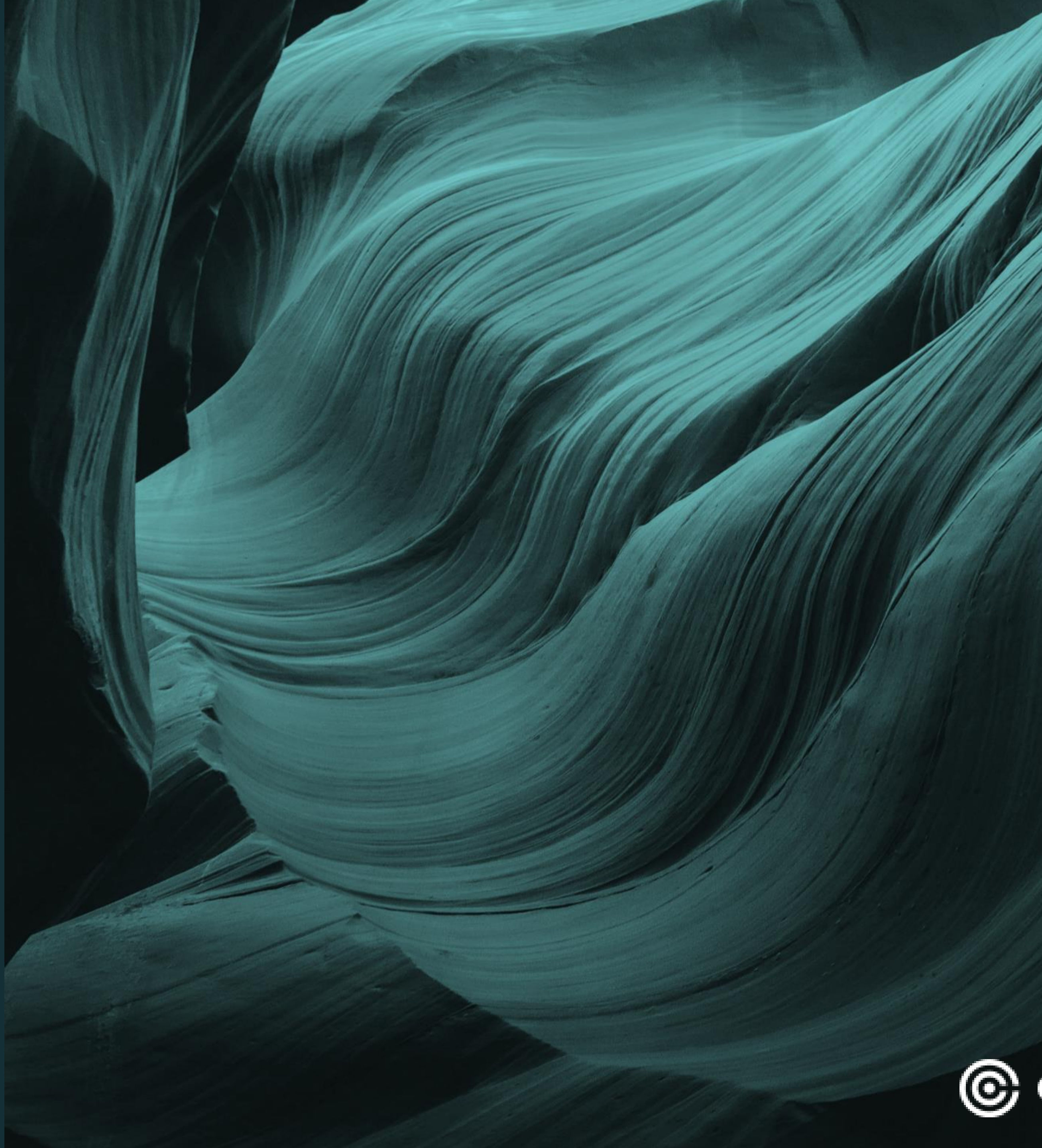
Why it is a good time for Geoscientists to get involved in CO_2 storage

Why exploration geophysical workflows are appropriate for CO2 storage,
Finding Petroleum, 18th May 2022

Chris Gent
Policy Manager
Carbon Capture and Storage Association



CCSA

Contents:

About the CCSA

- The Carbon Capture and Storage Association is unique in its representation of the entire CCUS value chain.
- Our focus is on:
    - Advocating for policy developments in UK, EU and internationally towards a long-term regulatory and incentive framework for CCS
    - Raising awareness of CCS as a vital tool in fighting climate change and delivering sustainable long-term clean growth
    - Driving progress on commercial-scale projects
    - A technology neutral approach (geological storage and utilisation, capture from industry, power, hydrogen, bioenergy, direct air capture and different capture technologies)
- Find out more at www.ccsassociation.org

CCSA Members

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CO_2 Storage

Shell, bp, equinor, GASSNOVA, CHRYSAOR, eni, NEPTUNE ENERGY, STOREGGA, PERENCO, HALLIBURTON, Schlumberger, TOTAL, SPIRIT ENERGY

Power & Industrial

Viridor, PHILLIPS 66, VEOLIA, VPI Immingham, BIOENERGY INFRASTRUCTURE GROUP, SIEMENS energy, CORY, ervia, SOLAR 21, BOC A Member of The Linde Group, sse Thermal, RWE, drax, AIR PRODUCTS, DOOSAN, enfinium, GIDARA ENERGY, uniper, FCC Environment, GE

Carbon Capture Developers

carbon clean, C-Capture, Carbon Engineering, PROGRESSIVE ENERGY, VELOCYS, AKER CARBON CAPTURE, Carbon8, MITSUBISHI HEAVY INDUSTRIES, calix

Engineering & Equipment

Baker Hughes, O·C·O TECHNOLOGY, BECHTEL, Endress+Hauser People for Process Automation, MOTT MACDONALD, Thornton Tomasetti, Worley, enpro SUBSEA, TEN TECHNIP ENERGIES, vallourec, B&W BABCOCK & WILCOX, 2JCP, olivervalves, wood., AFS

CO_2 Transport & Distribution

nationalgridESO, nationalgrid, interconnector fluxys, ABP ASSOCIATED BRITISH PORTS, NSMP NORTH SEA MIDSTREAM PARTNERS, ESB Energy International

Financial, Consulting & Others

DNV, ZURICH, RAS RISK & HAZARD MANAGEMENT, SCCS, ERM, UKCCS RESEARCH CENTRE, Dale Underwriting Partners, AFRY, TEES VALLEY COMBINED AUTHORITY, Scottish Enterprise, LATHAM & WATKINS LLP, CEIU, NPL National Physical Laboratory, Linklaters, SLAUGHTER AND MAY, PACECCS

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What is the purpose of the 'CCUS Delivery Plan 2035'?

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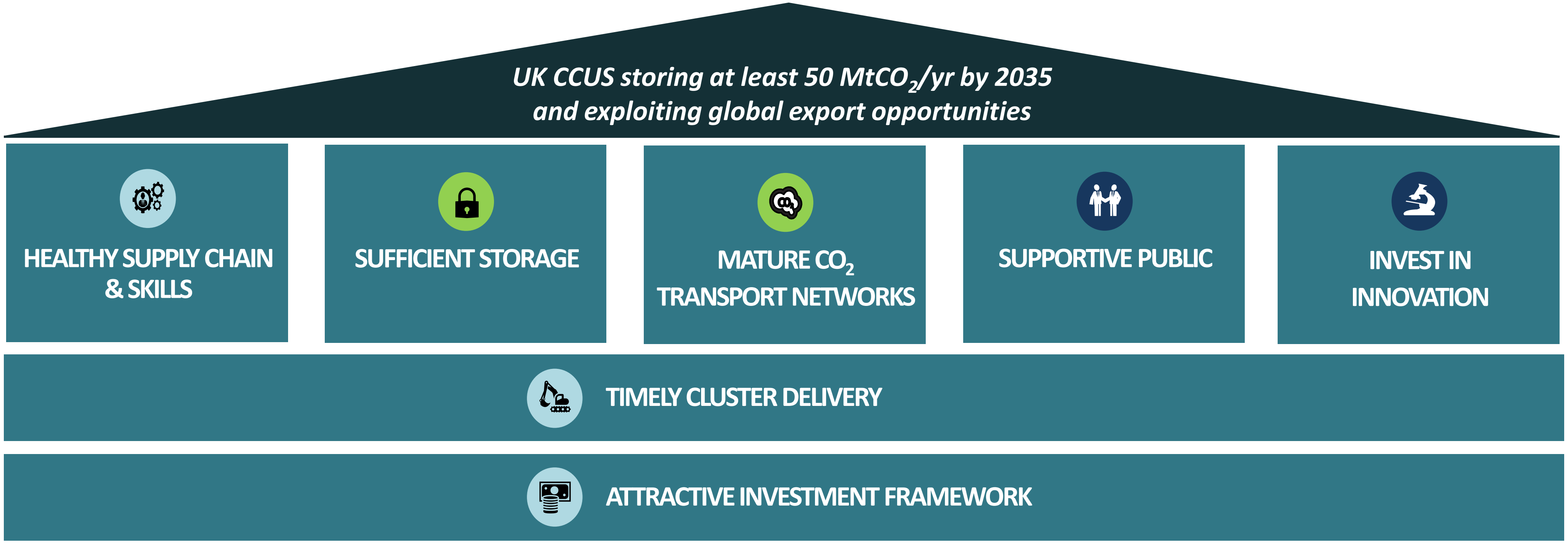
The report recommends how to best achieve the UK Government's 2035 CCUS ambition, in order to remain on track for Net Zero by 2050

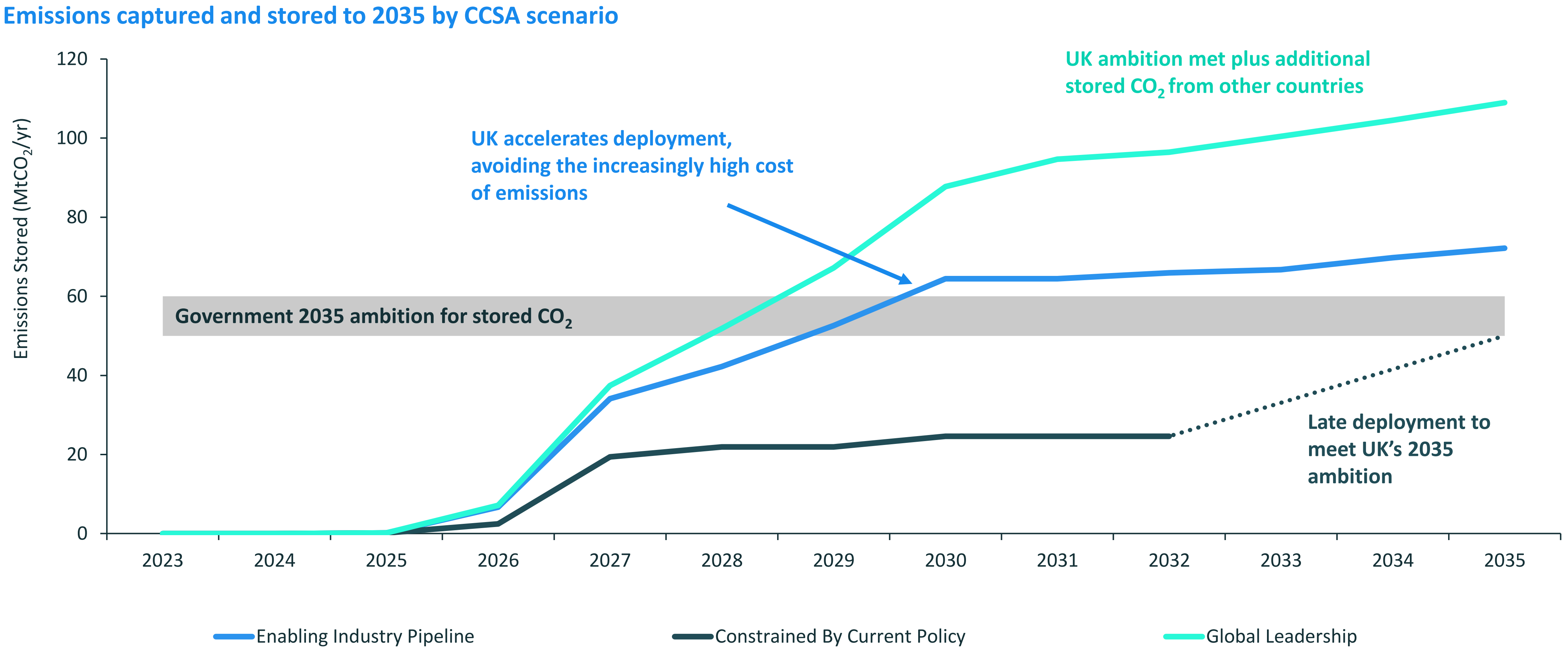
- The project had two strands:
    1. Profiling the recommended build-out rate of CCUS in the UK to reach the government's 2035 ambition; and
    2. Identifying actions required to enable its delivery

- Members, industrial clusters across the UK, and external stakeholders were engaged in a series of workshops to identify the building blocks for a successful industry and the enabling actions required



Build out rate analysis

Anonymised project data was aggregated from cluster leads to identify current and potential build-out rates



Industry can deliver a pipeline of storage and emitter projects that meets the 2035 ambition

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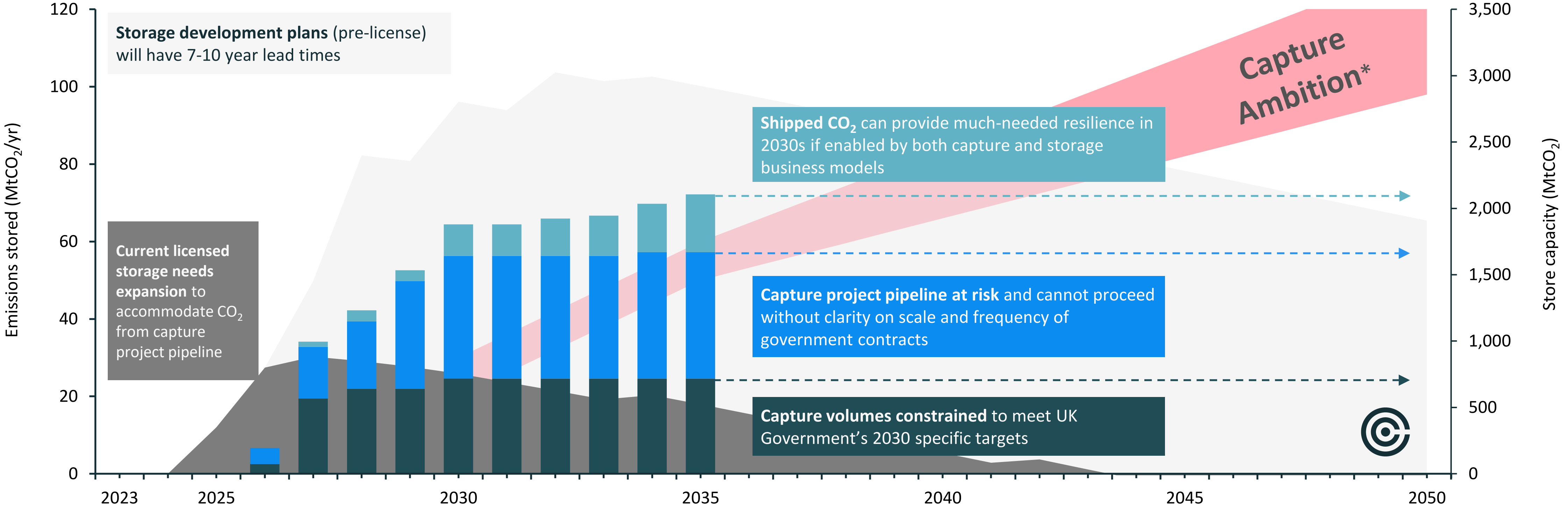
Constrained and additional emitter volumes and store capacity over time – 'Enabling industry pipeline' scenario

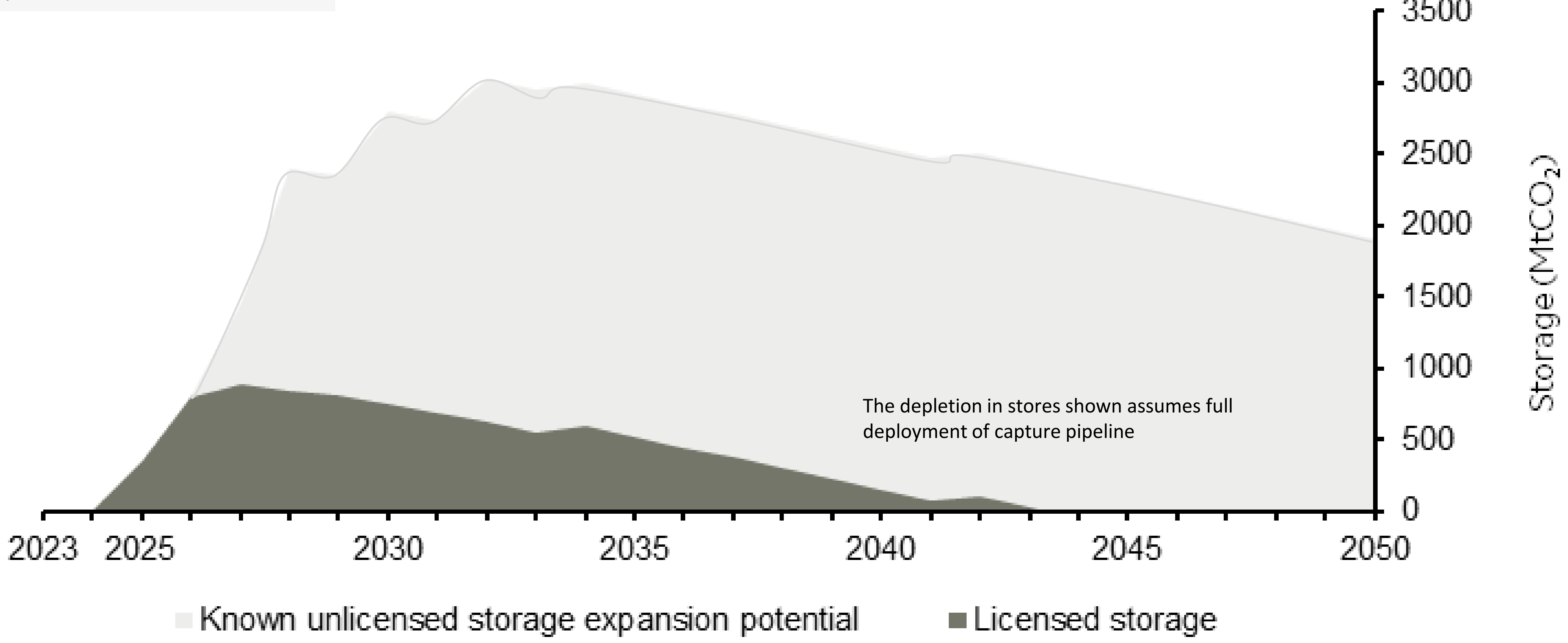


UK Gov. storage ambition (LHS)
Known unlicensed storage expansion potential (RHS)
Licensed storage (RHS)
Capture & storage constrained to meet 2030 ambitions (LHS)
Additional capture project pipeline (LHS)
Domestic shipping capture projects (LHS)

Notes: Emitter and storage data based on a mixture of publicly available information and information from projects. The timelines shown are indicative and based on an expedient Track-2 process launching this year, potential for FID in 2024 and operational in 2027. Licensed store capacity includes all licensed stores for both Track-1 clusters and other clusters. Unlicensed storage includes store volumes where license applications have been submitted, high confidence storage with a licence pending, or where approvals for licence expansion are required. Capture targets in 2030 and 2035 based on Net Zero Strategy; for 2050 targets refer to CCC targets, showing a range between the 'Tailwinds' and 'Widespread Innovation' scenarios

Projected Storage requirements for a 50Mt pa 2035 ambition

Storage development plans (pre-license) will have 7-10 year lead times



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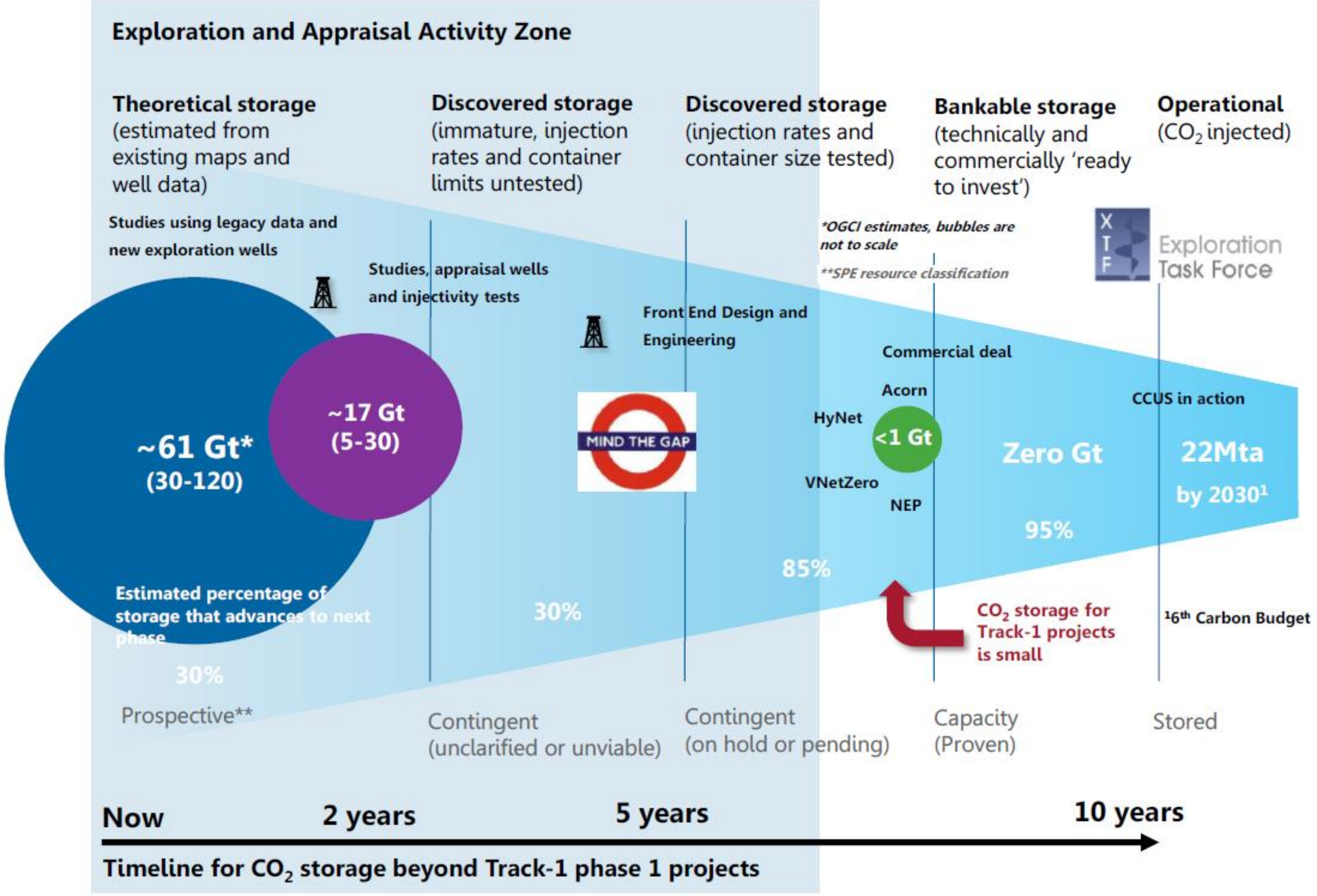
Contents:

Theoretical Storage to Operation – a 10 year journey



From: Exploration Task Force, 2021. Exploration and appraisal for CO2 storage sites in the UK. www.explorationtaskforce.org.uk

The role of the Geoscientist in a CCUS project

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Concept

Transfer to Government

Exploration

2D Seismic
3D Seismic
Legacy well data
Seismic reprocessing
Regional mapping
Velocity model
Structural model
Cap rock integrity
Geomechanical model

Appraisal

New 3D seismic
Appraisal well
Core samples and testing
Leak off test
Updated petrophysical data
Reservoir model (static & dynamic)
CO_2 migration model
Phase management
Capacity Assessment
Injectivity Assessment
Fault seal analysis
Compartmentalisation
Geochemistry
Injection scenarios
Abandoned well risk

Development

New 3D seismic
Injection well drilling
Production well drilling
Monitoring well drilling
Core samples
Petrophysical analysis
Fluid sampling
Shallow seismic survey
Injection testing
Validation
Verification
Interventions
Reservoir stimulation

Operation

Regular 3D seismic
Seismic reprocessing
Plume migration
Optimising injection
Pressure management
History matching
4D timelapse seismic
Capacity verification
Reservoir stimulation

Post-closure

Regular 3D seismic
Seismic reprocessing
Plume migration
History matching
4D timelapse seismic
Fault-seal monitoring

The UKCS – Exploring in a mature province

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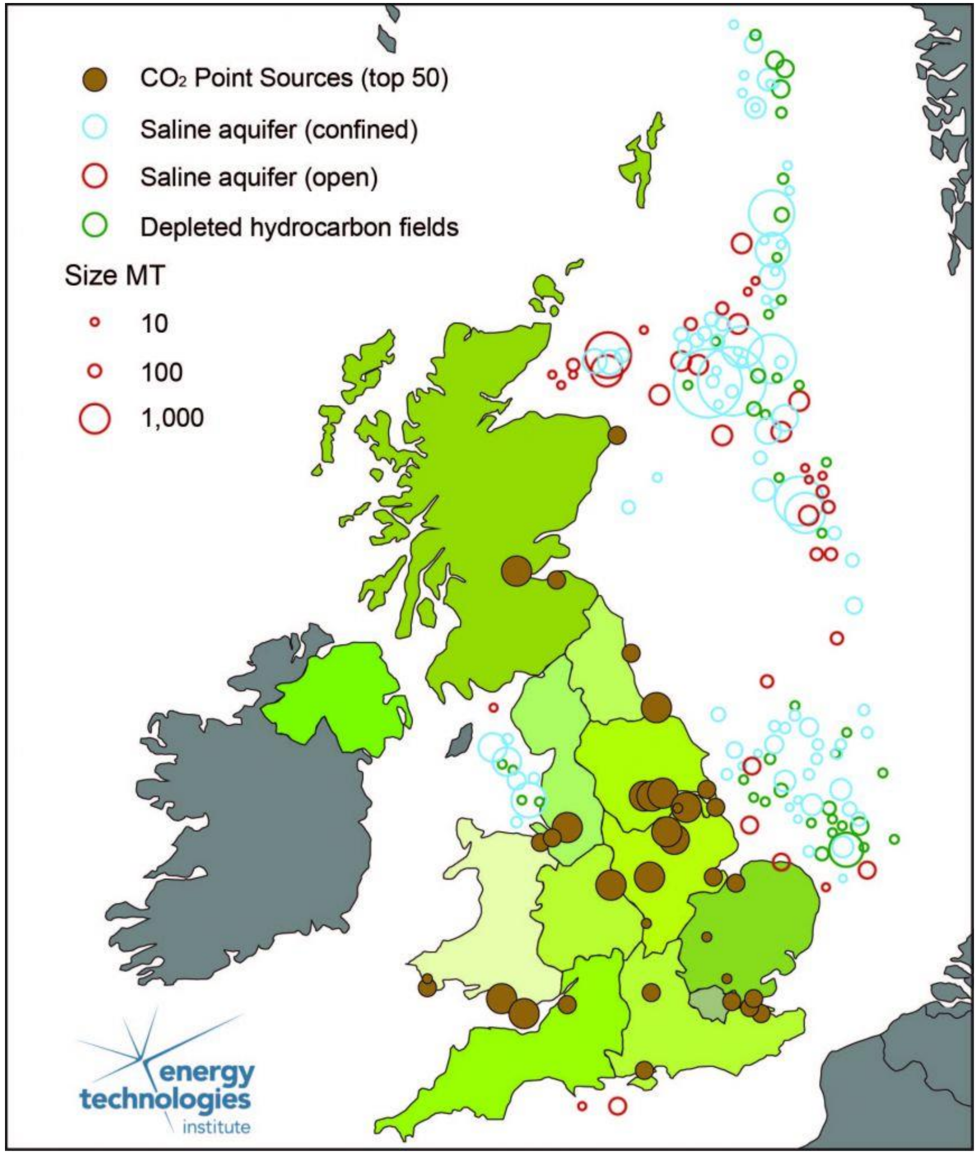
Description	Units	Min	Most Likely	Max	Source	Confidence (L,M,H)
Area	[km^2]	65.97	73.30	80.63		
Average Gross Thickness	[m]	243.56	250.91	259.24	PGS Surfaces	Medium
Estimated Relief	[m]		538.19		PGS Surfaces	Medium
Shape Factor			1.000			
Average Areal Net Sand	[frac]	0.98	0.99	1.00	BGS Shapefiles	Medium
Average Vertical NTG	[frac]	0.71	0.91	1.00	BGS held wells	Medium
Average Porosity	[frac]	0.05	0.14	0.24	BGS held wells	Medium
Gross Rock Volume	[$10^6 m^3$]					
Pore Volume	[$10^6 m^3$]					
Aspect Ratio						
Thickness Area	[$10^{-6} m^{-1}$]		3.4231			



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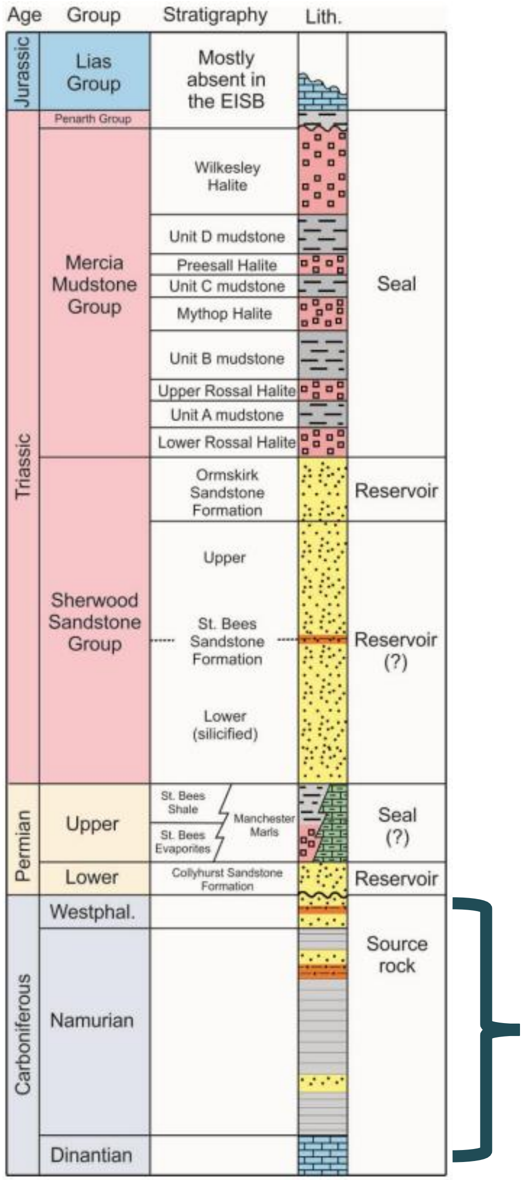
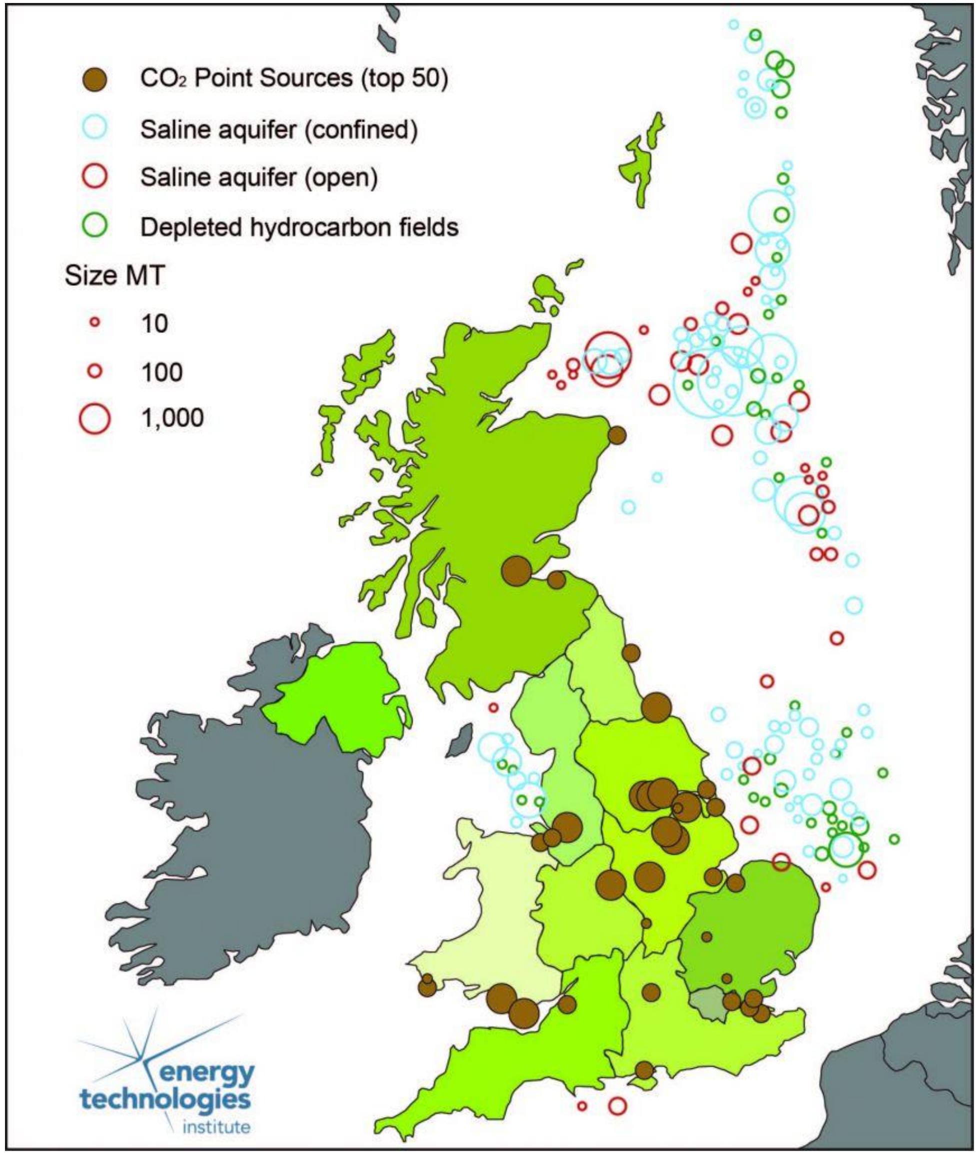
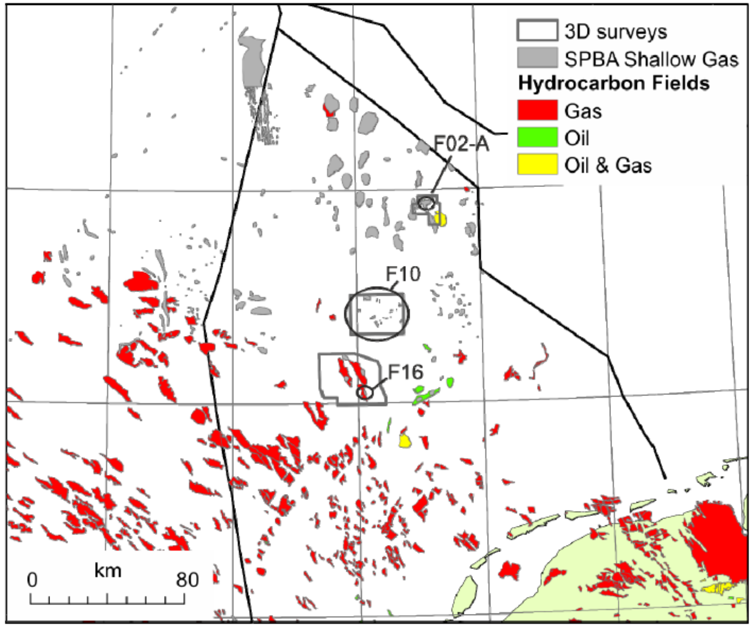
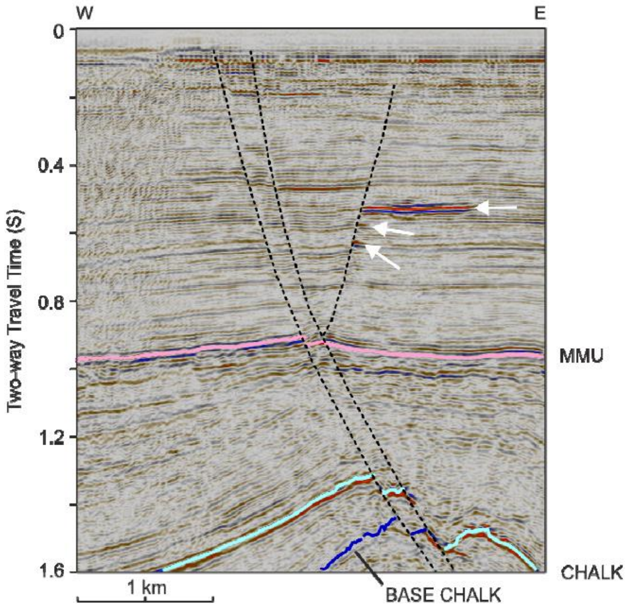
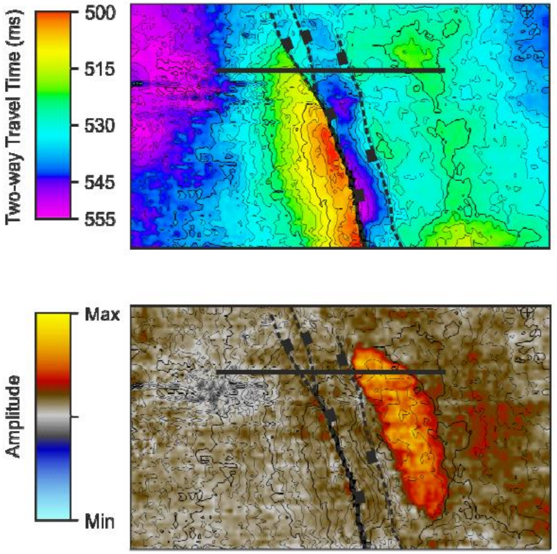


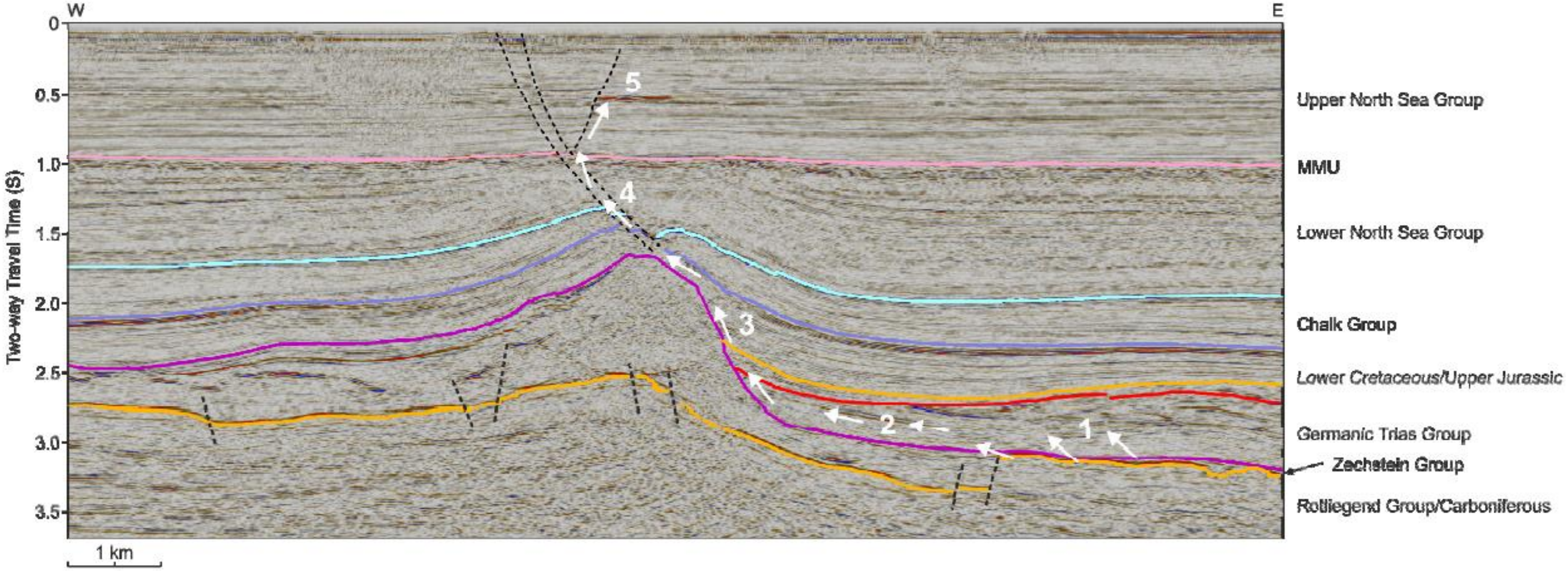


Pressure management – Fault seal integrity









From: Williams, J.O., & Gent, C.M.A, 2015. Shallow Gas Offshore Netherlands - The Role of Faulting and Implications for CO2 Storage. *Faults and Top Seals – Conference Almeria.*

Pressure management – Regional Stress Regimes

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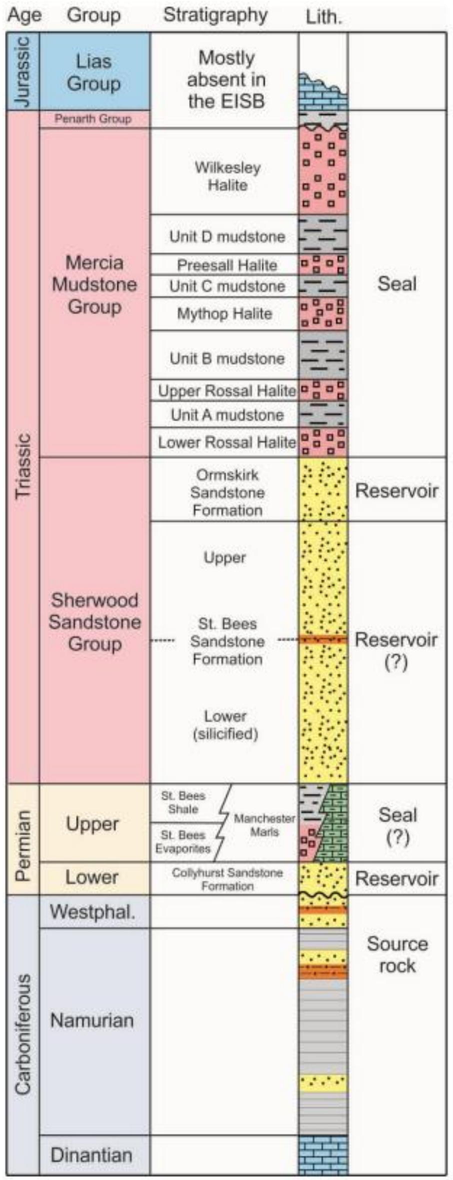
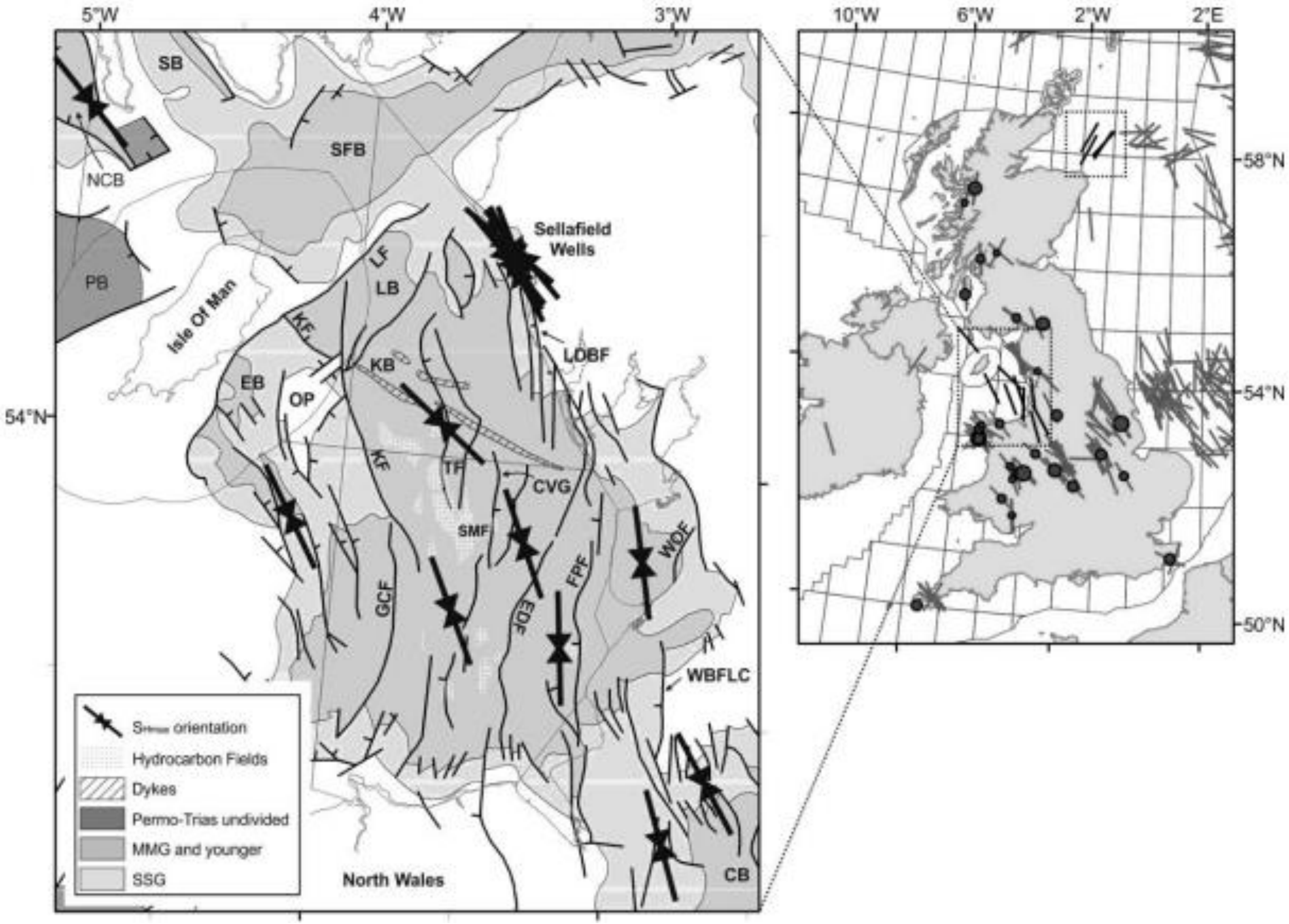
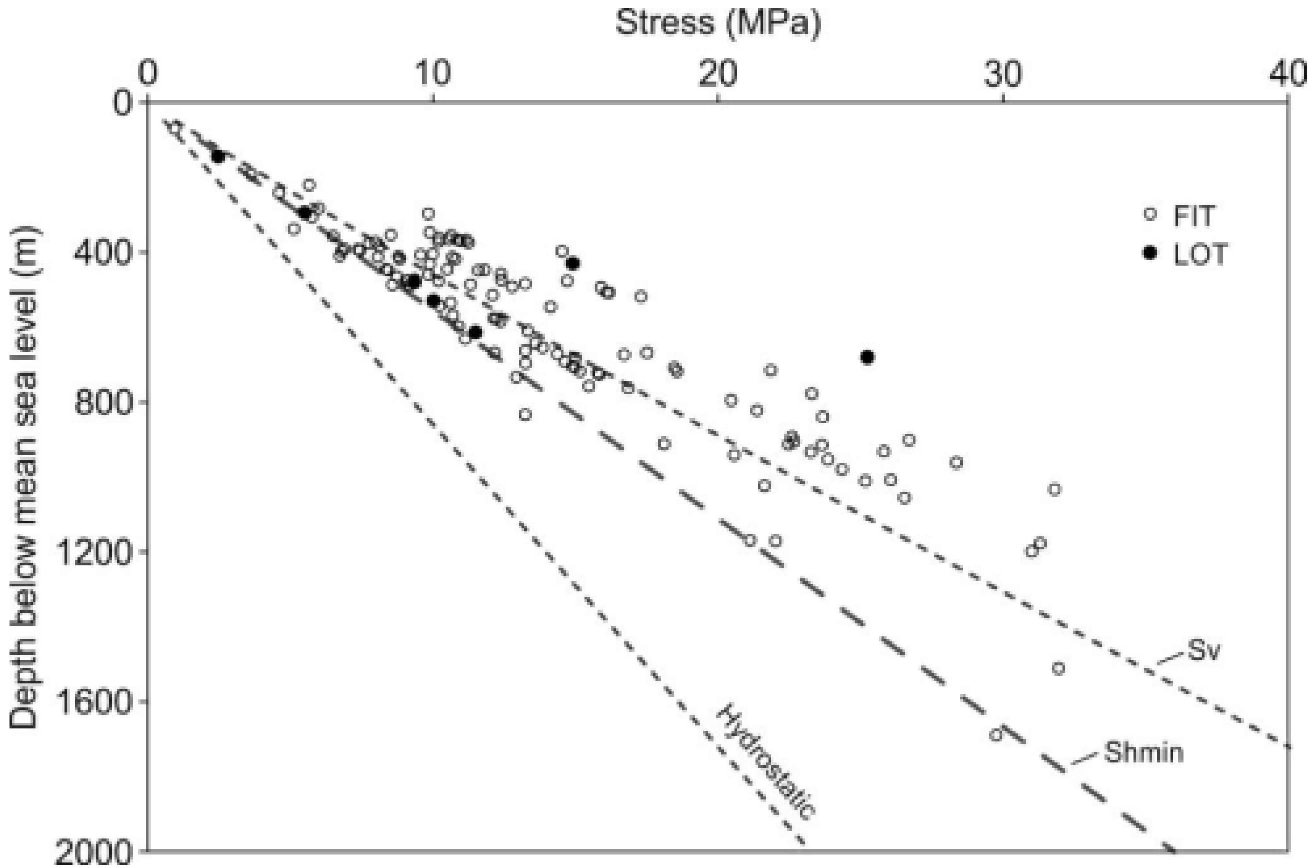
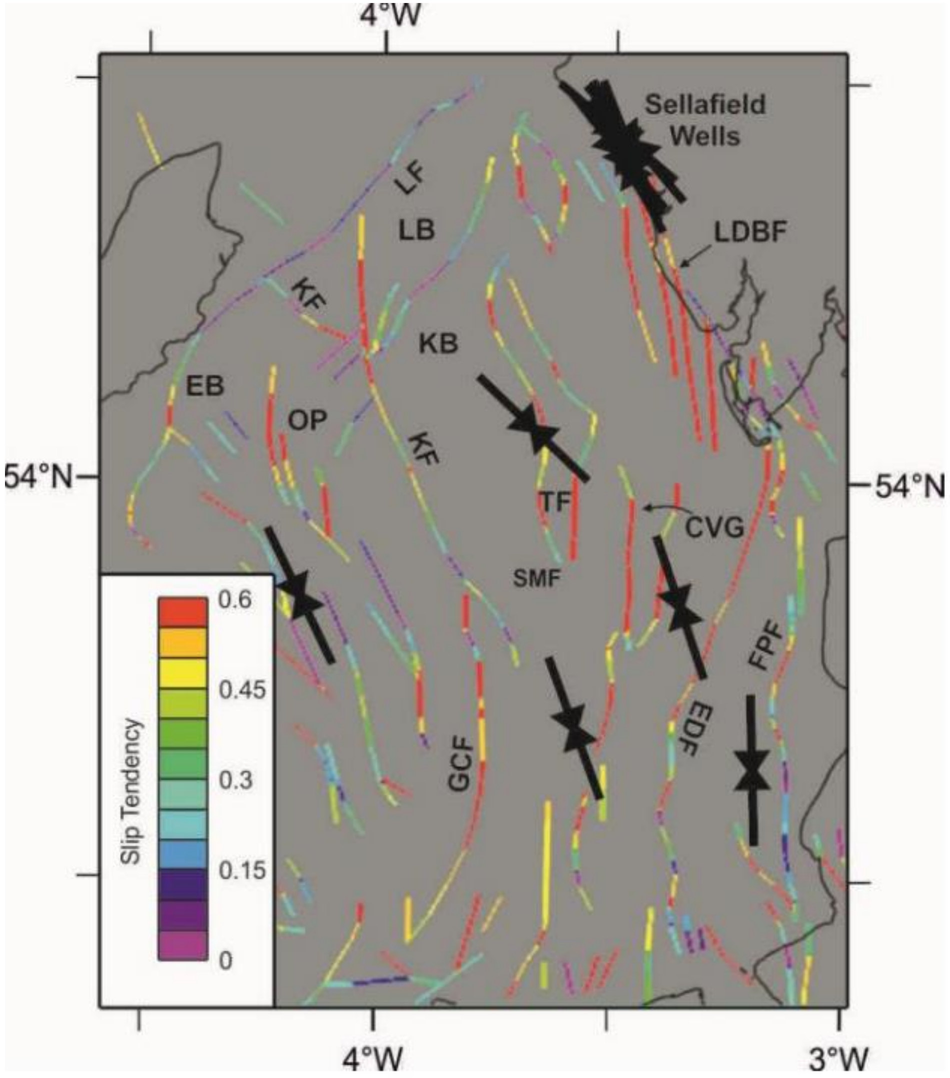




From: **Williams, J.D.O.**; **Gent, C.M.A.**; **Fellgett, M.W.**; **Gamboa, D.**. 2018 Impact of in situ stress and fault reactivation on seal integrity in the East Irish Sea Basin, UK. *Marine and Petroleum Geology*, 92. 685-696.

Pressure management – Regional Stress Regimes





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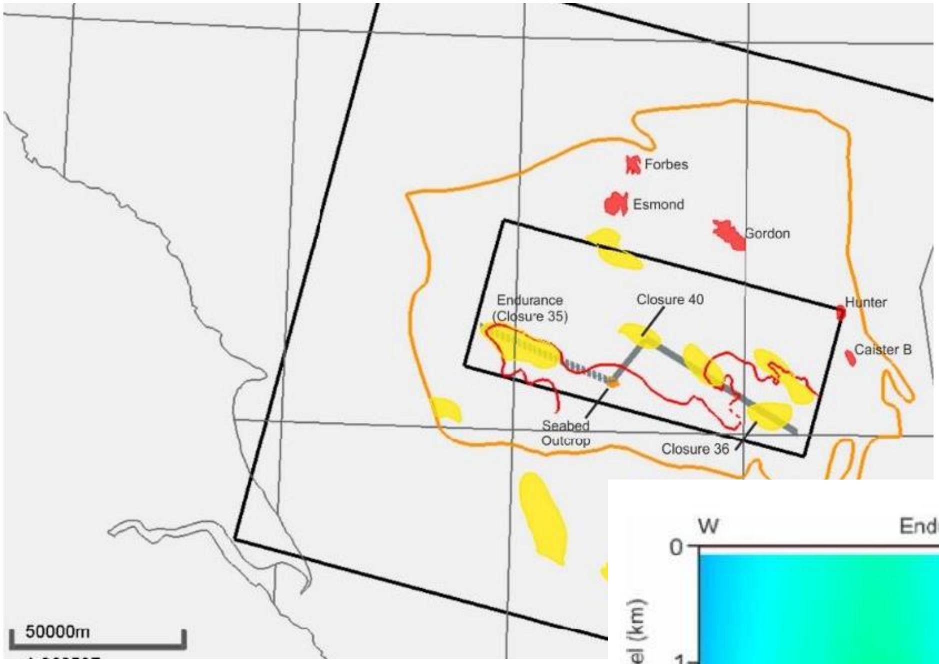
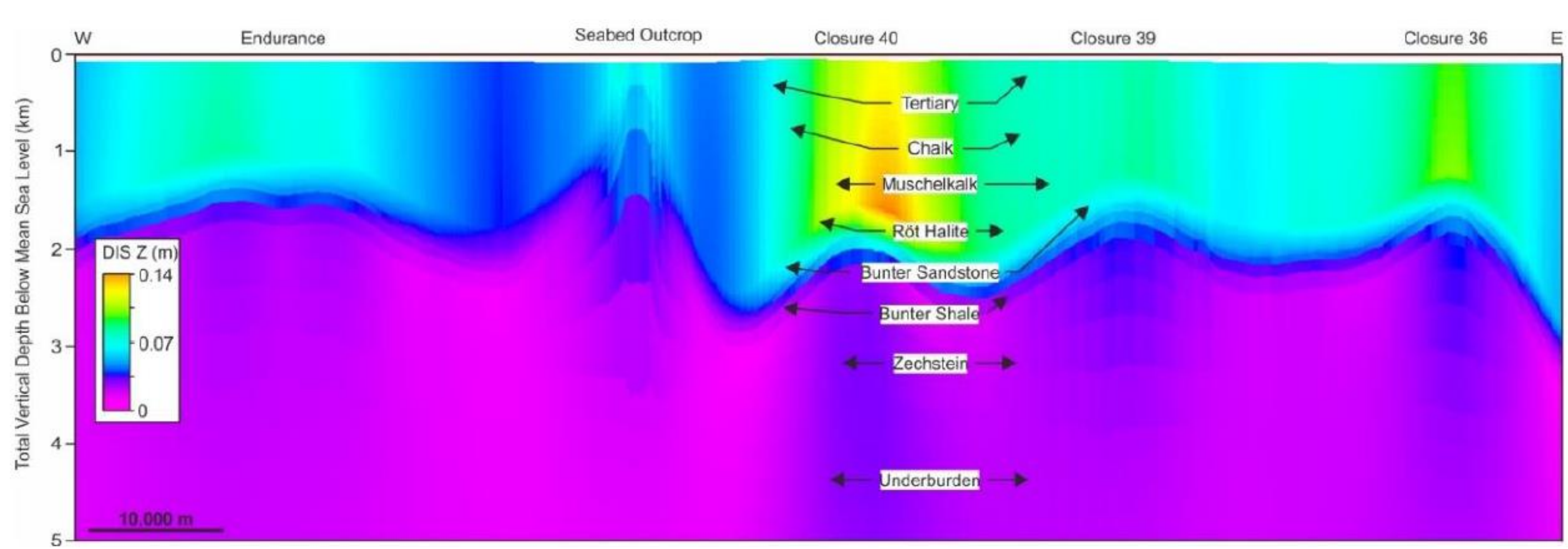
Pressure management – Regional Coupled Models

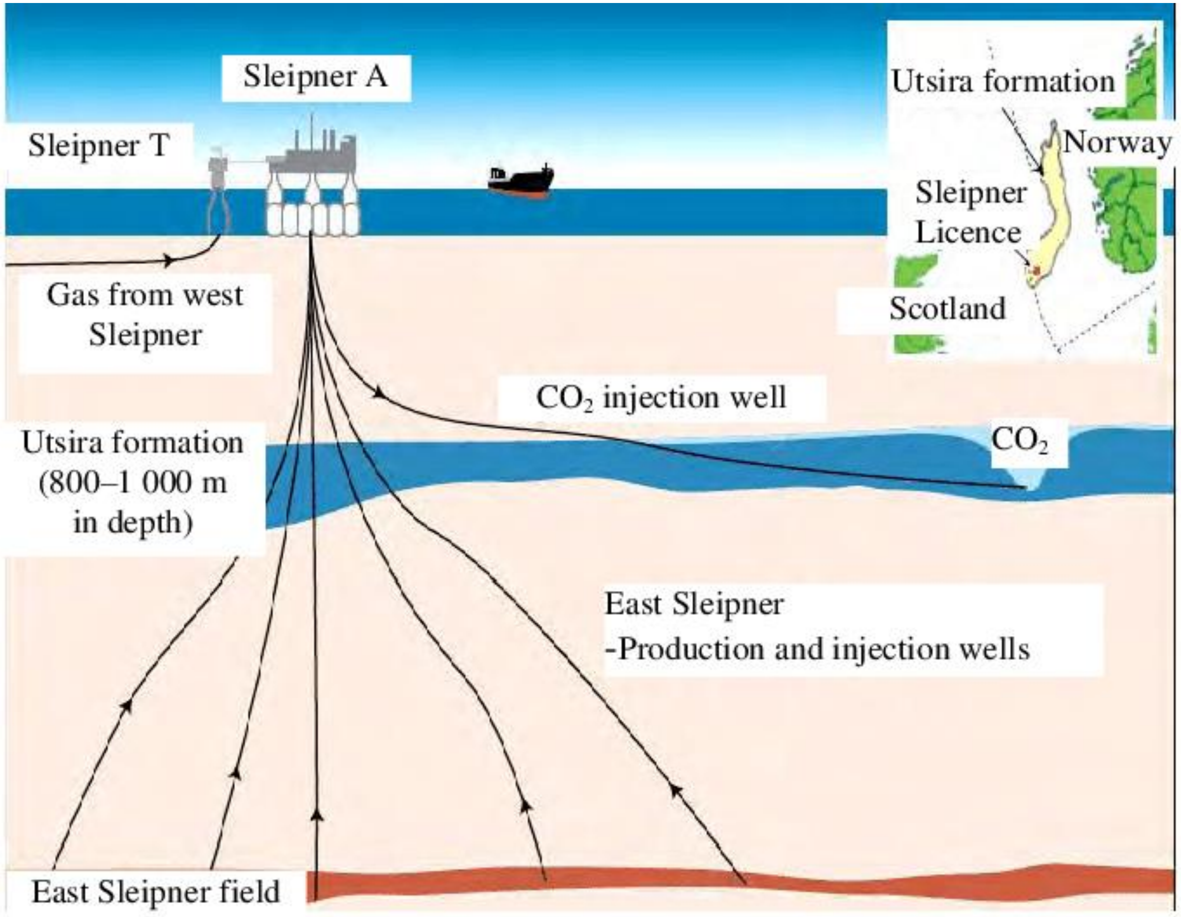




From: Williams, J.D.O.; Williams, G.A., Bridger, P. 2021. Regional geomechanical response to large-scale CO2 storage in an extensive saline aquifer formation. *EAGE 2nd Geoscience & Engineering in Energy Transition Conference.*

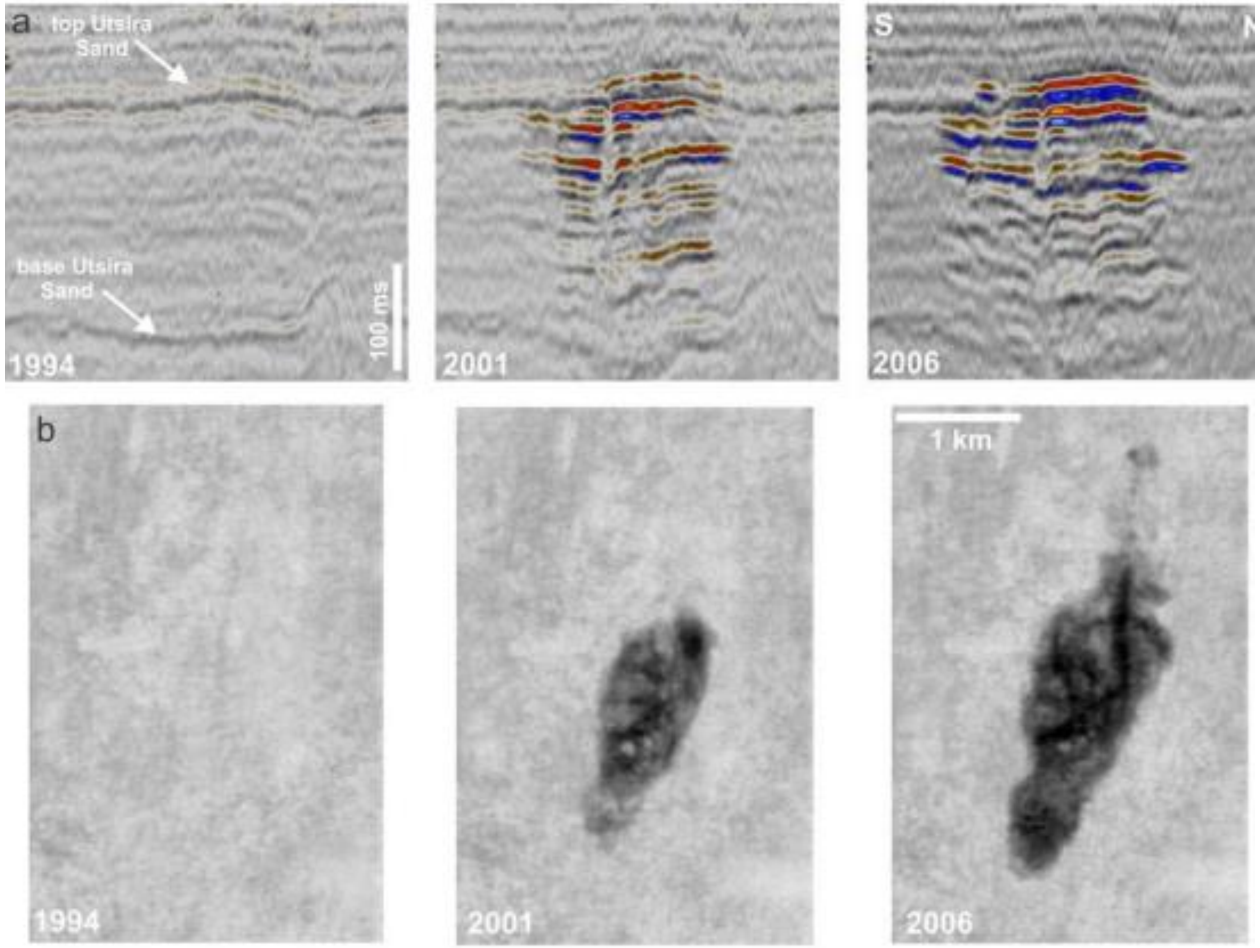
4D Timelapse Seismic - Sleipner

- CO_2 separated from natural gas from the East Sleipner Field
- CO_2 injection into the regional Miocene Utsira Sandstone Formation
- Shallow marine shelf deposit – with interbedded thin shale layers
- One single CO_2 injection well
- Injected ~1Mt p.a. since September 1996
- Regular 3D seismic surveys before and during CO_2 injection



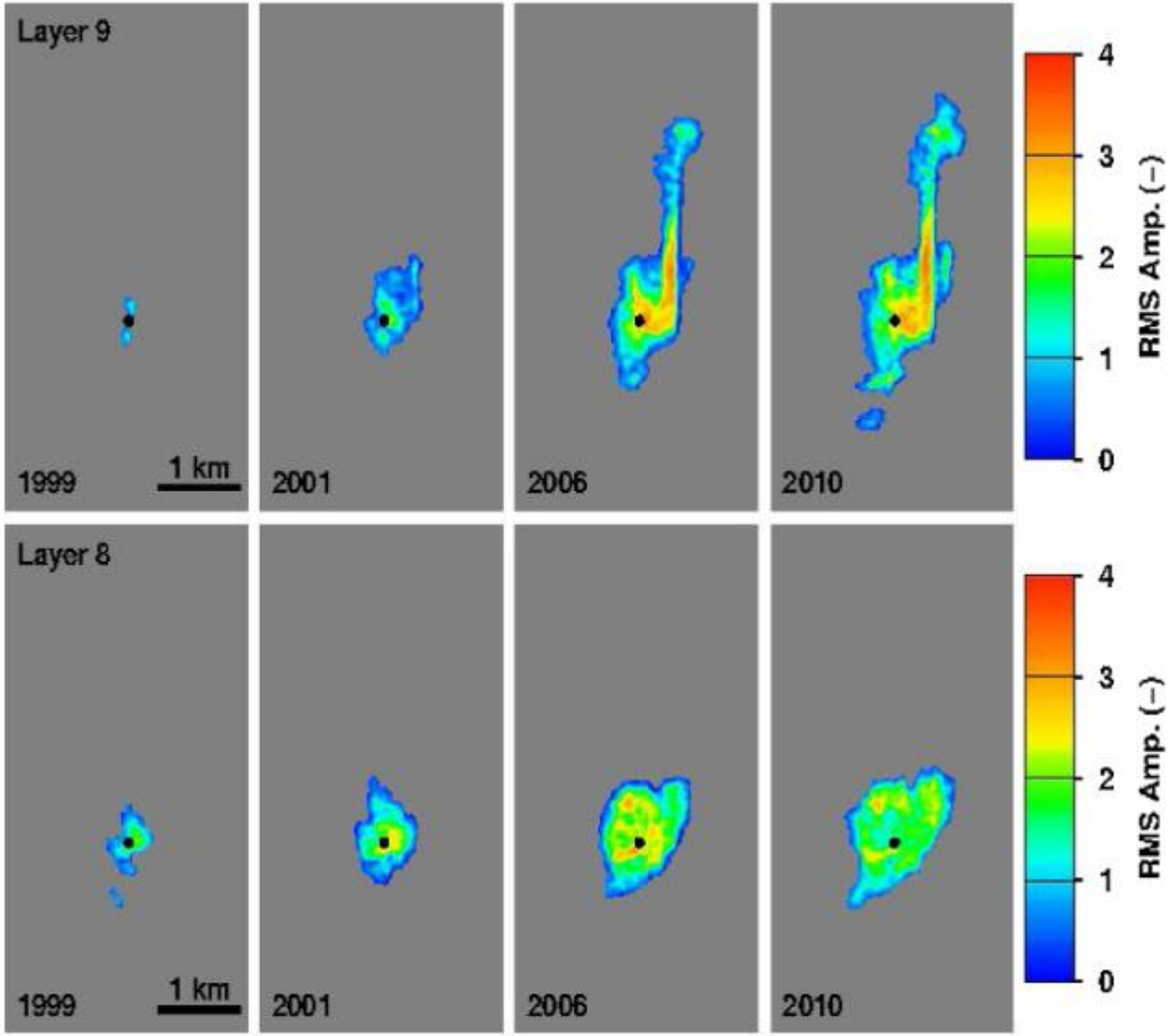
From He, Manchao & Sousa, Luís & Sousa, Rita & Gomes, Ana & Jr, Euripedes & Zhang, Na. (2011). Risk assessment of CO2 injection processes and storage in carboniferous formations: a review. Journal of Rock Mechanics and Geotechnical Engineering. 2011. 39-56. 10.3724/SP.J.1235.2011.00039. .

4D Timelapse Seismic - Sleipner



From Chadwick, R.A., Williams, G.A., Williams, J.D.O. and Noy, D.J., 2012. Measuring pressure performance of a large saline aquifer during industrial-scale CO2 injection: The Utsira Sand, Norwegian North Sea. *International Journal of Greenhouse Gas Control*, *10*, pp.374-388.

4D Timelapse Seismic - Sleipner



From Williams, G.A. and Chadwick, R.A., 2021. Influence of reservoir-scale heterogeneities on the growth, evolution and migration of a CO2 plume at the Sleipner Field, Norwegian North Sea. *International Journal of Greenhouse Gas Control*, *106*, p.103260.

4D Timelapse Seismic - Sleipner

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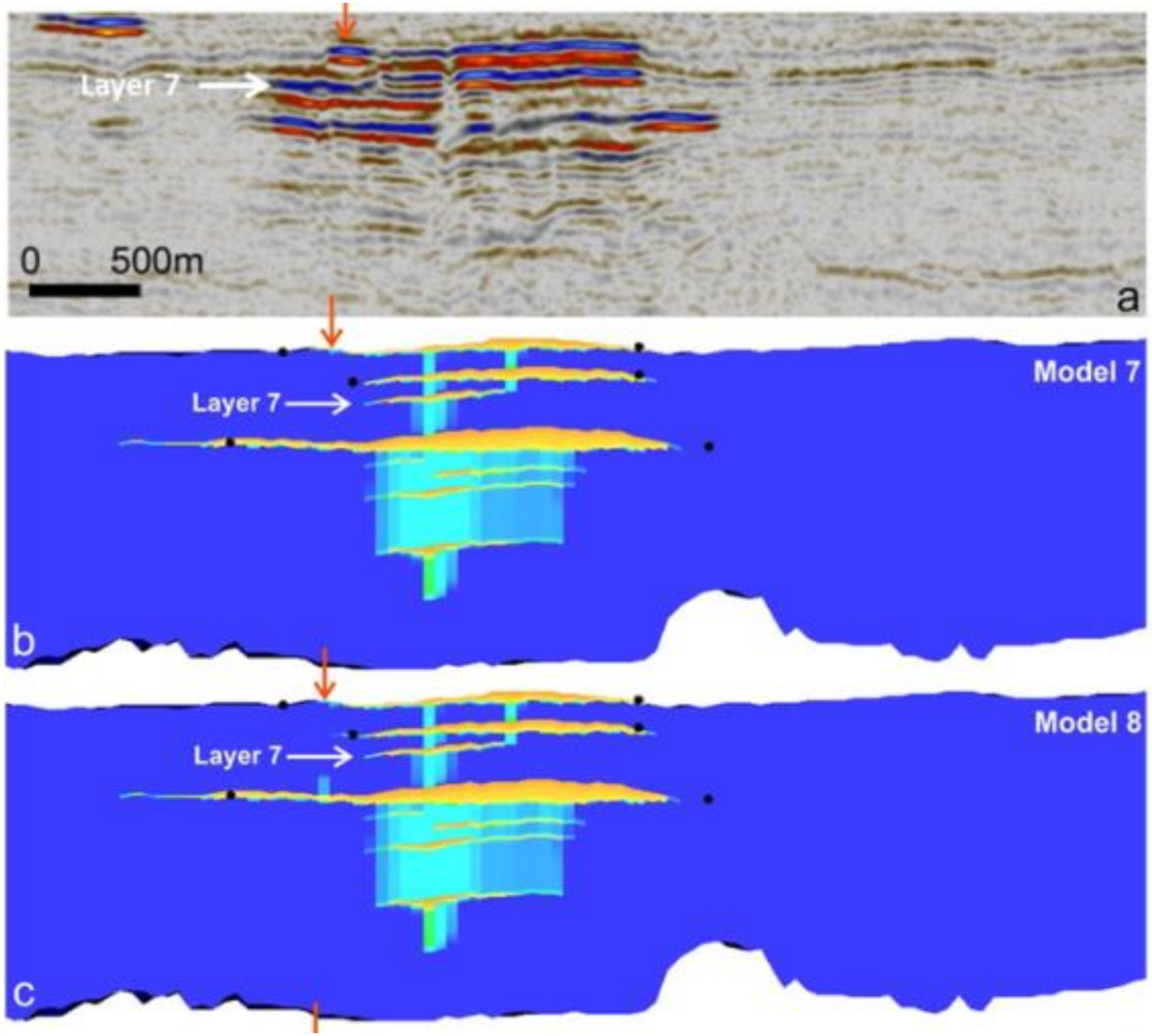

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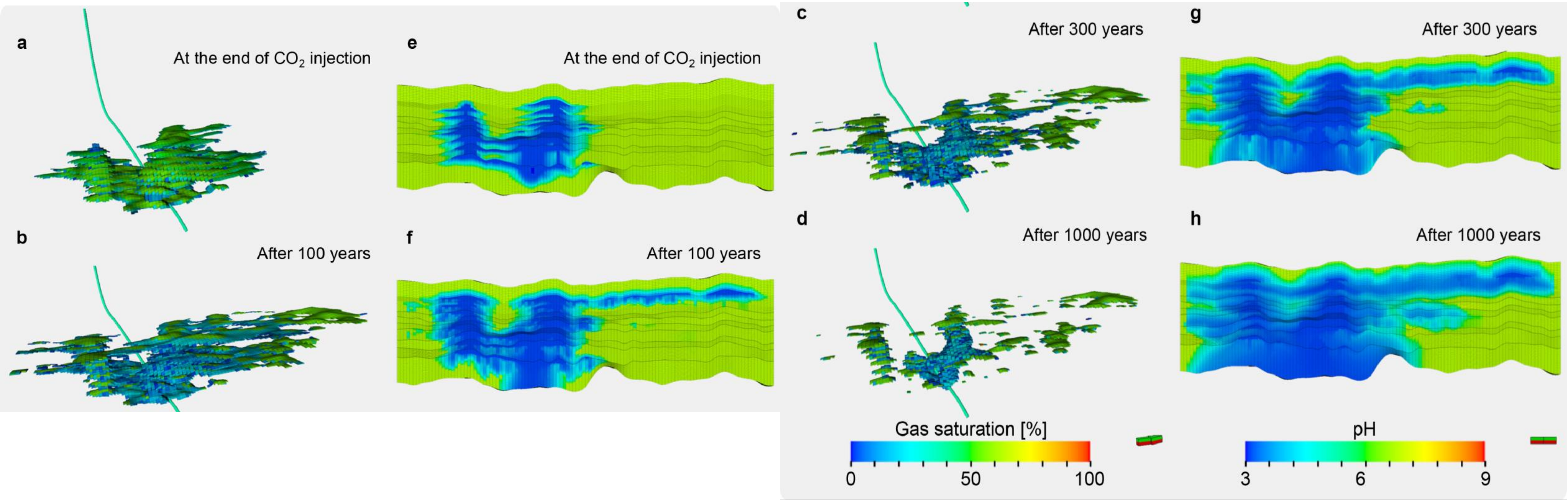


From Akai, T., Kuriyama, T., Kato, S. and Okabe, H., 2021. Numerical modelling of long-term CO2 storage mechanisms in saline aquifers using the Sleipner benchmark dataset. *International Journal of Greenhouse Gas Control*, *110*, p.103405.

Contents:

CCUS: The role of CCUS in achieving global net zero ambitions

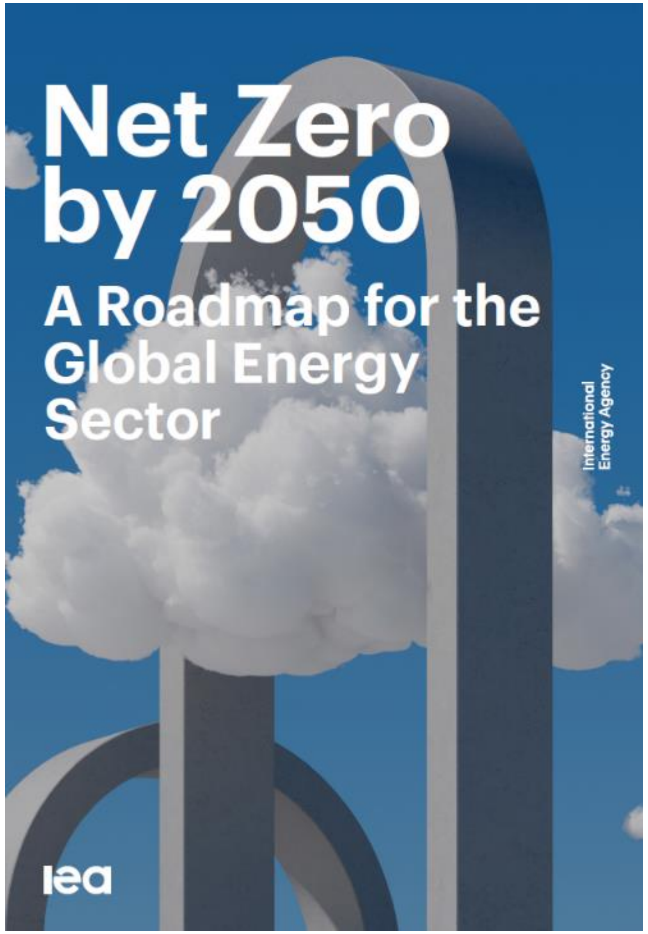
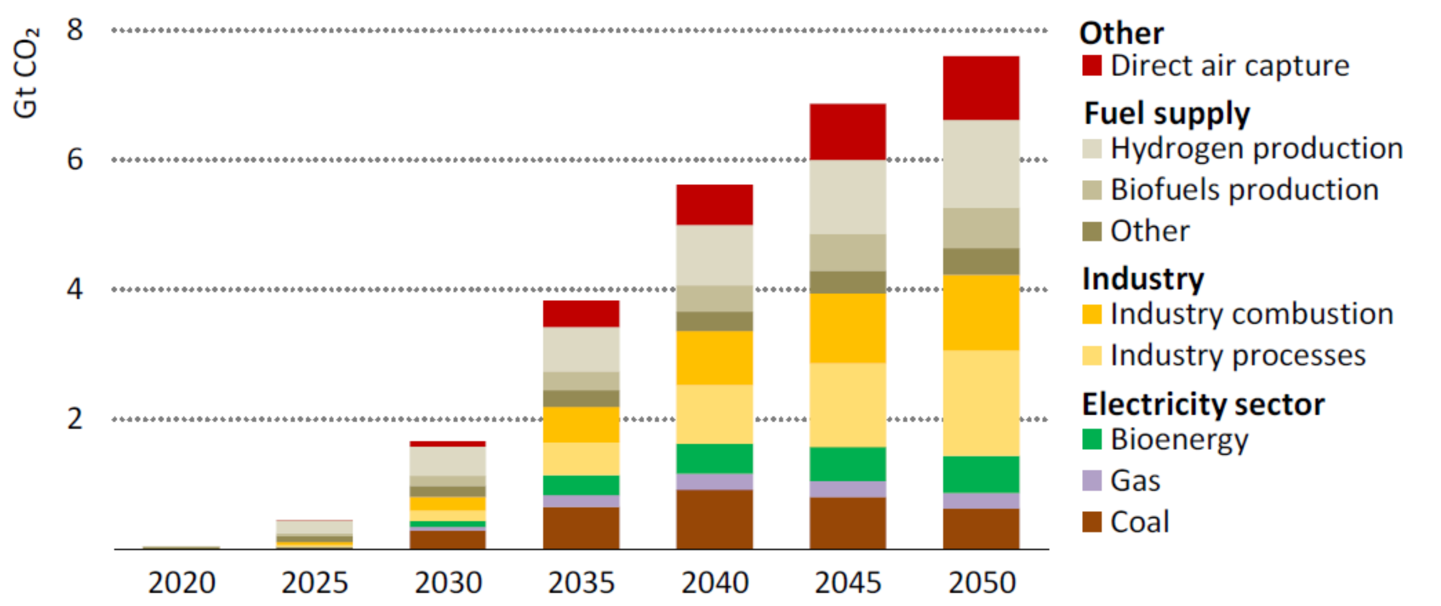


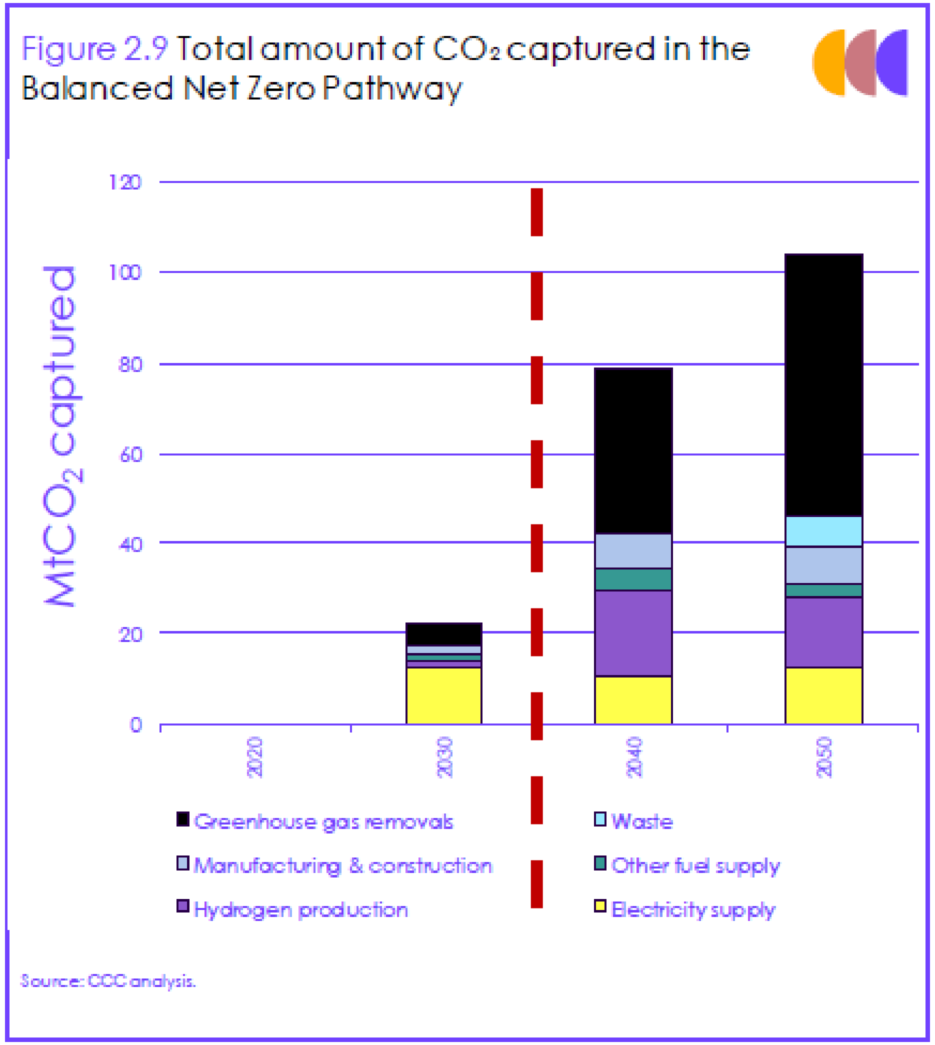
Figure 2.21 ▷ Global CO_2 capture by source in the NZE



By 2050, 7.6 Gt of CO_2 is captured per year from a diverse range of sources. A total of 2.4 Gt CO_2 is captured from bioenergy use and DAC, of which 1.9 Gt CO_2 is permanently stored.

"CCS is a necessity, not an option"

UK Climate Change Committee, 6th Carbon Budget Advice



CCUS Technologies

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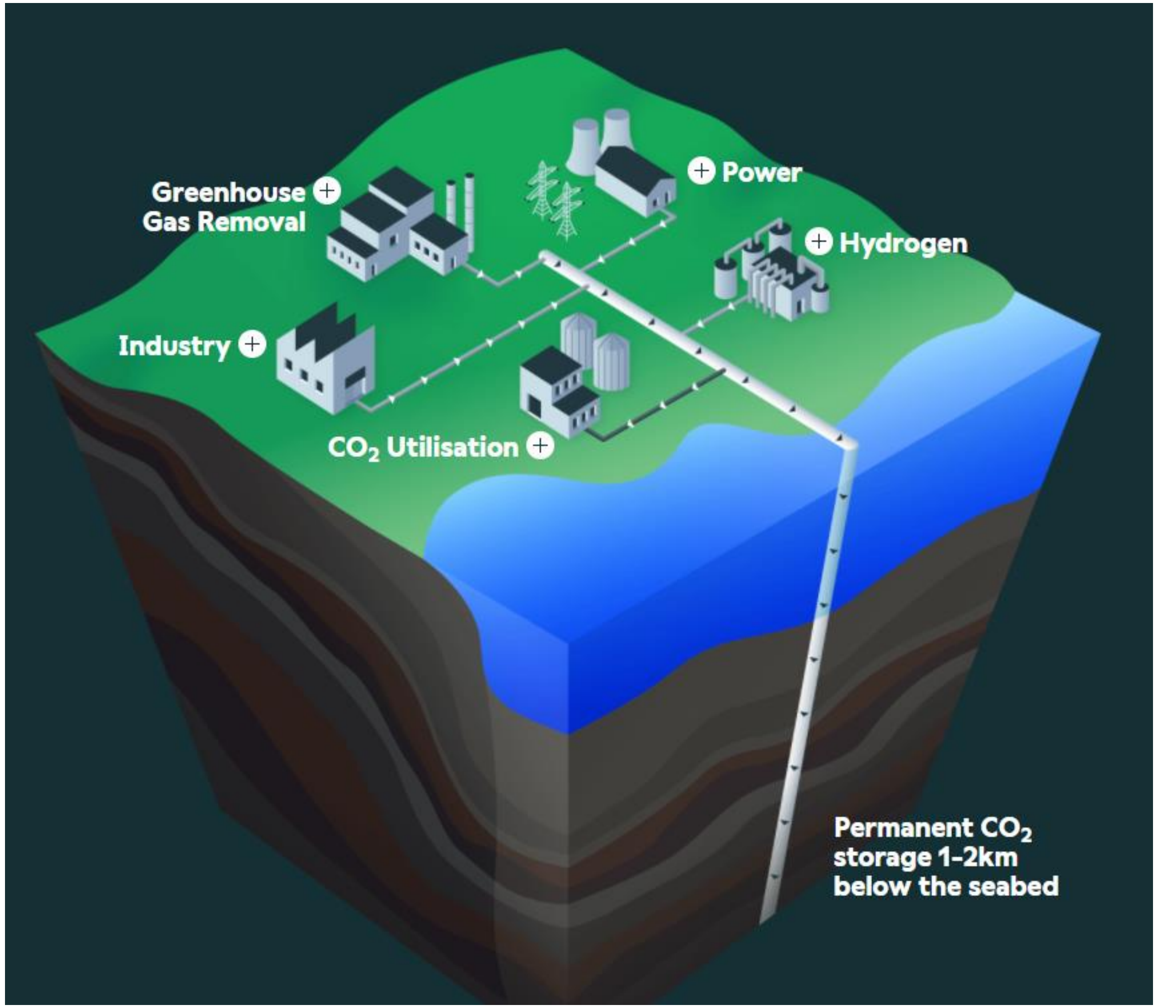
- **Capture CO_2:** use adsorbents to capture CO2 from:
  - Power generation
  - Industrial activity (cement, refinery, steel etc)
  - Hydrogen production
  - Bioenergy sources (BECCS) and the air (DACCS)
- **Transport CO_2** via pipeline or ship
- **Store CO_2** in deep geological formations, e.g. depleted oil & gas fields or deep saline formations.
- **Use CO_2** in products, albeit for more limited climate benefit.

- **Store Hydrogen**: Hydrogen storage in deep geological formations



Thank You

Chris.gent@CCSAssociation.org

www.**ccsa**ssociation.org

@The_CCSA