Assessing the Regional Demand for Geological Hydrogen Storage

Building a Strategic Case for Investment in the East Coast Cluster

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UK Energy Storage Conference, UKES 2024
Friday 12th April 2024

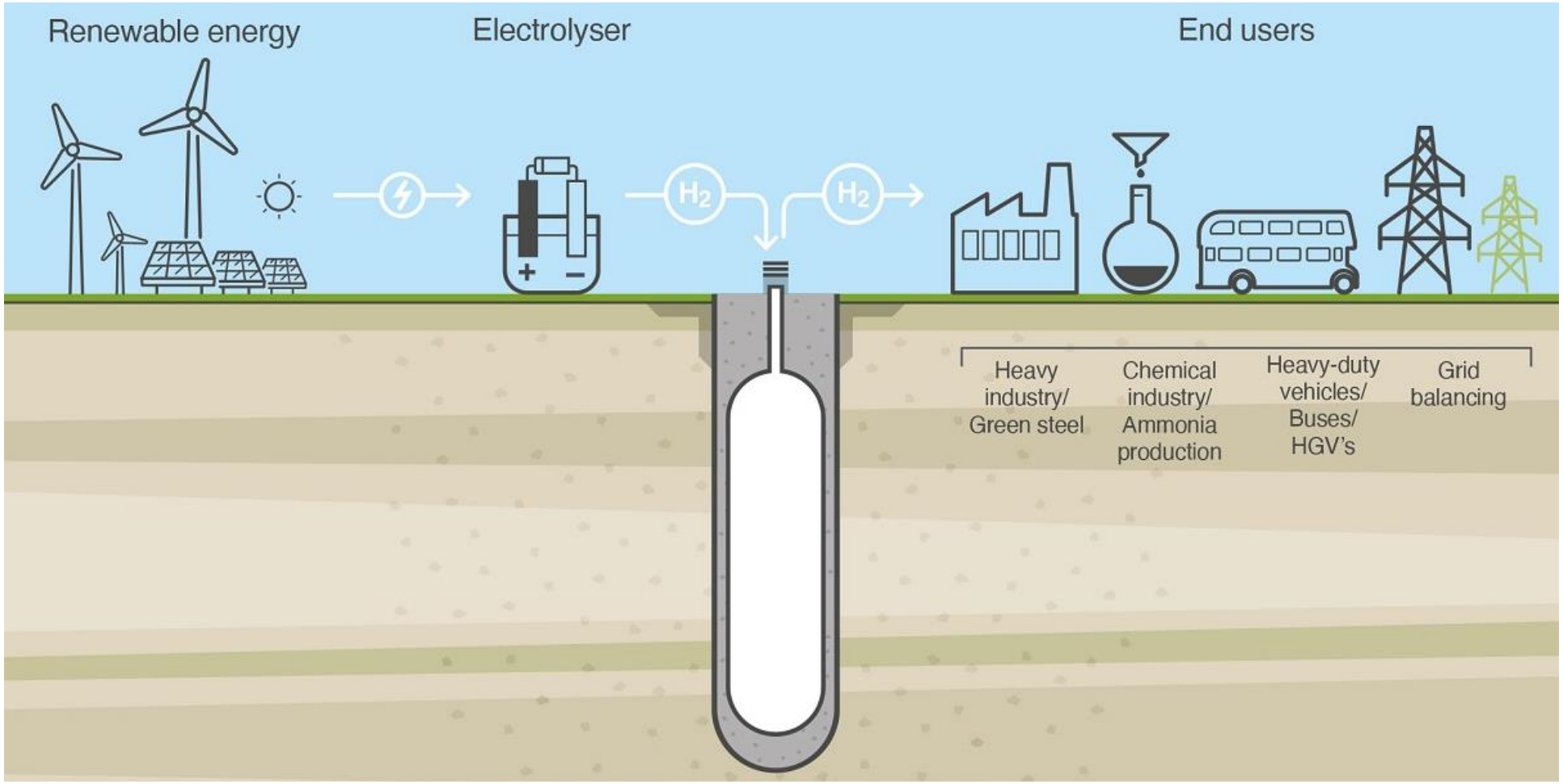
Agenda

Building a strategic case for geological hydrogen storage investment in the East Coast Cluster

1. Context
2. Study Overview & Research Focus
3. UK East Coast Region
4. WP1: Hydrogen Storage Demand Modelling
5. WP2: Hydrogen Storage Capacity Modelling
6. WP3: Establishing the Case for Change
7. Strategic Case for Intervention
8. Now What?
9. Questions/Open Discussion

Geological Hydrogen Storage

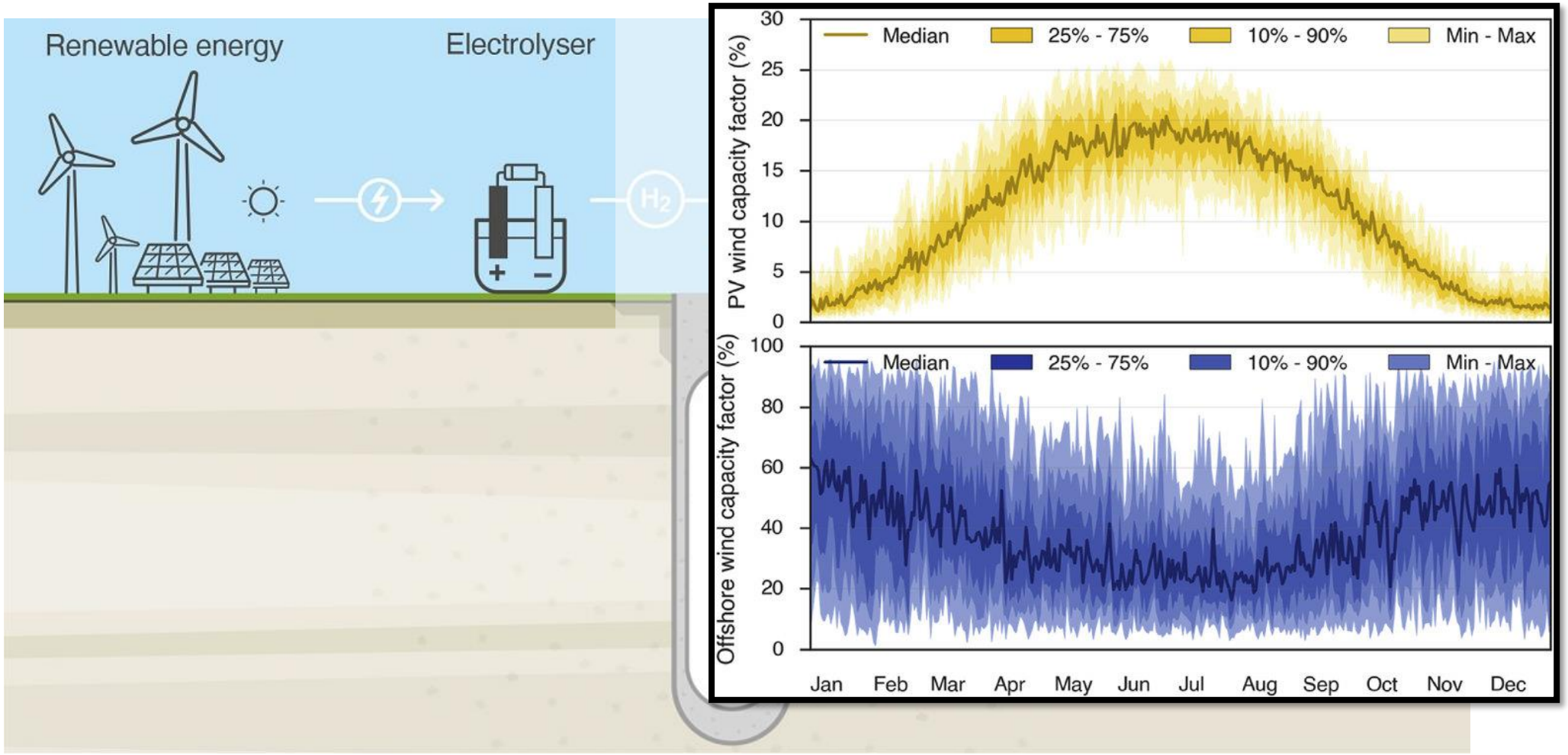
What is it?



Electrolytic hydrogen production and end uses
Gravitricity (Sep 2022)

Geological Hydrogen Storage

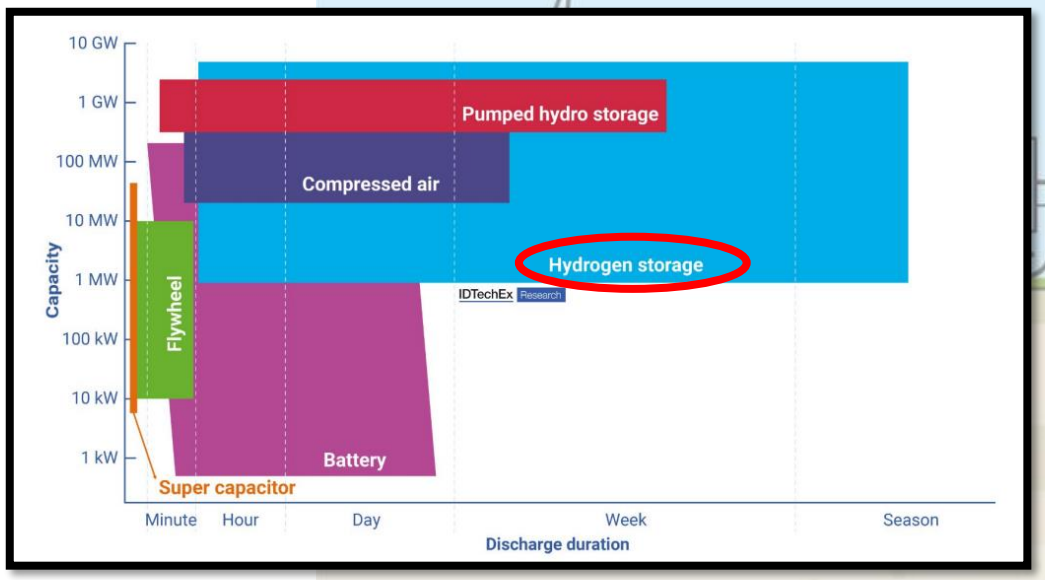
A solution to complement intermittent renewable production



Year-to-year variability of daily PV and offshore wind generation
I. Staffell & S. Pfenninger (Dec 2017)

Geological Hydrogen Storage

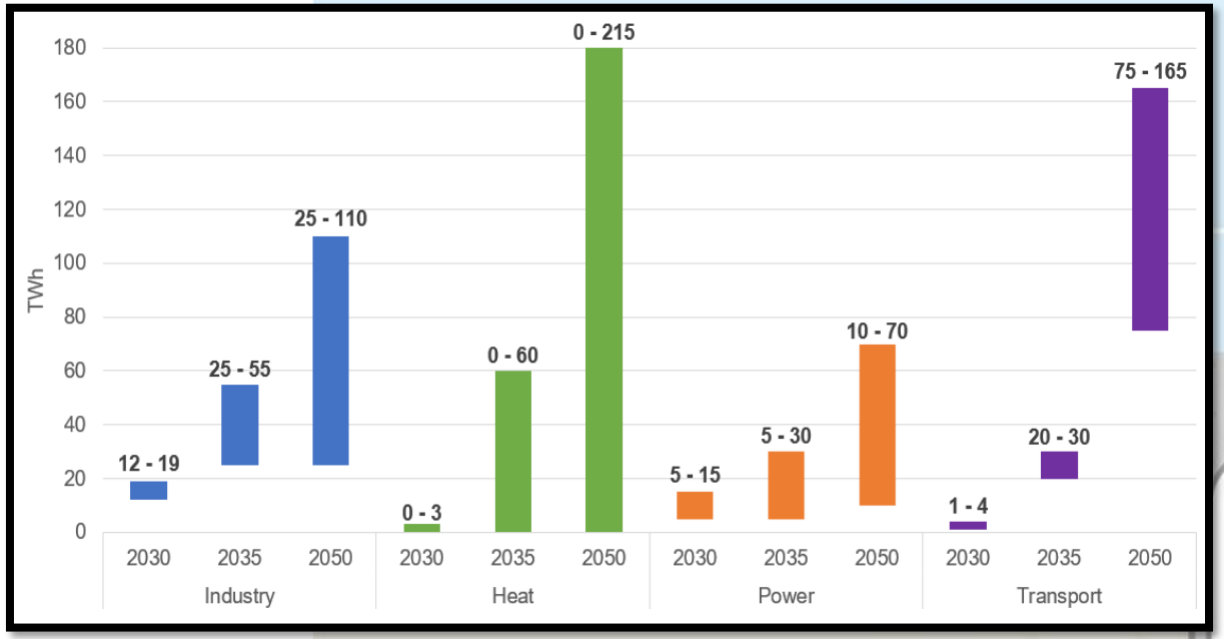
A form of long duration energy storage (LDES)



Storage capacity and discharge durations of proven storage technologies
IEA (2013)

Geological Hydrogen Storage

A grid balancing mechanism to accommodate variable demand



Forecasted UK hydrogen demands by sector in 2030, 2035 and 2050
DESNZ (Dec 2023)

Study Overview

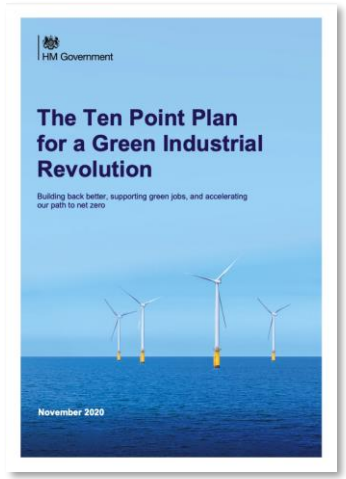
Building a Strategic Case for Investment in the East Coast Cluster

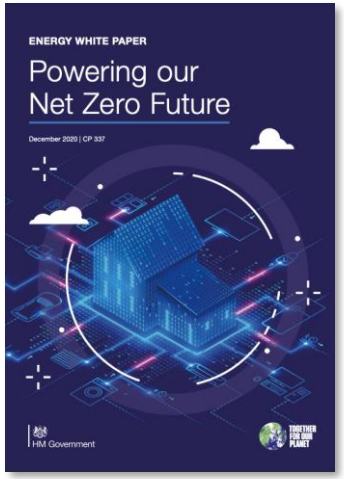
- **Client:** Industrial Decarbonisation Research and Innovation Centre (IDRIC)
- **Collaborators (Dec 2023 to Feb 2024):**
  - **Arup:** Energy Infrastructure (HW & AK) x Geotech/Rock Mechanics (JT, CG & MN) x Programme & Project Management (CH) x Digital Advisory (JS)
  - **Academic Partner:** University of Edinburgh (Katriona Edlmann & John Low)
  - **Non-Academic Partner:** British Geological Survey (Tim Armitage; former Arup!)
- **Drive:** *Establishing the case for change to ensure we have the storage required to support our hydrogen ambitions, that are intrinsically linked to our ability to reach legally-binding net zero targets.*

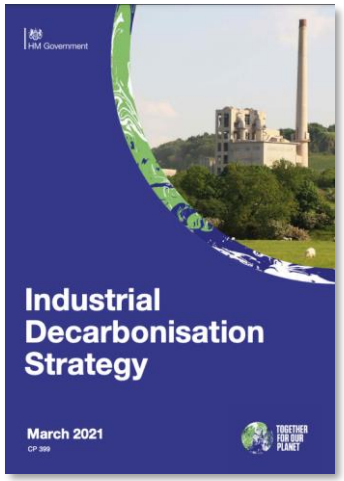
UK Hydrogen Storage

What are our hydrogen (storage) ambitions and how do they link to net zero?

*Includes a hydrogen economy roadmap with mention of hydrogen storage

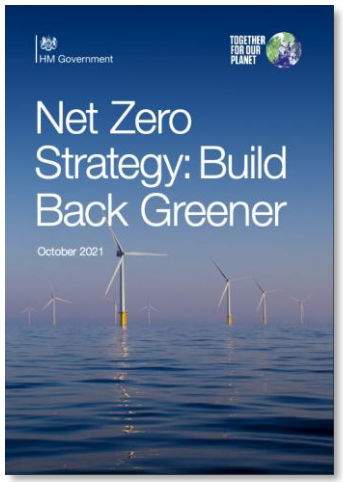


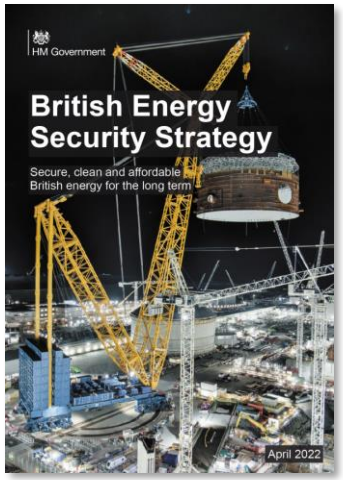




Nov 20

Aug 21





Oct 21

Dec 23

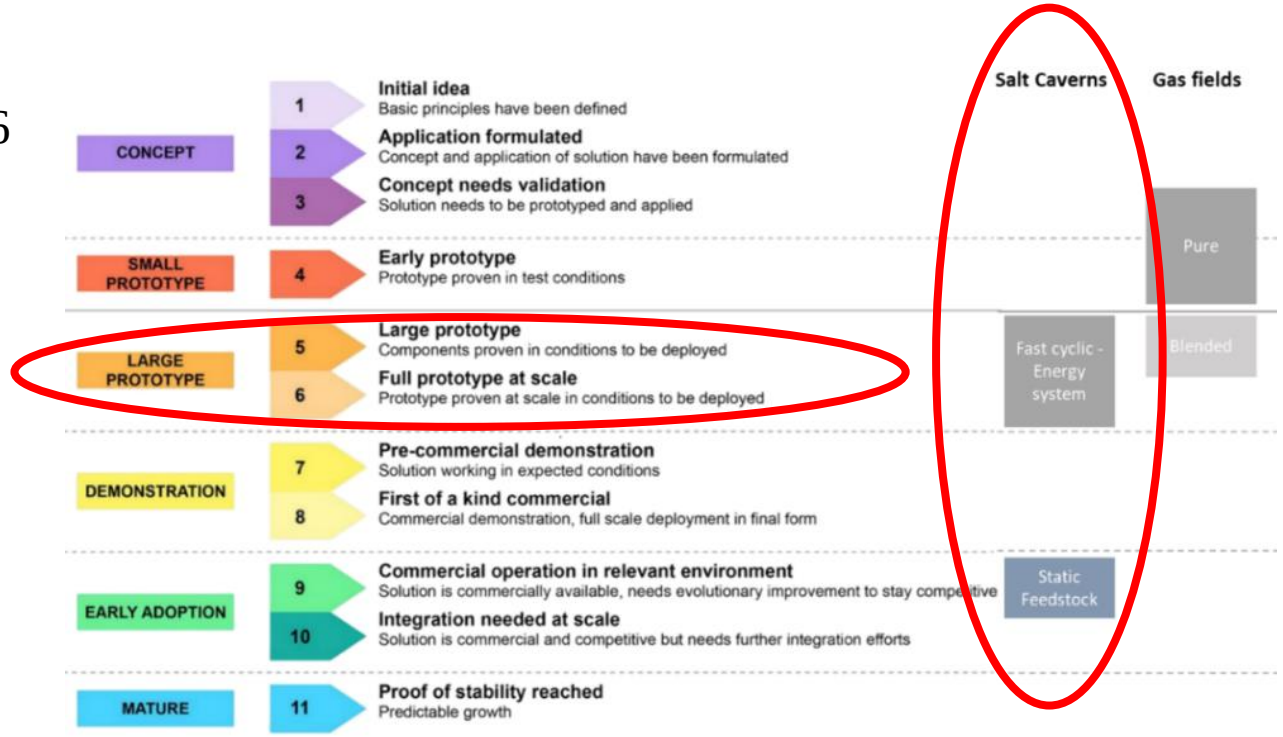
There's only 26 years to 2050

Research Focus

The need for large-scale hydrogen storage in the UK

- UK 2050 hydrogen storage forecasts:
  - **National Grid FES 2023 (Jul 2023):** 12 – 56 TWh
  - **The Royal Society: Large-Scale Electricity Storage (Sep 2023):** 60 – 100 TWh

  (cf. 2022 natural gas demand of ~800 TWh):
- Hydrogen storage capacities for context:
  - Above ground vessel (up to ~0.00003 TWh)
  - **Salt cavern (~0.03 – 0.2 TWh)**
  - Depleted gas field, *Rough* (~12 TWh)
- **Focus:** *To identify the need for storage technologies and the pace of delivery required to meet demand.*



Overview of Technology Readiness Levels (TRLs) for different UHS technologies
IEA Technology Collaboration Programme (TCP) (Apr 2023)

The UK East Coast Region

Teesside, the Humber and an abundance of suitable salt deposits for salt cavern development

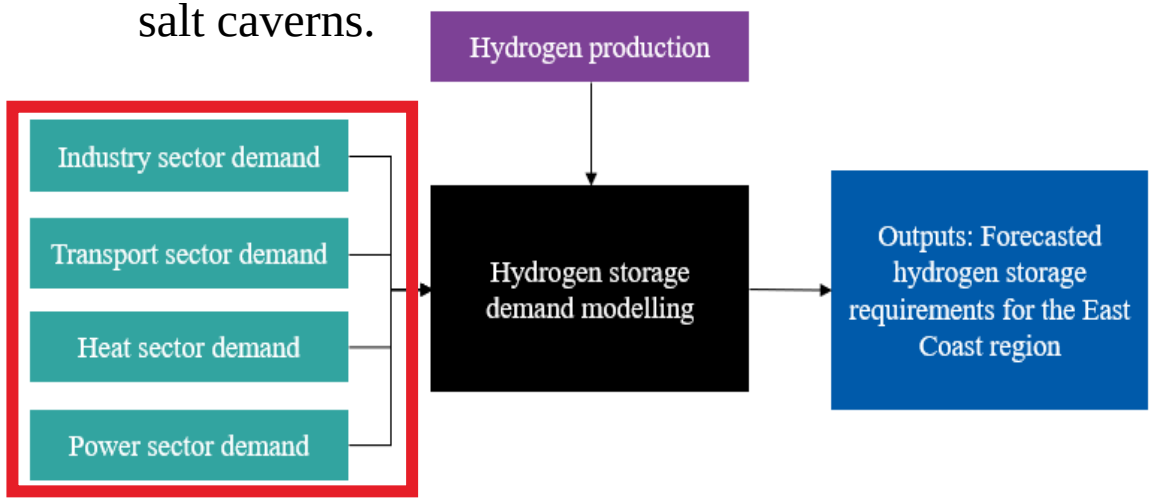
- Why the East Coast?
  - Abundance of suitable salt deposits for salt cavern development.
  - Proximity to Track-1 (Teesside/East Coast Cluster) and Track-2 (Viking CCS) CCUS Clusters: ‘relatively certain’ future hydrogen demand.
  - Several design studies exploring the development of key enabling infrastructure, e.g. East Coast Hydrogen Delivery Plan.

East Cost Hydrogen Delivery Plan system boundary
Cadent, Northern Gas Networks & National Gas (Nov 2023)

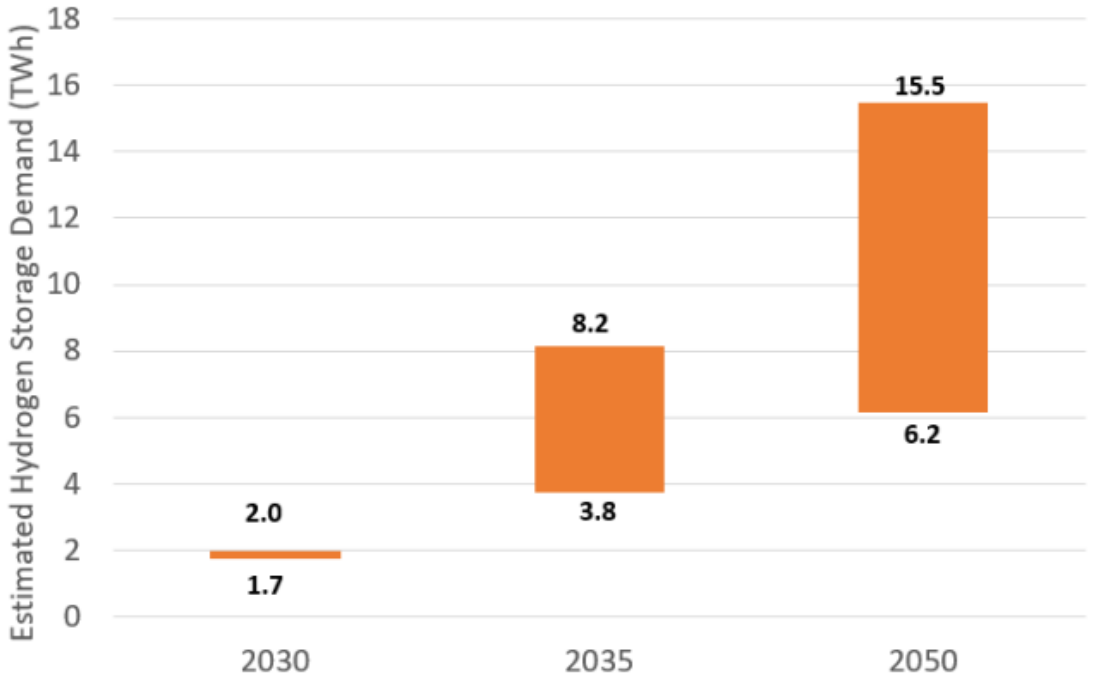
WP1: Hydrogen Storage Demand Modelling

Energy Infrastructure

- How much hydrogen storage demand is required in the East Coast region?
  - Localised hydrogen storage demand modelling for low/high scenarios for 2030, 2035 and 2050.
  - **By 2035, around 3.8 – 8.2 TWh of H2 storage demand** was estimated – it's a 'now problem', especially given the up to 10-year lead time for salt caverns.



Block diagram of hydrogen storage demand model
Arup

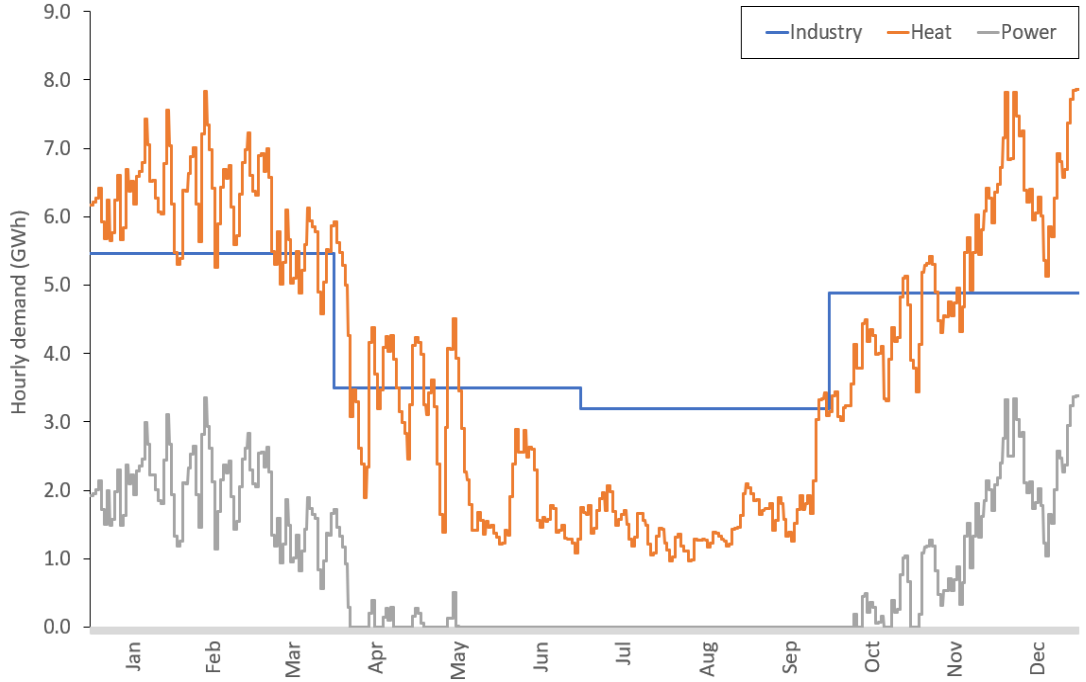


Forecasted hydrogen storage requirements for the East Coast region
Arup

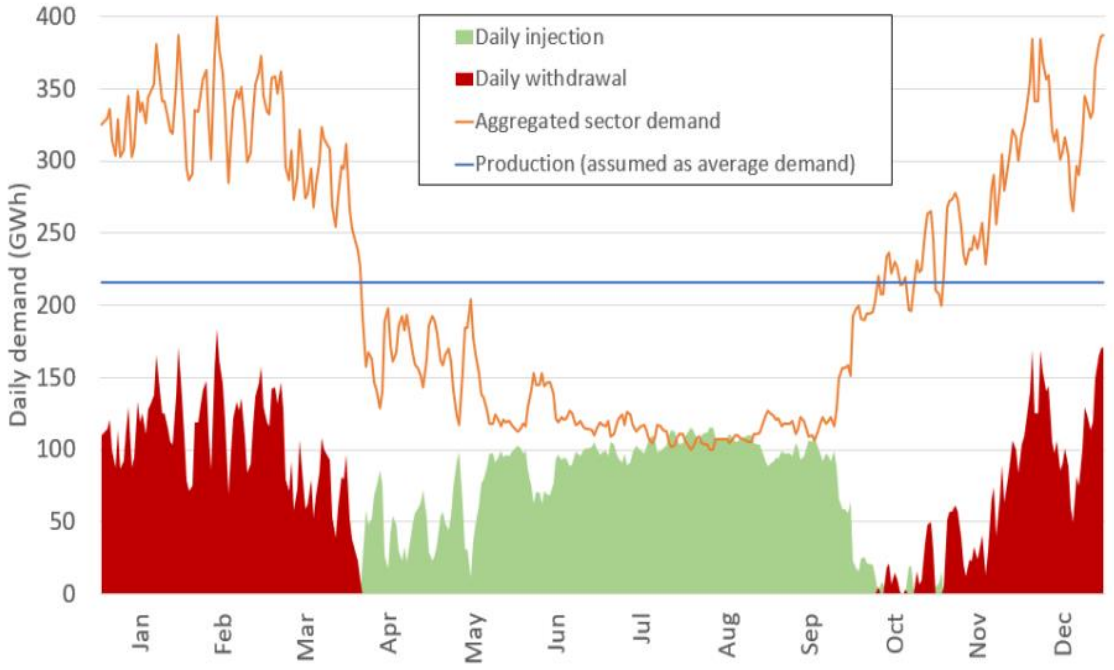
WP1: Hydrogen Storage Demand Modelling

Energy Infrastructure

While these plots highlight a high hydrogen demand scenario, our study also explores a low hydrogen demand scenario – full details included in our soon-to-be-published report!



Assumed sectoral hydrogen demand profiles in the East Coast region (2050 high hydrogen demand scenario)
Arup

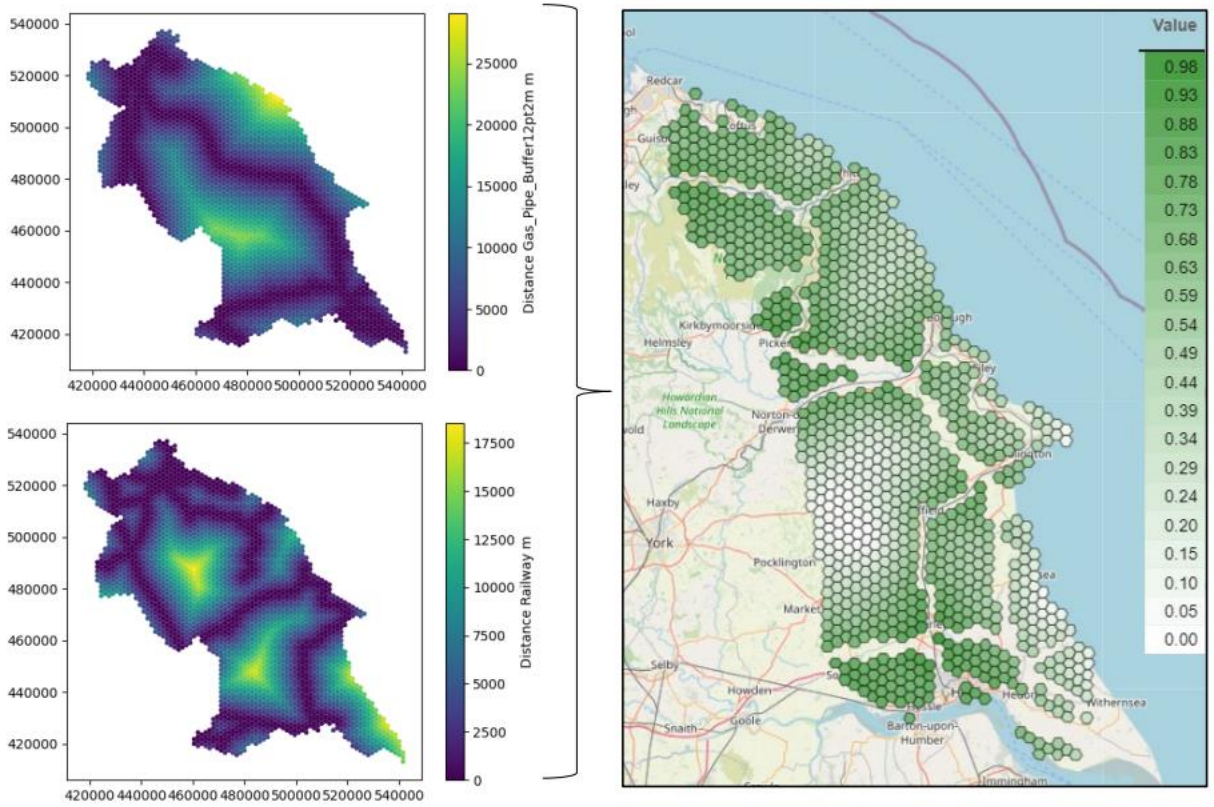


Daily temporal hydrogen production and demand matching with production at average demand (2050 high hydrogen demand scenario)
Arup

WP2: Hydrogen Storage Capacity Modelling

Geotech/Rock Mechanics and Digital Advisory

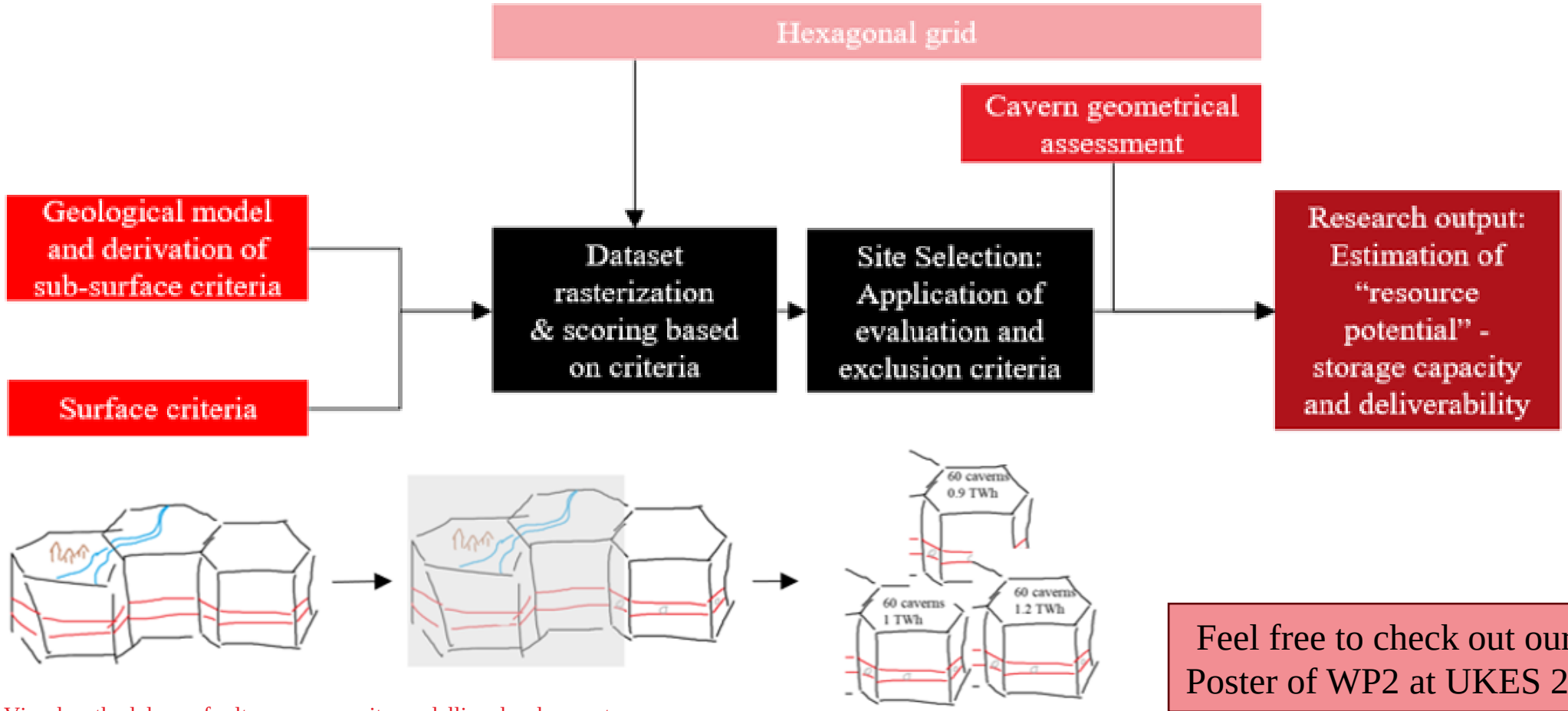
- Will salt caverns alone meet the demands required?
  - Interactive Power BI storage capacity evaluation mapping tool for Gov, policymakers & developers.
  - Previous studies range from 100-1000s TWh; **<u>our study estimates 22 – 48 TWh of theoretical resource potential</u>** by layering in further exclusions (>90% less actually available, even prior to site investigations).



Implementation of evaluation and exclusion criteria for subsurface and surface constraints mapping
Arup

WP2: Hydrogen Storage Capacity Modelling

Geotech/Rock Mechanics and Digital Advisory



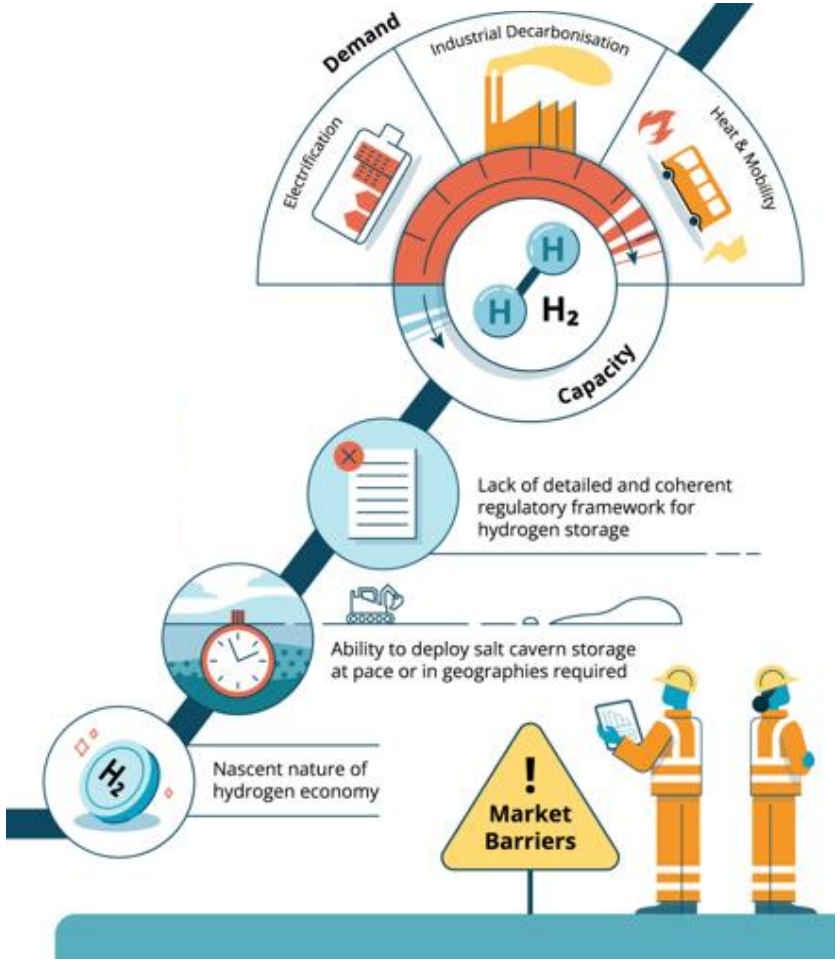
Visual methodology of salt cavern capacity modelling development
Arup

Feel free to check out our A0 Poster of WP2 at UKES 2024!

WP3: Establishing the Case for Change

Geotech/Rock Mechanics, People & Program Management, University of Edinburgh and British Geological Survey

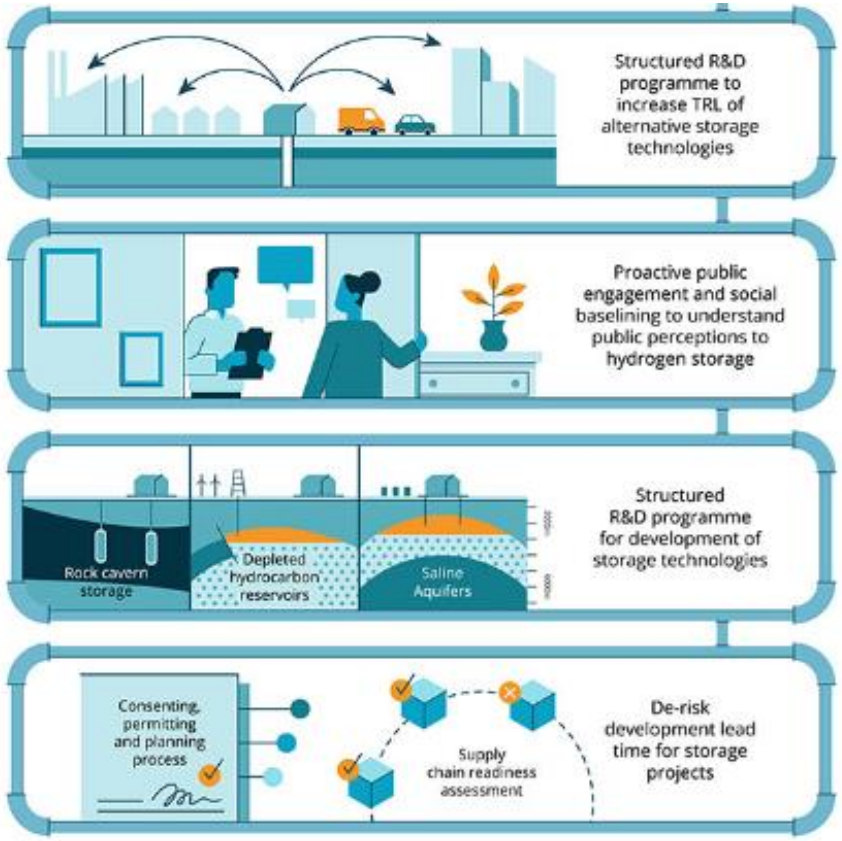
- Market barriers:
  - **Nascent nature of hydrogen economy** - uncertainty around how and when storage will be needed and the optimum mix of storage technologies.
  - **Ability to deploy salt cavern storage at pace** – large salt caverns can take up to 10 years to build and follow a complex development process.
  - **Lack of a detailed and coherent regulatory framework for hydrogen storage** – significant levels of up-front investment are required, far ahead of demand.



The Strategic Case for Intervention

What needs to happen to drive development?

- Minimum-regret interventions:
  - **Strategic planning -** to define the mix of storage technologies required and the optimum pace of development, establishing a consistent approach.
  - **Undertake proactive public engagement and social baselining -** to involve the community and assess attitudes, concerns and preferences.
  - **Implement a structured R&D programme –** for existing technology optimisation and to support the development of alternatives.
  - **Targeted interventions –** to de-risk the development lead time for storage projects, such as to the consenting, permitting and planning process.



Assessing the East Coast Cluster's Demand for Geological Hydrogen Storage:

The Strategic Case for Intervention

ARUP IDRIC THE UNIVERSITY of EDINBURGH

10GW low carbon hydrogen production by 2030

Decarbonise UK power system by 2035

Net Zero by 2050

All underpinned by long duration hydrogen storage

Strategic Context

Without strategic interventions, storage capacity will not keep pace with demand, putting UK Net Zero targets at risk

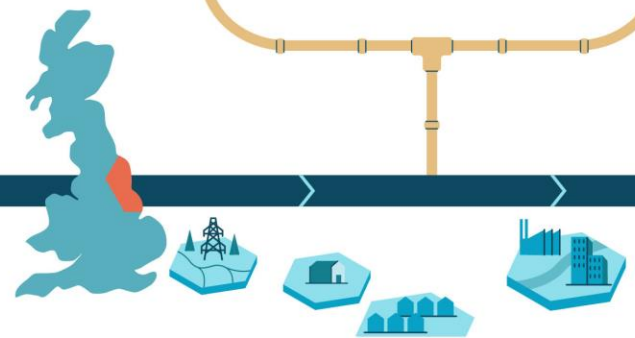
Research Findings

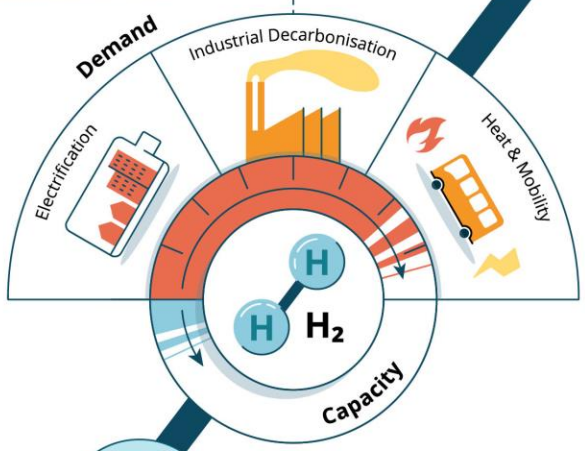
An assessment of the likely storage demand and workable capacity within the East Coast Cluster has concluded the following.

Only 5-10% of 2035 storage demand in East Coast met by current planned projects

Deliverable capacity of salt cavern storage is potentially 90% less than previous estimates

- Intrinsic link between demand and storage
- Power and heat are biggest drivers for storage demand
- Local storage demand may be outweighed by national demand
- Salt deposits vary in quality and geographical distribution
- Operational envelope adds further limitations





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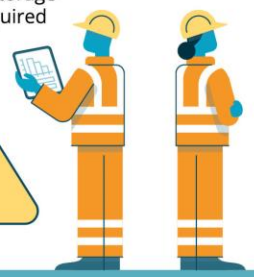
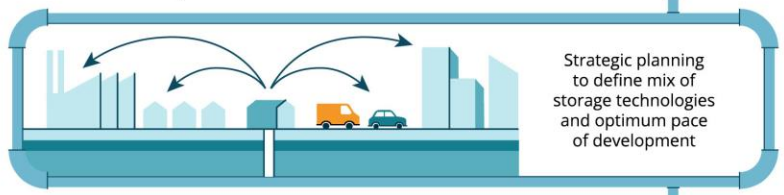
Market Barriers



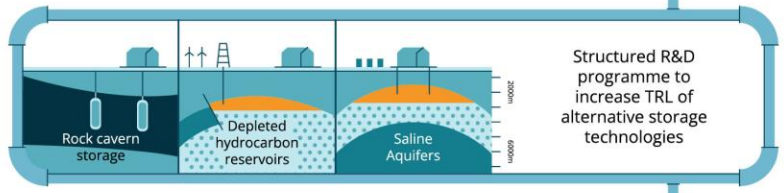
Interventions

A number of minimum-regret interventions have been identified to overcome the key barriers and allow forward movement.

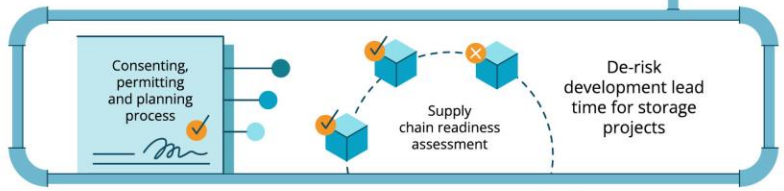


Strategic planning to define mix of storage technologies and optimum pace of development

Proactive public engagement and social baselining to understand public perceptions to hydrogen storage



Structured R&D programme to increase TRL of alternative storage technologies



De-risk development lead time for storage projects

Outcomes

- Unlock Innovation
- Job Creation
- Clean Growth
- Net Zero

Scriberia

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Demand · Industrial Decarbonisation · Electrification · Heat & Mobility · Capacity

- Lack of detailed and coherent regulatory framework for hydrogen storage
- Ability to deploy salt cavern storage at pace or in geographies required
- Nascent nature of hydrogen economy

Market Barriers

Interventions

A number of minimum-regret interventions have been identified to overcome the key barriers and allow forward movement.

- Strategic planning to define mix of storage technologies and optimum pace of development
- Proactive public engagement and social baselining to understand public perceptions to hydrogen storage
- Structured R&D programme to increase TRL of alternative storage technologies (Rock cavern storage · Depleted hydrocarbon reservoirs · Saline Aquifers)
- De-risk development lead time for storage projects (Consenting, permitting and planning process · Supply chain readiness assessment)

Outcomes

Unlock Innovation · Job Creation · Clean Growth · Net Zero

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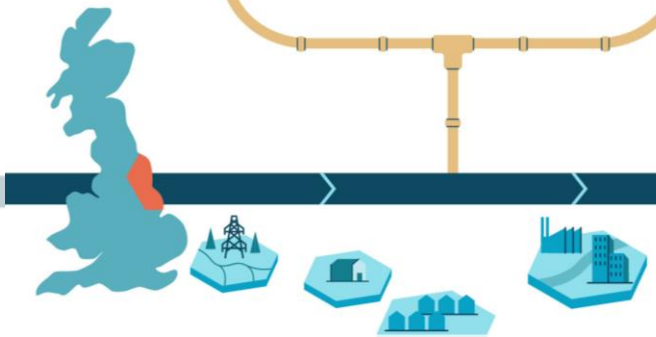

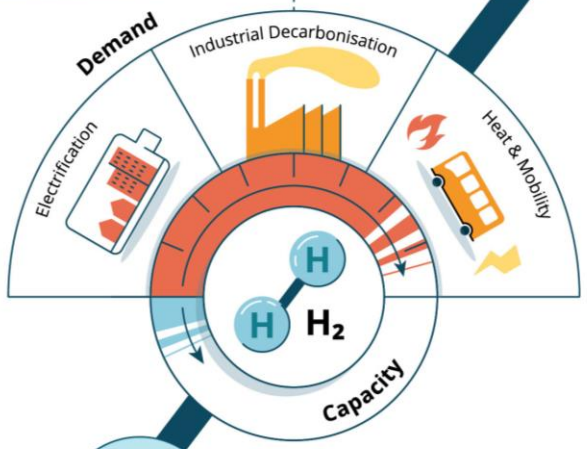

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  - Saline Aquifers
- De-risk development lead time for storage projects
  - Consenting, permitting and planning process
  - Supply chain readiness assessment

Outcomes

Unlock Innovation · Job Creation · Clean Growth · Net Zero

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Demand

Industrial Decarbonisation

Electrification

Heat & Mobility

Capacity

H_2

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Rock cavern storage

Depleted hydrocarbon reservoirs

Saline Aquifers

Structured R&D programme to increase TRL of alternative storage technologies

Consenting, permitting and planning process

Supply chain readiness assessment

De-risk development lead time for storage projects

Outcomes

Unlock Innovation

Job Creation

Clean Growth

Net Zero

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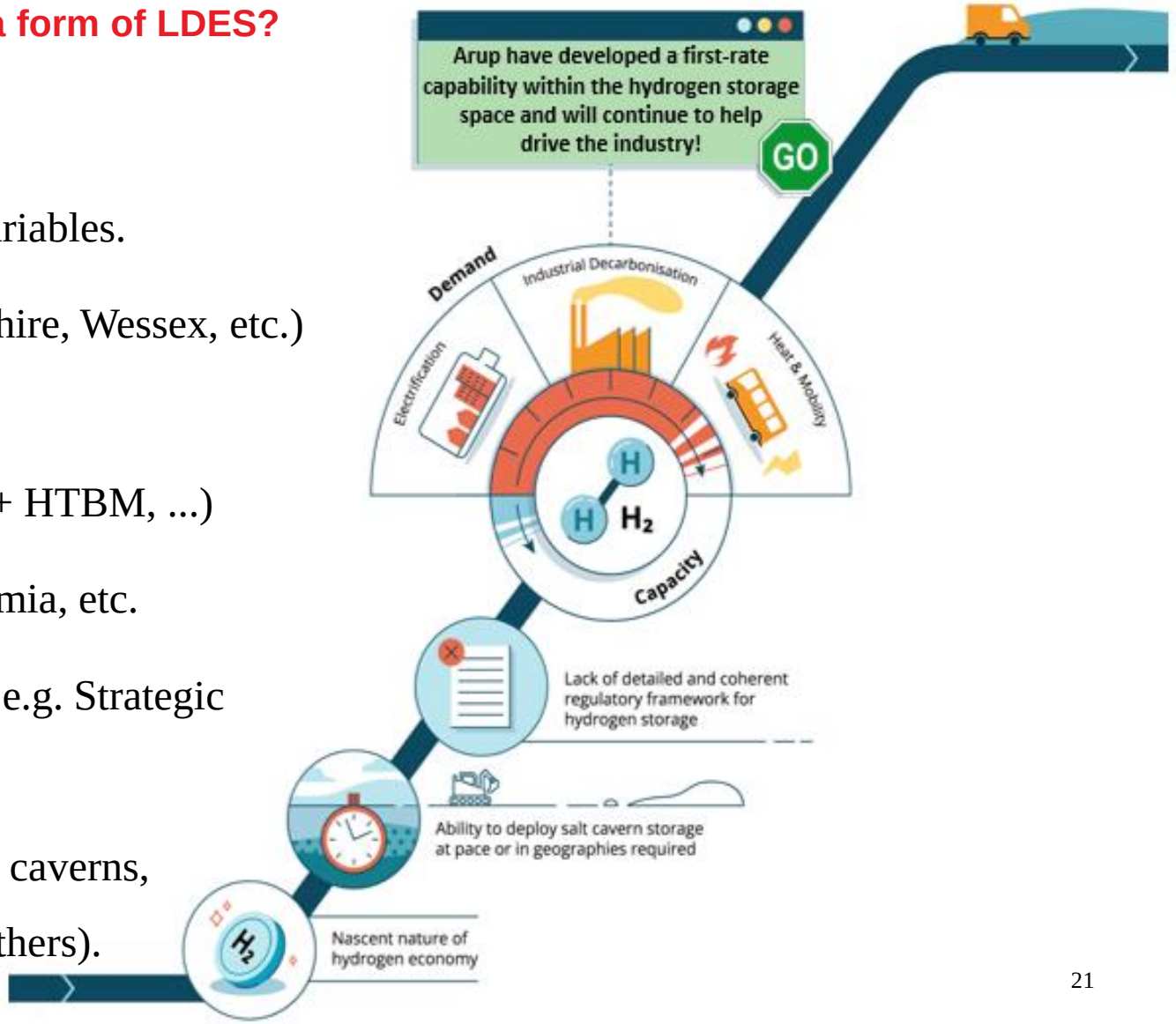
Now What?

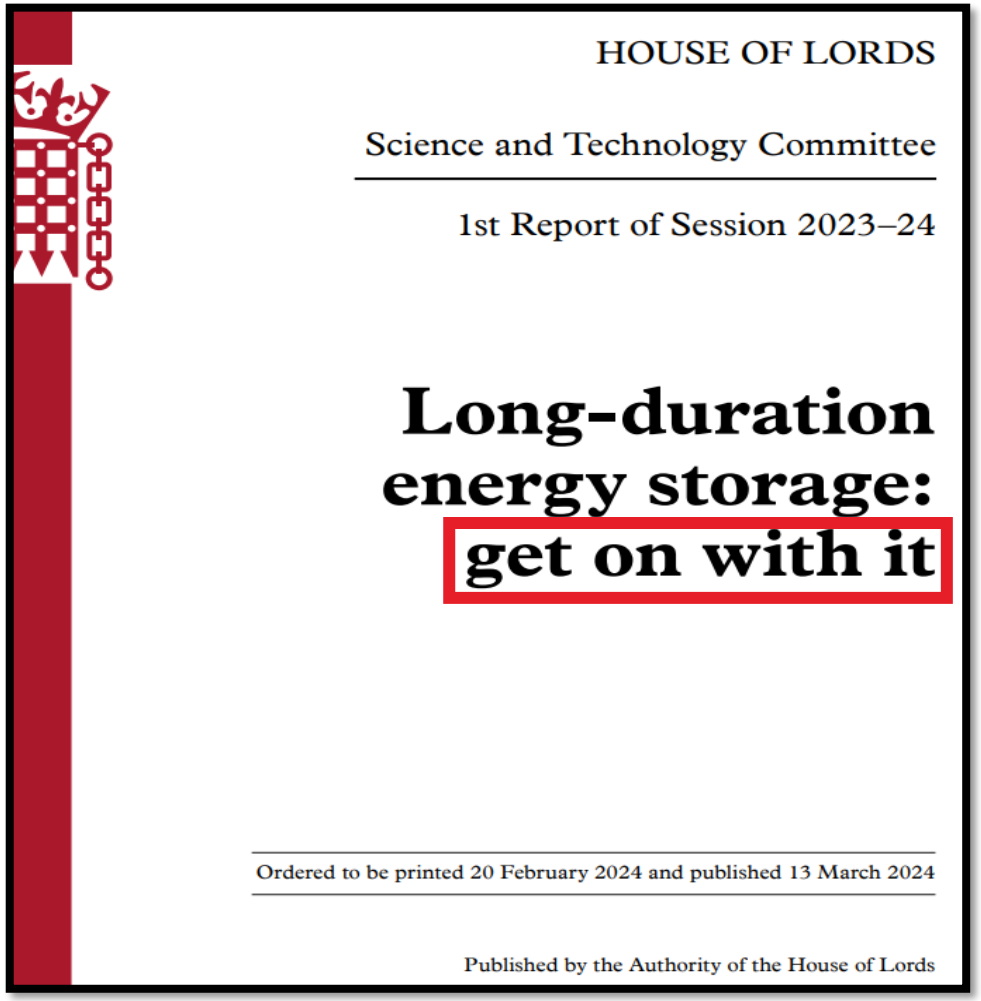
How do we realise the opportunity of hydrogen as a form of LDES?

- **Potential next steps to IDRIC study:**
  - Model refinement and introduction of more variables.
  - Modelling of other key UK regions (e.g. Cheshire, Wessex, etc.)
- **Wider industry:**
  - Hydrogen Storage Business Model (HSBM) (+ HTBM, ...)
  - Joined-up approach - DESNZ, industry, academia, etc.
  - Funding mechanisms and capital deployment, e.g. Strategic Innovation Fund (SIF).
  - Development of pilots and demonstrators (salt caverns, porous media - e.g. depleted gas fields - and others).



Hydrogen Storage - Let's Get On With It

Thank you for listening



HOUSE OF LORDS

Science and Technology Committee

1st Report of Session 2023–24

Long-duration energy storage: get on with it

Ordered to be printed 20 February 2024 and published 13 March 2024

Published by the Authority of the House of Lords

"A number of technologies could provide long-duration energy storage, but **for storage at scale over weeks and months, the front-runner is hydrogen**."

(House of Lords, March 2024)

Questions/Open Discussion?

Contributors to the study

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- Chemical & Process
- Hydrogen & CCUS

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- Hydrogen & Renewables

ARUP