UK developments:
"CCS is a necessity not an option"

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An independent assessment of the UK's Clean Growth Strategy - From ambition to action Committee on Climate Change, January 2018

- The Clean Growth Strategy sets out three illustrative pathways to 2050, one of which excludes carbon capture and storage (CCS).
- The Government should not plan to meet the 2050 target without CCS.
- A 'no CCS' pathway to even the existing 2050 target is highly challenging and likely to be much more costly to achieve.
- Furthermore, deeper reductions requiring the deployment of CCS will be needed to meet the aims of the Paris Agreement, whether by 2050 or subsequently.
- Although the Strategy states an ambition to deploy carbon capture use and storage (CCUS) in the 2030s, the level of detail and funding (which is directed at innovation only) are not commensurate with its importance.
- **The Government should set out plans in 2018 that kick-start a UK CCS industry in the 2020s.**

CCUS Cost Challenge Taskforce report delivered in July 2018

https://www.gov.uk/government/groups/ccus-cost-challenge-taskforce

The Taskforce has four key messages for Government

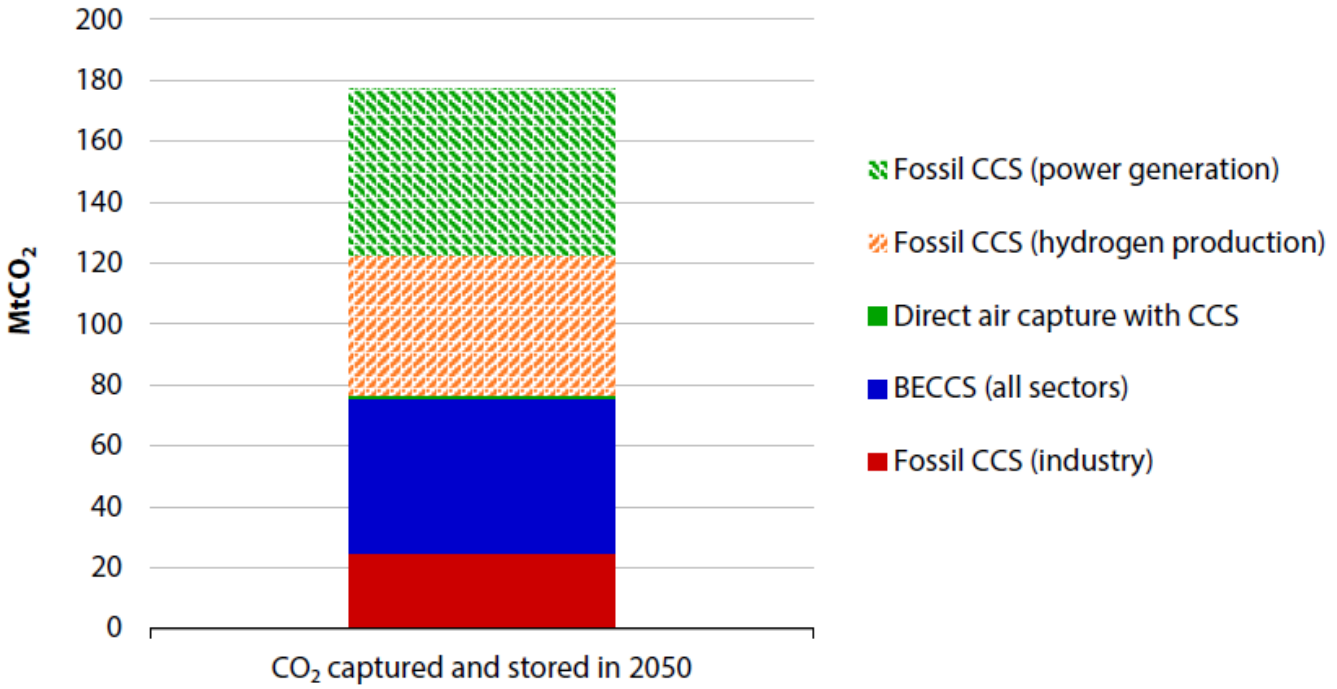
1. We need to recognise the CCUS opportunity and the urgency of acting now in order to deliver CCUS at scale, at lowest cost. Project lead times are long, and time is limited if we are to deliver CCUS on the scale which may be necessary by 2050, with potentially well over 100 million tonnes of carbon dioxide per year needing to be stored. This can be achieved with joint industry and Government vision, supported by the first projects becoming operational from the mid-2020s and an industry pipeline of financeable projects.
2. CCUS can unlock value across the economy to enable low carbon industrial products, decarbonised electricity and gas, a hydrogen economy, greenhouse gas removal, and new industries based around utilising CO_2.
3. We need viable business models to move the technology to a sustainable commercial footing.
4. We believe that CCUS can already be deployed at a competitive cost.

Project concepts being proposed are comparable on cost with other first of a kind low carbon technologies. Our approach is to focus on deploying CCUS in clusters, with the cluster stakeholders identifying how the value of CCUS can best be secured to benefit their local economies and needs.

Committee on Climate Change Net Zero report, May 2019

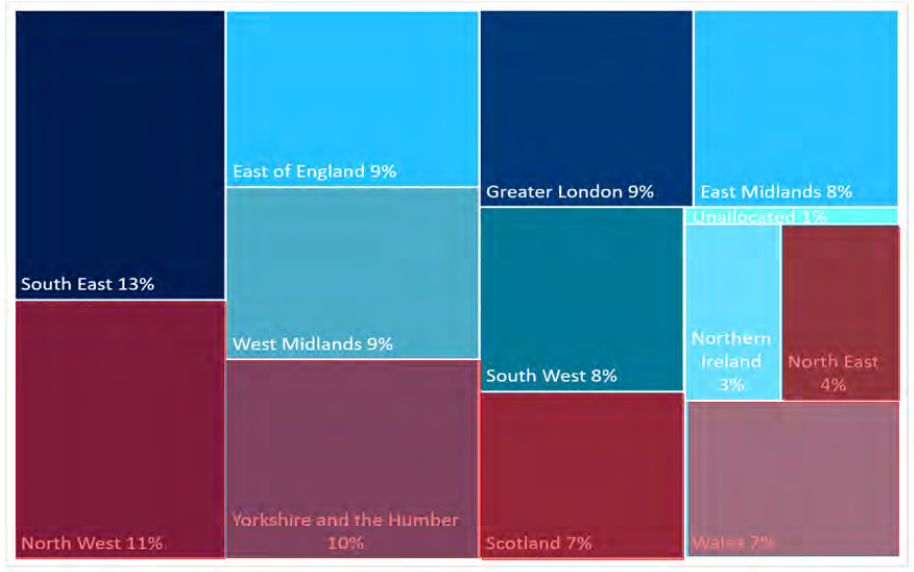
https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

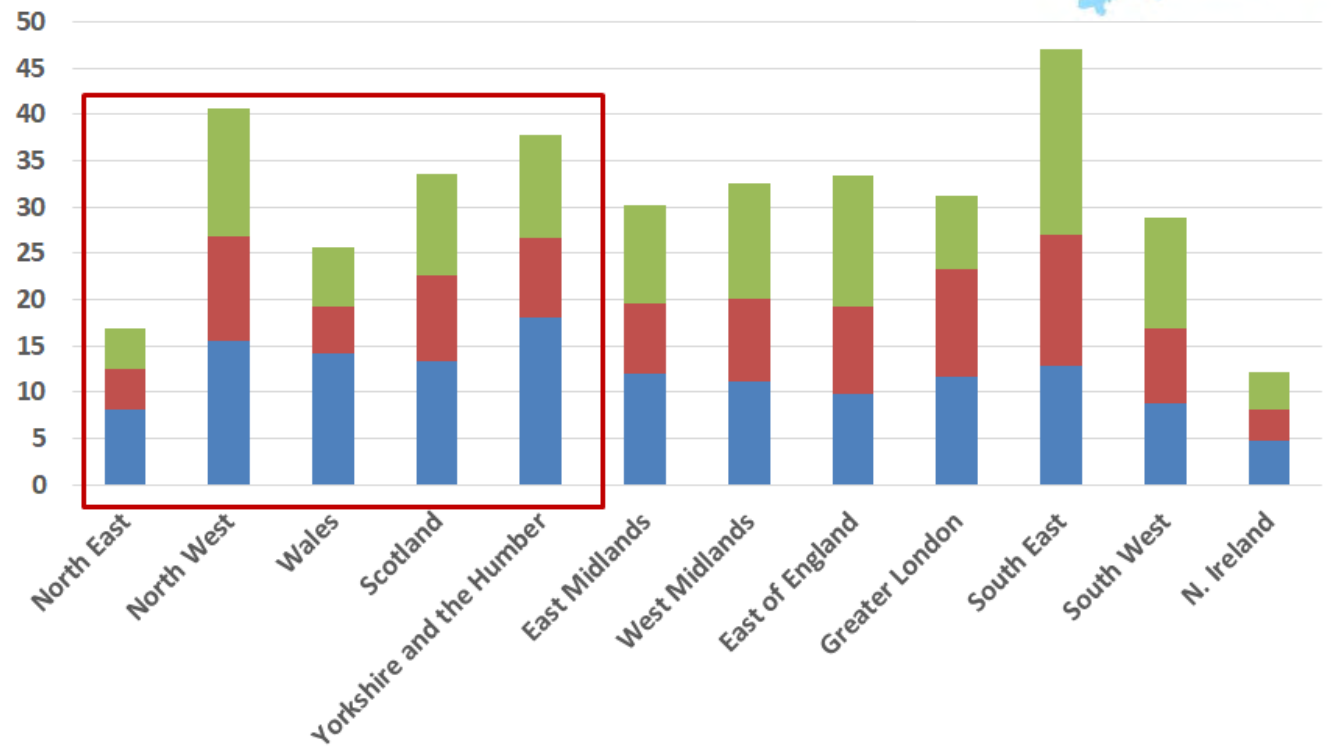
Carbon capture and storage (CCS) in industry, with bioenergy (for GHG removal from the atmosphere), and very likely for hydrogen and electricity production. **CCS is a necessity not an option.** The scenarios involve aggregate annual capture and storage of 75-175 $MtCO_2$ in 2050, which would require a major CO_2 transport and storage infrastructure servicing at least five clusters and with some CO_2 transported by ships or heavy goods vehicles.



Regions and Clusters

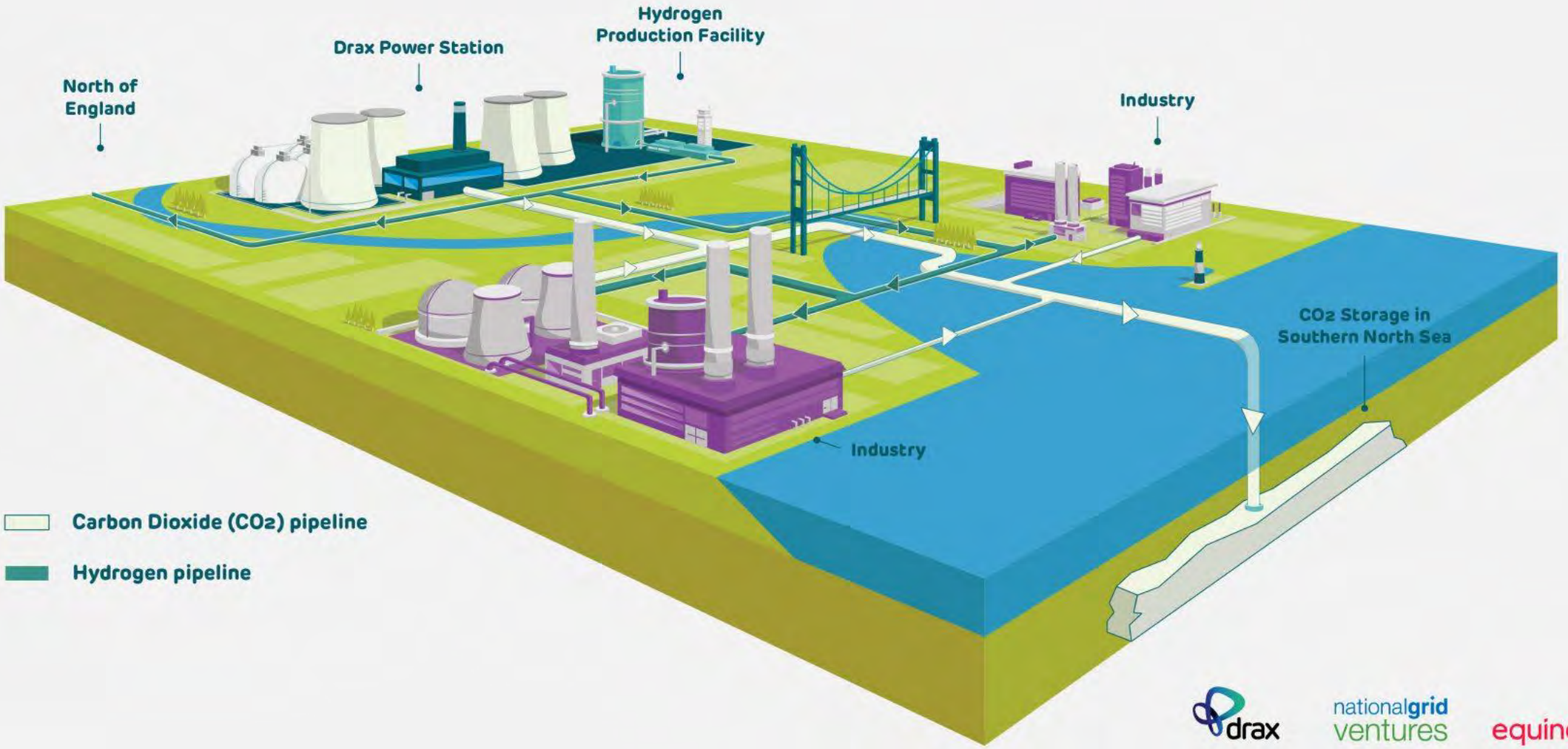
https://www.gov.uk/government/groups/ccus-cost-challenge-taskforce





https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-2016

WHAT A ZERO CARBON CLUSTER COULD LOOK LIKE IN THE HUMBER REGION



https://www.drax.com/press_release/energy-companies-announce-new-zero-carbon-uk-partnership-ccus-hydrogen-beccs-humber-equinor-national-grid/

HyNet North West

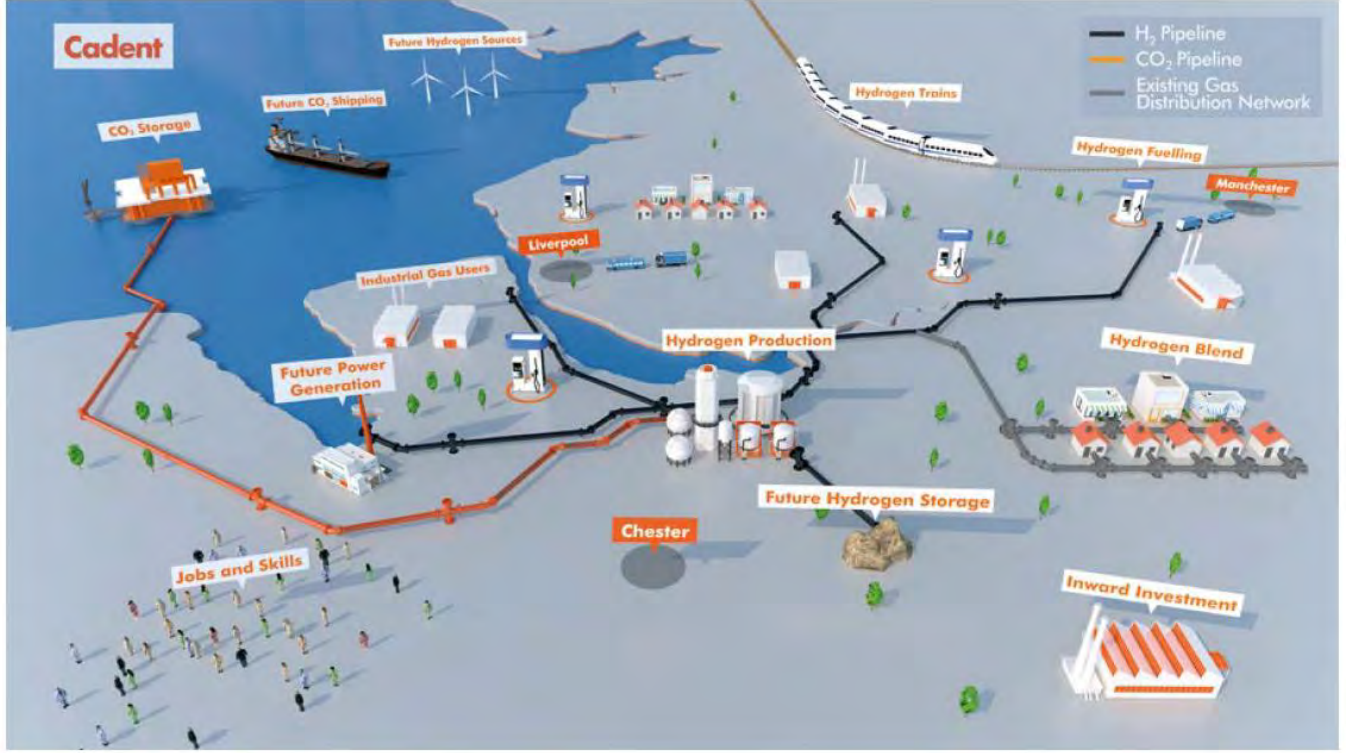
https://hynet.co.uk/

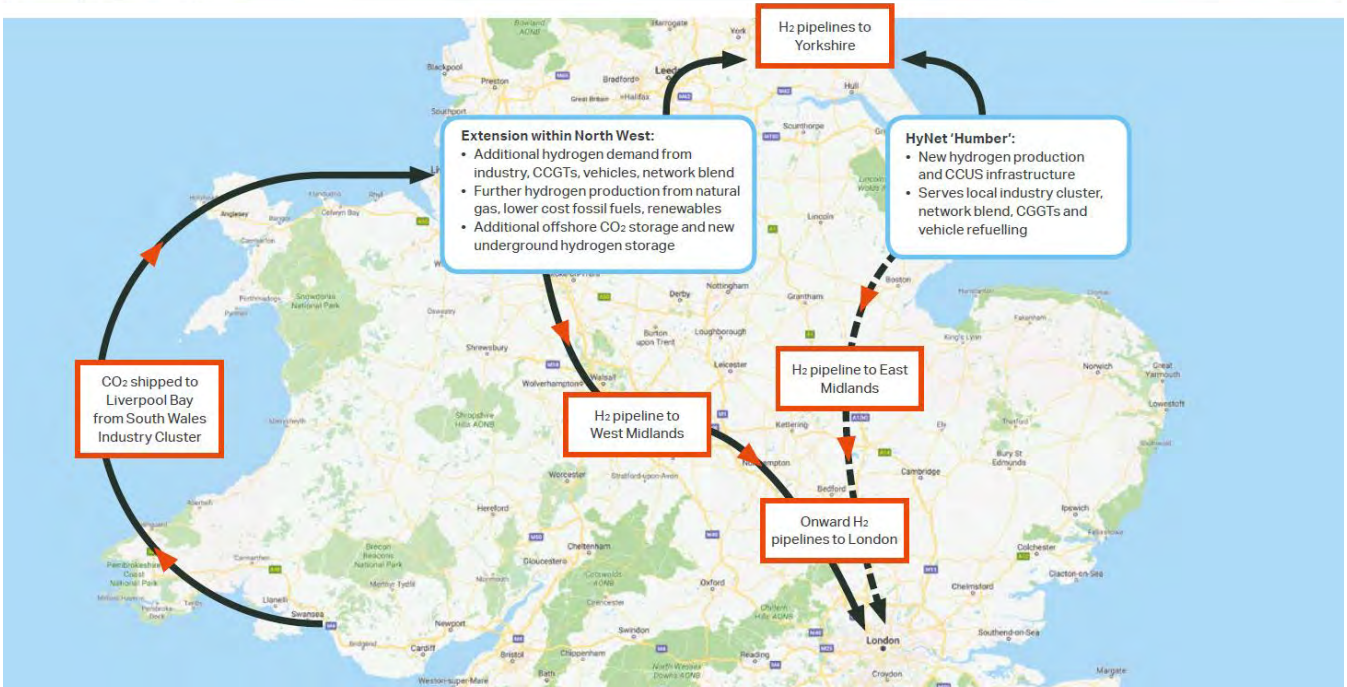
Table 2.2: HyNet Capex Data

Project Element[1]	Related Information	Average Unit Cost (£M)	Total Cost (£M)
Hydrogen Production and CO_2 Capture	HPCC plant comprises two ATRs, producing around 890 MW of hydrogen at pressure[2]	£256/unit	£513
Hydrogen Transport	Transport of 890 MW of hydrogen in new 109km onshore hydrogen pipeline from HPCC plant to industrial cluster and blend injection points	£1.65/km	£178
Hydrogen Compression and Injection to LTS	No compression required at HPCC plant, but additional equipment needed to inject hydrogen into the four LTS injection sites	£5/site	£20
Conversion of Industry to Hydrogen	Modifications to boilers, kilns and furnaces at 10 large industrial sites	£7.8/site	£78
CO_2 Transport	New 31km onshore pipeline from ATR plant to existing pipeline at Connah's Quay[3]	£2.03/km	£63
CO_2 Facilities	Modifications to existing Hamilton platform	n/a	£27
CO_2 Storage	Includes design, procurement, construction and commissioning of wells, licensing and permitting	n/a	£31
		TOTAL	£920

Notes:

1. The battery limit for CCUS costs is from the inlet to the CO_2 compressor at the HPCC plant
2. Includes costs of CO_2 compression
3. Also includes costs for modifications to existing gas pipelines which are repurposed for CO_2





‘South Wales’ + ‘HyNet’ form ‘West Coast cluster’

15Mt CO_2/yr injection capacity
1.5bt CO_2 storage - sufficient for 100 years
5Mt CO_2/yr from South Wales

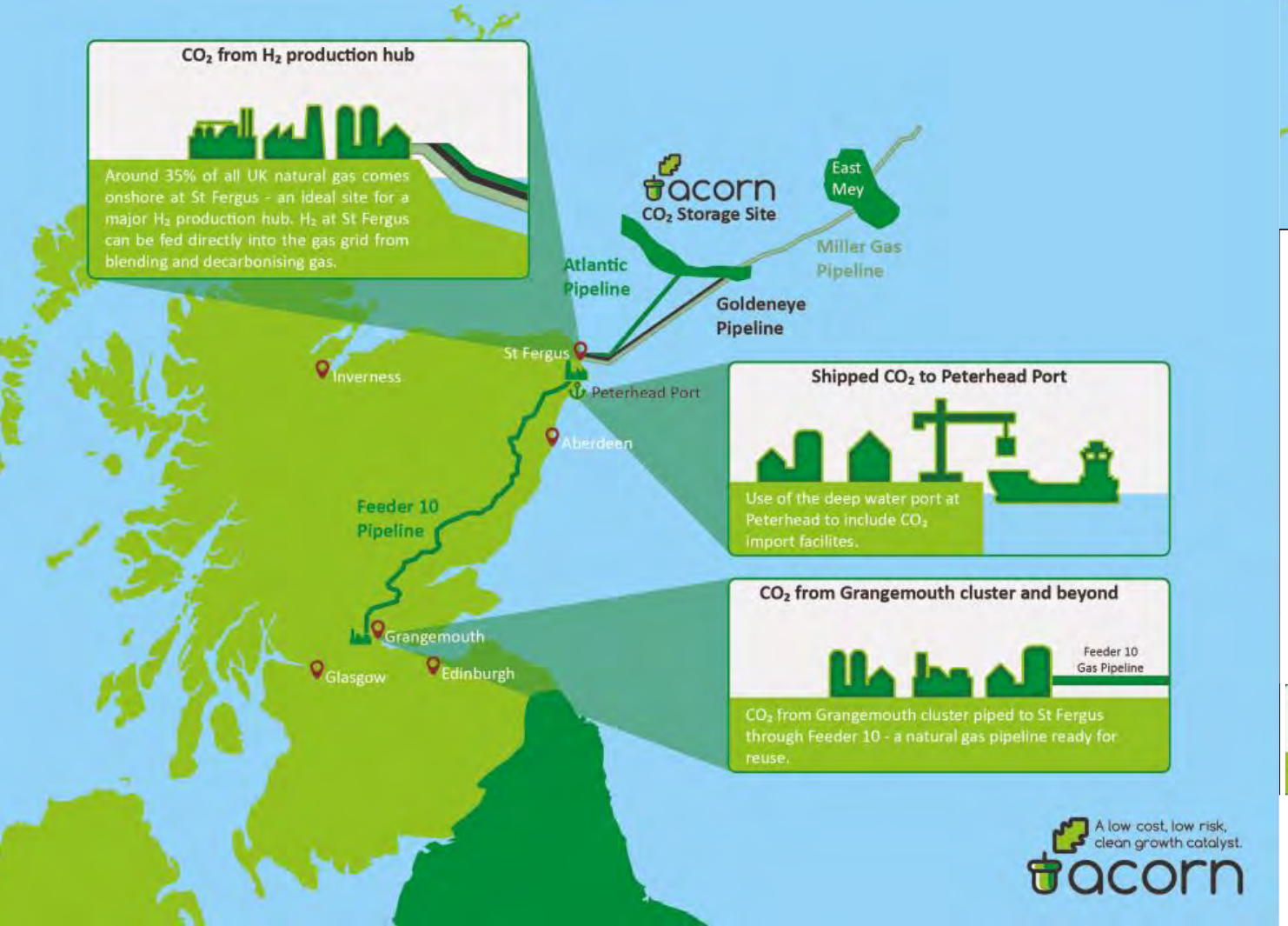
Developing a South Wales Cluster

Credit: Chris Williams, Manager, Energy and CO_2 Research, Tata Steel

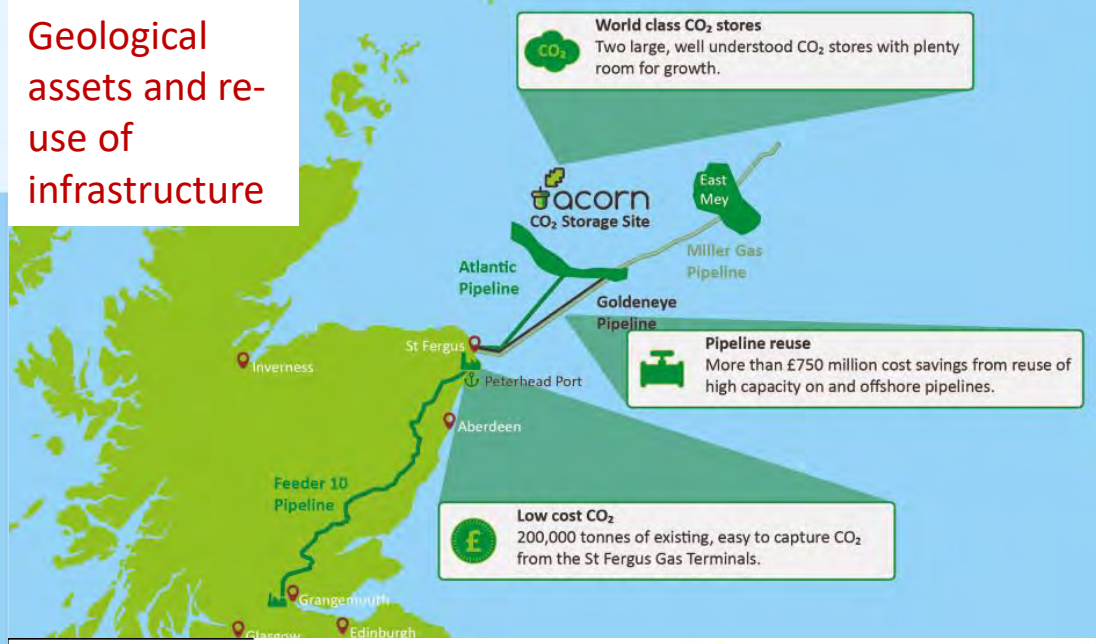
Thanks to Google Maps

acorn: a major clean growth catalyst

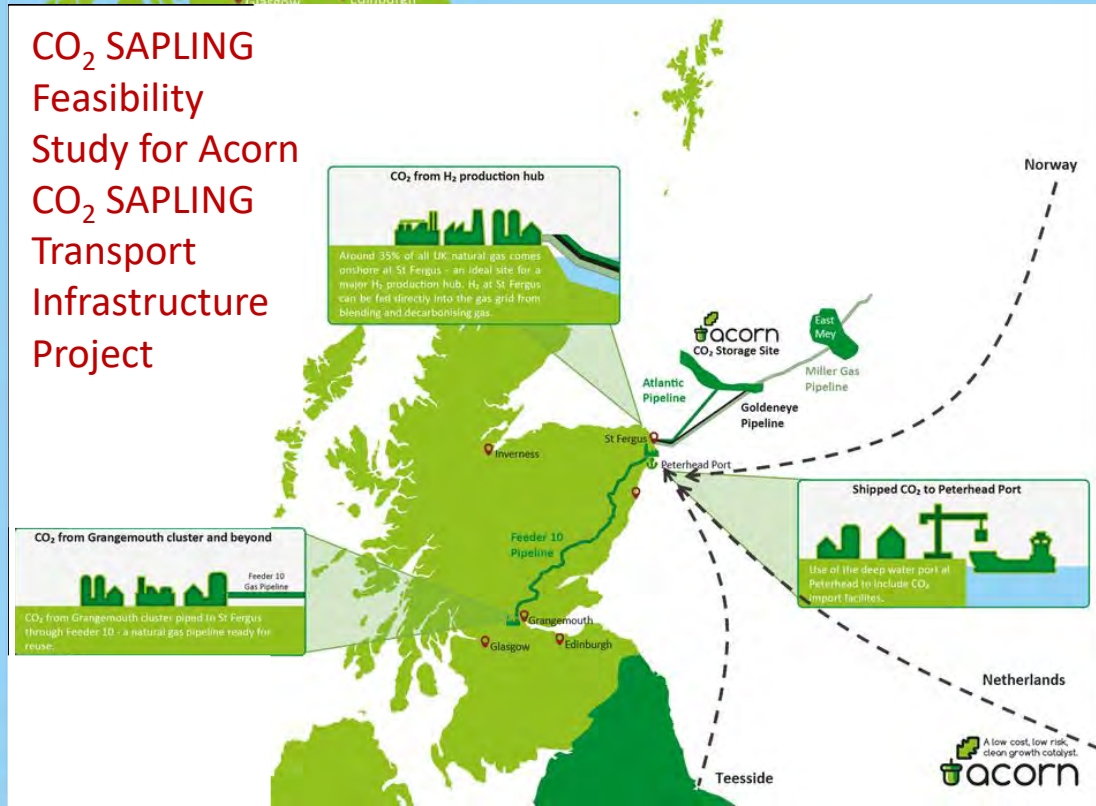
https://pale-blu.com/acorn/



Geological assets and re-use of infrastructure



CO_2 SAPLING Feasibility Study for Acorn
CO_2 SAPLING Transport Infrastructure Project



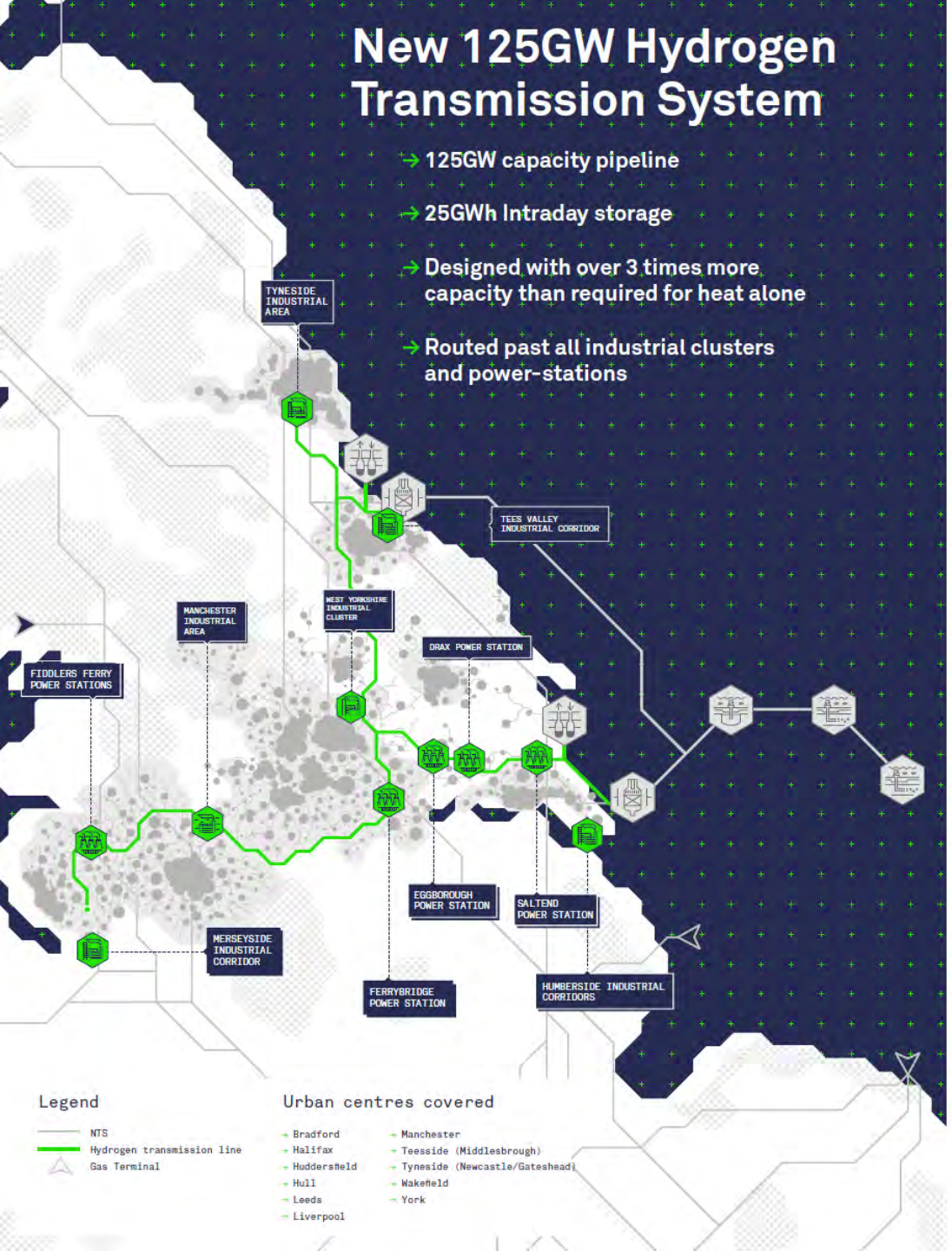
Teesside – Clean Gas Project

https://oilandgasclimateinitiative.com/climate-investments-announces-progression-of-the-uks-first-commercial-full-chain-carbon-capture-utilization-and-storage-project/

November 28, 2018, London, UK:
OGCI Climate Investments announced that it is entering into a strategic partnership with BP, ENI, Equinor, Occidental Petroleum, Shell and Total to progress the Clean Gas Project, the UK's first commercial full-chain Carbon Capture Utilization and Storage (CCUS) project in Teesside. The Clean Gas Project could form the heart of the Tees Valley CCUS Cluster that will deploy commercially viable, safe, environmentally responsible CCUS at scale. It will combine CO_2 capture from new efficient low-carbon power generation and local industrial emitters in Teesside.

ETI gas power with CCS project

https://www.eti.co.uk/programmes/carbon-capture-storage/thermal-power-with-ccs



Conversion of The North of England

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- Conversion 2028 – 2034
- Max time off gas 1-5 days
- Vulnerable customers less than 1 day off gas
- Supply and demand managed through engineering design.

↑ Conversion areas, 2028 year one position

Key Technical Parameters

H_2 Facility

Hydrogen production
12.15 GW
(12,150 times larger than 1 MW)

Carbon capture and storage scaling
20 Mtpa
by 2035

H_2 Storage

Hydrogen storage
8,052 GWh ≡62,000
Australian mega batteries

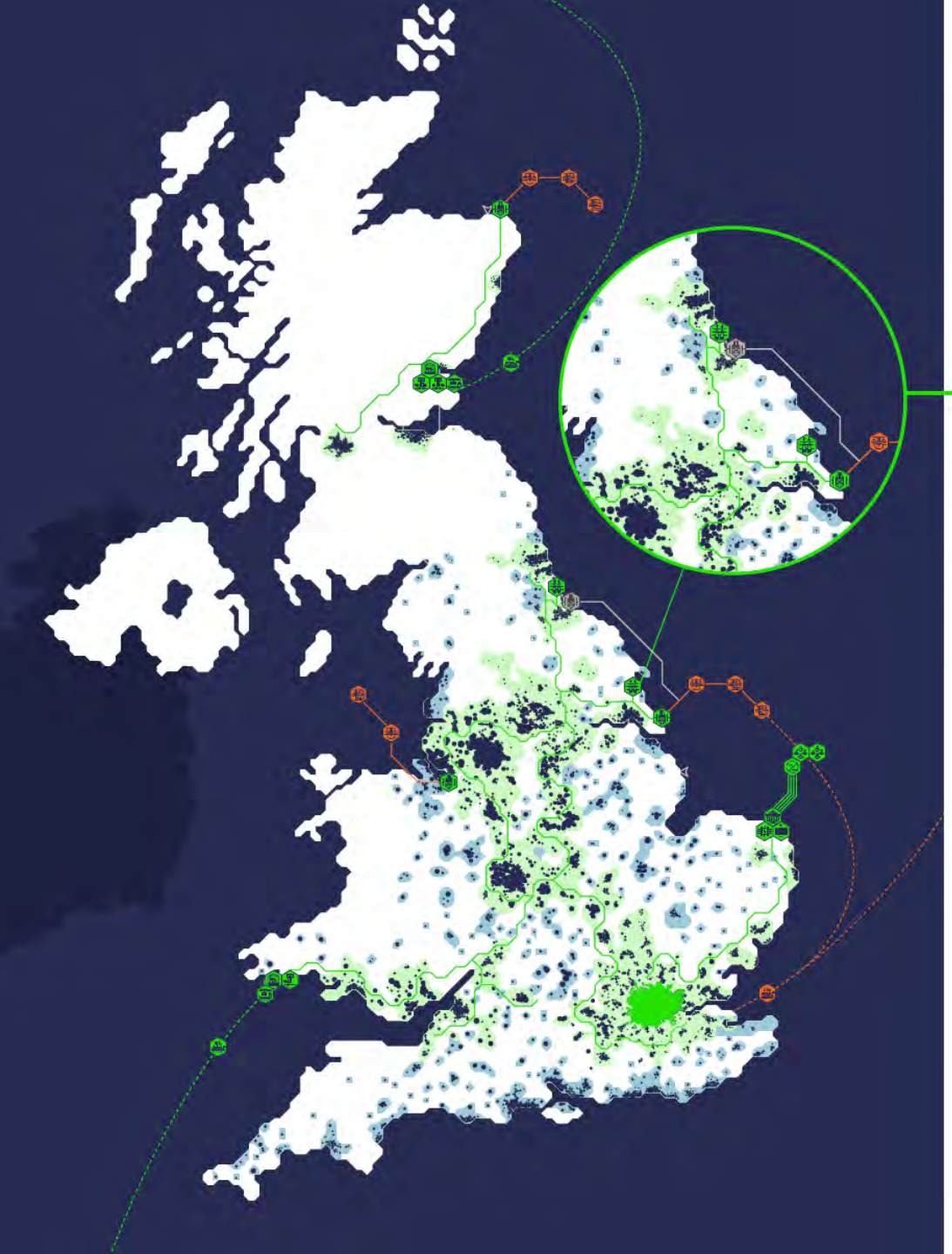
HTS

Hydrogen Transmission System
125 GW capacity +25 GWh
Intraday storage (≡200 Australian mega batteries)

Capital costs (£bn)

H_2 production	8.52
H_2 storage	1.99
CO_2 T&S	1.34
H_2 transport	3.43
Conversion	7.50
Total	22.78

https://www.northerngasnetworks.co.uk/wp-content/uploads/2018/11/H21-Meeting-UK-Climate-Change-Obligations.pdf



UK Hydrogen Conversion Position in 2050

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Phase 1
H21 NoE
Conversion 2028 - 2034
14% UK heat
30% Power (H21 XL) for North of England

Phase 2
H21 South Yorkshire & East/ West Midlands
2033-2038

Phase 3
H21 Scotland
2030-2032

Phase 4
H21 South Wales & South West
2036-2037

Phase 5
H21 East Anglia & Home Counties
2040-2045

Phase 6
H21 London
2045-2050

https://www.northerngasnetworks.co.uk/wp-content/uploads/2018/11/H21-Meeting-UK-Climate-Change-Obligations.pdf

Government funding to deliver on CCUS announced at COP 24

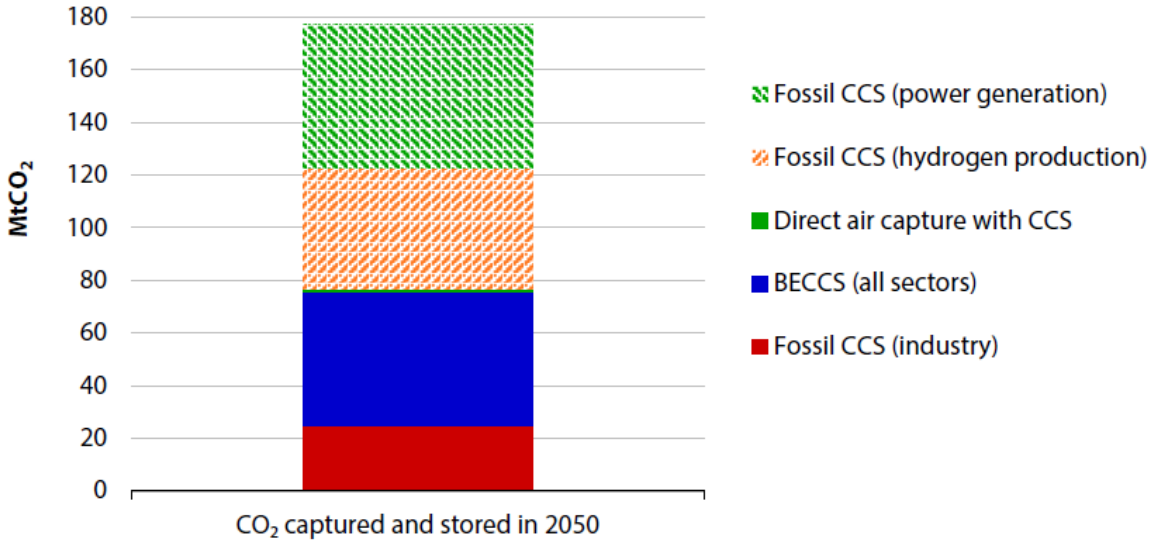
Claire Perry, Minister of State for Energy and Clean Growth, announced £170M funding for an Industrial Clusters mission under the Industrial Strategy with the objective 'We will establish the world's first net-zero carbon industrial cluster by 2040 and at least one low-carbon cluster by 2030'.

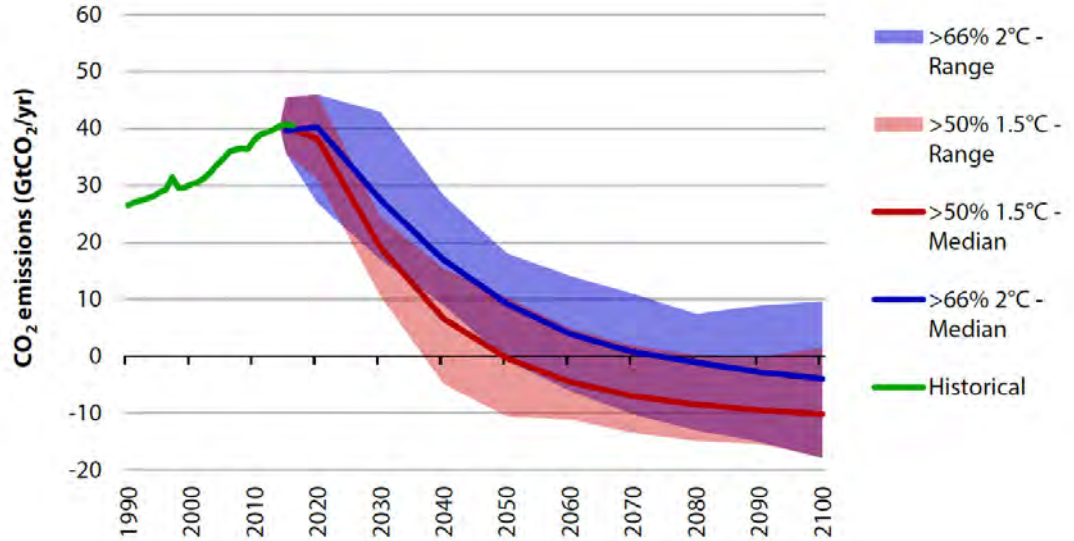
Critically for CCUS, 'in at least one cluster, by 2030, the low-carbon infrastructure needed to support industrial decarbonisation will be in place and operational.'

https://www.gov.uk/government/news/world-first-carbon-net-zero-hub-of-heavy-industry-to-help-uk-seize-global-economic-opportunities-of-clean-growth

Some personal observations in a fast-moving situation

- The Committee on Climate Change focuses on CO_2 emissions and cannot see how climate targets can be reached without CCS – 'CCS is a necessity and not an option'
- UK government policy on CCS has been moving fast but climate and industry ideas have been moving faster
- Industrial Strategy Fund award of £170M will be doubled or more by industry money, good for national planning and preparation for one or two projects
- But energy consumers need to be charged for CCS on electricity and hydrogen – and this will have to come from the same overall Levy Control Framework that also includes funding for renewables
- Things getting less attention so far than net zero CCS expectations:
  power with CCS, BECCS, DACCS, CCS outside existing clusters, CO_2 shipping/rail
- No discussion, yet, of net negative emissions from 2051 for 1.5 degrees – but 2050 is not the endpoint





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Katowice Airport, COP24, December 2018