centrica energy storage+

RougH$_2$

Transforming Rough for large-scale hydrogen storage

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Project & Interface Manager

UKES2024

We are an integrated energy & services business

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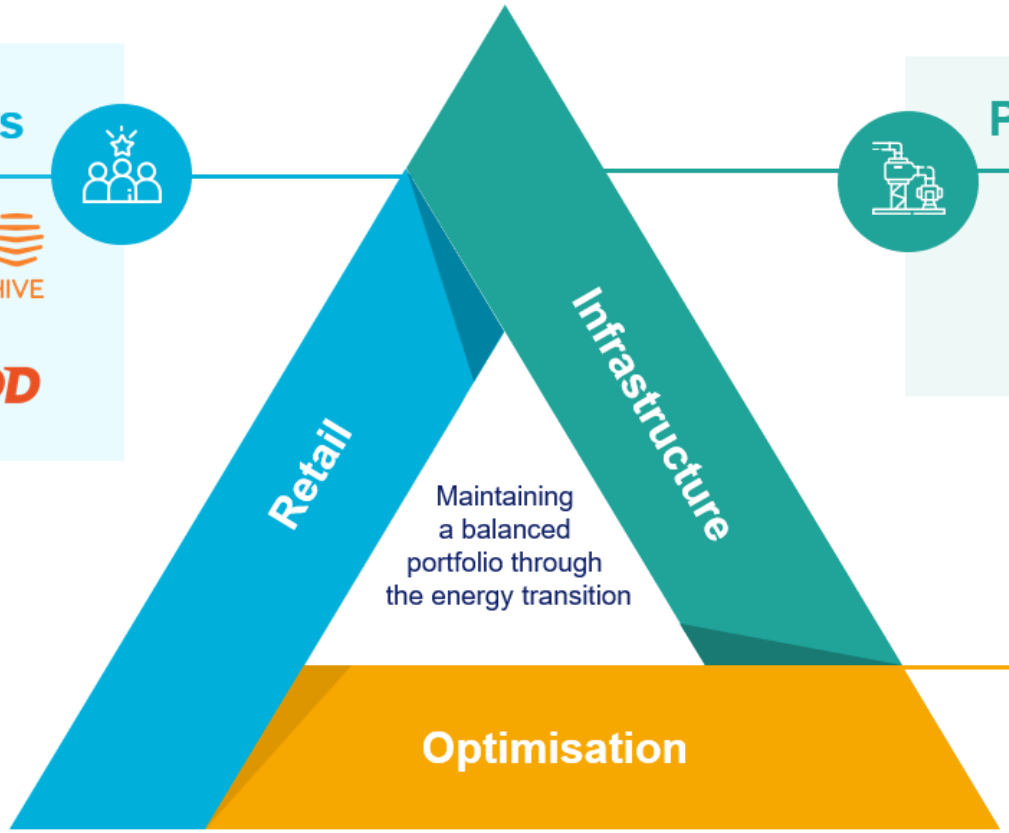
10m+ Retail customers

British Gas · Bord Gáis Energy · HIVE · phJones · DYNO-ROD



Power & Gas Infrastructure

SPIRIT ENERGY · centrica Nuclear · centrica energy storage+ · Bord Gáis Energy · centrica Business Solutions

Leading Optimisation capability

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Centrica’s large-scale UK infrastructure projects

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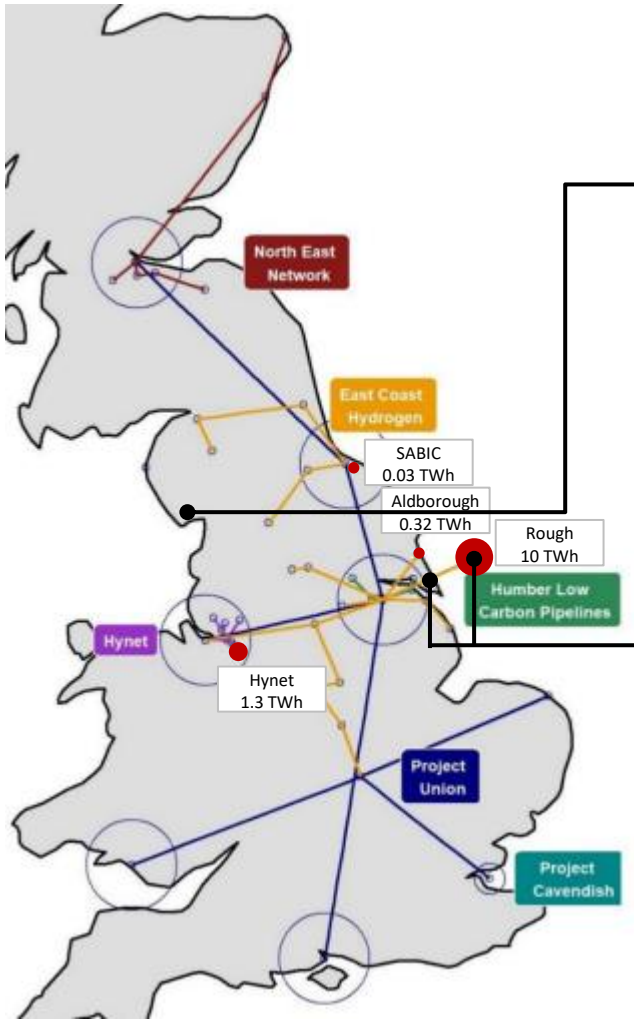

18 MAY 2023

Spirit Energy welcomes licence award for world-leading carbon storage facility

03 NOVEMBER 2022

Centrica and Equinor sign co-operation agreement for East Yorkshire hydrogen hub

28 OCTOBER 2022

Centrica re-opens Rough storage facility

30 JUNE 2023

Centrica bolsters UK’s energy security by doubling Rough storage capacity

The way Rough is used has evolved over its lifetime…

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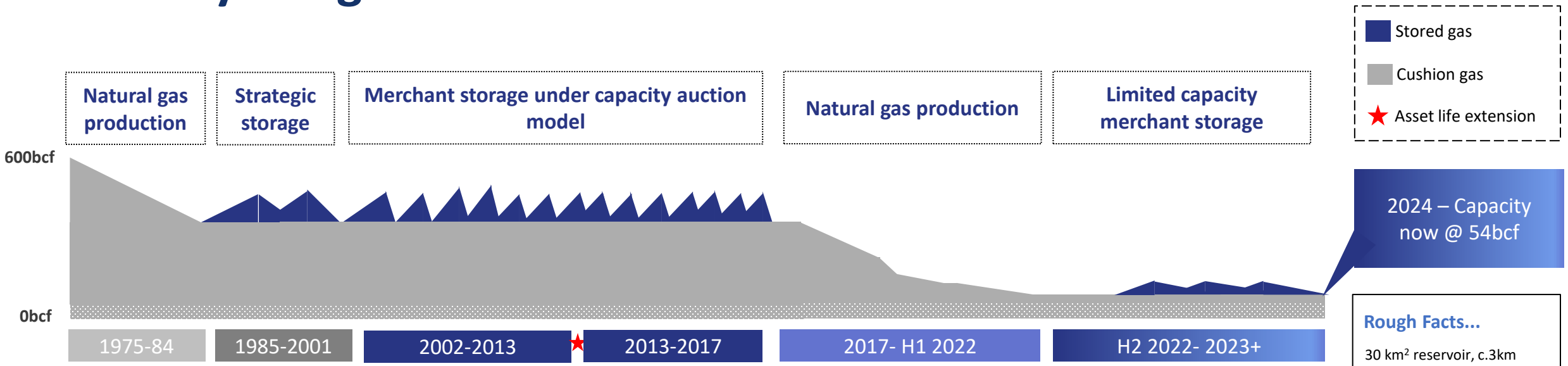


Production (Amoco) until 1984, converted for large-scale (150bcf) strategic storage by British Gas until 2001

Centrica buy Rough in 2002, operated as a profitable merchant storage site until around c.2015 subject to 'undertakings'

New UK gas import infrastructure reduces seasonal price spreads, undermining fundamental economics…

…and the UK government did not see a case for public support for storage capacity…

… the decision to stop storage taken in 2017 and convert back to gas production

Following market shocks, short-term signals for storage returned, and limited storage capacity (30bcf) was re-opened

Rough Facts…

30 km^2 reservoir, c.3km under seabed

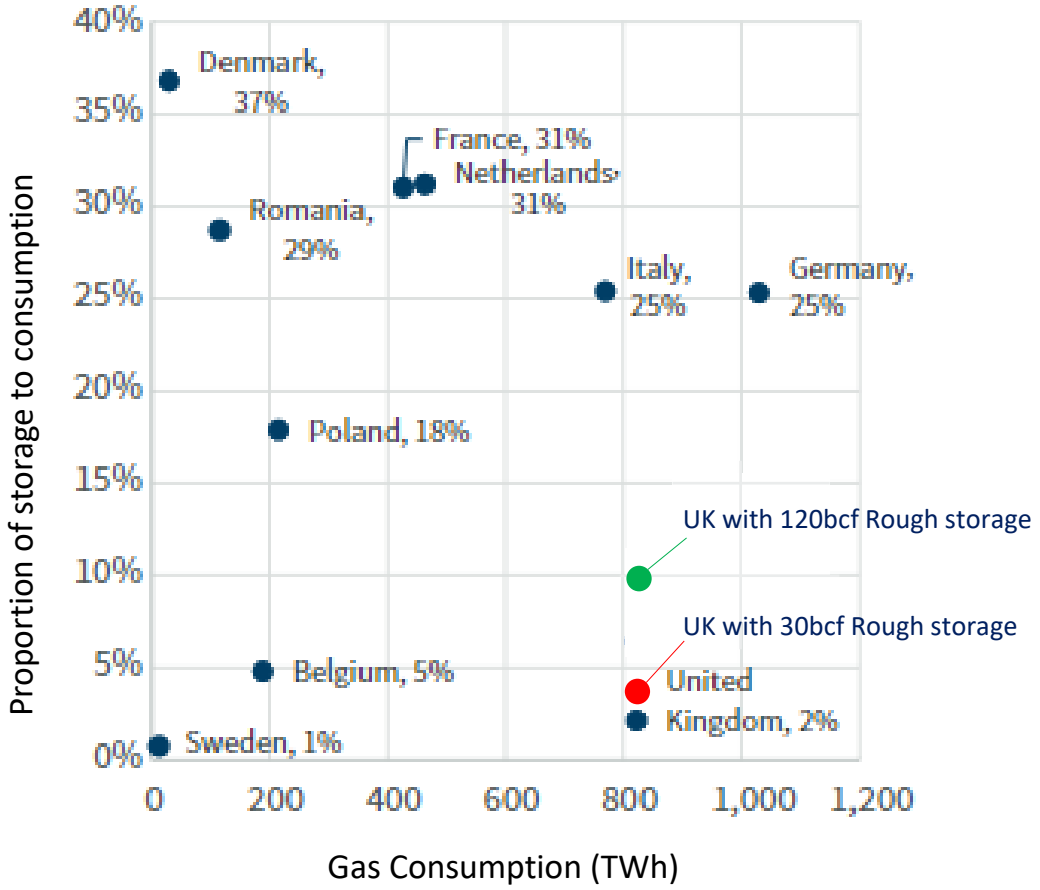
Only proven large scale storage site in the UK

"Goldilocks" of the sector as it meets requirements on temperature, dryness, size and proximity to land – the only proven offshore gas storage reservoir in the UK

Up to 200bcf storage (66 LNG Tankers)

Easington terminal—can process up to 20% of UK peak as demand

How do you factor in the value of gas storage?



- UK has ~2% of total gas demand covered by existing operational gas storage
- Other European countries with similar demographics have enough gas storage to meet more than 20% of annual demand
- This leaves UK consumers more exposed to global price changes
- **Rough has potential to increase UK gas storage up to 10% of total gas demand**

£2.4 bn

Total gas and electricity wholesale cost saving if Rough had been fully operational in Winter 21/22

Centrica plan to install new facilities at Rough to support increased natural gas storage capacity whilst ensuring new facilities are hydrogen-ready to support the UK's energy transition

There is increasing focus on the concept of long-term, strategic energy storage as a critical component of a resilient Net Zero energy system…

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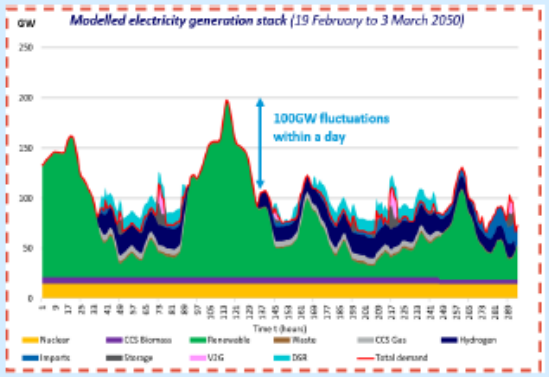
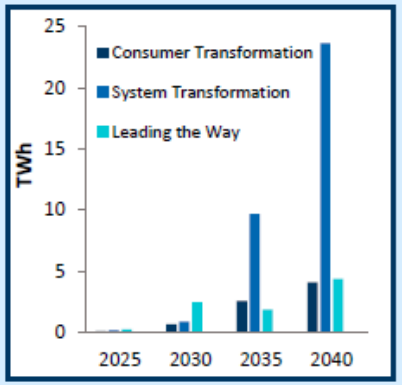
nationalgridESO

- The ESO's FES this year explored '**Dunkelflaute**' events in a decarbonised system for the first time…
- …with a focus on investigating how **system resilience could be met**…
- …and found that **11 TWh of H2 storage could be used within a two-week period**

- This sits on top of wider modelling of the volatility of generation in a decarbonised system…
- … which will require a balancing role that storage is uniquely well-placed to support





NATIONAL INFRASTRUCTURE COMMISSION

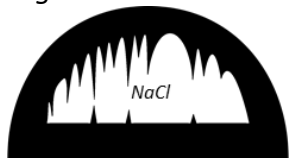
- A minimum of 8 TWh H2 storage is needed by 2035…
- Lead times for developing H2 storage can reach 10 years – **so action is needed now.**
- By 2040, 25 TWh strategic storage should be maintained under the government's control

THE ROYAL SOCIETY

- Analysis of multi-decade weather patterns suggest that 100 TWh storage capacity is required to prepare for wind droughts …
- .. H2 storage is well-positioned as it has low costs and stores large amounts of energy for years.

Total existing GB salt cavern storage capacity = c.3.5TWh of H_2 storage…

…but much of this capacity will continue to be required for gas storage.



In contrast, ***Rough can provide up to c. 16TWh of H_2 storage capacity*** *(equivalent to c.80 salt caverns) …*

…without cannibalising near term existing gas storage *(i.e. phased build-out with minimal downtime)*

… and Rough is uniquely well placed to provide this service in GB

Rough could store up to 16TWh of hydrogen via phase development…equivalent to 80 salt caverns

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Existing Offshore Asset
- 40yr old asset
- 10yr remaining lifespan
- 54 billion cubic feet capacity
- High CAPEX to maintain safe, reliable operations
- High OPEX
- 100-120 PoB

New Hydrogen-ready Offshore Asset
- 45yr lifespan
- 120 – 200 billion cubic feet capacity
- Potential as a UK strategic gas store
- Single jacket, remotely operated
- Design for flexible storage operations
- Low OPEX

Onshore Gas Processing
- Modification at Easington gas terminal for higher capacity storage operations
- New onshore hydrogen terminal (hydrogen compression & gas processing equipment)

Focus is on natural gas storage but making the asset hydrogen-ready to avoid having to wholesale replace infrastructure within 10 years.

The project will be circa. £2bn investment for redevelopment of offshore & onshore facilities.

New infrastructure should be constructed in parallel with running existing gas storage operation, minimising downtime on switchover.

Flexible infrastructure supports government options for a longer-term UK energy and price security and allows hydrogen economy to scale

Potential to create over 4800 project jobs and safeguard existing workforce – creating over £1.5bn in GVA[3]

Hydrogen storage in depleted reservoirs has first of a kind risks and CES+ are developing a scheme to reduce risk and meet business model requirements.

However, there are still challenges to overcome for geological storage projects like Rough…

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H2 storage in depleted fields is estimated at TRL3-4 (IEA, 2020)

How do we address the TRL gap?

Mitigation of subsurface and facilities risks via lab and industrial-scale testing, and desk-top modelling and engineering studies

- Seal Integrity
- Storage Performance
- Microbial risk
- Geochemical Risk
- Legacy Well Integrity

- Engineer onshore and offshore facilities suitable for high pressure H2 storage operation, capable of processing withdrawn H2 to required purity specification

Department for Energy Security & Net Zero

Hydrogen Storage Business Model: Market Engagement on the First Allocation Round

December 2023

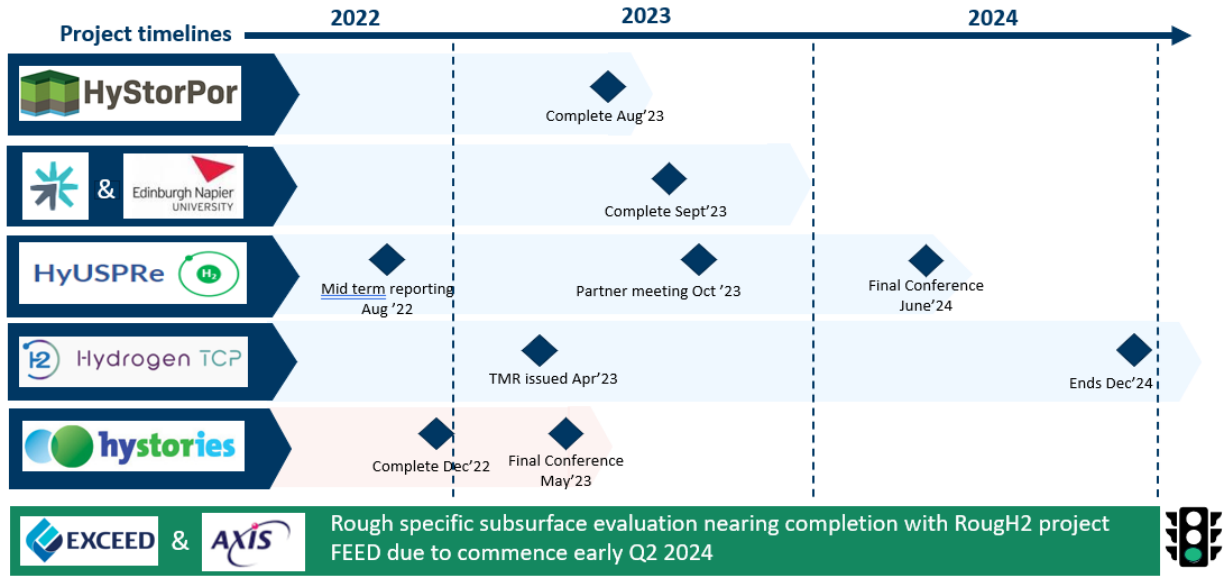
HSBM eligibility criteria required minimum TRL7 for project support (December 2023)

North Sea Transition Authority

HSE

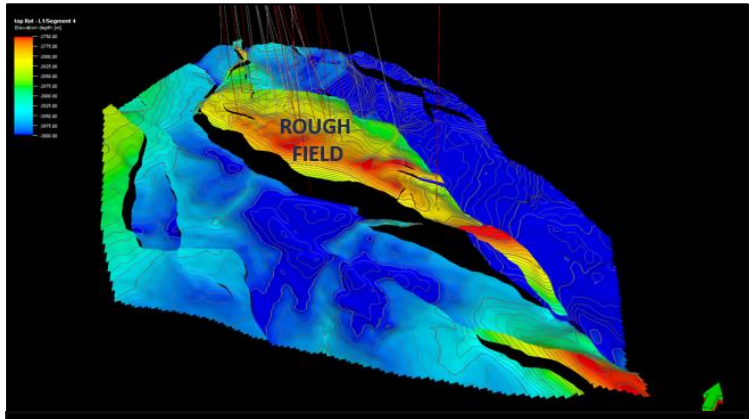
Offshore Petroleum Regulator for Environment & Decommissioning

Ensure regulatory approvals (licence, Safety Case, planning etc) can be obtained by project aligning with regulatory requirements



Through collaboration with academia and industry specialists we have carried out risk mitigation work scopes…

Investigation topic	*Rough specific findings*	Status
Geomechanics & Storage Integrity	■ Containment assessment complete – **Leakage/communication of any Rotliegendes fluid/pressures is not considered possible** ■ **Hydrogen does not reach the top of the Rough caprock boundary over 40yr simulated period**, even with addition of a damaged fault scenario (SPARK-2177)	
Geochemical	■ Core samples from Rough field show **no geochemical reactions with hydrogen** at field representative temp & press (HyStorPor WP1 & HyUSPRe WP2)	
Microbiological	■ Rough temperature (>90 DegC) at higher end of Methanogen & sulpher-reducer survival range. ■ **Rough categorised as 'low risk' and paleosterile** (Thaysen et al., 2023) ■ Fluid sampling planned for 2024/2025	
Storage Performance	■ **>89% H2 conc% achieved on cycle #1 withdrawal** with additional H2 cushion gas 'bubble' during cycle #1 injection (SPARK-2177) ■ **CES+ now have a fully history-matched multi-compositional reservoir model**. Dynamic modelling now complete and development forecast ongoing to optimise H2 purity.	



CES+ are now developing pilot scheme to demonstrate Rough H2 storage compatibility at industrial-scale…

Piloting would deliver outputs that could underpin development of other porous rock H2 storage projects in the UK and globally

We have some big ambitions…..

https://www.linkedin.com/posts/centrica-energy-storage_energyhub-netzero-jobs-activity-7166753173318148096-8D3f?utm_source=share&utm_medium=member_desktop

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Annex

Vision for the future in the Humber
…an integrated energy hub