



# The Feasibility of Direct Air Capture – A UK Perspective

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April 2025



**CITY SCIENCE**  
delivering decarbonisation

# Why are we hosting this webinar? City Science's DAC research

[Supporting research for the CCC 7CB](#), working with Imperial College Consultants, published 26<sup>th</sup> Feb

Upcoming research for Scotland's ClimateXChange (CXC)



The screenshot shows the Climate Change Committee website. The header is purple with the CCC logo and navigation links: Home, News, Publications, About, Climate action. The main content area has a purple breadcrumb 'Home / Publications' and a title 'Assessing the feasibility for large-scale DACCS deployment in the UK (City Science)'. Below the title is a photograph of industrial pipes and chimneys. To the right of the photo is the '1. Outline' section, which states the report was commissioned by the CCC from City Science to inform the 7th Carbon Budget. Below that is the '2. Key messages' section, which lists that DACCS deployment is not expected until at least 2030 and that the maximum feasible scale-up by 2050 is 20-30 MtCO2 capacity.

Climate Change Committee

Home / Publications

## Assessing the feasibility for large-scale DACCS deployment in the UK (City Science)



**1. Outline**

This report is an external piece of analysis commissioned by the CCC from City Science to help inform the CCC's Seventh Carbon Budget advice published in February 2025. This report assesses the feasibility of deploying large-scale direct air carbon capture and storage (DACCS) in the UK, including potential costs and constraints.

This report reflects the views of City Science and does not represent the views of the CCC.

**2. Key messages**

The key messages of this report are:

- DACCS deployment is not expected to begin until at least 2030 and the maximum feasible scale-up by 2050 is deemed to be in the region of 20-30 MtCO<sub>2</sub> capacity.

Cost and profitability of DAC in the UK

Greater a focus on CO<sub>2</sub> utilisation than the CCC study

# Objectives of this session

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On the assumption that DAC may be needed to meet the UK's net zero target, we attempt to answer the following questions:

- What will be the constraining factors to DAC deployment in the UK?
- What level of deployment could we feasibly expect in the UK by 2050?
- What is the cost of deploying DAC?
- Would it be better to deploy DAC in the UK? Or elsewhere?

What this session isn't:

- A comprehensive comparison of DAC vs its alternatives (e.g. BECCS)

# Content



The case for DAC



Fundamental realities and uncomfortable truths



UK drivers and needs



Technology requirements, expected constraints and inhibitors



The billion-dollar question – how much is it going to cost?



Should we even be deploying DAC in the UK? Or elsewhere?



The UK's opportunities and advantages



Concluding remarks: moving forward on DAC

A brief overview

The focus of today's session

10-15 mins at the end for audience Q&A

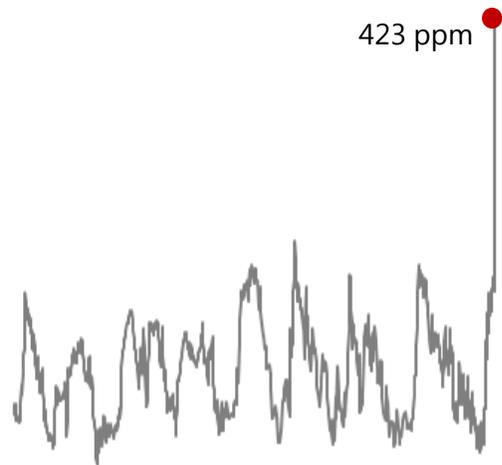
We will be recording main session but not Q&A



# The case for DAC



## The climate risk



Source: NOAA Global Monitoring Laboratory - Trends in Atmospheric Carbon Dioxide (2025)

## Removal of CO<sub>2</sub>

Offset hard-to-abate sectors such as shipping, aviation, livestock, and industrial processes  
Contain or reduce atmospheric CO<sub>2</sub> concentrations



## A carbon feedstock

Fossil carbon makes up many of the materials we use, we will need an alternative supply



Source: AI generated by DeepAI

# The case for DAC – advantages over alternatives



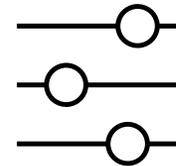
**Scalable** – provided we can supply enough energy, materials and supporting infrastructure



**Small land footprint** – of the DAC plant itself, but a large land area could be required for energy supply



**Verifiable** – comparably clear monitoring, reporting and verification (MRV) of CO<sub>2</sub> capture



**Location flexibility** – where supporting infrastructure can be provided

# Fundamental realities and uncomfortable truths



# DAC's uphill battle



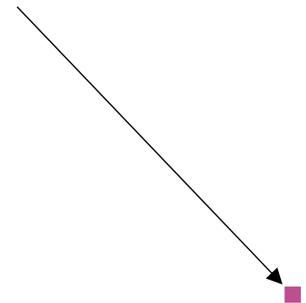
Fundamental realities  
and uncomfortable  
truths

Air

78% Nitrogen  
21% Oxygen  
1% Other stuff  
(420 ppm, 0.042% CO<sub>2</sub>)

CO<sub>2</sub> removal from air is  
needle in a haystack

Volume of  
CO<sub>2</sub>



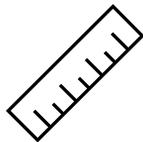
# A sense of scale



## Industry ambition

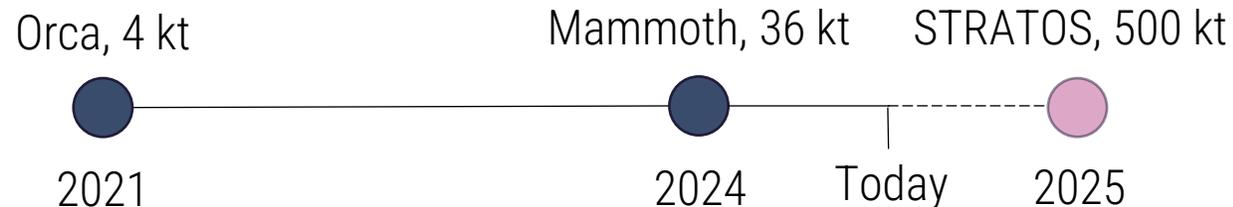
To capture 1 Gt of CO<sub>2</sub> – just 2% of current annual global CO<sub>2</sub>e emissions:

- Two thousand trillion (2x10<sup>15</sup>) m<sup>3</sup> of air processed – 400 grand canyons
- 2,000 TWh of energy – equivalent to about 10% of global electricity consumption
- 0.5 trillion dollars (at \$500 per ton) – 0.5% of global GDP

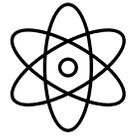


## Where we are today

- Only small commercial deployments and some tiny pilot plants
- Anticipated 2025 level of deployment equates to just 0.001% of current global emissions...



# But won't it become cheaper and better?



## Energy efficiency

- Separation of CO<sub>2</sub> from air (at 0.04% vol) has a fundamental energy minimum (200 kWh/tCO<sub>2</sub>\*)
- Current plants are achieving ten times this energy limit (2,000 kWh/tCO<sub>2</sub>).
- A reasonable minimum bound might be five times the limit (1,000 kWh/tCO<sub>2</sub>) ([Young et al, 2023](#))



## Cost reductions

- Do not expect cost reductions like we have seen for solar PV and batteries
- We must draw analogies against technologies with similar characteristics
- DAC is a complex technology; comparison against CCGTs, CCS, or nuclear power may be more appropriate

		Need for Customization				
		Standardized	Mass-customized	Customized		
Degree of design complexity	Complex	Standardized complex product systems <i>CCGT power plants</i>	Solid-State DAC	Platform-based complex product systems <i>SMRs, CCS</i>	Liquid-State DAC	Complex product systems <i>Nuclear power plants, BECCS,</i>
	Design-intensive	Mass-produced complex products <i>Electric vehicles</i>	Liberty Ships, Cars	Platform-based complex products <i>Wind turbines, concentrating solar power</i>		Complex-customized products <i>Biomass power plants, geothermal power</i>
	Simple	Mass-produced products <i>Solar PV, LEDs</i>	Washing Detergent	Mass-customized products <i>Rooftop solar installations</i>		Small-batch products <i>Building envelope retrofits</i>

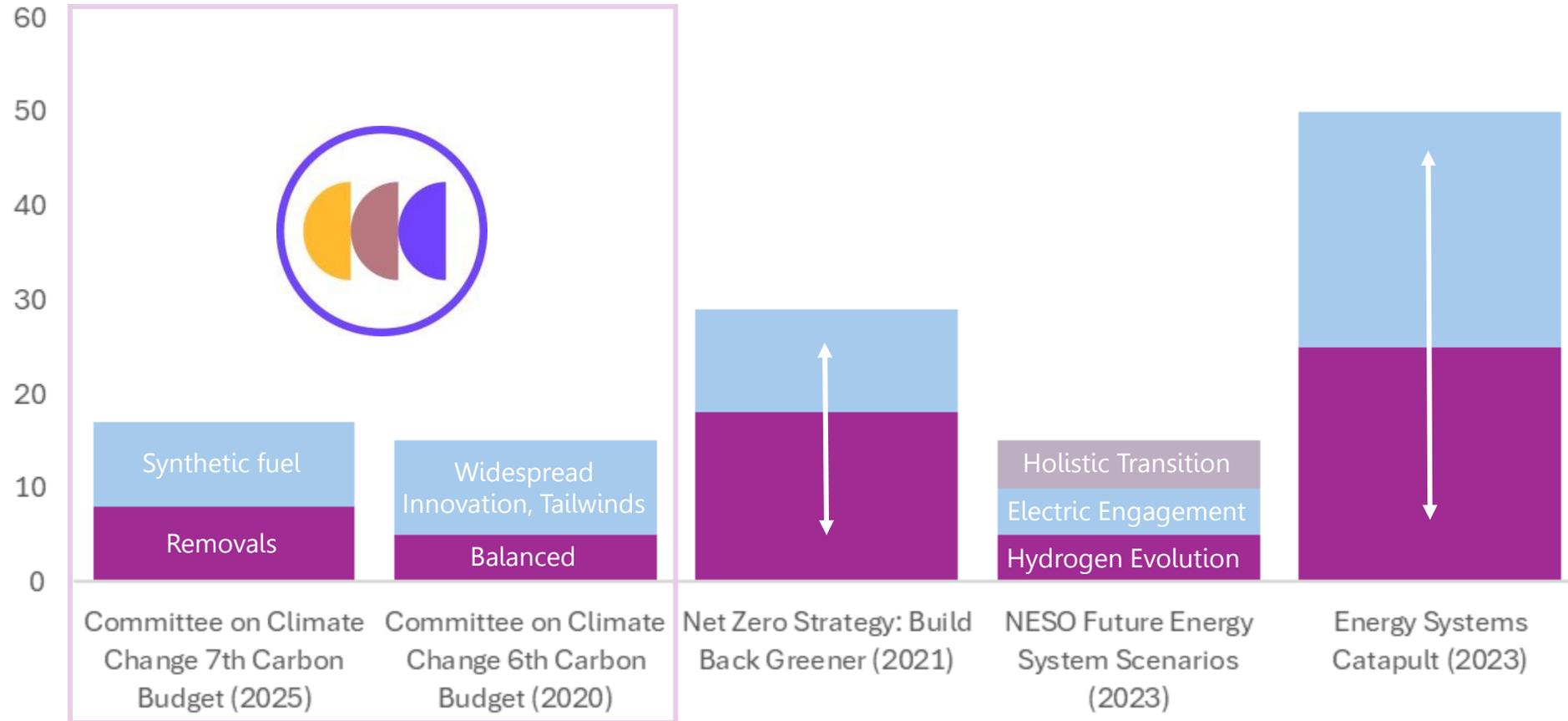
Source: [Roberts & Nemet, 2024](#), technology framework from [Malhotra and Schmidt, 2020](#)

# UK drivers and needs



# Views on future needs

2050 Deployment,  
MtCO<sub>2</sub>



# What might drive this uptake?

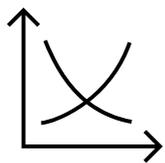


## **Voluntary Carbon Market (VCM)**

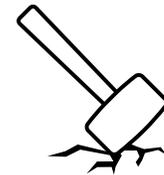
– voluntary purchases by interested organisations and individuals. Only expected to play a small role



**GGR Business Model** – a proposed contract-for-difference (CfD) scheme to support greenhouse gas removal technologies



**UK ETS removals** – removals have been proposed to be included in the UK ETS as a mechanism to meet emissions allowances



**UK SAF Mandate** - has a sub-mandate on power-to-liquid SAF, coming into effect in 2028

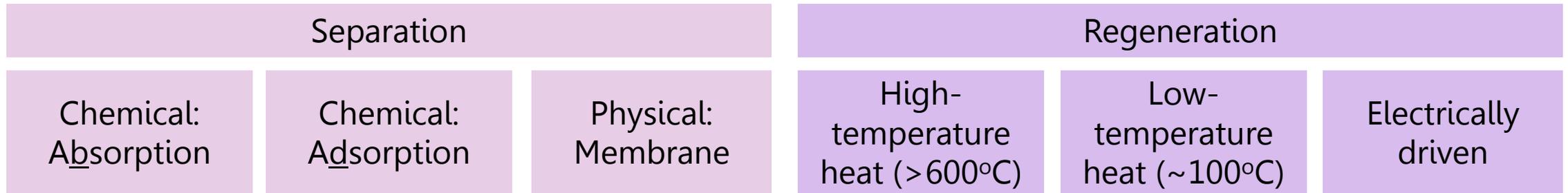
# Technology requirements, expected constraints and inhibitors



# Technology types and development status

Recent years have seen a boom in DAC investment and numerous startups pursuing a variety of technological approaches ([Wang et al., 2024](#))

The technologies can be categorised by separation and regeneration types:



Our view is that only the following two leading DAC technology manufacturers are > TRL 6



**"Solid"** DAC

Separation: Solid adsorbent  
Regeneration: Low-temperature (~100°C)



**"Liquid"** DAC

Separation: Liquid solvent absorption  
Regeneration: High-temperature (~900°C)

# Energy configurations for further study

Our research focussed on the two following configurations for further study on large-scale scale-up in the UK:

## Solid: Heat Pump, Grid Connected

Heat supply: An air source heat pump supplies the thermal requirements ( $\sim 100^{\circ}\text{C}$ )

Electricity supply: grid connection

## Liquid: Natural Gas, Grid Connected

Heat supply: Natural gas combustion ( $\sim 900^{\circ}\text{C}$ ), with resulting fossil  $\text{CO}_2$  emissions captured within process

Electricity supply: grid connection

### Alternatives

? Waste heat: opportunities are limited, not sufficient for large-scale deployment

? Nuclear: could supply heat directly from the reactor, but cost and timeline overruns have inhibited large-scale nuclear power development

? Hydrogen and electrified heat are possible, but supply chains are nascent and both are expensive solutions

✓ Onsite electricity generation by natural gas CCGT, but a firm grid connection may be preferred

# What will constrain DAC? Feasibility factors

Supporting factors required for both construction and operation:

## Construction factors

- Material availability
- Construction workforce availability

## Supporting infrastructure

- CCS infrastructure
- Grid capacity

## Operational factors

- Electricity
- Natural gas
- Water
- Chemical consumables (adsorbents and solvents)

Suppose money is no issue and we need to build a very large amount of DAC in a short timeframe, which of these factors is likely to inhibit development?

# The DAC “ceiling”

We hypothesise a DAC “ceiling”: the maximum amount of DAC the UK is ever thought to need, likely well in excess of future needs

The DAC ceiling is **not** a recommended level of deployment

Should a feasibility factor appear to be non-constraining even under this extreme level of deployment, we can have reasonable confidence that it is not likely to be a limiting factor.

## Ceiling capacity for 2050

- 88 MtCO<sub>2</sub> DAC capacity

## Ceiling build rate

- Assumed ceiling capacity built over ten years: 8.8 Mt capacity per year

Feasibility factor type	Assumed non-constraining level	Assessed on current or future estimated capacity
Construction material consumption	< 1% of UK consumption	Current
Construction and operational workforce required	< 5% of relevant UK construction/operational workforce	Current
Electricity grid connection and annual electricity requirements	< 1% of UK projected capacity/consumption	Future

Example non-constraining limits

# The most constraining factors

 Tech requirements, expected constraints and inhibitors

Feasibility Factor	Requirement to Meet Ceiling: 88 MtCO <sub>2</sub> capacity	Compared against projections of capacity to 2050 →				
		2025	2030	2035	2040	2050
CO <sub>2</sub> Transport & Storage Infrastructure	58 MtCO <sub>2</sub> /yr					
Electrical Grid Connection: Solid DAC	19.8 GW <sub>e</sub>	16.7%	12.4%	10.4%	8.5%	7.0%
Solid DAC (heat pump): Electricity demand	135 TWh	41%	38%	29%	23%	19%
Solid DAC adsorbent: PEI	240 kt/yr	137%	126%	118%	106%	101%
Liquid DAC solvent: KOH	600 kt/yr	344%	314%	296%	265%	252%

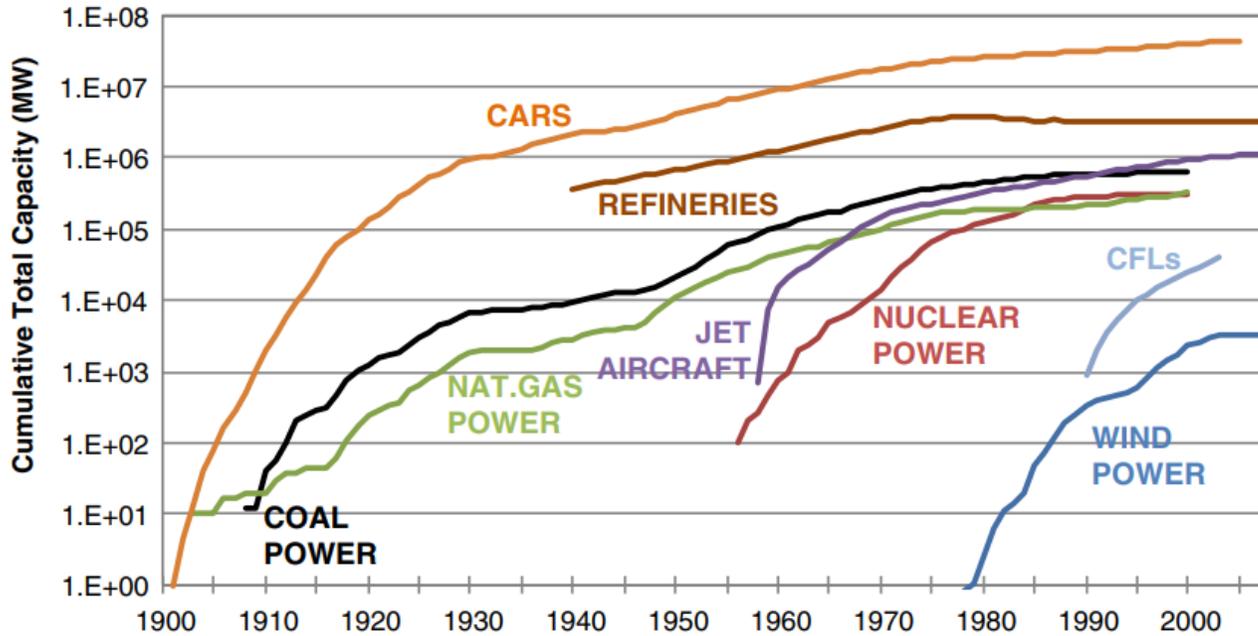
**Rating**      **Status**

	Very limiting
	Limiting
	Somewhat limiting
	Not limiting

CCS infrastructure and electricity are thought to be the most constraining factors

The solid adsorbent (PEI) and liquid solvent (KOH) demands of this DAC ceiling would greatly exceed current production, but these sectors are thought to be relatively elastic and so can scale to meet future requirements

# Beyond technical factors: historical analogues



Established technologies have gone through real-world conditions which extend beyond technical constraints, to economic, political, social, and cultural factors

The precedents set by historical deployment are therefore a useful indicator of future feasibility

More complex and more customised technologies are likely to scale more slowly

Source: [Wilson et al., 2013](#)

Technology	Achieved diffusion (%)
Natural gas power	7% (Global)
Nuclear power	11% (Global)
Flue gas desulphurisation (FGD)	15% (USA)
Wind power	20% (Denmark)

Source: [Iyer et al., 2013](#)

		Need for Customization			
		Standardized	Mass-customized	Customized	
Degree of design complexity	Complex	Standardized complex product systems <i>CCGT power plants</i>	Solid-State DAC	Platform-based complex product systems <i>SMRs, CCS</i>	Liquid-State DAC  <i>Nuclear power plants, BECCS,</i>
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	Simple	Mass-produced products <i>Solar PV, LEDs</i>	Washing Detergent	Mass-customized products <i>Rooftop solar installations</i>	Small-batch products <i>Building envelope retrofits</i>

Source: [Roberts & Nemet, 2024](#), technology framework from [Malhotra and Schmidt, 2020](#)

# Maximum feasible deployment scenarios

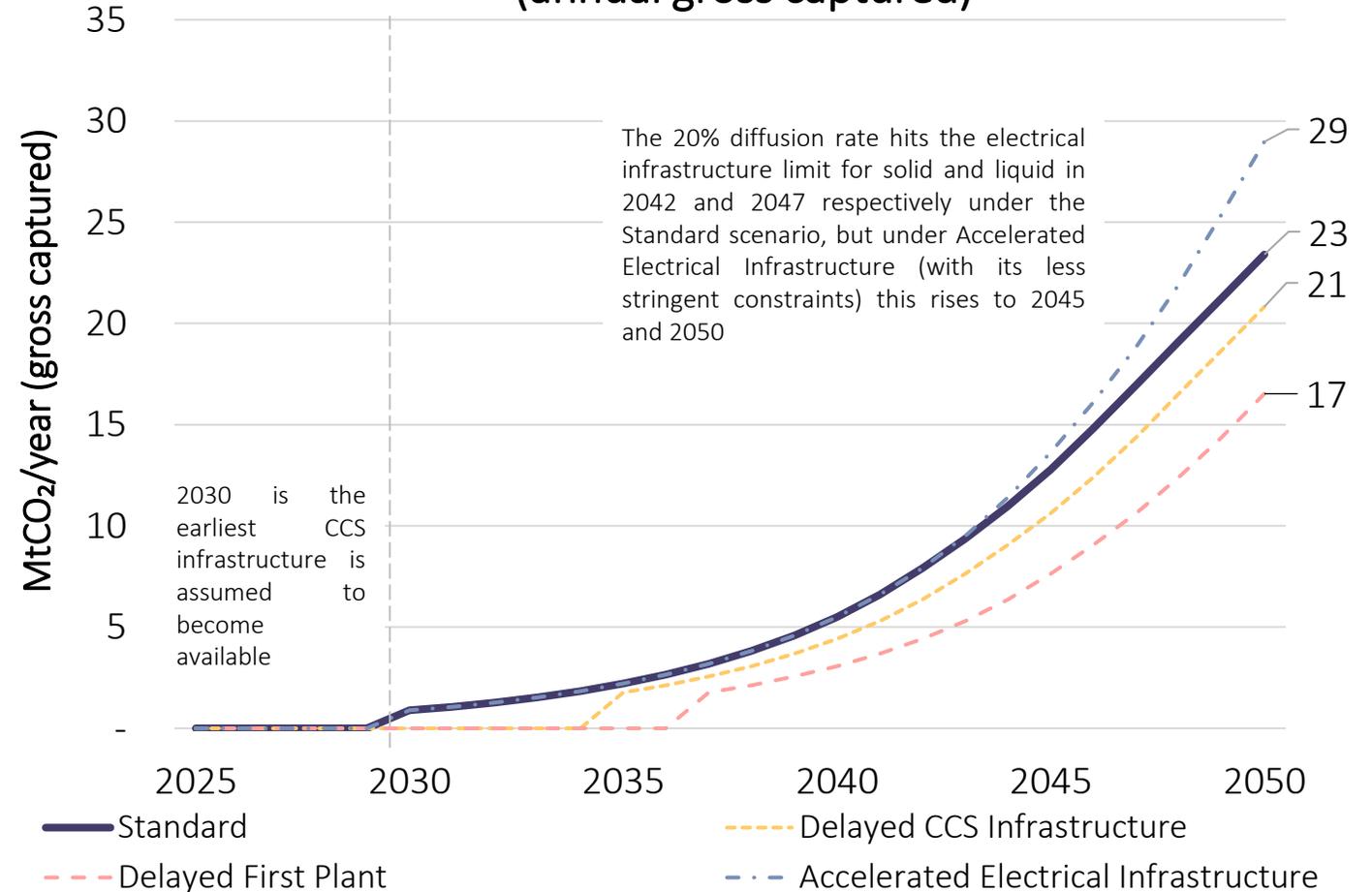
A set of **maximum feasible** scenarios – not to be confused with *recommended* or *probable* scenarios

Scenarios constructed with:

- Anticipated CCS infrastructure timelines and assumed grid connection constraints
- A maximum diffusion rate of 20% (equivalent to the historical expansion of wind power in Denmark)

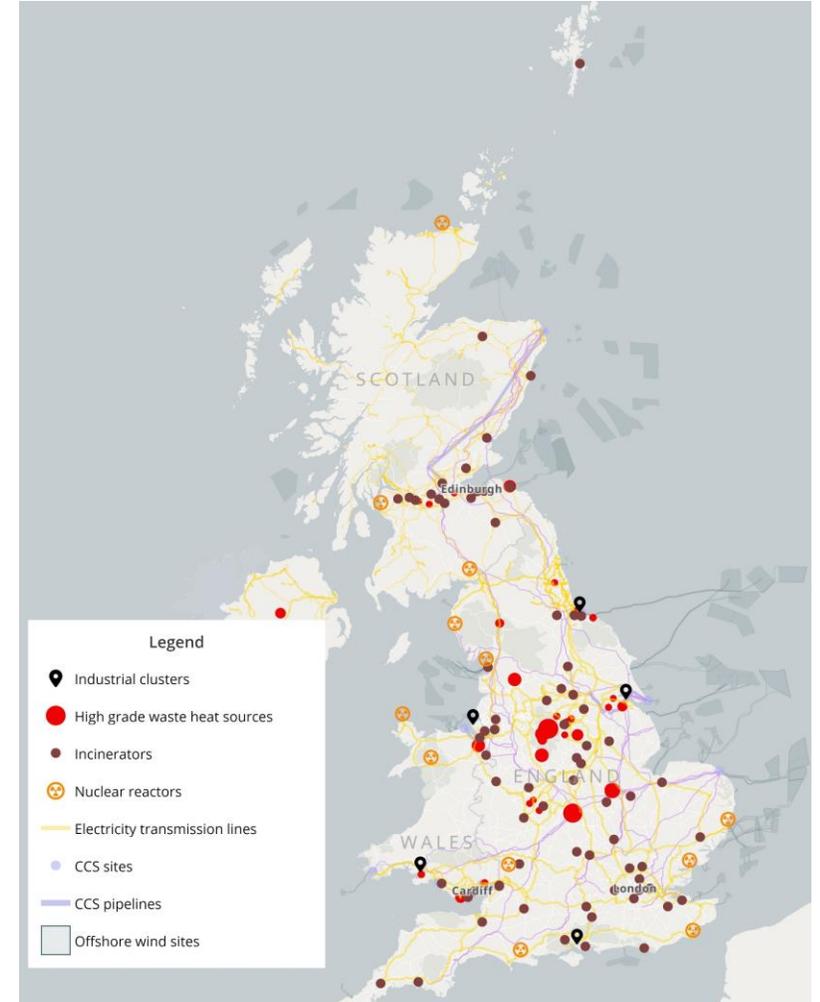
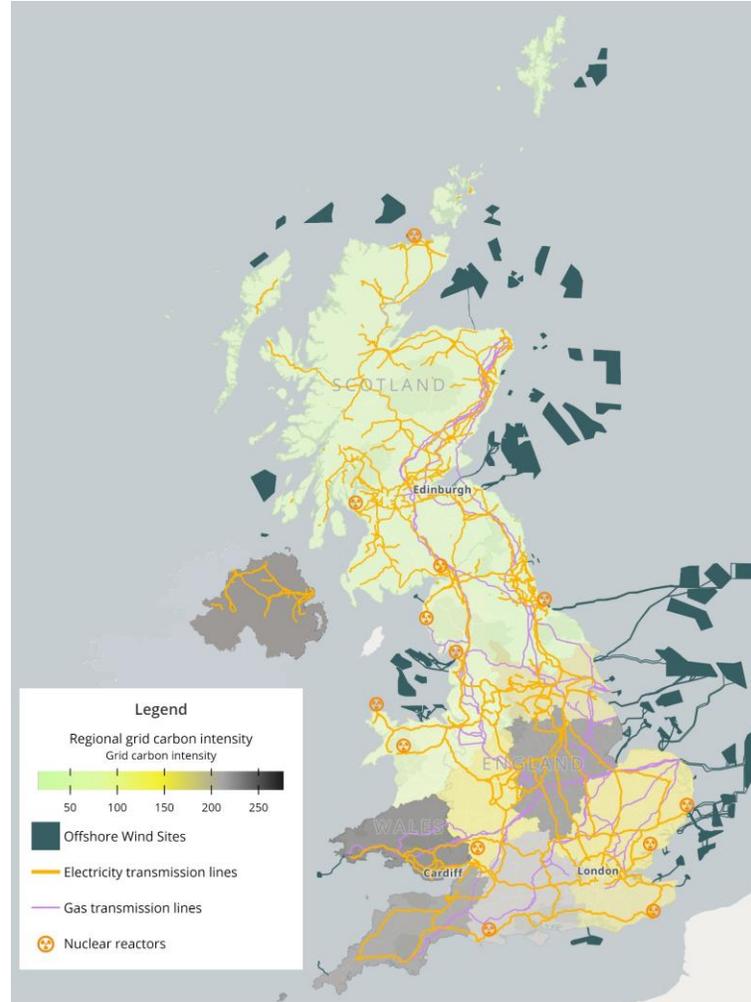
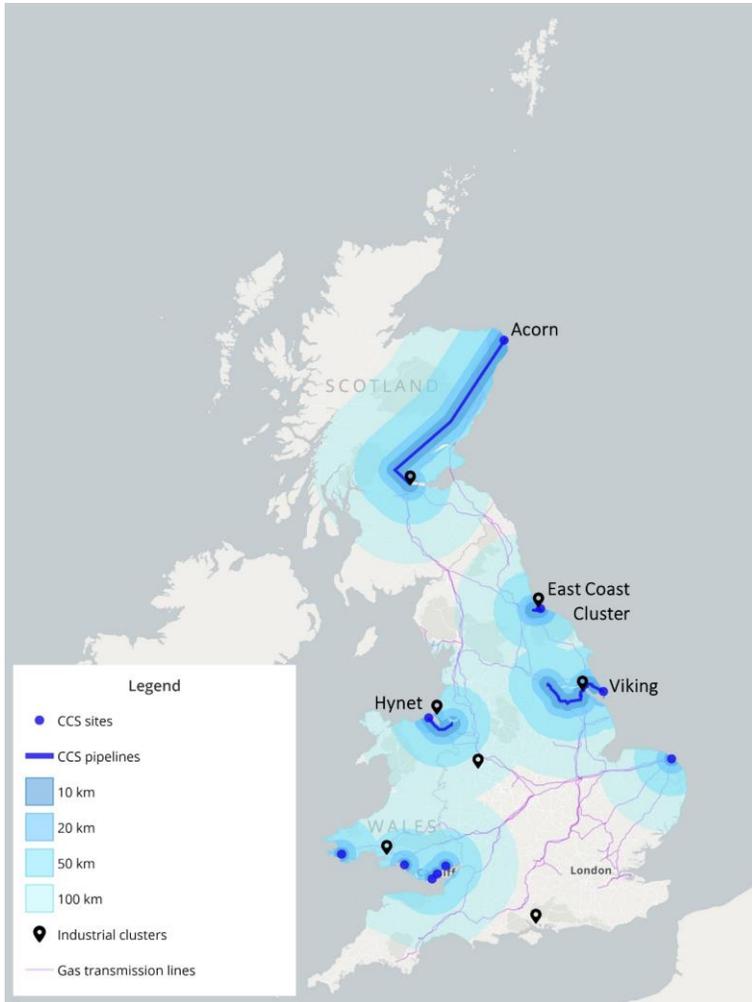
Standard scenario assumes first plants built in 2030, other scenarios delay first build or make the electricity constraint more stringent

## Maximum Feasible Scenarios (annual gross captured)



# Optimal locations in the UK

 Tech requirements, expected constraints and inhibitors



How much is it going to cost?



# Speculation and uncertainty



How much is it going to cost?

What's the future cost of DAC? *No one really knows*

A recent review of academic sources ([Sievert et al., 2024](#)) found ranges of costs in literature of:

- Initial costs (First-of-a-Kind): \$121-2,177/tCO<sub>2</sub>
- Future costs (Nth-of-a-Kind): \$37-386/tCO<sub>2</sub>

All assessments are uncertain and speculative

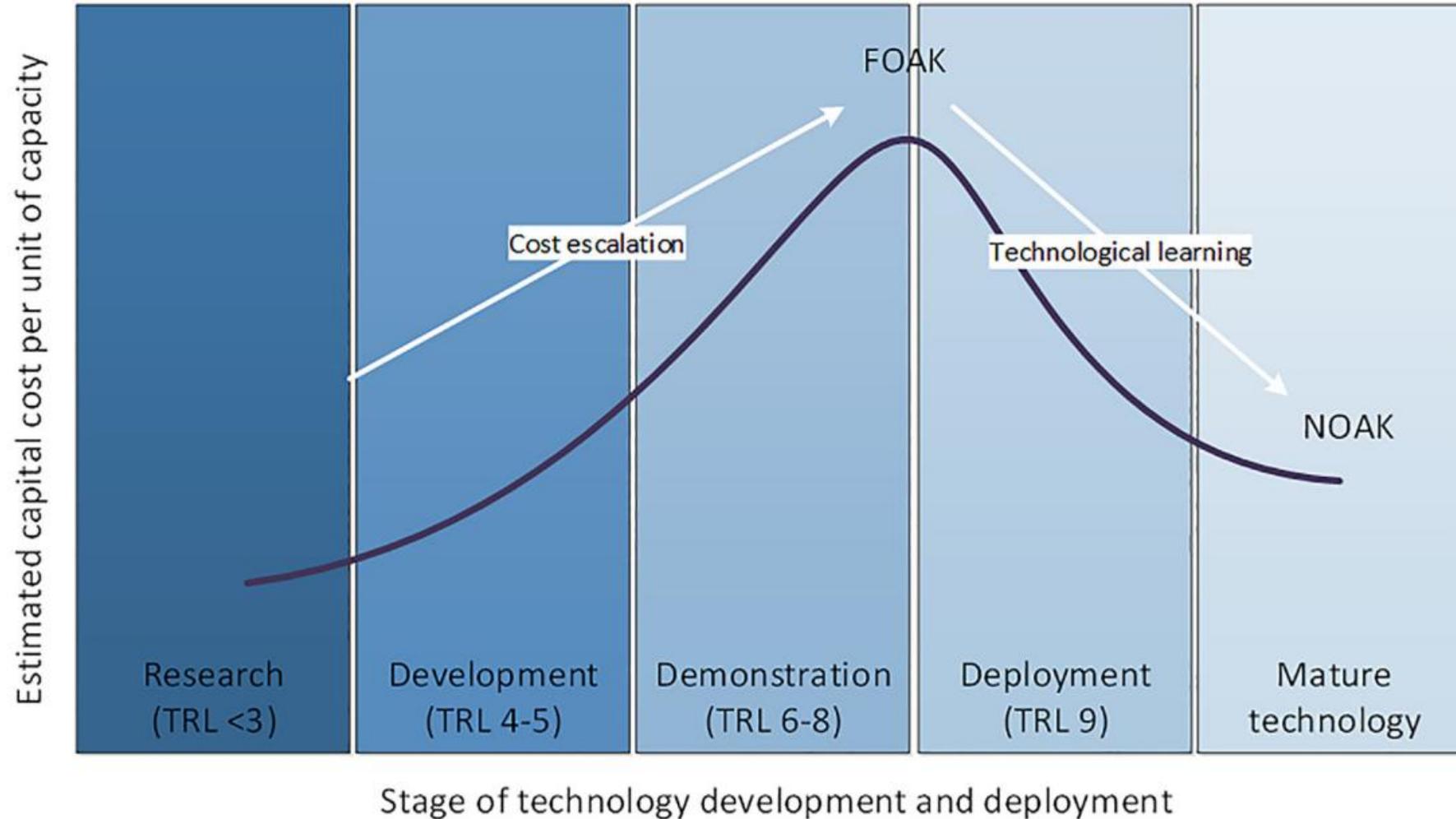
Data is scarce, particularly on plant capital costs for which only a few sources exist ([Keith et al., 2018](#); [Young et al., 2023](#))

We won't know the true costs until more plants are built – and the costs are shared.

# Cost escalation and technological learning

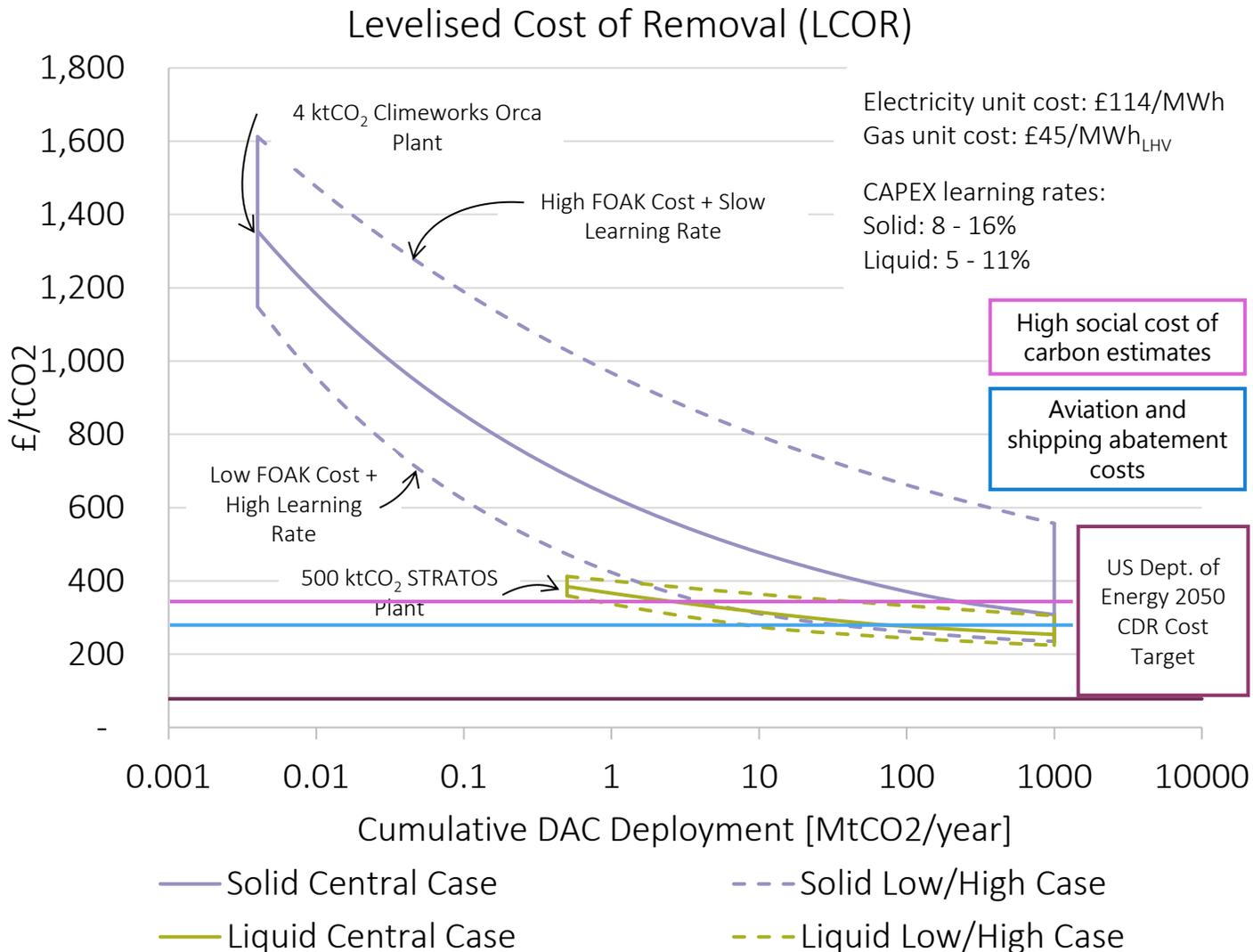


How much is it going to cost?



Source: [Young et al, 2023](#)

# Costs to 1 Gt deployment



Liquid DAC is cheaper initially, but solid DAC's cost reduction is quicker due to higher rates of learning

Neither reach the famous \$100/tCO<sub>2</sub> target proposed by the US Department of Energy

Technology	First plant	1 Gt deployment
Solid	1,148-1,612	235-557
Liquid	360-412	224-305

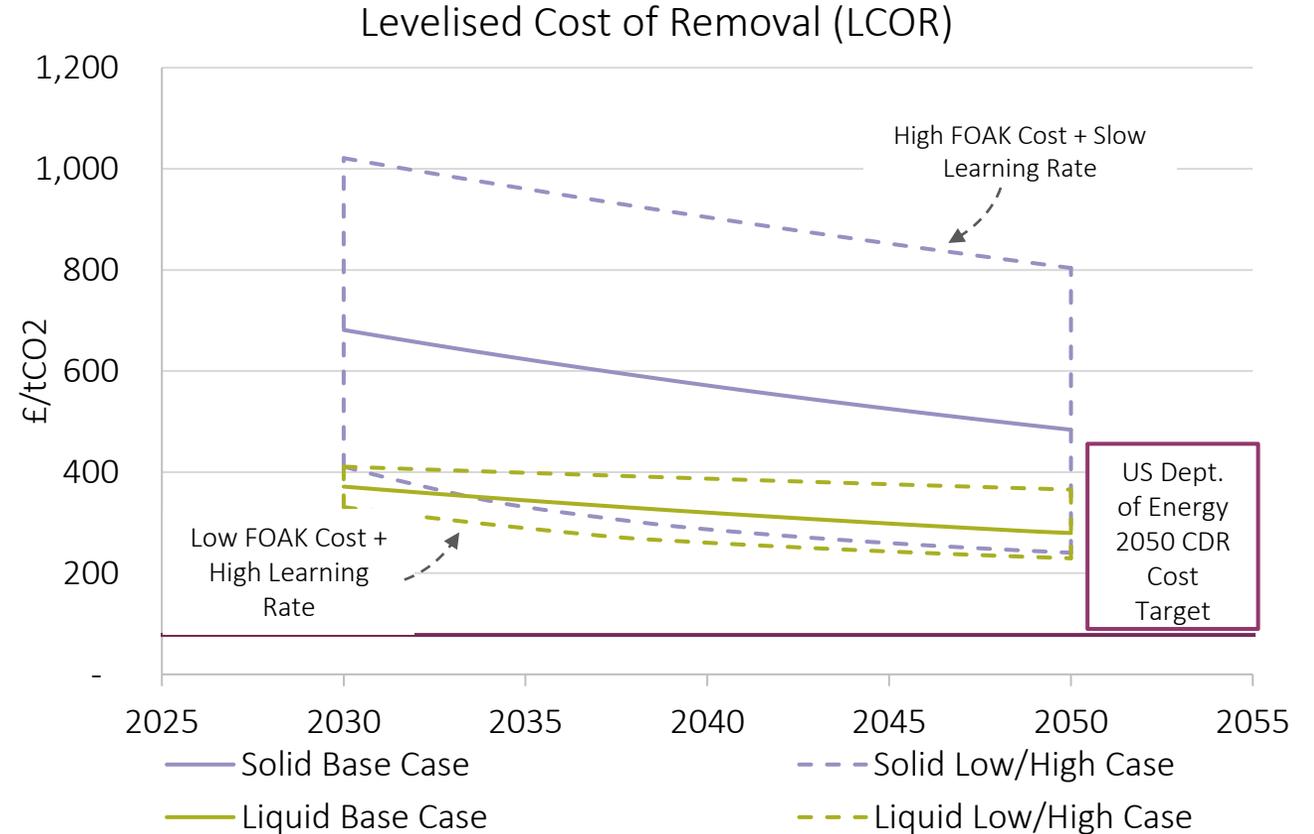
But, it could be less than the abatement costs of some hard-to-decarbonise sectors such as aviation and shipping ([Martin et al., 2023](#))

And it is less than some of the upper end of social cost of carbon estimates ([Rennert et al., 2022](#))

# But what if we don't get to 1 Gt? Estimates to 2050

Applying a range of diffusion rates from the expected 2025 global capacity:

	Low: 15%	Central: 25%	High: 35%
2025 starting capacity (Mt)	0.54		
2050 Capacity (Mt)	18	143	980
	Diffusion rate is fair, but global deployment appears pessimistic	Diffusion rate is high, deployment falls well below industry ambition	Diffusion rate is very high, but meets industry ambition



Technology	2030 deployment	2050 deployment
Solid	411-1,021	241-804
Liquid	331-411	230-365

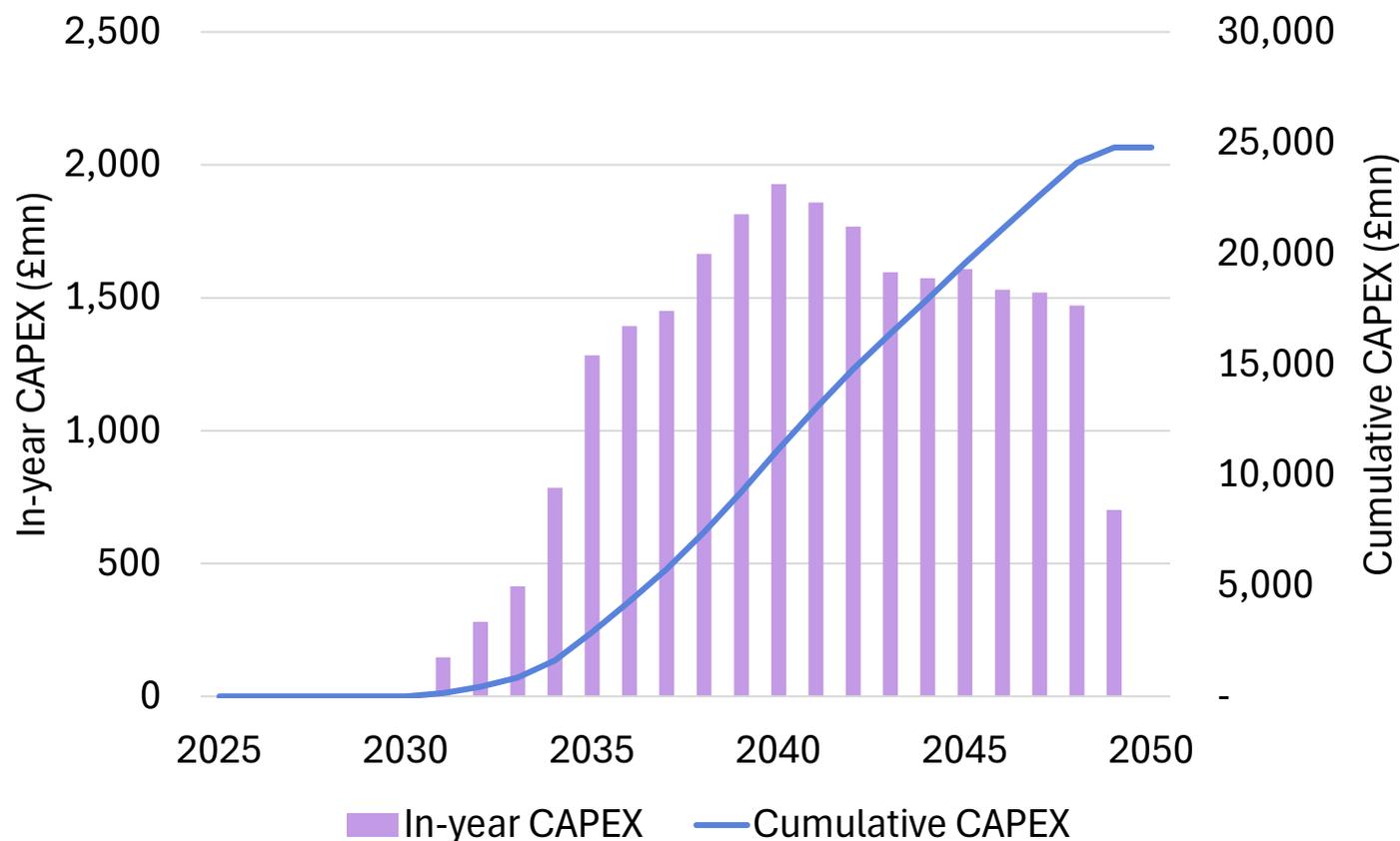
Under these deployment projections to 2050, our cost reductions are less dramatic

# A giga-pound level of investment



How much is it going to cost?

CCC 7CB Balanced Pathway, DAC Deployment, In-year and cumulative CAPEX\*



£25bn of capital investment required to reach 7CB level of deployment by 2050 (17 MtCO<sub>2</sub>)\*

In-year investment from mid-2030s requires in the order of £1.5bn per year

For a sense of scale, London's Crossrail has been estimated to cost £18bn

But DAC could attract private investment, provided there are marketplaces for CO<sub>2</sub> storage or utilisation

\*Assumes 50/50 split between solid and liquid DAC, uses central costing assumptions

Should we even be  
deploying DAC in the UK?  
Or elsewhere?



# Where else might be better?

Through discussions with industry experts, we chose the following four locations for further investigation:

## US (Gulf Coast)



- Has the most lucrative policy support, providing \$180/tCO<sub>2</sub> for CO<sub>2</sub> stored, along with direct support for DAC hubs
- Low electricity and gas prices, and high potential for solar, wind, and geothermal
- Extensive geology for onshore CO<sub>2</sub> storage

## China



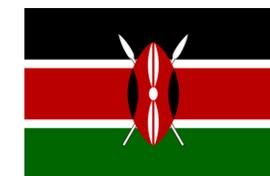
- An industrial powerhouse with a track record of delivering megaprojects
- Low-cost, abundant energy sources with large renewable potential and relatively low industrial electricity prices
- Initial estimates suggest over 1,000 GtCO<sub>2</sub> of potential geological storage capacity

## Middle East (United Arab Emirates)



- Excellent solar potential and low natural gas prices
- Widespread depleted oil and gas reservoirs suitable for CO<sub>2</sub> storage

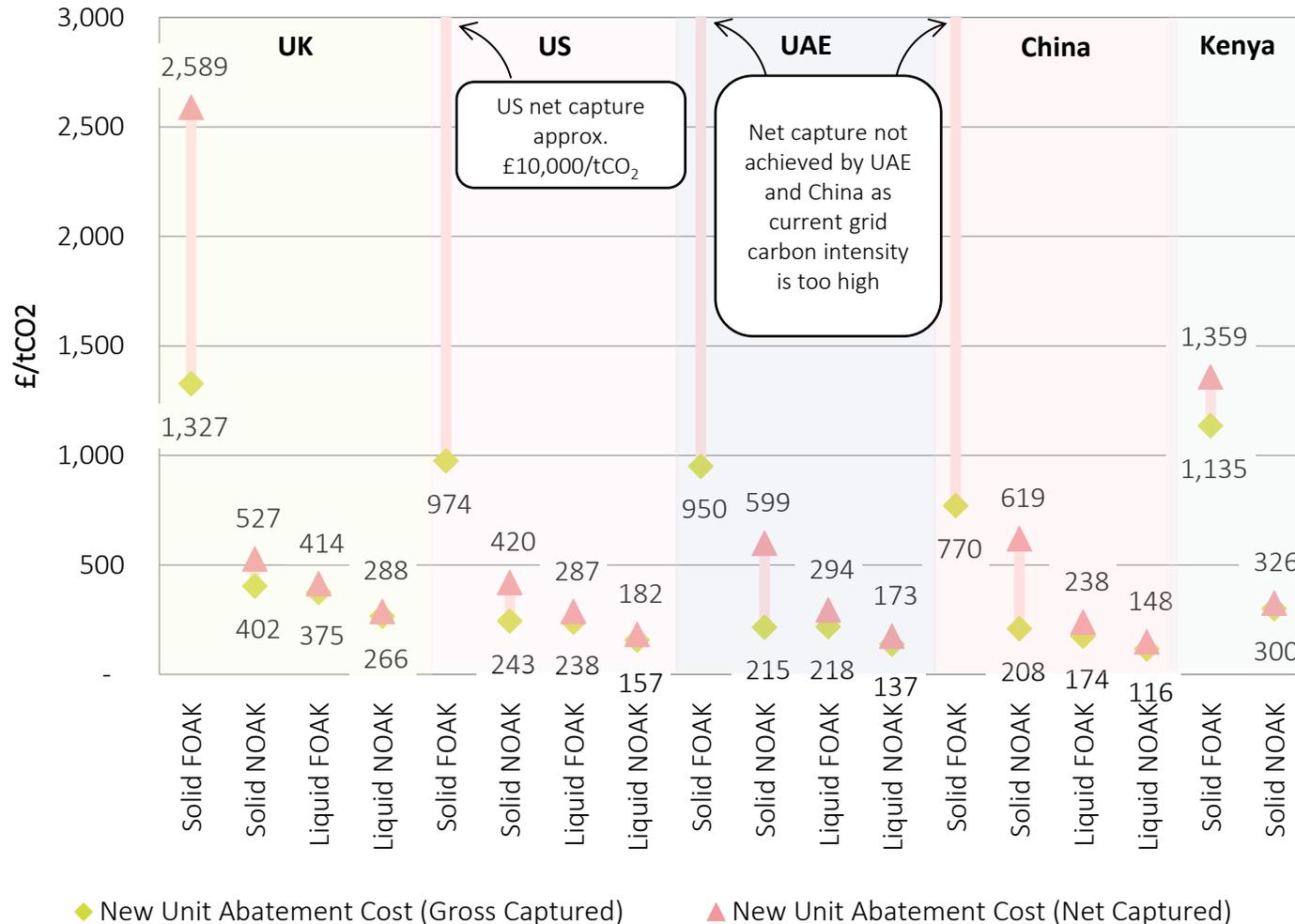
## Kenya



- Geology for geothermal energy and onshore CO<sub>2</sub> storage, coupled with excellent climatic conditions, makes the Kenyan Great Rift Valley a “goldilocks” location for DAC
- Indicative estimates that the Great Rift Valley could store up to 400 GtCO<sub>2</sub>

# The UK is unlikely to be cost-optimal

New Unit Abatement Cost (gross captured & net captured) - Central Case  
(NOAK is at 71.5 GtCO<sub>2</sub> cumulative deployment)



Factoring in differences for:

- Material costs
- Energy prices
- Labour costs and productivity
- National grid emissions intensity

The UK is a higher cost location in most of the situations investigated

But, the lower emissions intensity of the UK's national grid results in "net captured" costs being lower against UAE and China for solid DAC (which is fully electrically powered)

# The UK's opportunities and advantages



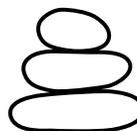
# The UK still has a chance



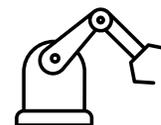
**CCS infrastructure** – plans for CO<sub>2</sub> transport and storage with the Track Cluster developments



**Upcoming policy support & a commitment to net zero** – proposed GGR business model and removals inclusion in the UK ETS. UK SAF mandate could drive DAC CO<sub>2</sub> feedstock. The UK is at less risk of reversing this policies than other countries due to political swings



**Geology and advanced assessments** – at 78 GtCO<sub>2</sub> we have ample storage capacity for our own emissions and others. Assessment and mapping of this storage capacity is advanced too.



**Skills and innovation** world-class engineering talent, research institutions, and a track record of innovation in clean technology



**Low-carbon electricity** – a rapidly decarbonising grid with ambitious further targets: Clean Power 2030

# Concluding remarks: Moving forward on DAC



# Concluding remarks

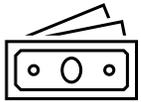
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Assessments are still speculative and uncertain



Supporting infrastructure will be a constraint – particularly electricity and CO<sub>2</sub> transport and storage



Estimated costs are high, and whilst there will be cost reductions through learning, do not expect this to become cheap



Drawing parallels with the scale-up of other technologies reveals a much lower level of deployment than many authoritative scenarios and corporate targets suggest



Furthermore, there is not yet a firm market to drive uptake of CO<sub>2</sub> removals – waste removal services require mandates from governments

The above statements set a pessimistic outlook for DAC; the scale of physical challenges is huge, the costs will be high, and public policy support is essential

# Concluding remarks

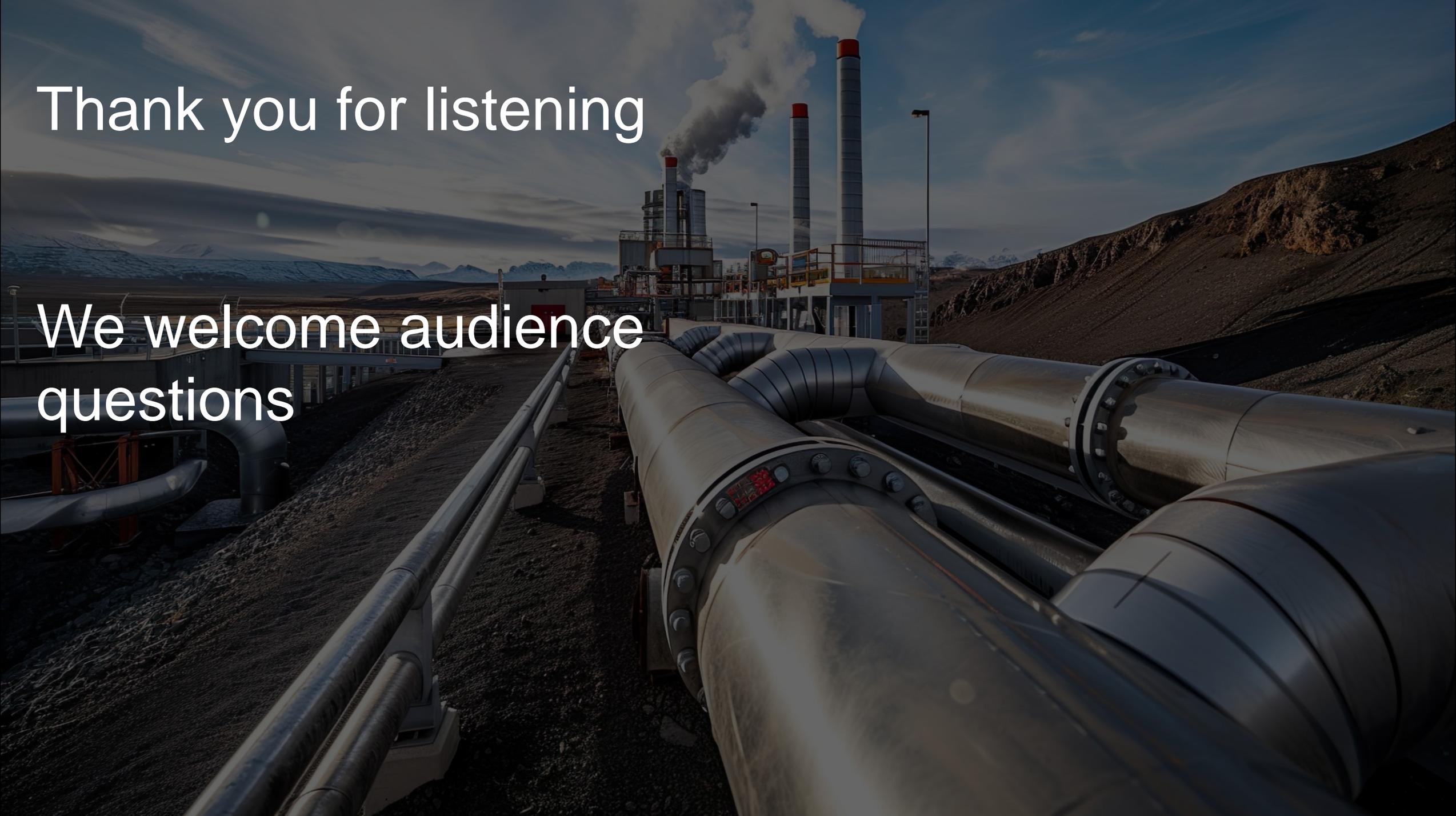
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Yet, the key arguments still hold:

1. We need significant amounts of removals to maintain safe levels of CO<sub>2</sub> concentrations, and it is too early to say whether other removal methods can fulfil that need without DAC
2. We need sustainable carbon feedstock, and it is not clear whether biogenic carbon will be enough to meet future needs
3. Whilst DAC will never be cheap, its costs could fall below abatement costs in some sectors, and could fall below the upper end of social cost of carbon estimates

Moving forward then, it seems fair to argue that at least some of our resources should be directed towards the research and development of this technology.

We will never know its true potential until we see more large-scale plants built...

A photograph of a geothermal power plant. In the foreground, several large, dark-colored pipes run parallel to each other on a gravelly ground. In the background, there is a complex of industrial structures, including two tall smokestacks with red caps, and a building with a chimney emitting a plume of white smoke. The sky is a mix of blue and grey, suggesting an overcast day. The overall scene is industrial and set in a rugged, mountainous landscape.

Thank you for listening

We welcome audience  
questions