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Quantification of the UK CO_2 storage export potential for a carbon capture and storage service

IDRIC

BGS British Geological Survey

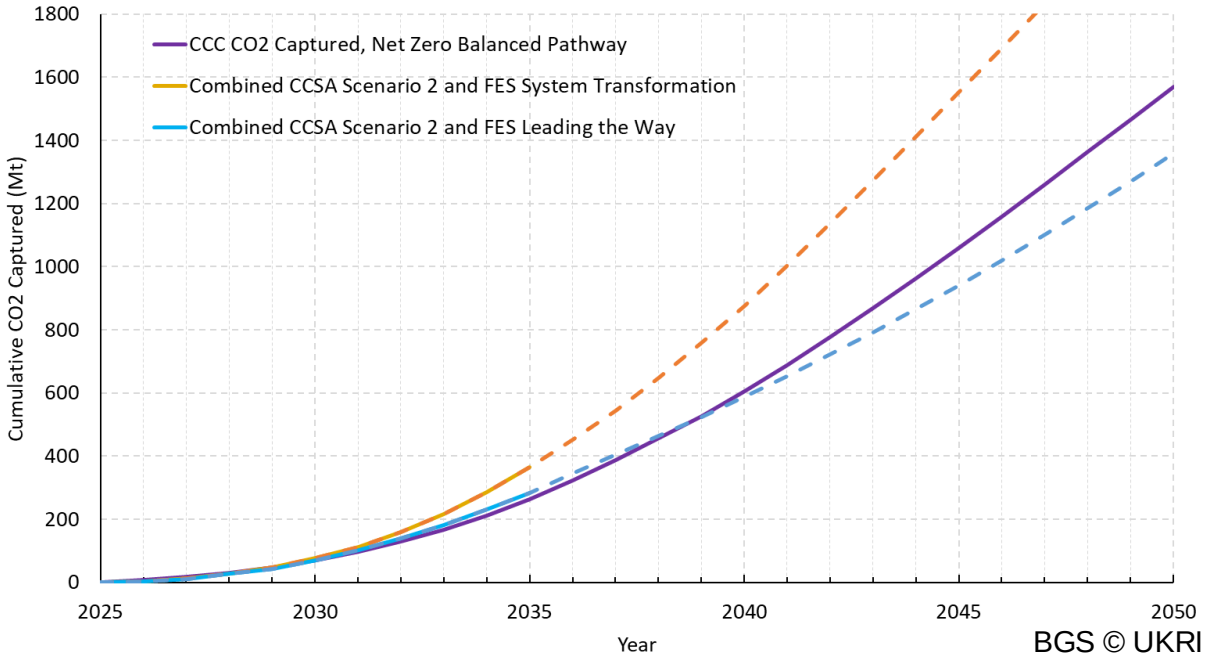
Rationale and objectives

- As Carbon Capture, Utilisation & Storage (CCUS) deployment from UK industrial clusters grows, there is an opportunity to reduce costs, reduce risks to investors and speed up the rate of storage development through the import of CO_2 captured in Europe.
- The scale of this opportunity and the steps needed to realise it have not been fully quantified.
- The BGS has compared the potential UK CO_2 storage resource ‘pipeline’ with the European export potential, from 2025 to 2050.
- This study integrates:
  - a review of publicly available documents and information
  - an assessment of the UK’s appraised CO_2 storage resource
  - modelled uncertainty of available storage capacity
- The study was supported by the Industrial Decarbonisation Research & Innovation Centre.

HOW MUCH STORAGE CAPACITY WILL BE NEEDED BY THE UK?

Cumulative CO_2 captured to meet Net Zero Pathway, using CCS that does not solely rely on public behavioural change, from CCC (2020).

CO_2 for geological storage sourced from energy and industry combined, to achieve net zero:
- from energy generation, **lower** and **higher** supply scenarios, from FES (2023),
- from industry and domestic sources to 2035, from the CCSA (2022), extrapolated (dashed curves) to 2050.



Mt, million tonnes.

UK CO_2 STORAGE RESOURCE MODELLED AVAILABILITY

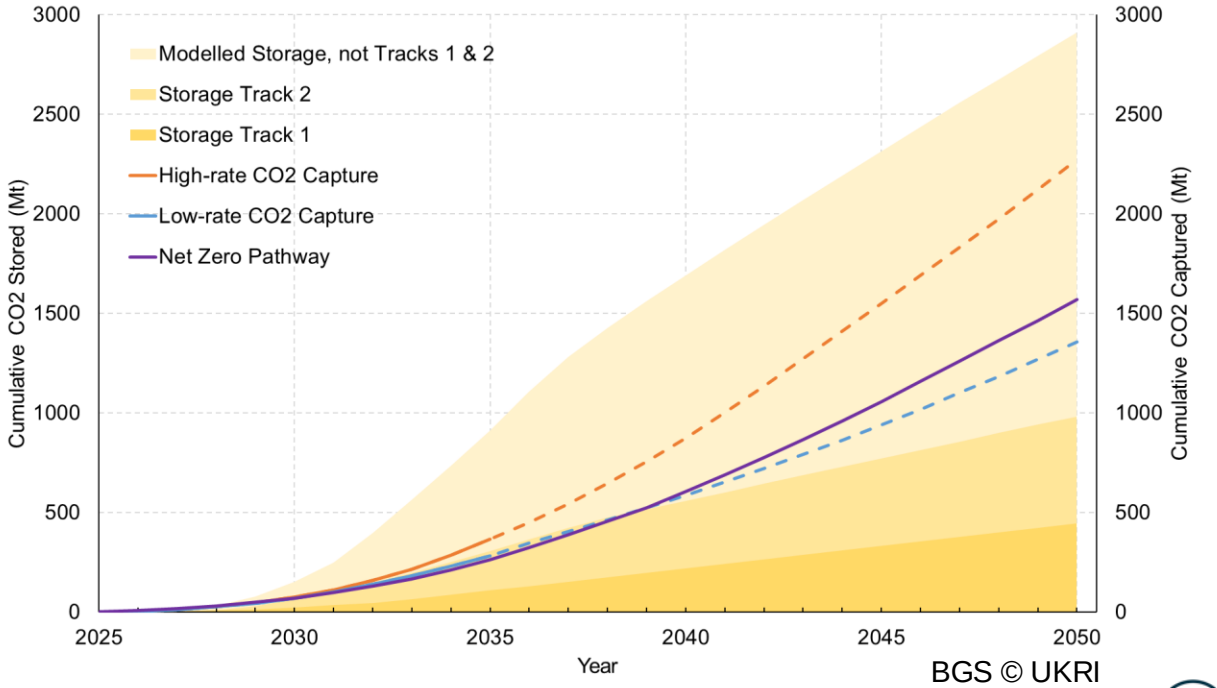
- As of April 2024, twenty-eight storage licences have been awarded in the UK by the North Sea Transition Authority (NSTA).
- Capacity for each UK licensed area is estimated, and Storage Readiness Levels (SRLs) were applied to the scheduled work programme in the awarded NSTA licences.
- The dates at which the 28 licenced sites are likely to become operational are tabulated, for example:

CS appraisal licence number	Site name	SRL 5 completed End Assess Phase	SRL 6 completed End Define Phase	SRL 7 completed Storage Permit Application	SRL 9 date operational	Duration from SRL 7 to planned SRL 9
CS001	Bunter Closure 35	Jun-22	Dec-23	Mar-24	2030	6 years
CS003	Acorn South	Apr-23	Dec-23	Dec-24	2028	4 years
	Acorn Central	Mar-25	Sep-25	Jul-26	2030	4 years

- The storage capacity and the date of its proposed availability are plotted as cumulative available storage resource.
- The focus of UK decarbonisation strategy is on the development of industry clusters, so licences strongly linked with the Track-1 and Track-2 clusters are calculated separately.
- The licensed capacity data are ‘stacked’ to provide the total modelled UK storage capacity; this is the Base Case modelled storage in this study.

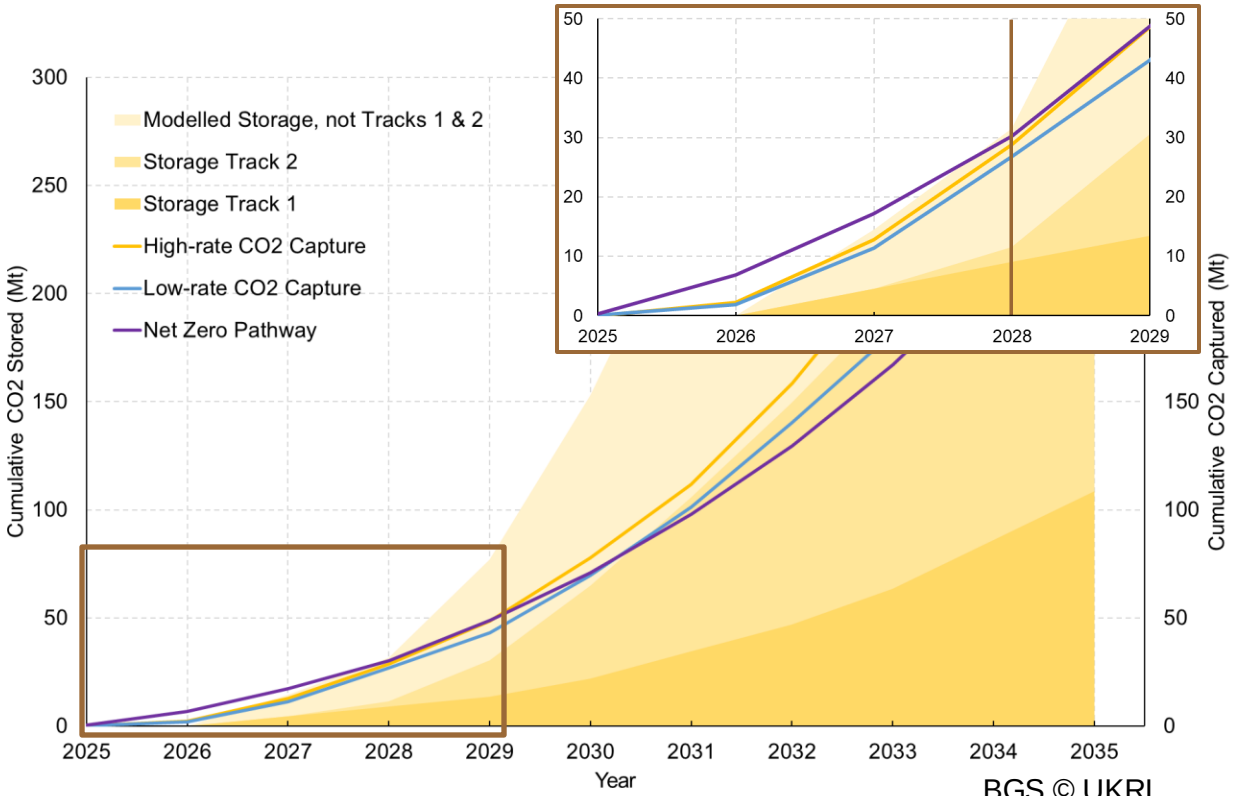
COMPARING CAPACITY WITH ESTIMATED UK CO_2 CAPTURE RATES, 2025 TO 2050

- Modelled cumulative CO_2 storage capacity, yellow – Base Case.
- Assessed UK capture scenarios:
  - CO_2 storage needed to meet **Balanced Net Zero Pathway** emissions (CCC, 2020), (**purple curve**).
  - Cumulative captured CO_2 combined from energy, (FES, 2023) and industry and domestic sources (CCSA, 2022). **Low** and **high** capture rates. Dashed lines indicate extrapolated data included after 2035.



IMPLICATIONS TO NEAR-TERM AVAILABILITY OF UK STORAGE CAPACITY

- Comparing the **Net Zero Balanced Pathway** (**purple**) with the Base Case modelled storage, capture in 2025 is now unlikely and storage will now not commence until 2027.
- From 2025 to **2028** (**brown line**), inset, there is a risk that capture rates will exceed available CO_2 storage capacity.
- Early development of capacity will be sufficient to meet CO_2 supplied for storage at **lower** (**blue**) or **higher** (**orange**) rates if **all** licenced capacity achieves **full** operation.



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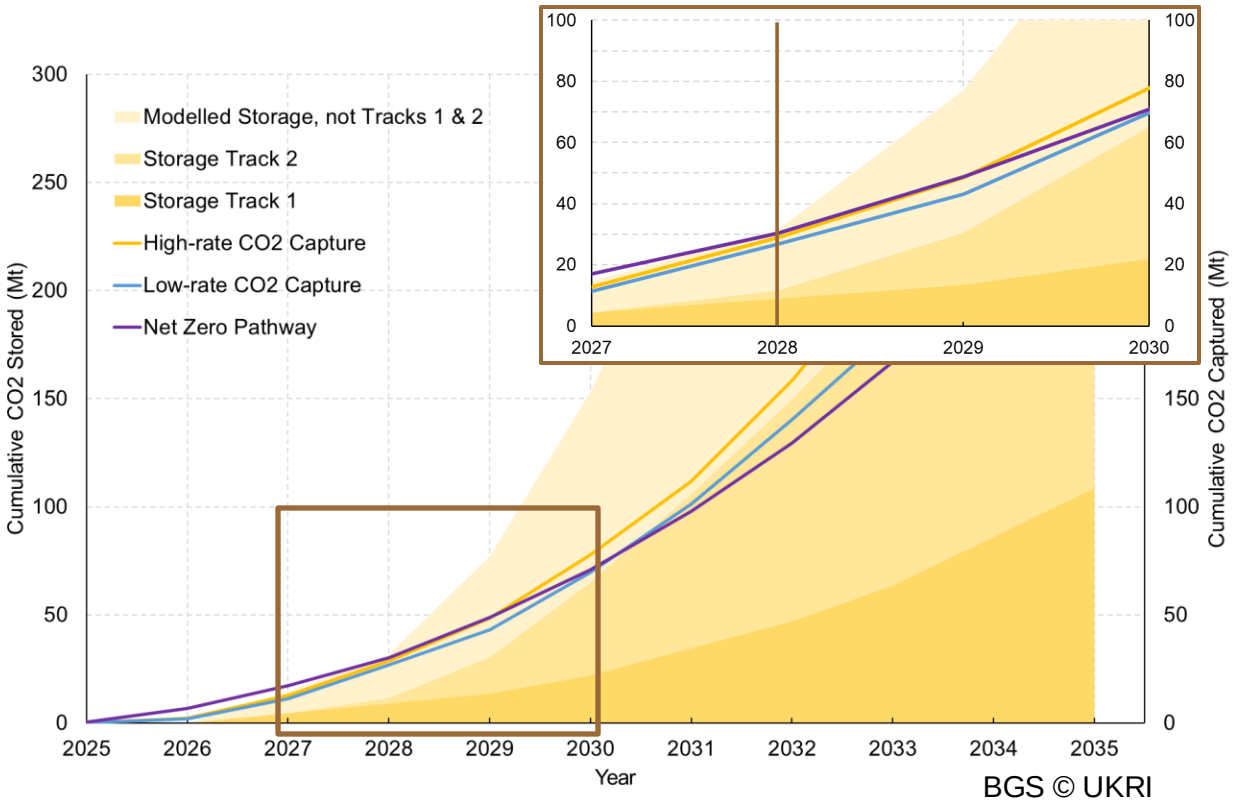
Note change of axis scales relative to previous slides

IMPLICATIONS TO MID-TERM AVAILABILITY OF UK STORAGE CAPACITY

- From **2028** (**brown**) sufficient storage capacity is expected to become operational. The modelled available capacity (yellow) is greater than CO_2 captured for storage for one or both combined (**orange** or **blue**) CCSA and FES curves, inset.
- Sufficient capacity from **2028** will only be available **if all** the Track-1 and Track-2 storage projects are operational, **and all** the additional licensed storage sites achieve operation as planned.



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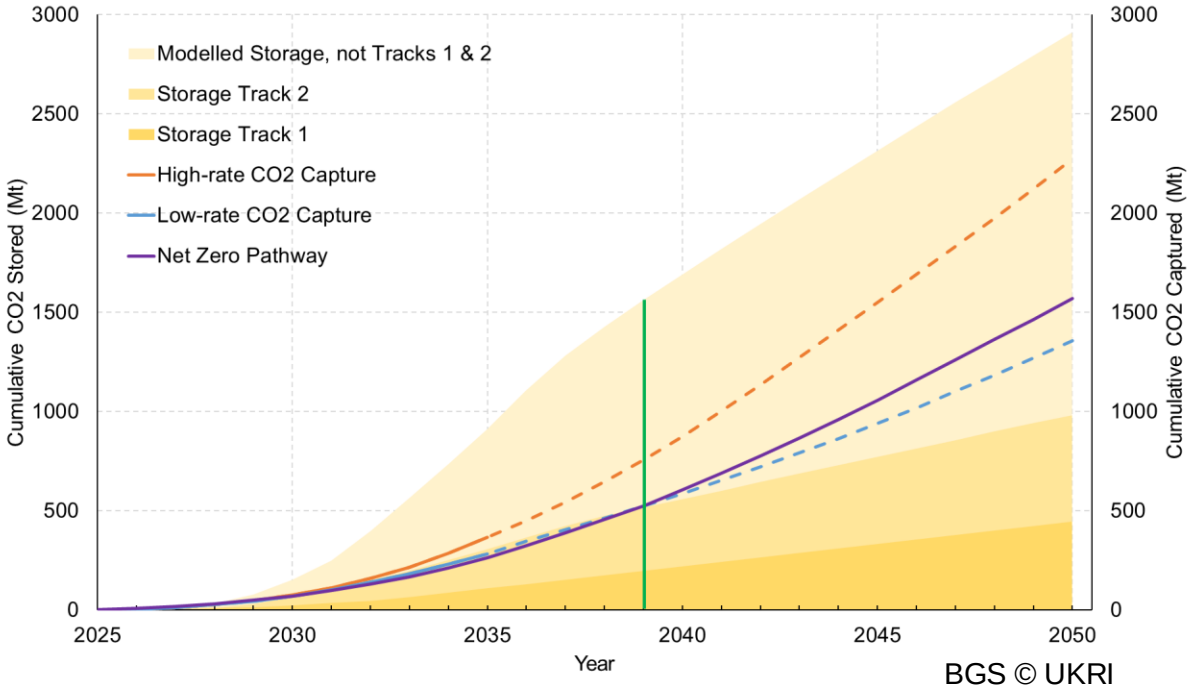
IMPLICATIONS TO LONG-TERM AVAILABILITY OF UK STORAGE CAPACITY

- Track-1 and Track-2 storage licences could provide sufficient capacity, at the **lower rate of CO_2 supply** (**blue curve**), until 2038.
- From **2039** (**green**) Track-1 and Track-2 storage capacity **alone** will not be sufficient to meet required CO_2 capture at either the lower or higher rate.
- If **all** the modelled storage capacity at all currently developing licenced storage sites becomes operational in **full**, there would be more than sufficient storage capacity for UK need



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MODELLING UNCERTAINTY IN AVAILABILITY AND TIMING OF UK CO_2 STORAGE CAPACITY

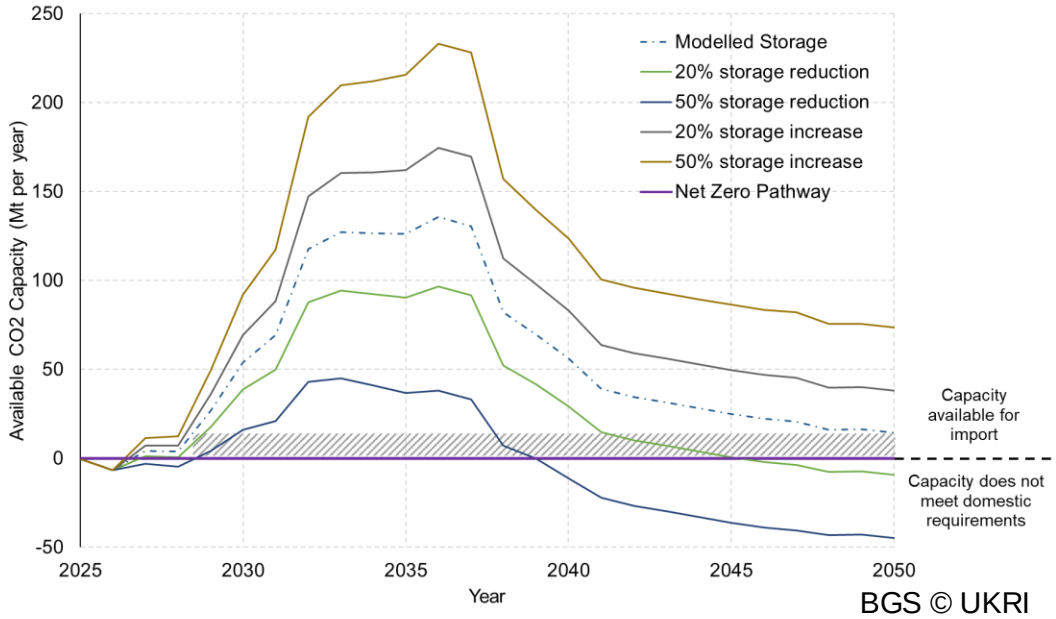
- The modelled Base Case assumes that injection will occur at the annual rates planned in the awarded appraisal licences until a CO_2 storage site reaches its maximum capacity and all storage sites are filled.
- Additional cases were modelled as there is uncertainty in injection rates, available storage capacity and the timing of its availability.
- Storage capacity could also be increased through more licensing rounds or increased efficiency.
- If injection rates vary from the planned rates or licenced sites do not progress to operational storage, uncertainty in storage availability is modelled by increasing or reducing capacity by 20% and 50%.
- Delay to implementation is modelled by delaying onset of storage by three and five years relative to the Base Case.

IMPACTS OF REDUCED CAPACITY AND DELAYS TO ACHIEVING OPERATIONAL STORAGE RELATIVE TO THE BASE CASE

- With a five-year delay together with a 20% reduction in storage, the remaining storage in the current permitting process will be *just* sufficient to meet the higher required capture rates.
- A 50% reduction in storage would not meet the highest modelled capture rate but would be just sufficient to meet the lowest.
    - The implication is that additional storage will be needed, to de-risk storage availability
- New licensing rounds will be needed to meet expected future UK capture rates, given the potential impacts of the risks of delay and reductions in modelled storage identified here
- Increasing the storage capacity, through the development of new storage sites and optimising the capacity of existing licences will help to reduce the risks posed by delays and reductions in the current pipeline of permitted storage:
    - An increase of only 20% from our Base Case modelled storage would achieve this.
    - Whilst this may be perceived as an overinvestment to mitigate a risk, any additional capacity could be used to store CO_2 captured from Europe.

AVAILABILITY OF UK STORAGE CAPACITY FOR IMPORTED CO_2

- The **Balanced Net Zero Pathway** is used as a baseline to meet UK domestic requirements
- Comparing storage capacity with capture rates indicates the excess capacity available for import or a deficit where capacity does not meet domestic requirements
- The difference between the modelled storage availability (**blue dot-dash curve**) and the **Balanced Net Zero Pathway** indicates the capacity available for storage of imported CO_2
- It is assumed that agreements to store imported CO_2 would need to secure storage for periods of ten years or more



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- An import capacity of 14 Mt per year is estimated, which may be available from the late 2020s (grey shaded area).
- Although there would be increased capacity available for import from the early 2030s the subsequent decrease, during the mid-2040s, defines the maximum the UK could consistently import at 14 Mt per year

CAPACITY FOR STORAGE OF CO_2 CAPTURED IN EUROPE

- Assuming the Base Case modelled storage becomes available as currently predicted, up to approximately 14 Mt per year CO_2 captured in Europe could be stored in the UK
- This storage could be available from the late 2020s and equivalent to more than 5% of the European storage target projected for 2050
- Increasing storage availability in the mid-2030s, noting the time taken to achieve operating stores, would further increase UK storage of CO_2 captured in Europe.
- Increasing capacity to enable storage of European CO_2 could support the UK Government's vision for the UK to transition to a merchant-based market for CCS, from 2030.
- A 20%, or greater, **reduction** in modelled storage would mean that no storage would be available for CO_2 captured in Europe.
- A 20% **increase** in modelled storage would enable the UK to store up to 38 Mt CO_2 imported per year requiring new storage, not currently developed, to be operational

SUMMARY OF UK CO_2 STORAGE AVAILABILITY

- BGS has assessed the UK CO_2 storage capacity 'pipeline' to 2050.
- From 2025 to 2028, there is a risk that capture rates could exceed available capacity.
- Storage capacity available during implementation of first CCS projects will be sufficient to meet CO_2 capture rates **if** all Track-1 and Track-2 storage projects **and all** additional licenced storage sites achieve operation as planned.
- Track-1 and Track-2 storage licences could provide sufficient capacity, at the lower rate of CO_2 supply, until 2038. From 2039, Track-1 and Track-2 storage capacity alone will not be sufficient to meet required CO_2 capture at the lower rate.
- If **all** currently licensed storage projects become operational, they would provide more than sufficient storage capacity for UK and could accommodate imported CO_2 through to 2050.
- A 50% reduction in storage capacity, not unfeasible for construction of first projects would create a notable deficit until 2030, but then sufficient capacity to 2048
- Timely development of early CO_2 storage projects & additional licensing rounds would reduce the risk of insufficient capacity

SUMMARY OF CAPACITY FOR STORAGE OF CO_2 CAPTURED IN EUROPE

- Approximately 14 Mt per year CO_2 captured in Europe could be stored in the UK from the late 2020s to 2050.
- A 20% reduction would mean no storage would be available for imported CO_2
- A 20% increase would enable the UK to store up to 38 Mt imported CO_2, requiring new storage to become operational
    - This could become available between 2032 and 2036, assuming a new storage licensing round was initiated as early as possible in 2024
- Increasing storage availability in the mid-2030s would allow increased storage of imported CO_2 to support the transition to a merchant-based market for CCS.
- Increasing storage capacity by 50% would enable Europe to store up to 74 Mt per year in the UK with availability sometime in the mid-2030s, equivalent to approximately one third of Europe's highest target storage rate for 2040.

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R. Cownden and Prof M. Lucquiaud, University of Sheffield, advised on the mass of CO_2 produced for geological storage by gas-fired power generation and hydrogen reformation from methane.

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