Large capacities	- Large surface area for reactions with microbes and minerals, i.e. Sulphur - High risk of mixing/contamination with remaining hydrocarbons - Limited turnover frequency - High cushion gas content - No experience with H₂ storage
Aquifer-formations	- No mixing/contamination with possible residual hydrocarbon components - Often very large capacities - Widespread distribution	- High exploration effort to assess capacity, permeability and tightness - Large surface area available for reactions with microbes and minerals, i.e. Sulphur - Limited turnover frequency - High cushion gas content - No experience with H₂ storage
Salt caverns	- Tightness proven - High turnover frequency possible - Salt layer in the Humber area at 1-2km depth allowing higher operational pressures compared to Cheshire and Teeside, where salt layer is at 0.2-0.5km depth - Lower reaction potential related to microbes, minerals and residual hydrocarbons due to limited surface area - Relatively small amount of cushion gas - Used for H₂ storage since 1972 in Teeside	- Need to dispose large volumes of brine during leaching process - Medium exploration expenditure - Salt layering and hence impact on mechanical stability difficult to predict in 3D - Restricted areal distribution of sufficiently thick salt layer at shallow depths

Storage types



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Layered evaporite sequences (LES)



Aldbrough Well data

Laminated anhydrite-polyhalite and halite

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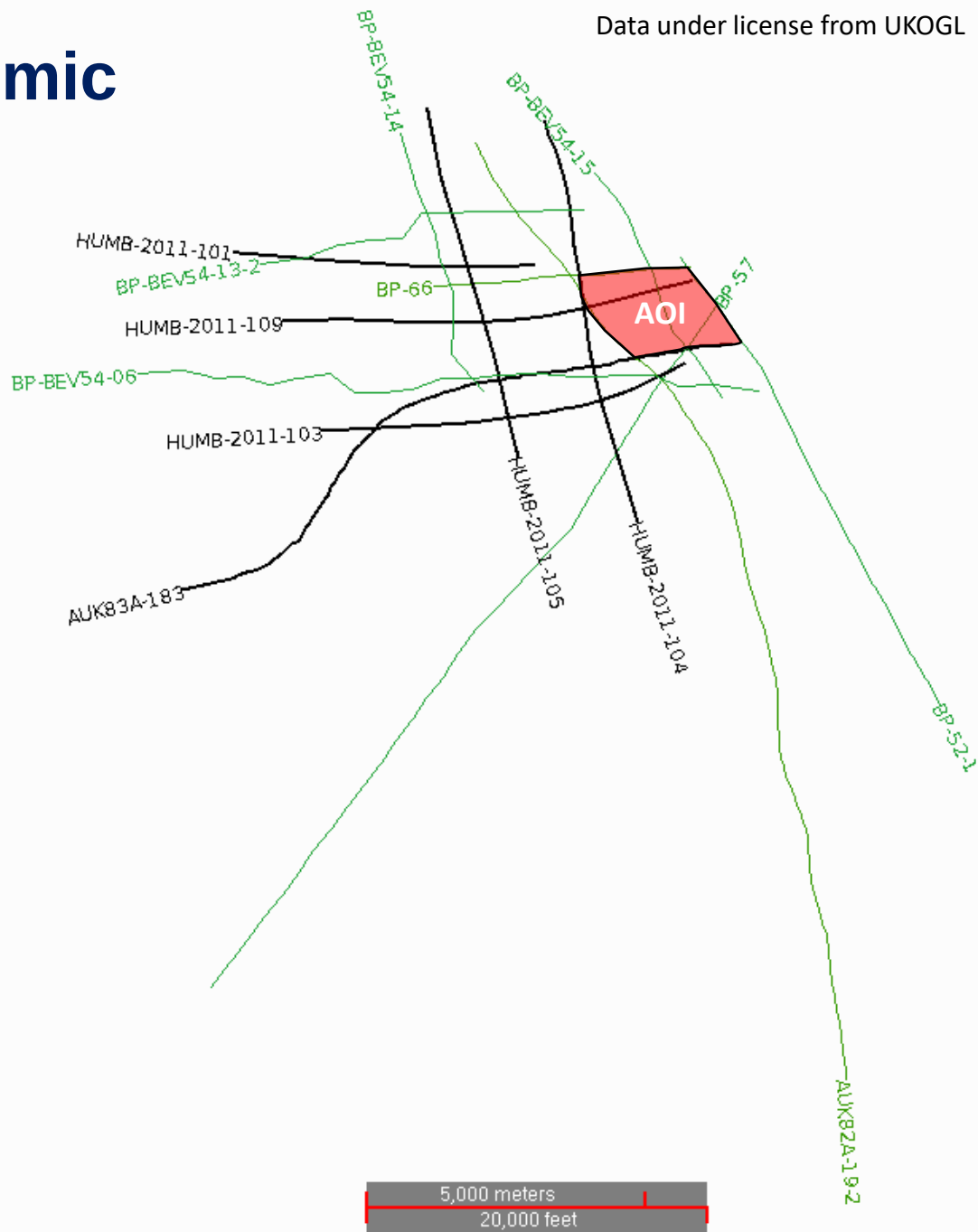
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	Anhydrite
	Carnallite
	Dolomite
	Halite
	Polyhalite
	Mudstone
	Kieserite

Aldbrough 2D Seismic

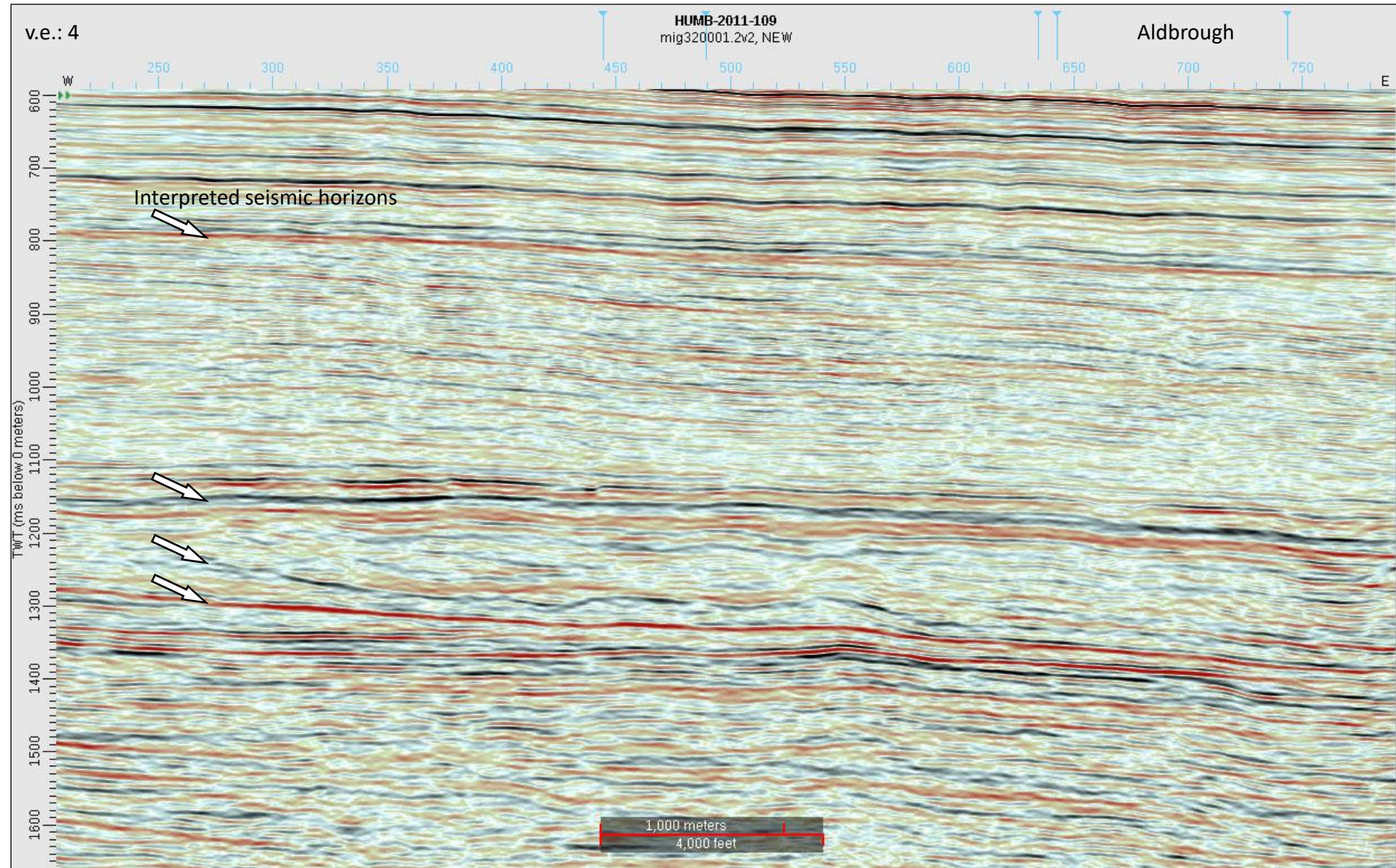
Data under license from UKOGL



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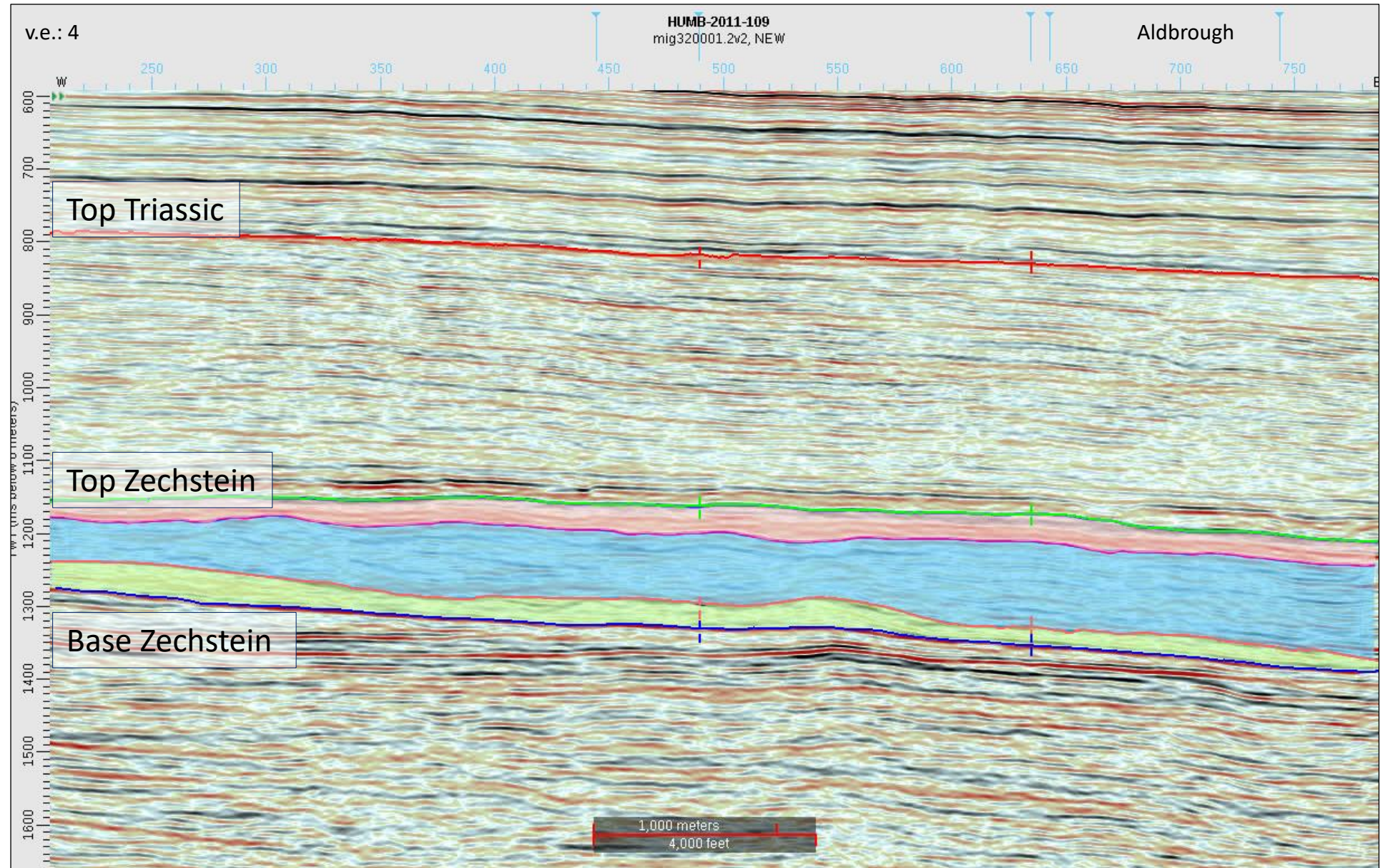
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2D Seismic interpretation



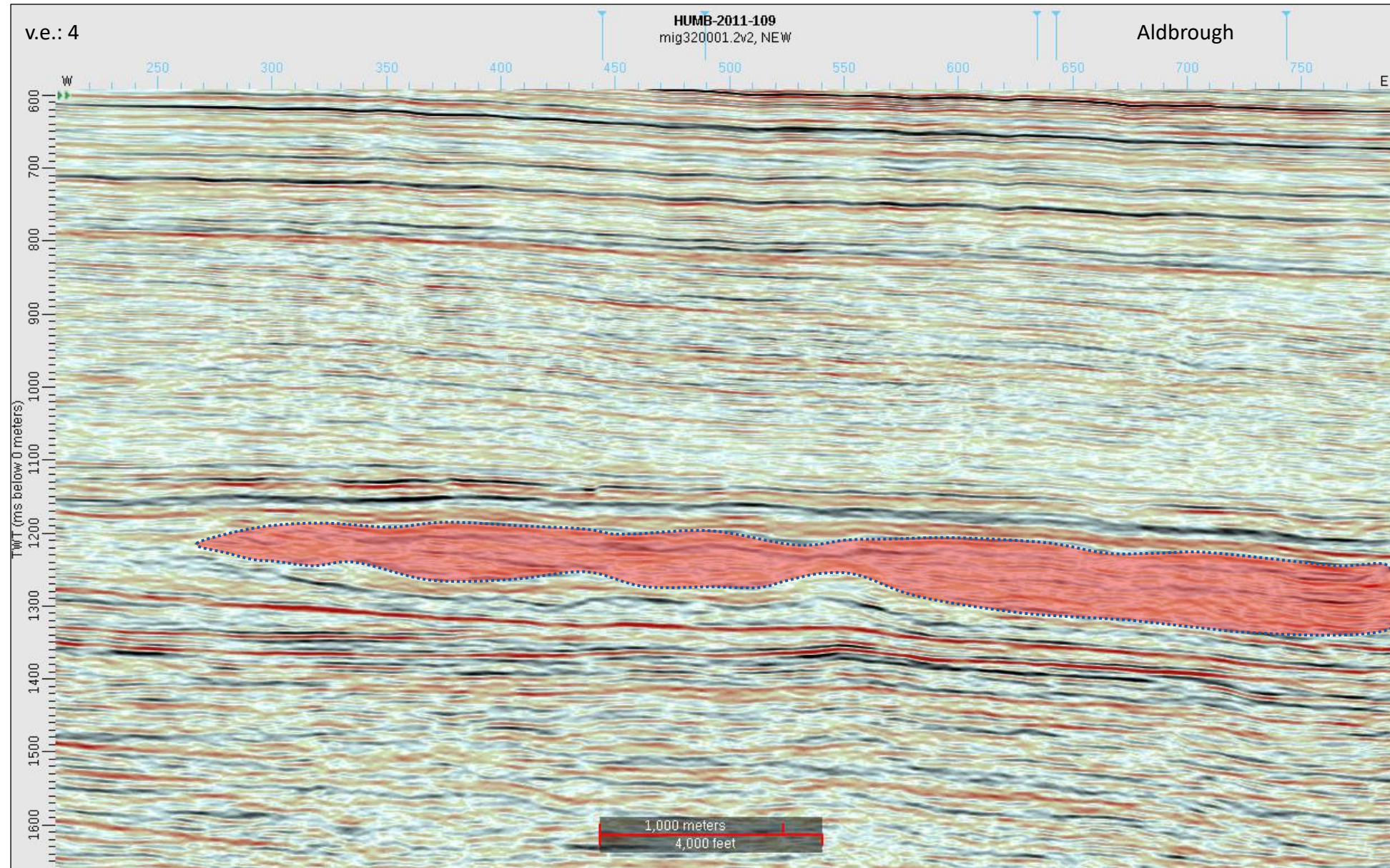
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2D Seismic interpretation



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Turtle structures

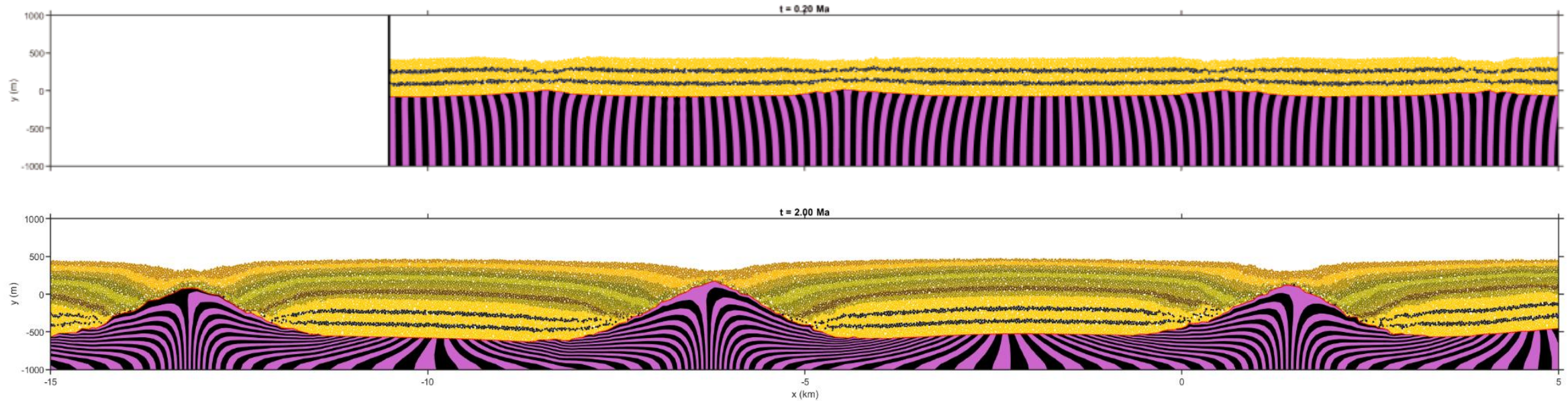


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Turtle structures

Constant strain rate layer-parallel extension with sedimentation – 1000 m salt, $\mu_{base} = 0.7$



Turtle structures form in response to margin tilt, extension and differential sediment loading, by sediment progradation

Link well data with geometries observed on 2D seismic sections to predict presence of halite and carnallite to support cavern placement

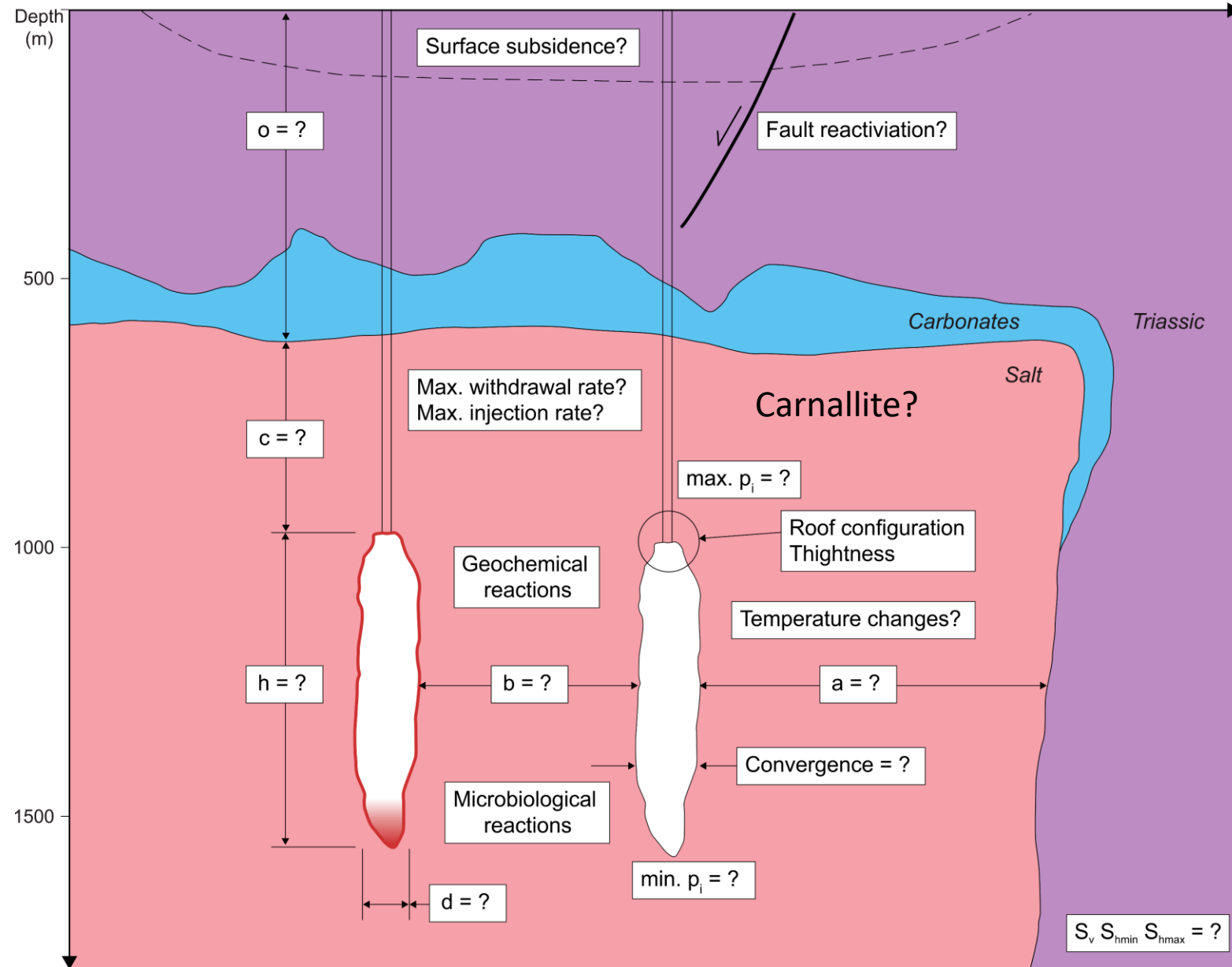
Understanding risks

Related research activities

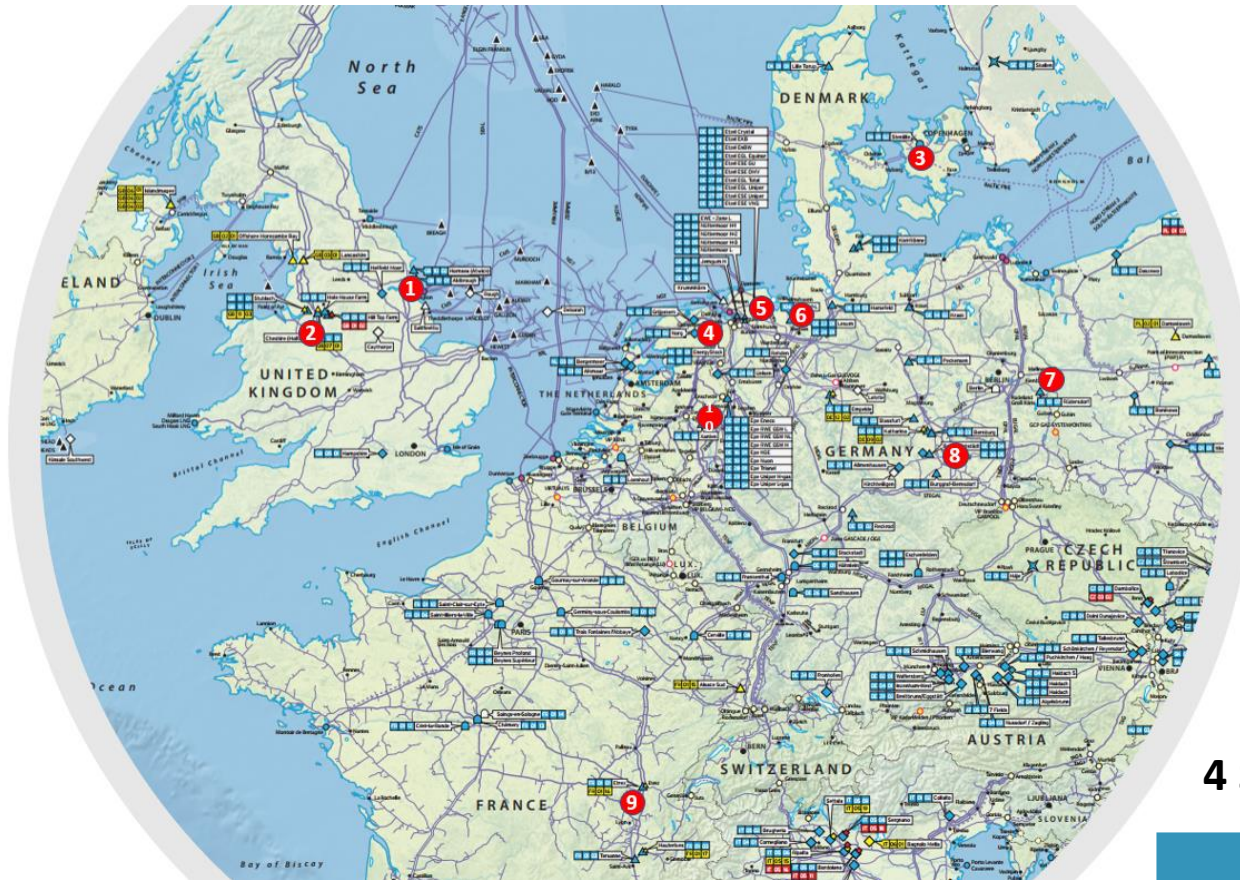
- HyStoreReact
- HyUSPre
- HyStorPor

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Status and Outlook



Several ongoing projects ongoing

No.	Project
1	AHS Aldbrough
2	HyNet NorthWest
3	Green Hydrogen Hub
4	NorthH2, HyStock
5	H2CAST Etzel, HYDRA
6	Clean Hydrogen Coastline
7	HyCAV mobil
8	Green Octopus
9	Hypster
10	Get H2

4 Storages in Operation

Source: Crotogino (2016b) Larger Scale Hydrogen Storage

	Teeside (UK)	Clemens Dome Texas (US)	Moss Bluff Texas (US)	Spindletop Texas (US)
Salt formation	Bedded salt	Salt dome	Salt dome	Salt dome
Operator	Sabir Petrochem.	Chevron Phillips Chemical Comp.	Praxair	Air Liquide
Commissioned	1972	1986	2007	n.a.
Geometrical Volume [m ³]	210.000	580.000	566.000	906.000
Mean cavern depth [m]	365	1000	1200	1340
Pressure range [10 ⁵ Pa]	45	70-137	55-152	68-202
Net energy stored [GWh]	27	81	123	274
Amount of H ₂ [t]	810	2400	3690	8230
Net volume [m ³ std]	9.12 x 10 ⁶	27.3 x 10 ⁶	41.5 x 10 ⁶	92.6 x 10 ⁶

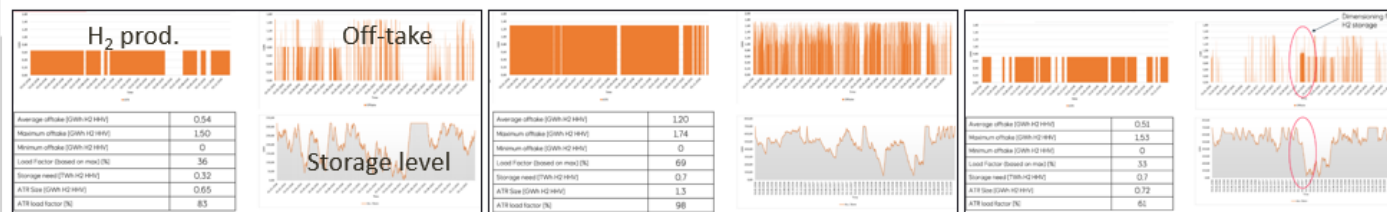
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Need for Storage

- **Strong and clear need** for storage to integrate variable H₂ demands with both Blue and Green production.
- Pressing requirement for **new low-carbon power generation capacity towards 2035** decarbonisation target.
- Increasing renewables means load factors for dispatchable low-carbon plant **will be lower and flexibility therefore vital**.
- Storage is necessary to **efficiently** deliver power generation demands.
- Power is therefore in a position to provide an **early key anchor demand** for storage, underpinning growing **wider system value for a variety of emerging hydrogen users**.
- Working with Government to support development of the necessary business models to support storage, building on the progress made for Hydrogen Production support.

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Simulation with 10 years data of three different power plants (recalculated to H₂) as off-taker. Feed by two different capacities of H₂ production units gave results of 4 to > 9 caverns storage volume needed.



Result for storage = 4 caverns

Result for storage = 9 caverns

Result for storage >9 caverns

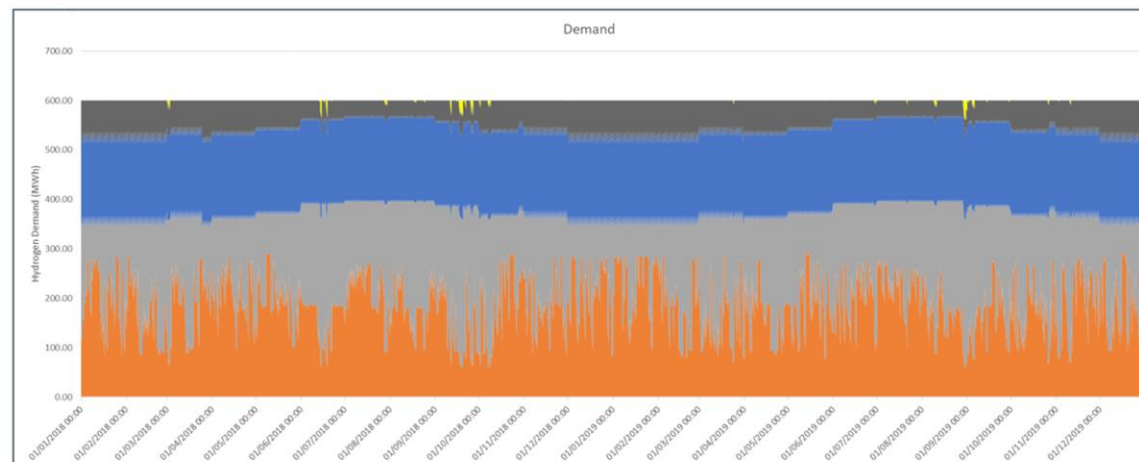
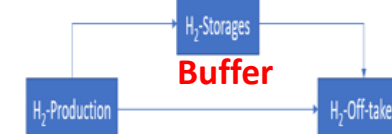
Operational parameter

(Note of caution: subject to further investigation):

Cavern capacity:	~ 80 GWh (working gas)
Cavern pressure range:	~ 140-275 barg
Estimated volume per cavern	~ 26 million Nm ³
Assumed withdrawal rate per cavern	~ 100,000-150,000 Nm ³ /h
Estimated injection rate per train	~ 200,000 Nm ³ /h

Injection rate = (max.) production rate
(i.e. off-taker shut down)

Withdrawal rate = off-taker peak rate
(i.e. H₂ plant shut down)



Offtake

Power Generation
Industrial (flat-ish' profile)
Ammonia (Providing some flexibility)
Flare (or operational efficiency)
Blending (Say Hull (11MW - 120MW swing))
Hydrogen Production (c100% - maximum efficiency)

Keadby Hydrogen | World first at scale Power Production Storage

Aldbrough Hydrogen Storage



- Current day existing natural gas storage approx. 330 mcm in 9 caverns
- Nine underground salt caverns, each roughly the size of St. Paul's Cathedral
- New planned H2 capacity : 320 GWh
- Connector: H2H Saltend to Aldbrough
- Timeline: By end of the decade



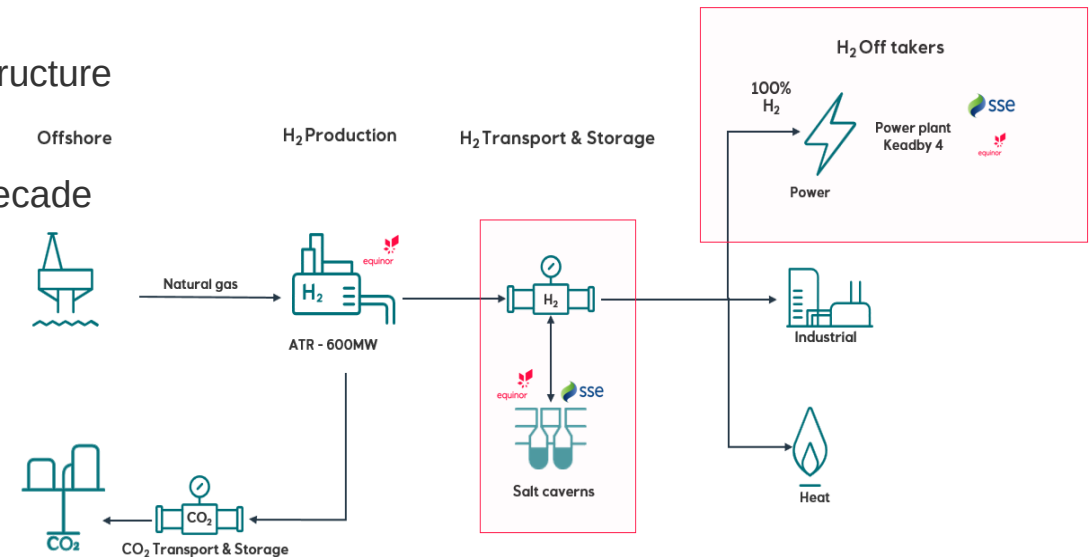
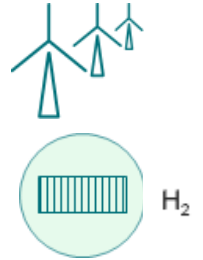
Keadby Hydrogen Power Plant



- World's first 100% hydrogen-fired power station with zero emissions
- 1.8 GW H2 intake approx. 900 MW of electricity
- Base load 50% : 1.2 GW H2 for about 600 MW
- Feed into the ZCH infrastructure
- CCGT Turbine driven
- Timeline: By end of the decade

Future Work : Electrolyser?

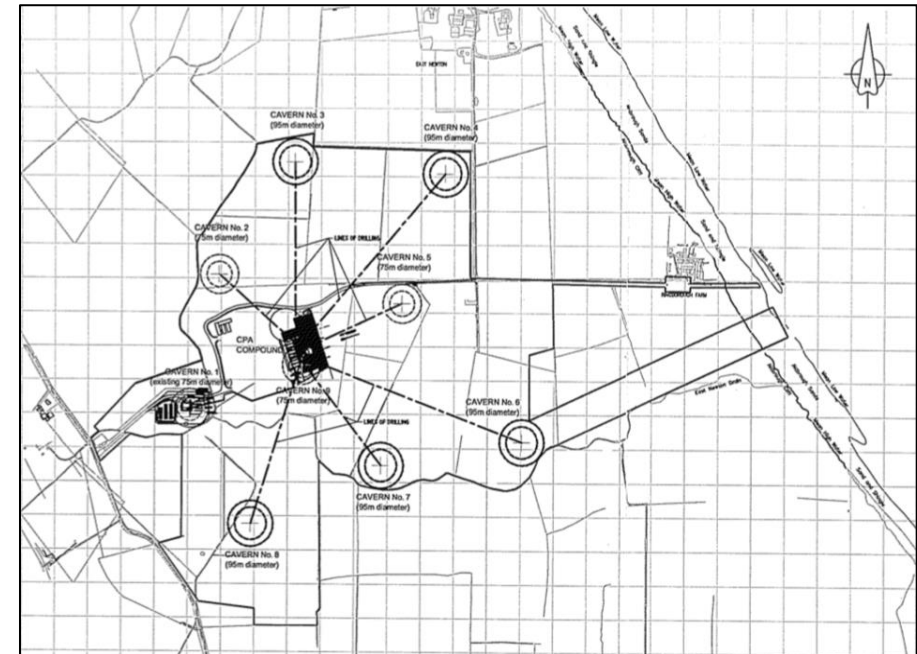
- Planned Green hydrogen
- Still in development



Project Timeline

- FID 2024-2025 (Government support critical)
- First Hydrogen 2028
- Aligned to assist with the Government 5 GW ambitions by end of the decade
- Critical to build hydrogen economy

Zero Carbon Humber (ZCH)



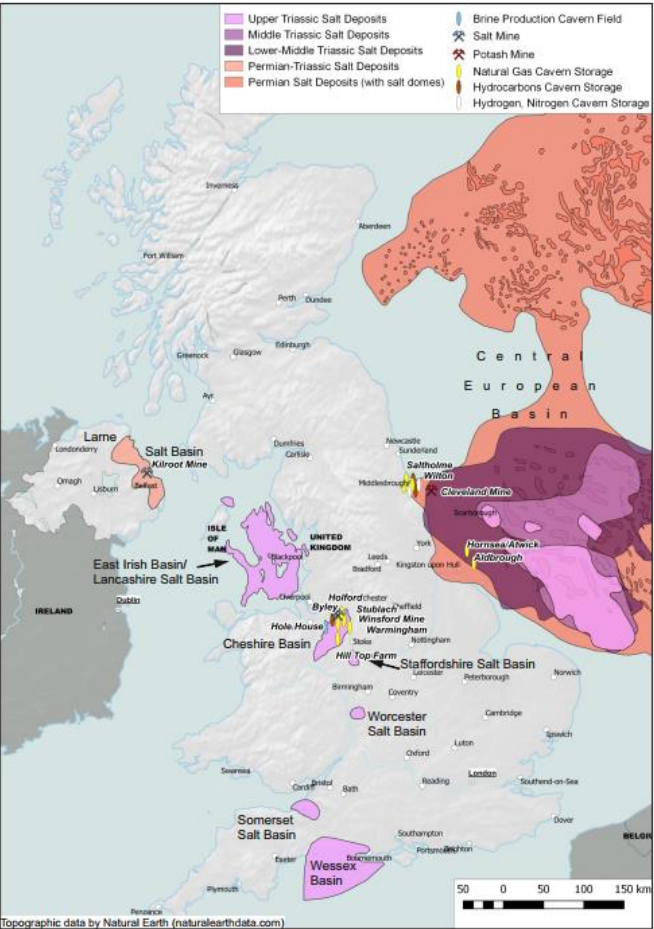
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Questions?



Salt cavern storages – H21 information

Update of SMRI's Compilation of Worldwide Salt Deposits and Salt Cavern Fields
Enclosure 34: Salt deposits and cavern fields / mines of the United Kingdom



PARAMETERS	CHESHIRE	TEESSIDE	YORKSHIRE
Type	Triassic	Permian	Permian
Depth (m)	200-500	300-400	1,000-2,000
Thickness (m)	250-300	30-45	75-100
Maximum pressure (bar)	34-100	51-80	170-400

CASE	A) HYDROGEN FACILITY CAPACITY (GW)	B) DESIGN FACTOR	C) SIMULATED STORAGE (GWH)	D) PEAK MONTH SUPPLY (GW)	E) ADDITIONAL STORAGE TO MEET PEAK MONTH DEMAND (GWH)	F) INTER- SEASONAL STORAGE BASED ON PEAK MONTH DEMAND (GWH)	G) INTER- SEASONAL STORAGE BASED ON PEAK YEAR DEMAND (GWH)
Peak demand	9,74	100%	11,319	25.46	0	11,319	14,039
Case A	11.3	116%	7,373	21.54	0	7,373	10,047
Case B	12.15	125%	5,521	19.82	130	5,651	8,052
Case C	12.74	131%	4,263	18.66	960	5,223	6,674
Case D	16.99	174%	104	17.13	2,060	2,164	636
Case E	21.23	218%	0	21.23	0	0	0

Source: SMRI and H21 report

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H21 North of England report

PDF 100 MB

