



CCUS Delivery Plan Update 2023



September 2023

The Carbon Capture and Storage Association (CCSA) is the trade association focused on accelerating the commercial deployment of carbon capture, utilisation and storage (CCUS).

We work with our members, governments and other organisations to ensure CCUS is developed and deployed at the pace and scale necessary to meet net zero goals and deliver sustainable growth across regions and nations.

The CCSA has over 100 member companies who are active in exploring and developing different applications of carbon capture, CO₂ transportation by pipeline, ship and rail, utilisation, geological storage, and other permanent storage solutions, both for end-users of the technology and those in the supply chain, as well as members from management, legal and financial consulting sectors.

Foreword



This has been a critical year for the future of carbon capture, utilisation and storage (CCUS) in the United Kingdom.

Significant strides forward have been taken as the Government allocated £20 billion of revenue support to the industry. It also selected eight carbon dioxide (CO₂) capture projects from the first two Track-1 clusters to enter into negotiations, and chose the next two Track-2 clusters that will deploy before 2030.

The response of business has been positive. As this *CCUS Delivery Plan Update* sets out, the number of carbon capture and storage projects planned for the UK has grown from 55 projects to over 90, with enough schemes now in the pipeline to capture around 94 million tonnes (Mt) of CO₂ – up 29% from 73 Mt last year. Collectively, these plans could make significant steps on net zero and deliver the government's target of capturing 50 MtCO₂/yr by 2035, if they come to fruition. There is tangible progress on supply chain engagement and an increased focus on skills within and between businesses.

The reward is clear. A vibrant CCUS industry could unlock almost £40 billion in direct investment to our country, deliver 70,000 new jobs and protect 77,000 more in existing carbon-intensive industries. This technology will not only secure the future of many of our UK-based industries, but also help to secure our energy supply in the long term with low carbon power, all whilst helping transition our expertise as an oil and gas producer, re-using the pipelines and underground stores which held carbon-based fuels for millions of years.

But as our *CCUS Delivery Plan Update* also sets out, the risks to successful deployment in the UK are just as clear. Almost a third of the potential projects told us they would consider relocating outside the UK if they cannot progress here, particularly as other countries begin to catch up and move ahead on support, regulation and licensing. At the time of publication, the UK has still not passed its Energy Bill – critical to enabling CCUS business models – into law, or set out a timeline for when the promised £20 billion will be spent and how it will be allocated across different sectors, nor set out the deployment plan called for in the government's Net Zero Review, necessary to drive investment in both the capture project pipeline and recently licensed storage facilities.

Many countries are interested in securing investment from CCUS innovators and not every country will win the chance to become an international hub for this new technology. Only a few places will secure the tens of thousands of jobs and export potential that can come from harnessing widespread global CCUS deployment. The United States has its Inflation Reduction Act acting as a global magnet for investment, and we can see Northern Europe and the Middle East all developing industrial strategies that are attracting international investors.

The opportunity is in our hands, which is why this autumn the Carbon Capture and Storage Association (CCSA) is launching a manifesto for the upcoming General Election year. We are inviting UK politicians on all sides to accelerate the execution of the first four clusters and build on this momentum to develop a world-leading UK CCUS industry.

A blue ink signature of Ruth Herbert.

Ruth Herbert
CEO, CCSA



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Executive Summary

The change to the profile of the CO₂ capture project pipeline since March 2022 indicates that the number of projects aiming to commission pre-2030 has reduced, but there is an increase in projects that are planning to commission in the 2030s.

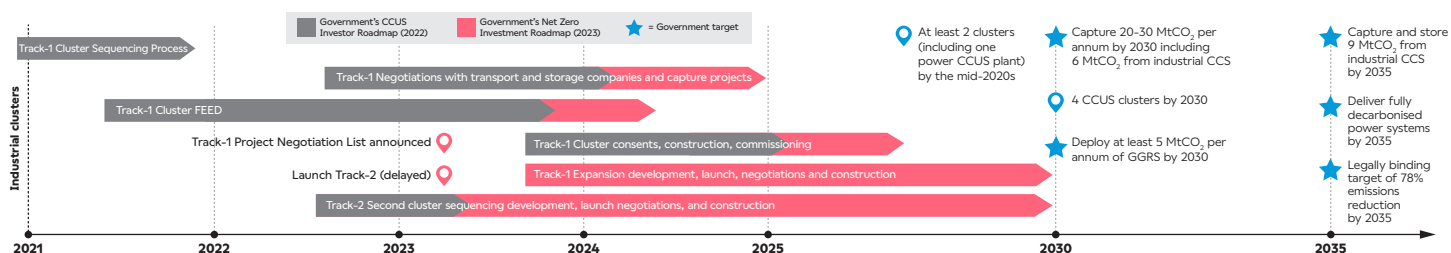
This change in profile may be a reaction to the delays to the government's CCUS cluster programme as shown in figure 2, however there remains a healthy pipeline pre-2030 sufficient to meet the government's 2030 targets whilst ensuring competitive tension.

The government has committed £20bn of revenue support to help deliver CCUS projects. This will unlock similar levels of industry investment, front-loaded over the next few years, once contracts are signed. Over £1bn of industry investment into CCUS so far is just the tip of the iceberg – if government can stimulate the industry to achieve its ambitions, total industry investment could reach around £40bn by 2030.

Figure 1:
Projects in negotiation and Projects at risk against Government 2035 ambition



Figure 2:
Changes to the Government's Investor Roadmap timelines between 2022 and 2023



Key findings from the CCUS Delivery Plan Update

Following the success of last year's *CCUS Delivery Plan 2035*, we have updated the key analysis and figures to reflect progress made by industry in the past year.

We updated the analysis on the project pipeline, to demonstrate and acknowledge the progress made by industry, and sent a survey to members. We hope this analysis will drive action from policy makers, in the aim of accelerating CCUS deployment including beyond the ongoing cluster selection process.



- **The carbon capture project pipeline has grown by approximately 30% since 2022, with over 90 projects now in development in the UK**
- CO₂ capture project developers have invested an estimated £814m in developing projects

- With only eight capture projects in Track-1 negotiations, the majority of this pipeline remains at risk
- **Government must increase the frequency of contract allocation rounds to unlock further investment into the UK**



- There are now **12 clusters in development in the UK**, and following the latest NSTA licensing round, data collected for the Delivery Plan indicates that **licensed storage capacity may have increased by over a factor of 4**
- However, **developers of almost half the UK's storage capacity are unlikely to continue to invest without clarity on future support**

- Transport and storage (T&S) developers face uncertainty over the commercial frameworks for their stores. **The Government must publish a clear deployment plan for CCUS to 2035, with a vision to 2050 and beyond**
- This would incentivise investment now in the development of CO₂ stores that will be required post-2030 Government



- **Around a third of sites planning to retrofit carbon capture, and almost half of the T&S capacity in development, require non-pipeline transport (NPT)**

- **Government must define commercial models for NPT, particularly crucial for dispersed sites, if it wishes to meet mid-to-long long-term CCUS targets** and take advantage of a £30bn per year CO₂ storage export industry*



- 77% of project developers do not envisage deploying CCUS based on Emissions Trading Scheme (ETS) pressure alone
- **29% of capture project developers consider relocating abroad if they cannot access T&S infrastructure and are unsuccessful in obtaining CCUS revenue support**

- **Attractive and accessible subsidy schemes overseas are competing for UK investment, and action from policy makers is required to prevent critical growth industries leaving the UK**

* CCSA analysis: assumes that government support package is available and volume of allocation rounds is sufficient to drive private sector investment in storage site development. Based on exploiting 2/3 of 78 Gt CO₂ storage potential at an average long-run cost of £20/t. Value of onshore industrial inward investment not captured.



Key achievements since our last Delivery Plan

Since our last delivery plan, published in March 2022*, industry and government have worked together to progress towards enabling investment in large-scale CCUS towards the government's CCUS deployment and net zero targets.

There is still a lot to do to ensure delivery of CCUS, but significant highlights and achievements include:

Government has led on:

-  allocating up to £20 billion in revenue support for early stage CCUS deployment
-  selecting eight Track-1 Phase-2 CO₂ capture projects
-  naming two Track-2 transport and storage (T&S) systems
-  introducing the primary legislation needed for CCUS in the Energy Bill
-  awarding 21 new CO₂ storage licenses
-  working with industry to progress business models across the CCUS landscape
-  working with industry to develop CCUS network codes
-  developing secondary legislation on the dispatchable power business model
-  consulting on secondary legislation for the hydrogen producer and industrial business models

Industry has led on:

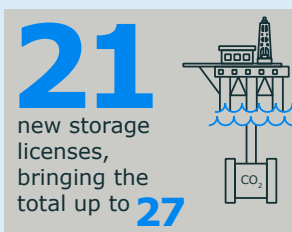
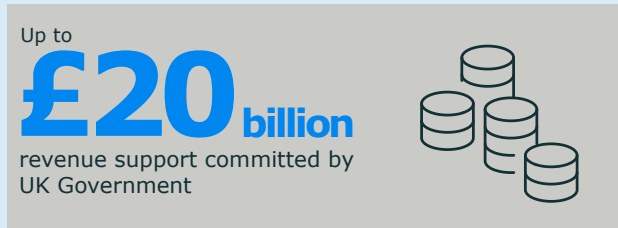
-  growing the pipeline of CO₂ capture projects from 73 MtCO₂/yr to 94 MtCO₂/yr
-  maturing the pipeline of CO₂ storage projects and accepting 21 new carbon storage licences
-  producing a CCUS Supply Chain Strategy, including Good Practice Guidance
-  committing to an ambition of achieving 50% UK content across manufactured components and goods and services provided which underpin CCUS
-  publishing a Workforce & Skills Position Paper with recommendations to address shortages in the availability of skills for CCUS
-  agreeing a strategic approach to communications for CCUS
-  establishing and maintaining an effective dialogue with non-governmental organisations (NGOs)

* <https://www.ccsassociation.org/wp-content/uploads/2022/03/CCSA-CCUS-Delivery-Plan-2035-MASTER-Final.pdf>

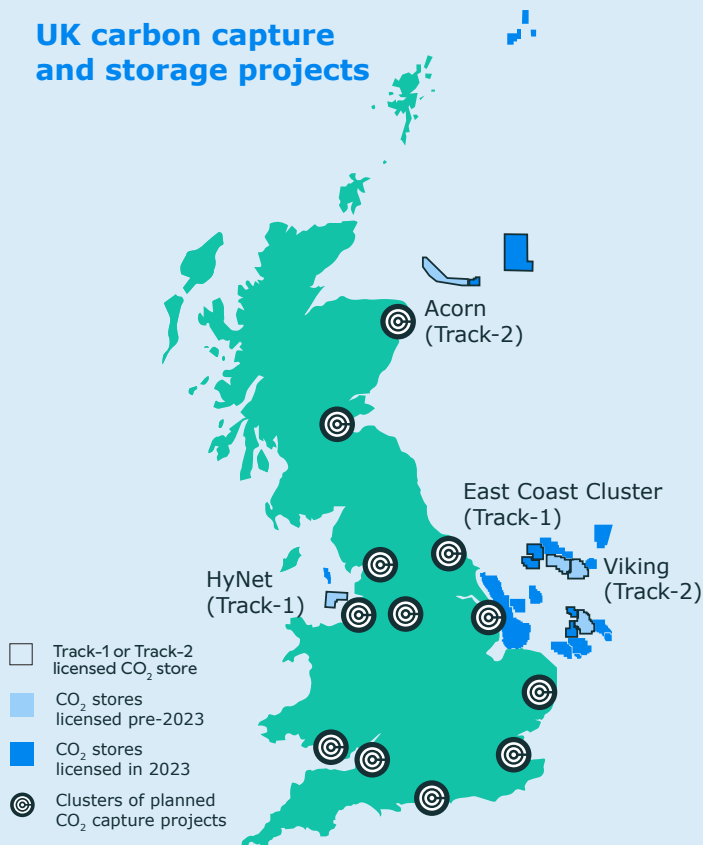


CCUS Delivery Plan

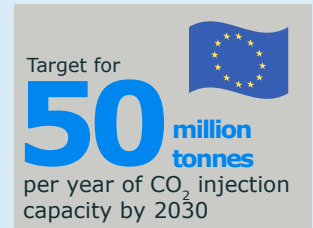
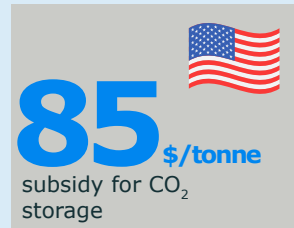
UK Achievements



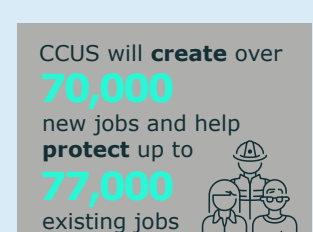
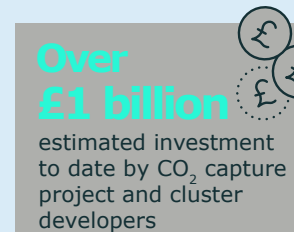
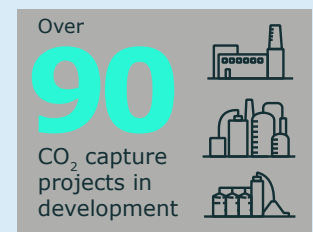
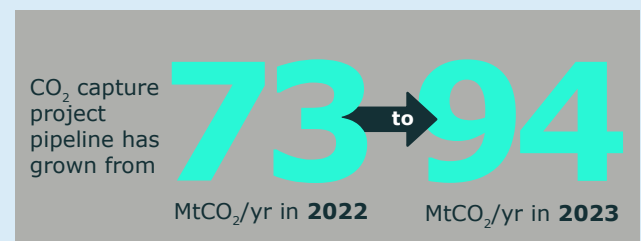
UK carbon capture and storage projects



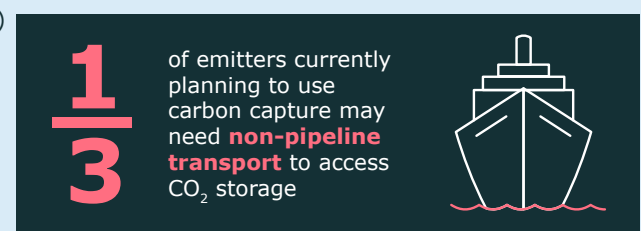
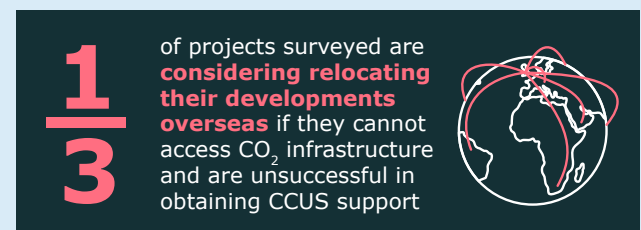
Global Developments



The CCSA has identified...



Policy makers must take action...



Update on 2022 Delivery Plan actions

This scorecard revisits the 10 most urgent actions that we identified in last year's delivery plan. Work is in progress across all actions, although some are falling behind schedule, making achievement of CCUS targets more challenging.

Not started	1. Hold regular funded contract allocation rounds Since the last delivery plan, government has announced up to £20bn in funding for early stage CCUS deployment¹. However, industry still needs certainty about how this will be allocated amongst the first projects and what capital and revenue support will be available for subsequent clusters and projects, and the timing and process for selecting them.
Behind schedule	2. Finalise business models across the value chain The Transport and Storage Regulatory Investment model (TRI), Dispatchable Power Agreement (DPA), Industrial Carbon Capture business model (ICC) and Waste ICC are near completion, and the Low Carbon Hydrogen Agreement (LCHA) is well advanced. Whilst negotiations are continuing alongside business model development, it is increasingly urgent that outstanding issues are resolved swiftly so that the models can be finalised, to allow the clusters and projects to take final investment decision (FID). Greenhouse Gas Removals (GGRs) and Power Bioenergy with CCS (BECCS) are at earlier stages of development and will be needed for subsequent clusters and projects, including Track-1 Expansion and Track-2. Commercial models for non-pipeline transport, particularly crucial for dispersed sites, and CO₂ utilisation, are also yet to be defined².
Completed (late)	3. Launch the next cluster selection process in the first half of 2022 Government selected the first eight capture projects to connect to the Track-1 clusters in March 2023³ and identified the two Track-2 Transport and Storage clusters in July 2023⁴ (originally set out for Q3/4 and Q2/3 2022 respectively in Government's Investor Roadmap 2022), when it also announced the intention for a Track-1 expansion programme⁵. Investors are now waiting for the launch of the process to select Track-1 expansion and Track-2 capture projects, as the next opportunity for projects not successful to date.
Behind schedule	4. Legislate a policy framework to enable projects to develop at pace The Energy Bill⁶ provides the enabling legislation for the business models – Contracts for Difference (CfDs) for CO₂ capture projects and economic regulation for CO₂ transport and storage networks. Once this receives Royal Assent, it will need to be complemented by secondary legislation, which must be passed before CfDs can be signed.
On track	5. Gain consensus on UK strengths in product and skill areas to prioritise for investment Government and industry have identified areas of comparative UK strength within the CCUS supply chain, where targeted investment, if provided in a timely way, could enable scale up of capacity, increasing UK content in the government's CCUS programme and creating a strong base for future exports. There are also areas where there is a significant gap to achieve the required future UK capability and capacity⁷. Industry has begun to engage with suppliers and potential suppliers to gauge potential and desire to move into the space.



Behind
schedule

6. Incentivise UK content in the supply chain

Industry has published a strategy and committed to annual benchmarking and reporting on supply chain performance, to continually identify where future capability and capacity need to be addressed. This includes a voluntary holistic approach to defining and reporting UK content⁸, particularly in supply chain procurement – due to be implemented by clusters by end of 2023. Government is yet to respond with targeted supply chain support to maximise UK content.

On track

7. Accelerate entry into the workforce to meet demand

The CCSA's Workforce & Skills position paper⁹ has identified the need to consider transition pathways for the existing workforce as well as encouraging new entrants into the industry. While there are pockets of good practice, coordinated national action now needs to be taken across all sectors of the economy to address the skills gap for the net zero transition, both by encouraging new entrants and re-training existing workers.

Behind
schedule

8. Accelerate permitting and consenting

The CCSA has worked with industry and regulators on potential solutions to permitting challenges related to provision of the infrastructure and capture projects. A clear permitting framework with associated guidance, taking into account devolved and local government responsibilities, needs to be published and adequately resourced.

On track

9. Rapidly bring additional storage capacity to a commercial level of readiness by 2030

Despite significant progress over the past year with the CO₂ storage licensing round accelerated by the NSTA and 21 licenses awarded¹⁰, the lead time for development of stores remains a lengthy 5-7 years¹¹, so new sites must be developed quickly to remain on track to meet expected UK demand for storage in the 2030s. Store developers need clarity on when they can obtain an economic licence to serve that demand as well as when they can take CO₂ from emitters outside of the UK, given that the UK has a large proportion of Europe's storage capacity. The Offshore Wind and CCUS Co-Location Forum has identified interactions and issues between different uses of the seabed¹² and a commercial agreement has been reached in relation to one site in the North Sea where two leases were issued for competing uses¹³. A clear strategy for early resolution of these issues, which could cause delays to future deployment, is still needed.

On track

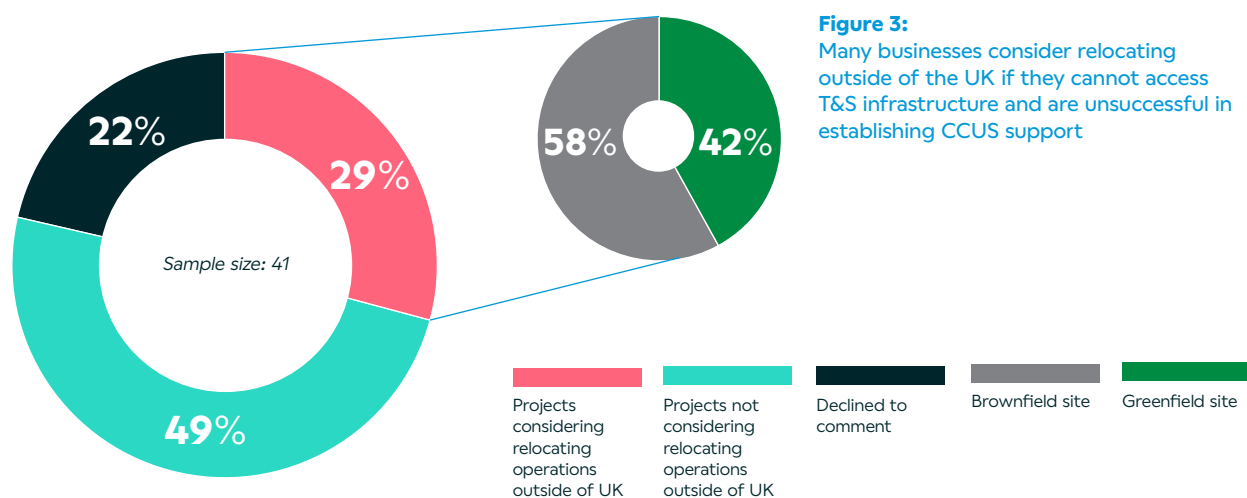
10. Establish strategy to support national, cluster and project-level communications

CCSA members have produced a communications toolkit and guidelines to support communications, including alignment of messaging, and raising awareness amongst industries of the benefits of CCUS. It now needs to be implemented and continually reviewed and updated, to build public support, which is crucial for the successful deployment of CCUS and achievement of net zero.



Growth of projects needing CCUS and global competition

The capture project pipeline has grown by 29% from 73 MtCO₂/yr to 94 MtCO₂/yr, since 2022 - the equivalent of 28% of overall UK emissions¹⁴ - signalling the significant investment[†] made by industry to meet the UK's decarbonisation ambitions. However, almost a third of the projects surveyed are considering relocating their developments overseas, including critical growth industries such as hydrogen, sustainable aviation fuel (SAF) production and GGRs.



New storage developments

The latest NSTA licensing round has significantly increased the pipeline of licensed storage and our data indicates that licensed storage volumes could now be sufficient to accommodate the current capture project pipeline out to 2050*. This may change as storage concepts are further appraised and developed. However, the commercial structure under which many of these storage sites will operate is currently unclear and without resolving this, not all licensed stores will reach operation. Only 31% of transport and storage (T&S) developers surveyed said they would continue to invest in their projects without clarity on government plans for future T&S systems beyond Track-2, in particular when they can obtain an economic licence and on what terms.

Development of non-pipeline transport (NPT)

Roughly one third of capture sites have indicated that they may require NPT - such as shipping, road or rail - to connect to CO₂ stores. As more projects emerge, particularly in dispersed locations, this proportion is expected to increase.

* Storage volume (MtCO₂) data used for this report is based on a combination of data collected through the CCSAs membership and announcements made by companies that were successful in the recent NSTA carbon storage licensing round.

† The calculated number from the survey of reported investment is £382m. If we extrapolate this over the total pipeline of capture and storage projects, the estimated investment could be as high as £1,042m.



Industrial emitters

The project pipeline of industrial and energy from waste (EfW) CCUS projects is around three times greater than the Government's 2035 ambition for industrial CCUS¹⁵. However, limited projects were successful in progressing to negotiations with the Government this year; one cement project, no refinery capacity, and in total only around a third of the required volumes for 2030¹⁶. If EfW is not counted towards the 2030 ambition, the projects that have progressed to negotiations with Government only account for a sixth of the required volumes.

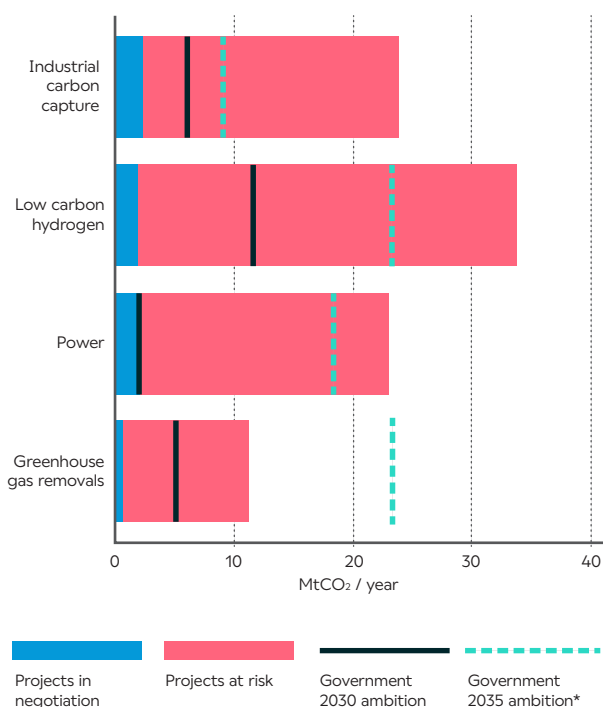
Energy security

The Government's target for a net zero power system by 2035¹⁷ could require at least 10GW of power generation with CCUS, potentially requiring around 18 MtCO₂/yr^{**} of carbon capture capacity – this contrasts with the 2030 goal of one power CCUS plant¹⁸. Similarly, the CCUS enabled hydrogen production projects currently in negotiation only correspond to a fraction (17%) of the Government's 2030 ambition of up to 5GW¹⁹, and only around 5% of the total pipeline, which may be 'lifted and shifted' to other locations if investors do not see a clear strategy for the UK as a world-leading hydrogen economy.

Greenhouse gas removals

There is a greater than 10 MtCO₂/yr pipeline of Greenhouse Gas Removals (GGRs) projects, more than double the Government's ambition of 5 MtCO₂/yr by 2030²⁰. There is an increasing demand from the aviation sector for these technologies, alongside Sustainable Aviation Fuel (SAF), however there is currently no clarity for these projects on access to CO₂ infrastructure within the first four clusters. This pipeline is at particular risk of leaving the UK as GGR technologies, such as bioenergy CCS (BECCS) and direct air capture (DAC), are more mobile and incentivised in other jurisdictions through attractive and accessible subsidy schemes.

Figure 4:
Updated CO₂ capture project pipeline by project type, compared to Government ambitions



* For information on the interpretation of government and CCC ambitions and estimated requirements, please see the Methodology section of this report. Energy from waste (EfW) emissions have been grouped with industrial carbon capture for illustrative purposes. For details on the categorisation of EfW in this report, please refer to the Methodology section.

^{**} Captured CO₂ from power CCUS is highly dependent on plant efficiency and load factor assumptions. For information on the calculation used here, please see the Methodology section of this report.



Urgent action areas from 2023 onwards

There are five urgent actions that government and industry, with wider stakeholders, now need to take to deliver CCUS in a way that maximises the benefits to the UK and enables us to achieve net zero.



1. Enable timely cluster delivery

Now that the first four CCUS clusters have been selected, a clear focus must be on delivering them in a timely fashion: this must include allocating the £20bn from the 2023 Spring budget and committing to regular allocation rounds going forward. Government should set out clear processes and adhere to timelines to ensure all Final Investment Decisions (FIDs) can be taken in the next two years. Government and industry must work together to complete key actions, as any further delays or revised timelines will have a detrimental impact on delivery of targets by 2030.



2. Publish a clear deployment plan for CCUS to 2035

The first four clusters will establish the CCUS industry in the UK and their networks will need to continue to expand to meet demand, so the regulatory framework will need to enable investment now in expansion required from 2030. However, there are many other regions that will need to deploy CCUS if they are to decarbonise. In order to maintain investor confidence, prevent the loss of manufacturing jobs and meet net zero targets, government, working closely with industry, must publish a clear deployment plan for CCUS to 2035, with a vision to 2050 and beyond. This would need to include detailed plans to incentivise investment now in the development of CO₂ stores required post-2030, as well as in capture projects.



3. Accelerate permitting and consenting

Industry is still encountering challenges in permitting and consenting for CCUS deployment, both in terms of the time it takes, and the number of agencies involved. Government must take the lead in understanding, resourcing and streamlining the permitting and consenting pathway for projects and ensure that this is communicated to stakeholders. This includes engaging, funding and building capacity in regulators to implement CCUS legislation, as well as working with relevant agencies, regulators, devolved and local governments to provide a consistent approach to planning and permitting and improved coordination.



4. Deliver a healthy supply chain and skilled workforce

Industry now needs to implement annual benchmarking of local content delivery in line with CCSA's Good Practice Guidance. Increased engagement of the UK supply chain by CCUS developers will only be successful in driving up UK content if government also now provides some targeted support and intervention to supply chain companies in the high value opportunity areas identified, to increase capacity in areas where UK has comparative strengths. A cross-sector coordinating body for skills and training across the net zero transition needs to drive investment and ensure quality of jobs over the longer-term.



5. Build public support

The priority now is for government and industry to urgently work more closely together with academia and civil society to increase the public's understanding of CCUS. This includes local and national engagement to increase knowledge and awareness, communicating the benefits of CCUS and addressing any areas of public concern.



Section 1 – New Analysis



Growth of CCUS projects and global competition

The capture project pipeline has grown by 29% since 2022, signaling the investment made by UK industry to meet the UK's decarbonisation ambitions.

The CCSA has updated the *CCUS Delivery Plan 2035* analysis, collecting data from capture, cluster and T&S project developers across the UK. Since the original Delivery Plan analysis in 2022:

- The UK capture project pipeline has grown from 73 MtCO₂/yr to 94 MtCO₂/yr, signalling the level of investment made by industry, in many cases at risk, to help the UK meet its decarbonisation ambitions.
- Eight capture projects have progressed to negotiations with Government for business model support through the Track-1 process.
- The Government has selected Viking CCS and Acorn T&S as Track-2 clusters. Acorn remains the Track-1 reserve cluster.

However, progress on capture project funding allocation rounds for the Track-2 process has been delayed from original timescales set out in the Government's 2022 Investor Roadmap, with little forward clarity, creating uncertainty within industry.

Additionally, the industry faces significant uncertainty over Government plans for support for the clusters and networks, and their associated capture projects, that have not been successful in the Track-1 and Track-2 processes. Without clarity on future government support and the timeline for obtaining it, the majority of the project pipeline is at risk.

The next 6-12 months will be critical if the UK is to seize the opportunity and become a global leader in CCUS. Attractive and accelerated policy regimes in other jurisdictions are competing for investment and rapid, targeted action from policy makers will be necessary for the UK to realise its full potential.

Figure 5:
Updated CCUS project pipeline by project type, compared to government targets

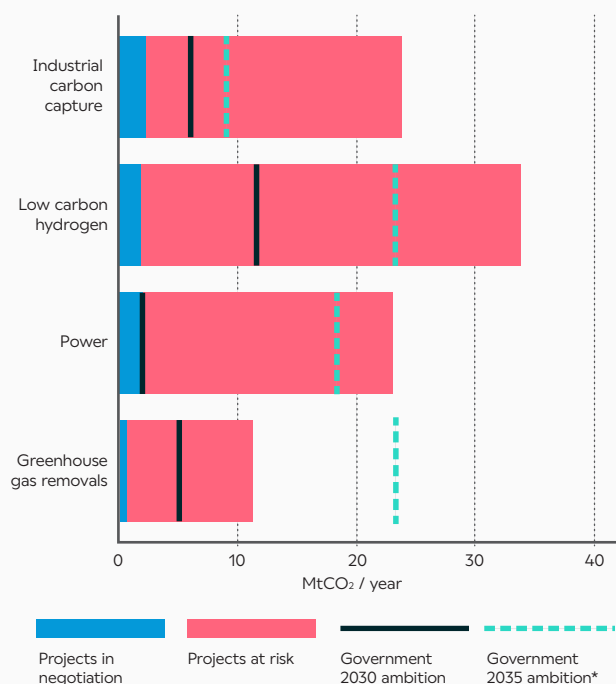
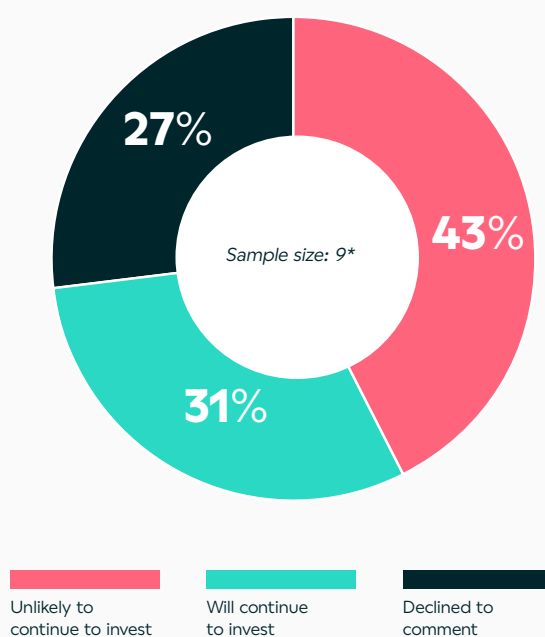


Figure 6:
T&S developers are unlikely to continue to invest in projects without clarity on T&S funding mechanisms beyond Track-2



* Responses by cluster or network developers are weighted by storage capacity (MtCO₂) for this analysis. Analysis excludes responses from confirmed Track-1 and Track-2 clusters.



Investing in CCUS

Despite slow progress in the cluster sequencing process thus far, the developers that responded to the CCSA survey have invested a reported total of £382m. If extrapolated over the CCUS project pipeline, the estimated investment is as high as £1,042m. A recent Aldersgate Group report estimates businesses in the CCUS and hydrogen industries turnover £1.7bn and are expected to grow at a rate of 20% per year²¹.

This represents just a fraction of the total potential – if the UK can stimulate the industry to achieve its ambitions, inward investment is expected to be around £40bn by 2030²².

Critical growth industries such as low carbon hydrogen and GGRs are investing significant amounts of money in UK developments. This investment could go elsewhere as other jurisdictions make subsidies more readily accessible. The opportunity for the UK Government to unlock additional investment is time-limited – without clarity on further allocation rounds, the Government risks damaging investor confidence.

T&S developers who were unsuccessful in Track-1 and Track-2 face challenging decisions on whether to continue to invest and develop their projects in the absence of any direction from policy makers on what happens post-2030, once four clusters have been established and the Government's near-term ambition is met.

The Government's current targeted deployment trajectory, of rapid scale up of CCUS capacity between 2030 and 2035, will be challenging to meet without the availability of additional networks, especially given the lead time for the development of T&S infrastructure can be 5-7 years.

If developers are not given clarity over plans for support beyond Track-2 imminently, the UK risks missing its 2035 CCUS ambition, and the opportunity to develop a future growth industry in the form of CO₂ storage from international emitters.

Figure 7:

UK businesses are investing into CCUS projects

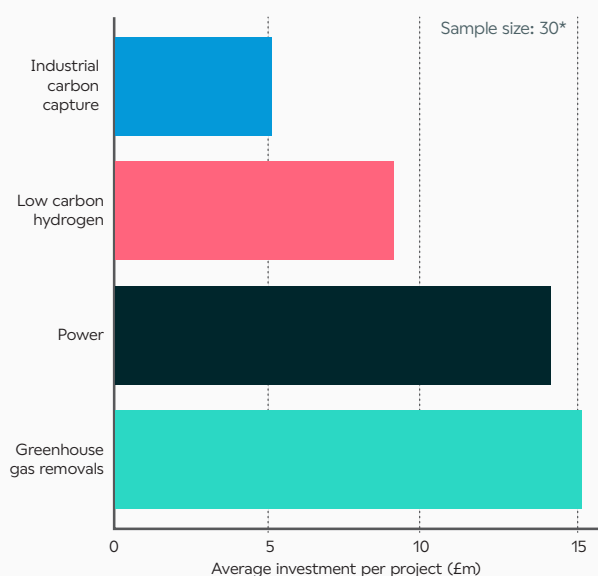
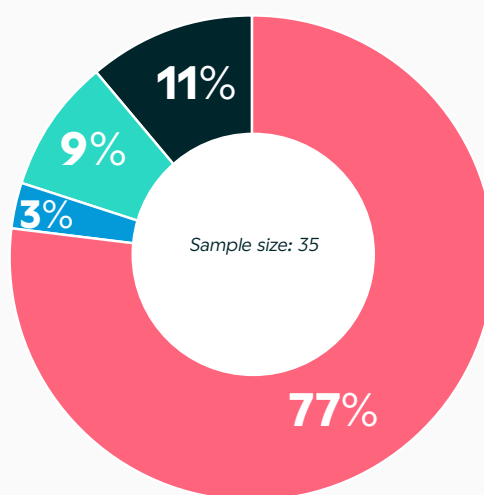


Figure 8:

Most businesses do not envisage deploying CCUS based on Emissions Trading Scheme (ETS) pressure alone



The number of projects requiring revenue support demonstrates the need for the UK Government to increase the frequency of contract allocation rounds, if the UK is to meet its decarbonisation goals. Since this survey was undertaken, the UK Government has made it cheaper for industry to pollute by vastly increasing the number of free allowances issued in the UK ETS between 2024 and 2027²³. This is likely to further decrease the incentive to decarbonise and increase the reliance on business model support to do so.

Despite this, some businesses, in varied sectors, are willing to invest today, providing they can access the T&S infrastructure. This proportion is expected to increase over time as deployment drives down the cost of CCUS and increases investor confidence, but only if the Government is successful in stimulating the industry in the next 5-10 years.

Global competition

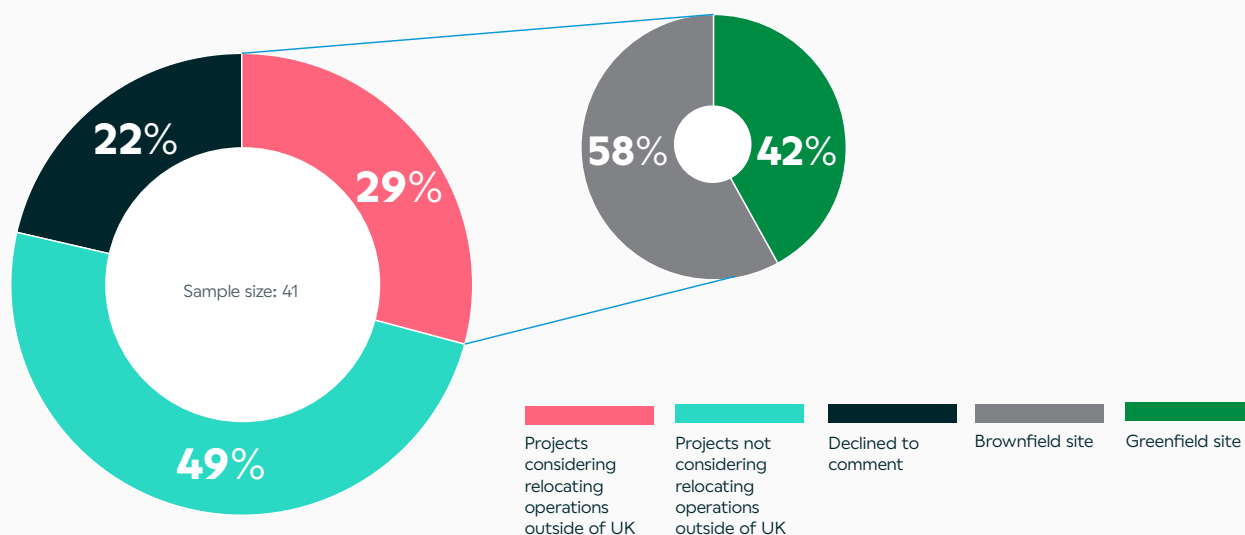
Almost a third of the projects surveyed are considering relocating their developments overseas, including critical growth industries such as hydrogen, SAF production and GGRs.

These projects at risk include a similar split of greenfield and brownfield sites, highlighting the threat of loss of existing jobs, in addition to the loss of potential additional jobs and economic growth prospects.

The UK cannot lose over a third of its current capture pipeline and still meet mid-and long-term goals. Access to subsidy schemes that are competitive with the international market is required to prevent companies in these industries relocating and maintain UK's position as a global leader in the energy transition.

Figure 9:

Many businesses consider relocating outside of the UK if they cannot access T&S infrastructure and are unsuccessful in establishing CCUS support



New storage developments

New cluster, network and storage concepts are emerging, but face uncertainty over the commercial frameworks that will support them. Without this, not all licensed stores will proceed.

The CCSA's Delivery Plan recommended that the government and industry rapidly bring additional storage capacity to a commercial stage of readiness. Over the past year, significant progress has been made by industry to achieve this:

- In May²⁴ and June 2023²⁵, the NSTA offered 21 carbon storage licenses; and in September 2023 it announced that all 21 had been accepted.
- The NSTA estimates that the new sites could store up to 30 MtCO₂/yr, approximately 10% of UK annual emissions²²⁶.
- Industry has commenced development activities on a series of new cluster, network and storage projects.

Whilst the progress made by the NSTA and industry is laudable, the commercial structures under which these stores will operate is currently unclear. In particular store developers do not have clarity on when they can obtain an economic licence or when and where future capture projects, who will be users of their networks, will come from.

With high lead times for CO₂ storage development, up to 5-7 years, Government needs to provide clarity urgently on how these stores will be incentivised. This is to allow for sufficient time for developers to develop assets such that they can be utilised to help the UK meet its near to mid-term decarbonisation goals.

In 2022, the 'CCUS Delivery Plan 2035' highlighted the need for additional storage to accommodate the capture project pipeline:

- Only a limited amount of storage capacity had obtained a CO₂ storage license from the NSTA.
- The vast majority of storage was unlicensed, putting mid to long term Government carbon capture targets at risk.

Figure 10:
Delivery Plan 2022: Impact of captured and stored CO₂ from known pipeline of projects on storage capacity over time

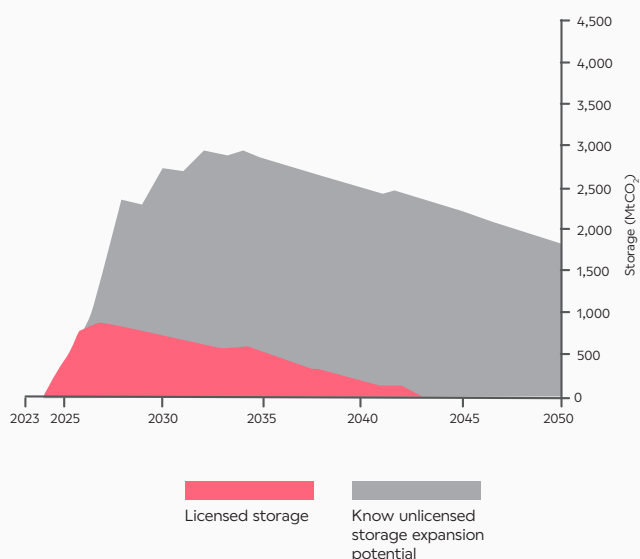
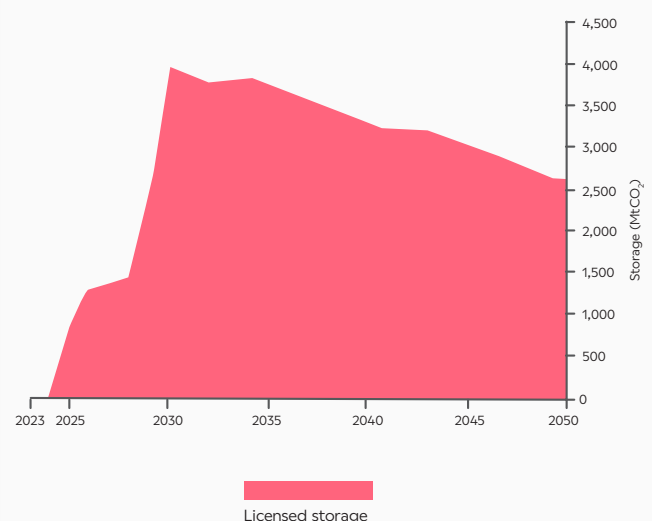


Figure 11:
Delivery Plan 2023: Impact of captured and stored CO₂ from known pipeline of projects on storage capacity over time

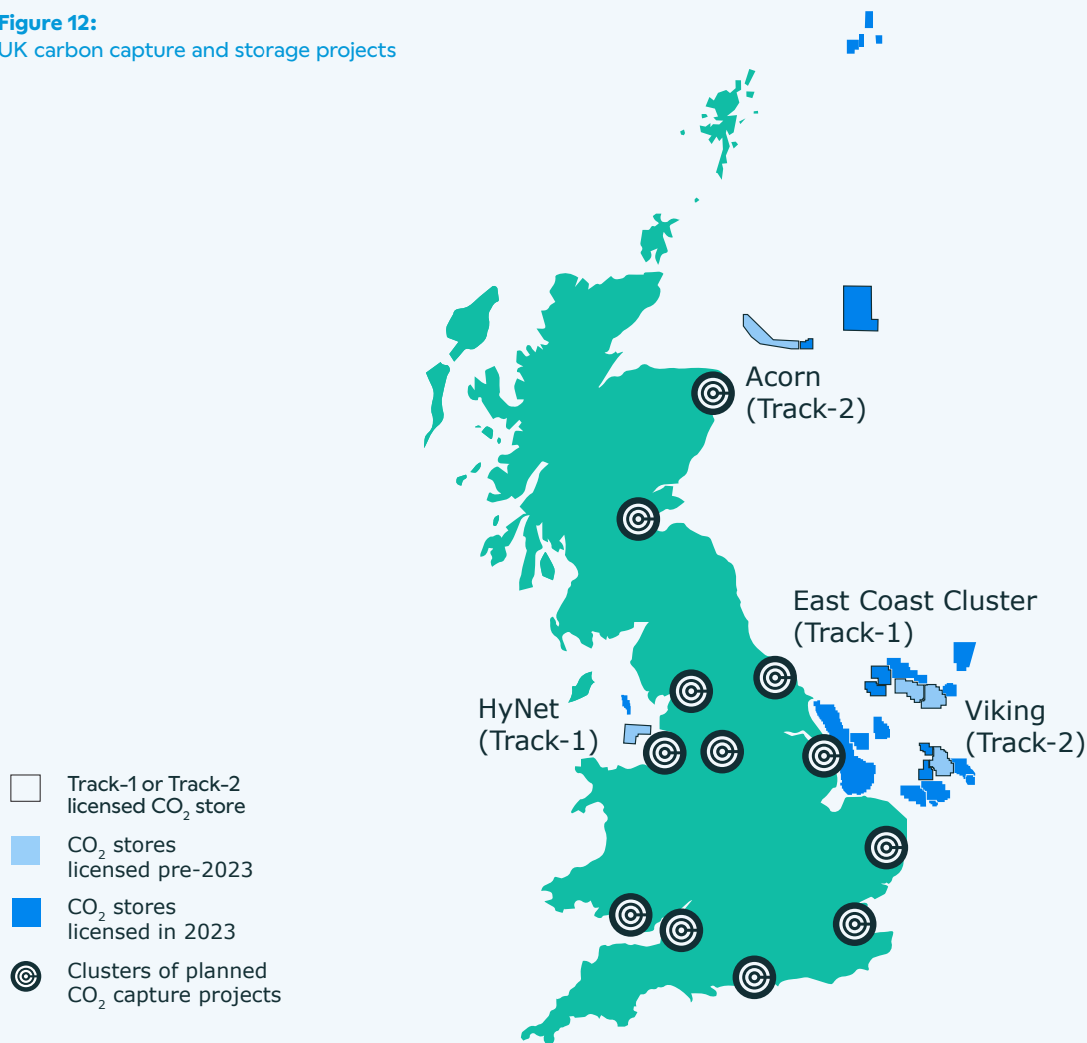


The 2022/2023 NSTA licensing round was carried out in response to this and has significantly increased the pipeline of licensed storage:

- Data provided to the CCSA indicates that licensed storage volumes could now be sufficient to accommodate the current capture project pipeline out to 2050. This may change as storage concepts are further appraised and developed.
- However, the commercial structures under which many of these storage sites will operate are currently unclear. Store developers need clarity on when they can obtain an economic licence to serve growing UK demand for storage as well as when they can take CO₂ from emitters outside of the UK, given that the UK has a large proportion of Europe's storage capacity.
- Clarity is still yet to be given from the Government on plans for support post Track-2, once 4 clusters have been established and the Government's 2030 ambition is met. Additionally, many cluster and storage concepts require shipping or other non-pipeline transport (NPT) to transport CO₂.
- Without clarity on these commercial structures, storage developers face challenging decisions over whether to invest in developing their storage sites.

If the UK is to take advantage of its significant geological resources and fulfil its potential as a global leader in a new storage export industry, potentially worth £30bn per year²⁷ by 2050, clarity is needed urgently over future support structures and the inclusion of NPT within these.

Figure 12:
UK carbon capture and storage projects



Industrial emitters

Without rapid action to support private sector investment in industrial carbon capture projects the Government's 2035 CCUS ambition cannot be achieved – putting at risk jobs in the UK's industrial heartlands.

Industry has developed a pipeline to deliver substantially above the UK's ambition for industrial decarbonisation.

- The project pipeline of industrial and energy from waste (EfW) CCUS projects is around three times greater than the Government's 2035 ambition for industrial CCUS. However, only around a third of the required volumes for 2030 have progressed to negotiations with Government; this falls to a sixth if emissions from EfW projects are not counted towards the Government's industrial CCUS ambition.
- Further clarity on support for projects that were unsuccessful in the Track-1 process is critical if the UK is to meet its 2035 and 2050 goals. Industries are particularly exposed to delays in deployment timelines – lead times of capture project development, interactions with investment decisions relating to existing equipment, and increasing carbon price exposure over time result in a time-limited window to invest in CCUS.
- Without clarity, development plans may be abandoned as multi-national boards seek results on invested development costs, potentially moving investment to geographies where access to subsidy is more certain, putting at risk the future of the sites themselves and their workforces.
- 90% of the projects surveyed are able to take FID by the late 2020s if this is enabled by the policy measures described above. However, without these measures the UK stands to miss out on an estimated 1450 additional, direct jobs, over £15bn in capital investment and risks losing 3500 existing jobs due to potential site closures.

Figure 13:
Industrial Carbon Capture Project Pipeline vs Ambition

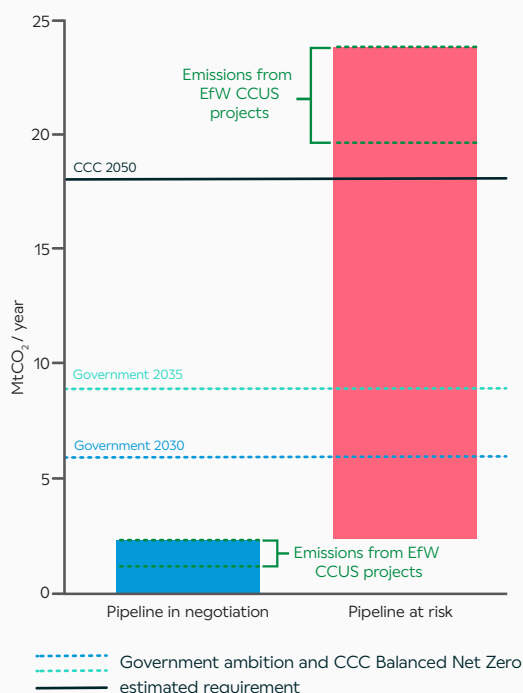
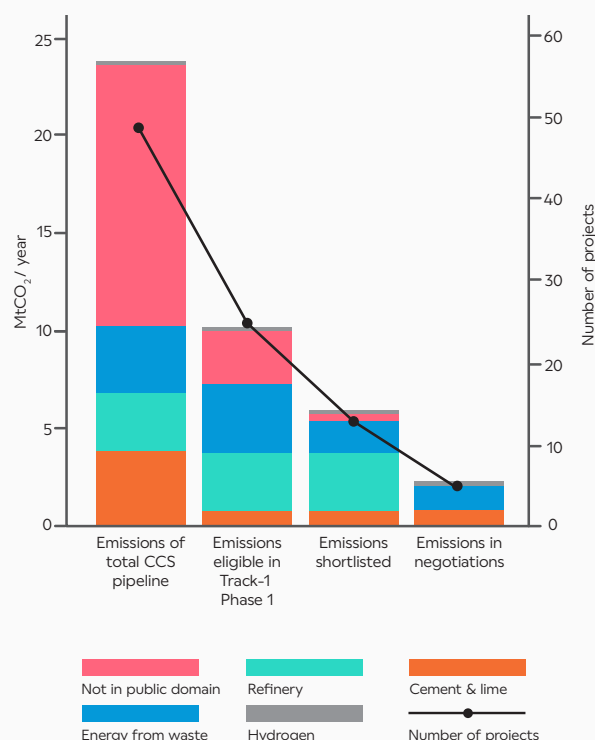


Figure 14:
Industrial Carbon Capture Project Pipeline by Sector



Of the UK's industrial base that is interested in CCUS, only a small portion is actively engaged in Government negotiations.

- Businesses that have developed plans to retrofit CCUS are spread across cement/lime, refineries and EfW sectors.
- EfW projects have demonstrated an interest in CCUS, particularly as this sector will be included in the UK ETS from 2028 – responses to our survey indicate the majority of these installations will require non-pipeline transport (NPT) to decarbonise, requiring effective integration of NPT into Track-2 and the business model for T&S beyond this.
- Of the eight capture projects selection in Track-1, only one cement project and no refinery projects, were successful in progressing to negotiations with Government.
- Cement and refining capacity are critical to the UK's clean industrial growth, and both have significant process CO₂ emissions, on top of any fuel requirement. As a range of infrastructure projects gather pace in the late 2020's and early 2030's, there is a risk that:
 - The UK does not have access to low carbon industrial products.
 - Jobs are lost as these industries are offshored.
 - The UK is forced to import products which may not be low carbon or will end up paying for CCUS elsewhere through the purchase of low carbon products from other countries.



Energy security

Clear investment signals are needed for hydrogen and low carbon power; together they will deliver UK energy security.

CCUS enabled hydrogen

The Government has set an ambitious target for CCUS enabled hydrogen production by 2030, and industry has answered with a pipeline of projects to meet this. Without rapid action, this pipeline of assets is at risk.

- The projects currently in negotiation only correspond to a fraction (17%) of the Government's 2030 ambition for CCUS enabled hydrogen of up to 5GW.
- This means that a significant proportion of the CCUS enabled hydrogen assets in development will need to be successful in subsequent emitter selection processes if the UK is to meet its goal.
- The source of funding to subsidise these projects is not certain until the Energy Bill reaches Royal Assent – without clarity on this there is additional pressure on the pipeline at risk.
- Further to this, attractive and accessible subsidy schemes overseas, such as the 45Q/V in the US, are competing for UK investment.
- If the assets in development are realised, the UK could benefit from around 24Mt** of annual CO₂ reduction in industrial operations. Additional benefits include over 2000 direct jobs and £21bn of private sector capital investment – these figures only account for the hydrogen production itself and none of the associated benefits from a decarbonised and thriving industrial sector. The multiplier effect of inward investment from hydrogen off-takers is expected to be 10 times greater²⁸, estimated at over £210bn.

Low carbon power

- In 2021, the Government set an ambitious target for a net zero power system by 2035.
- Government estimate this could require around 10GW of power generation with CCUS, potentially requiring around 18 MtCO₂/yr^{††} of carbon capture capacity – policy signals are needed to provide industry with a vision of how to reconcile this with the 2030 goal of one power CCUS plant.
- Despite this, the power industry has invested in developing a pipeline of assets, with an estimated £270m already invested in the UK economy, and a pipeline that is close to meeting the 2035 ambition.
- These assets can be delivered at accelerated timelines – 80% of assets can reach FID at or before 2027.
- Additionally, the pipeline at risk could support an estimated 2400 additional, direct jobs, provide a boost to the UK economy with £16bn in private investment, whilst enabling increased renewable deployment and providing much needed security of supply to the national grid.^{‡‡}

** For information on the calculation of industrial emissions abated, please see the Methodology section of this report.

†† Captured CO₂ from power CCUS is highly dependent on plant efficiency and load factor assumptions. For information on the calculation use here, please see the Methodology section of this report.

‡‡ Additional direct jobs, capital investment, and investment into UK figures are estimated from responses to the CCSA data collection exercise. Data obtained from project developers has been aggregated and normalized to a per MtCO₂/yr basis for the different project types. This figure is then extrapolated across the known pipeline of projects to develop a sector wide estimate.



Figure 15:
Hydrogen Project Pipeline vs Ambition

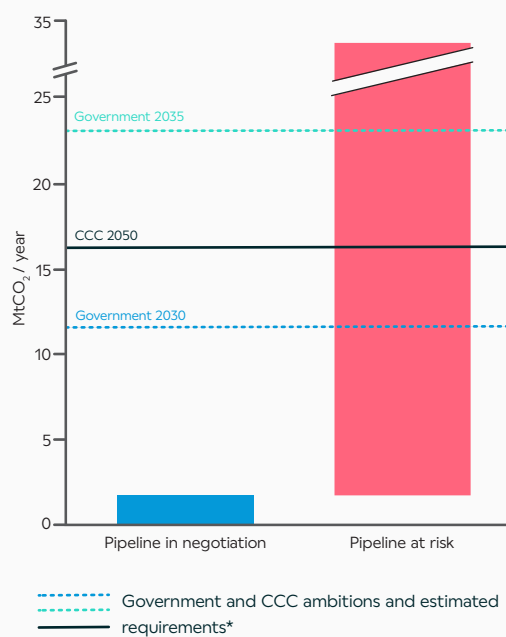
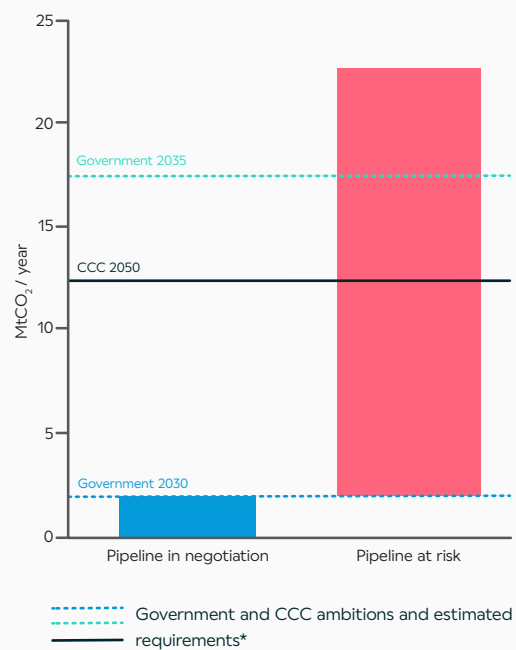


Figure 16:
Power CCUS Project Pipeline vs Ambition



* For information on the interpretation of government and CCC ambitions and estimated requirements, please see the Methodology section of this report.



Greenhouse gas removals

A large GGR sector must be created if the UK is to meet its net zero commitments.

Government's ambitious goal to scale a new GGR industry to 5 MtCO₂/yr by 2030 can be supported today, but is a particular flight risk for the UK.

- Government ambition to achieve 5 MtCO₂/yr of engineered GGRs by 2030 is achievable based on existing planned projects today.
- It is expected that government will count the biogenic portion of CO₂ emissions from EfW sites successful in the Track-1 process towards its goal – however this alone will be insufficient.
- A greater than 10 MtCO₂/yr pipeline is more than double this 2030 ambition but is at particular risk of leaving the UK as GGR technologies, such as bioenergy CCS (BECCS) and direct air capture (DAC), are incentivised in other jurisdictions through attractive and accessible subsidy schemes, such as the Inflation Reduction Act in the USA²⁹. The EU is also rapidly progressing its policy to define and incentivise negative emissions³⁰ – making it a time limited opportunity for the UK to become a leader.
- Private sector demand for high quality carbon removal credits is also ramping up – in June 2023, Microsoft signed an 11-year deal to purchase 2.76 Mt of carbon removal credits from a Power BECCS plant being developed by Ørsted in Denmark³¹. This revenue stream was coupled with subsidy from the Danish Government – demonstrating how private and public sectors can combine to stimulate the industry whilst reducing the burden on the taxpayer.

Figure 17:
Greenhouse Gas Removal (“GGR”) Project Pipeline vs Ambition

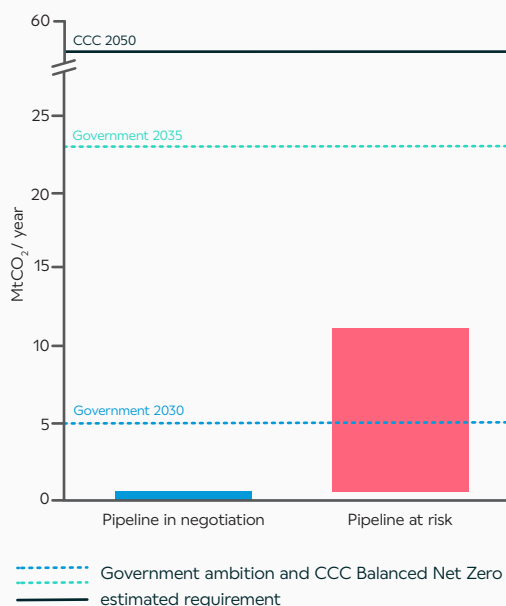
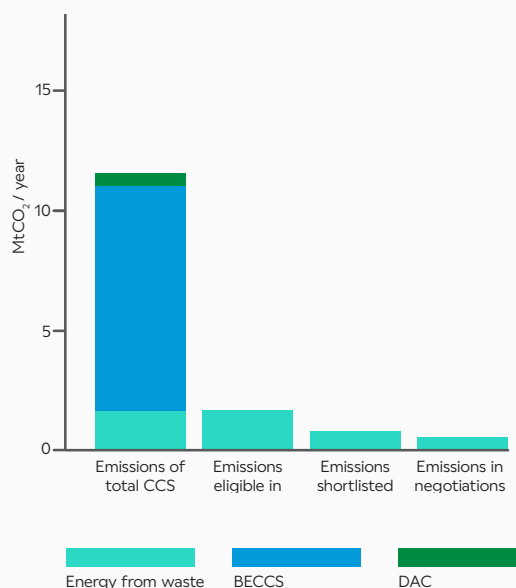


Figure 18:
GGR Project Pipeline by Technology Type



* For information on the interpretation of government and CCC ambitions and estimated requirements, please see the Methodology section of this report.



Power BECCS projects are driving the UK pipeline, but these are particularly exposed to pressures for global relocation

- Power BECCS projects represent 9 MtCO₂/yr, or 75% of the GGR project pipeline.
- As the Power BECCS business model has lagged behind the development of business models for other CCUS sub-sectors, industry is under significant pressure to shift development activity away from the UK.
- Subsidy schemes for existing biomass power generators, that can be hastily converted to Power BECCS, stand to expire within the next few years. Without a clear signal to invest in BECCS, the UK risks losing out on precious dispatchable low carbon power generation and the option for rapid scale-up in negative emissions capacity.
- Establishing DAC technology in the UK will also be critical to meeting medium and long-term negative emissions ambitions – the CCC estimate that up to 15 MtCO₂/yr of DAC will be required by 2050³² for a net zero UK.
- All of the projects surveyed are able to take FID by the late 2020s – if this is not enabled by the policy announcements as mentioned above, the UK stands to miss out on an estimated 1100 additional, direct jobs, over £5bn in capital investment and risks losing over 1000 existing jobs due to potential site closures.



Development of non-pipeline transport

Developers highlight the need for inclusion of non-pipeline transport (NPT) in commercial structures to continue investing in UK projects

As more CCUS projects emerge, particularly in dispersed locations, the proportion of sites requiring NPT to connect to CO₂ stores is expected to increase.

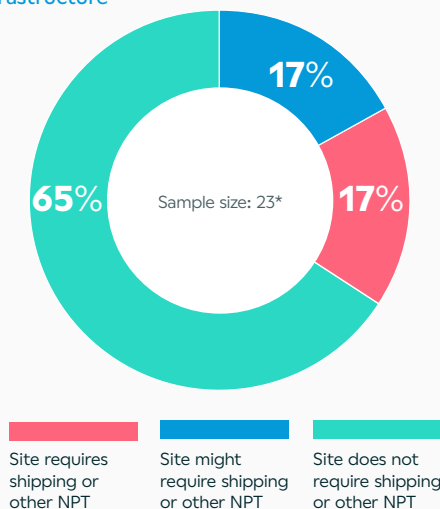
Arrangements for NPT – including any adaptation of the TRI model – need to be clarified to give both capture and T&S project developers the confidence to invest in the UK. Additionally, capture projects requiring NPT must be considered eligible for future contract allocation rounds. Without this, the UK risks missing out on inward investment now, and decarbonisation ambitions in the mid- to long-term

CCUS is expected to be a global industry, with many projects requiring international shipping being developed, and bilateral agreements between governments for the CO₂ T&S emerging in real time.

The UK is extremely advantaged in its geological CO₂ storage potential – estimated to be 78Gt³³, almost one-third of Europe's geological CO₂ storage capacity³⁴. If the UK is to capitalise on its potential as a global leader in a new export industry, potentially worth £30bn per year by 2050, it must give clarity on how NPT is to be included in commercial structures.

Figure 19:

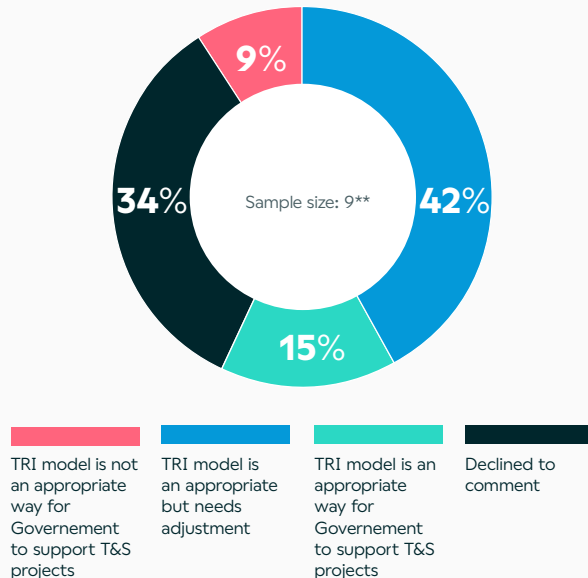
A third of sites planning CO₂ capture retrofit will or may need shipping or other non-pipeline transport to access T&S infrastructure



* Only responses from brownfield capture project developers were considered for this analysis

Figure 20:

Almost half of the T&S capacity in development requires modification to the TRI for transport and NPT optionality



** Responses from cluster or network developers are weighted by transport capacity (MtCO₂/yr). Analysis excludes responses from confirmed Track-1 and Track-2 clusters

The majority of T&S developers agreed that the TRI is an appropriate mechanism for initial project development. However, modifications to the model as it is currently defined are required. All the respondents who stated that adjustments are needed, or that the TRI is not appropriate, highlighted the need for accommodation of cluster developments requiring NPT and/or aiming to utilise third party CO₂ storage.

Whilst the Track-1 and Track-2 Government ambitions could potentially be met without this, not providing the necessary adaptations to allow different types of cluster concept to compete will inevitably reduce competition in the near-term and put meeting mid- to long-term CCUS ambitions in doubt.

Of the T&S developers that responded, all could be operational at or before 2030. With long lead times for infrastructure development, Government must act quickly to signal its intent to allow for different technology solutions.



Section 2 – Urgent Actions





Enable timely cluster delivery

The Government has now selected the first four CCUS clusters to be deployed in the UK: Track-1 clusters HyNet and East Coast Cluster, and Track-2 clusters Acorn and Viking. The Government has also selected the first eight capture projects that will connect to the Track-1 clusters.

Now that the first four CCUS clusters have been selected, a clear focus must be on delivering them in a timely fashion, maintaining momentum and harnessing industry commitment. This must include allocating the £20bn from the 2023 Spring budget and committing to regular funding allocation rounds.

As noted by the CCC in their Progress Report to Parliament 2023^{*** 35}, the timetable for delivering the clusters has slipped, which means that delivery must be accelerated to remain on track to reach net zero. In our previous Delivery Plan (March 2022), we expected initial cluster projects to take FID in early 2023, and the first capture projects to begin taking FID later this year. We now need to see government and industry work together to speed up negotiations so that Track-1 clusters and projects can take FID by summer 2024.

At the same time, we are still waiting for the Energy Bill to reach Royal Assent and set down the enabling primary legislation. Business models for T&S, DPA, ICC, waste ICC and LCHA must also be finalised to allow Track-1 projects to take FID. Business models that are currently at an early stage, including GGRs and power BECCS, will be needed for subsequent projects and clusters, including Track-1 Expansion and Track-2. A commercial model for NPT, which is particularly crucial for dispersed sites, and for CO₂ utilisation, must also be defined and developed.

Government should set out clear processes and adhere to timelines to ensure all FIDs must be taken in the next two years. Track-2 must operate at a significantly accelerated pace to Track-1, to make up time, avoid cost increases and be on track to deliver net zero. Government and industry must work together to complete key actions, as any further delays or revised timelines will have a detrimental impact on delivery by 2030.

First eight CO₂ capture projects to enter negotiations with the UK Government (Track-1, Phase-2)

East Coast Cluster

- Net Zero Teesside Power
- bpH2 Teesside
- Teesside Hydrogen CO₂ Capture

HyNet Cluster

- Hanson Padeswood Cement Works Carbon Capture and Storage Project
- Viridor Runcorn Industrial CCS
- Protos Energy Recovery Facility
- Buxton Lime Net Zero
- HyNet Hydrogen Production Plant 1 (HPP1)

These projects represent a wide variety of sectors such as dispatchable low carbon power generation, industrial process emissions (cement, lime and energy from waste) and low-carbon hydrogen production.

*** CCC Recommendation R2023-091 – “the Government must publish a detailed timeline specifying each stage of the process of CCS development for Tracks 1 and 2 of the CCUS Cluster Sequencing Programme from now through to first capture and storage of CO₂ in each cluster and sector, including completion of engineering design, contracts and permitting, construction and commissioning, and publish a plan of how the Government will ensure this timeline aligns with their planned first capture dates for each cluster and sector.”





Publish a clear deployment plan for CCUS

The first four clusters will establish the CCUS industry in the UK and will continue to expand with Track-1 expansion and beyond. However, there are many other regions that need to deploy CCUS throughout the UK if they are to decarbonise. In order to maintain investor confidence, prevent the loss of manufacturing jobs and meet net zero targets, government, working closely with industry, must publish a clear deployment plan for CCUS to 2035, with a vision to 2050 and beyond.

Government must build on the work it has started on the CCUS Vision to 2035, to set out a long-term deployment plan for the industry, including the route to commercialisation and further funding frameworks to enable industry to move towards this. This would incentivise investment now in the development of CO₂ stores that will be required post-2030, as well as in the capture project pipeline. It should include regular funded CfD allocation rounds to kick-start CCUS deployment; provide certainty to the industry of future opportunities, building on the cluster sequencing programme; and set out the anticipated route out of subsidy. The deployment plan needs to build on the elements we identified in our 2022 Delivery Plan: creating an attractive investment framework, mature CO₂ transport networks, a pipeline of storage, and a supportive public; and it should be reported on regularly.

A key feature of the deployment plan should be an industrial strategy, setting out priority industries that will be guaranteed access to CO₂ infrastructure. This will give more certainty to cluster developers on demand for CO₂ storage, and more clarity to industrial sectors on the role of CCUS in the government's decarbonisation ambition, as well as clear signals on priority industries for inward investment. To support this, there will need to be a stable and predictable UK Emissions Trading Scheme (ETS) and an effective carbon border adjustment mechanism (CBAM).

Early investment in capture projects would be driven by clear timetable of regular funded allocation rounds, from 2025. This programme would build on the initial clusters to establish CCUS across the UK and provide a line of sight for storage developers of demand profiles. The deployment plan should also include measures to accelerate delivery of operational storage at the scale that will be required beyond 2030: long lead times mean that development of these stores needs to start as soon as possible,

Since the last Delivery Plan, the CCUS industry in the UK has grown significantly: there are now 12 CCUS clusters developing, some of which will act as CO₂ collection hubs, transporting CO₂ to storage sites in other clusters. Data collection for this update found that there are over 90 CO₂ capture projects, across the UK. We will need all of these projects, and more, to deploy if we are to decarbonise the UK's industries and reach net zero.

The deployment plan must set out policy to develop all industrial decarbonisation clusters and ensure that dispersed industrial sites are also able to use CCUS. This includes providing clarity and certainty to the industry regarding support and mechanisms to unlock more challenging dispersed emitter locations through NPT, including development of stores that can operate in both a regulated and merchant capacity, support for CO₂ shipping, and delivery of the NPT strategy referenced in the 2023 CCUS Investment Roadmap³⁶.

This strategy must cover merchant demand for CO₂ transport and storage within the UK and across borders. Merchant demand will bring down the costs of CO₂ T&S networks and create system redundancy and resilience. Prospective clusters need clarity from government on the steps it is taking to enable the UK to play its full role in a Europe-wide CO₂ market: including bilateral agreements under the London Protocol with key EU member states, and engaging with the EU regarding its current position on CO₂ storage in non-EEA countries.³⁷

Case study: Business models for greenhouse gas removals and non-pipeline transport



Denmark: 20-year support contracts for two negative emissions projects were agreed in May 2023

- The support to Ørsted for two BECCS projects will be provided on a volume basis, adjusting for negative taxes for negative emissions and the carbon price.
- The project will derive revenues from sales of carbon removal credits, purchased by Microsoft, which will decrease state support.
- The projects will ship CO₂ to the Northern Lights project in Norway.

Insights for UK policy:

- It is possible to achieve rapid action in bringing investable contract terms to market for negative emissions projects, through collaboration between Government and the voluntary carbon markets.
- The rapid integration of non-pipeline transport into the Danish business model for capture applications demonstrates the potential for progressing the development of investable commercial terms for these projects at pace.





Accelerate permitting and consenting

Industry is still encountering challenges in permitting and consenting for CCUS deployment, both in terms of the time it takes, and the number of agencies involved. Government must take the lead in understanding, resourcing and streamlining the permitting and consenting pathway for projects and ensure that this is communicated to stakeholders.

These include central government, devolved government, local government, regulators (which may be UK-wide or devolved) and agencies. These bodies need to have an understanding of the entirety of the permitting process and align requirements as far as possible, including the timescales involved. This will ease the development of cross-boundary projects, facilitating the development of geographical networks of CO₂ transport and storage that can work together and increase reliability.

Government and regulators with both existing and new functions in relation to CCUS need to have sufficient funding and capacity building to deal with CCUS-related applications in a timely manner and develop guidance at pace for developers, supported by secondary legislation where appropriate.

Introducing accelerated permitting procedures for onshore capture developments and pipelines, through a maximum time requirement or other tools to streamline the process, could provide greater visibility to project developers as they sequence various phases of cluster projects.

Having a clear line of sight across the permitting landscape, including CO₂ monitoring, air quality and water access, is critical to project timelines. In order to allow industry players to ensure appropriate and efficient planning is implemented, and to encourage industry and regulators to work together effectively, Government needs to:

- Expedite permitting and provide an upper timeline limit.
- Provide greater visibility on the planning and permitting processes, including sector specific targets.
- Explore ways to reduce the time for conversion of a storage license to permit.
- Explore ways to enable closer collaboration between public and private organisations (e.g. a regulatory sandbox approach) to maximise the available resource while accelerating delivery.

Cluster and project developers have, in particular, highlighted the need for clarity on the lease process from the Crown Estate and Crown Estate Scotland, and improved coordination between the NSTA and DESNZ over licensing fulfilment.



EU: Accelerated permitting of CO₂ storage sites as part of the Net Zero Industry Act

- The act sets a target for European CO₂ storage of 50 MtCO₂/yr, and allows CO₂ storage facilities to obtain Net Zero Strategic Project (NZSP) status.
- Projects which receive NZSP status designation will be required to receive their storage permits within 18 months, which will hasten the development of storage capacity in Europe.

Insights for UK policy:

- Reducing the maximum time period for conversion of a storage licence to permit could provide an incentive to both industry and the regulator to work together to effectively bring early-stage storage development concepts to fruition quickly.
- Introducing accelerated permitting procedures for onshore capture developments and pipelines, through a maximum time requirement or other tools to streamline the process, could provide greater visibility to project developers as they sequence various phases of cluster projects.





Deliver a healthy supply chain & skilled workforce

Industry and government have undertaken work as set out in the last delivery plan to identify the UK's strengths in products and skills.

Industry set out its ambition of an overall UK content of 50% in manufacturing, goods and services underpinning CCUS. This is subject to the Government providing a committed forward allocation programme for capture projects to drive confidence in the supply chain; flexibility in bilateral negotiations on cost and delivery dates to secure higher UK content and targeted financial support for building capacity and transitioning existing businesses to serve the CCUS programme.

The industry is focusing on achieving and reporting good practice in supply chains to allow it to work towards identifying and achieving best practice over time, targeting an increasing volume of UK content and technology with continuous intervention and improvement and encouraging transparency in the process. By following the guidance³⁸, industry aims to improve the transparency of the procurement process and ensure that local supply chain engagement is prioritised from early on in the development cycle.

Government needs to provide targeted support for the high value opportunity areas that have been prioritised for intervention, and must maintain momentum on the supply chain strategy, throughout negotiations with Track-1 and Track-2 clusters. The strategy also specifically requires Government to target investment on manufacturing yards which have the potential to supply high value items to the CCUS industry and will be delivering multiple large strategic infrastructure developments over the next decade.

Measures also need to be taken to enhance the quantity and quality of jobs created or protected in the CCUS sector and to work across the energy sector with the Green Jobs Delivery Group to drive the necessary investment in skills and training. This includes measures to stimulate greater uptake of careers in the CCUS sector, and to allow existing workers to move easily between sectors.

Case study: Project support linked to domestic manufacturing and workforce



USA: Supplemental incentives to federal renewable energy tax credits based on levels

- Both the Investment Tax Credit (ITC) and the production tax credit (PTC), which are used to incentivise new renewable electricity deployments (including wind and solar projects), have domestic content 'adders' applied, which increase the support provided if specific conditions are fulfilled.
- The rates of these credits can be increased by 10% if projects utilise iron and steel that is 100% domestically produced, and manufactured products that are 40% domestically produced.
- The PTC will offer a base tax credit of 0.55¢/kWh for construction of eligible projects prior to 2033, receivable for the first 10 years of an asset's life.
- However, this is increased to 2.75¢/kWh if wage and apprenticeship requirements are satisfied.
- The inclusion of these 'adders' to clean energy tax credits, alongside additional tax credits such as the 48C PTC (which supports new clean energy technology manufacturing facilities, including for the CCUS





Build public support

The CCSA and its members have developed a strategic approach to communications, including an industry communications toolkit and a coordinated approach to build wider public understanding of CCUS.

Successful delivery of CCUS deployment in line with government ambitions will depend on positive public sentiment. This strategic approach to communications provides access to a common evidence base and enables stakeholders to amplify positive messaging and provide a feedback loop to identify and support responses to risks and issues.

However, building and maintaining public support for CCUS – at all levels, from national to local – is a continual process, and communication tools will need to be continually reviewed, refined and updated in light of progress on the cluster programme. At the same time, it is crucial to build on the public engagement already being planned and carried out by clusters, actively engaging with the public to build support and listen to and address criticisms.

The CCSA has established an NGO Forum which provides a regular space for academics and civil society organisations to discuss and learn about CCUS, including raising concerns and questions related to plans for its deployment in the UK. The CCSA and its key stakeholders will continue to compile and update the evidence base on CCUS and make it available to members in order to address public concerns.

The priority now is to implement and continually update the communications toolkit in order to continue to build public support for CCUS at all levels, from local to national. This includes:

- Government and industry to work together to improve and increase public engagement on decarbonisation ambitions and the role of CCUS in delivering them.
- Continue to identify and address areas of public concern related to CCUS, and build the evidence base to address them.
- Continue to engage with non-governmental organisations (NGOs) to understand any concerns relating to CCUS and build better understanding of the technology and the project pipeline.
- Facilitate information sharing and lessons learned between CCUS clusters and projects.
- Work with local and devolved governments to engage with the public on CCUS.



Section 3 – Methodology

A photograph of two male industrial workers in a factory setting. The worker on the left is wearing a white hard hat with safety glasses perched on top, blue earmuffs, black-rimmed glasses, and a high-visibility yellow-green safety vest over a dark blue jacket. He is pointing his right index finger towards a large, circular, metallic industrial component in the background. The worker on the right is also wearing a white hard hat and safety glasses, and is looking towards the first worker. Both are wearing yellow work gloves. The background is filled with industrial machinery, pipes, and a large circular metal flange with many bolts.

Methodology

To update the analysis in the *CCUS Delivery Plan 2035*, the CCSA undertook a data collection exercise with its membership

CCSA members were requested to provide capture or cluster⁺⁺⁺ project data, including:

- Projected CO₂ capture or storage volumes.
- Development status.
- Projected economic benefits data including jobs and investment metrics.
- Responses to a qualitative survey
 - Capture project developers were sent a different version of the survey to cluster leads and T&S developers.
 - The survey aimed to identify the greatest blockers to CCUS deployment and actions for industry and policy makers to expedite CCUS deployment so that the UK Government's decarbonisation targets can be met.

In total, the CCSA received 61 project data responses and 46 responses to the qualitative survey. The responses were aggregated and anonymised for use in the report.

Responses from the data collection exercise were used to inform the analysis in the report

- Figures 1, 4, 5, 10, 11, 13, 14, 15, 16, 17 use the data collected from cluster leads. This means that capture projects which do not have an established relationship with a cluster that is known to the CCSA will not be included in the analysis. Therefore, the capture project pipeline figures calculated are likely an underestimation of the total pipeline.
- Figures 14 and 18 use publicly available data to inform the sub-sector breakdown of the carbon capture pipeline for industrial carbon capture and greenhouse gas removal projects. The 'not in public domain' portion represents CO₂ capture volumes for projects that are known to cluster leads but are not currently in the public domain. Where publicly available CO₂ capture volume data exceeds the CO₂ capture volume data collected from cluster leads, the total volumes presented in the sub-sector breakdown figures may not precisely align to the totals presented in figures 7 and 11.
- Figures 3, 6, 7, 8, 9, 19, 20 use the data collected from the qualitative survey.
 - Figures 3, 7, 8, 9, 19 are calculated from data collected from capture project developers.
 - Figures 6 and 20 are calculated from data collected from cluster leads.
 - Certain members elected to withhold responses to certain questions, and therefore the useable sample size for each question is included in a footnote below each figure.

Interpretation and use of Government and CCC ambitions and estimated requirements

- To ground the capture project pipeline analysis, the data collected has been compared to published figures from the Government and the CCC.
- The majority of figures from the Government are defined as 'ambitions', rather than targets.
- To estimate the long term demand for CCUS, capture project pipeline figures have also been compared to requirements estimated by the CCC in the 'Balanced Net Zero' scenario from their Sixth Carbon Budget dataset. A categorisation exercise has been conducted to convert this data into the estimated requirements for each of the asset classes used in this report. More information on this exercise is available upon request from the CCSA.

Conversion of Government ambitions and estimated requirements to MtCO₂/yr

⁺⁺⁺ Reference to cluster leads or cluster projects also includes storage developers in the CCSA's membership



Government ambitions and estimated requirements for power CCUS and hydrogen are expressed in 'GW'. For the purposes of this report, these figures have been converted to MtCO₂/yr according to the following methodology:

- **Power CCUS:** The Government estimated Power CCUS requirement of up to 10GW by 2035 was converted to 18.2 MtCO₂/yr capture. The calculation indicatively assumes a CCGT with CCS efficiency of 47%³⁹, a plant load factor of 55%⁴⁰ ^{†††} and a CO₂ capture rate of 90%⁴¹.
- **Hydrogen:** The Government ambition for non-electrolytic, low carbon hydrogen (H₂) of up to 5GW by 2030 and up to 10GW by 2035 were converted to 11.5 MtCO₂/yr and 23 MtCO₂/yr respectively. This calculation assumes a capture rate of 9.2kg CO₂/kgH₂⁵⁵⁵ ⁴² and a plant load factor of 95%⁴³.

Calculation of CO₂ abatement potential of low carbon hydrogen

- The calculation utilises the lower heating values for hydrogen and natural gas, a carbon intensity of low carbon hydrogen of 0.8kg CO₂/kgH₂ⁱⁱ and a carbon intensity of natural gas of 2.75 kgCO₂/kgCH₄, and assumes that 100% of the hydrogen produced is used for fuel switching from natural gas.

Treatment of Energy from Waste (EfW) projects in this report

- CO₂ capture from EfW projects has been assumed to be counted towards the Government ambition for industrial carbon capture, unless stated otherwise, for illustrative purposes. We understand that Government may not count EfW emissions towards industrial carbon capture targets.
- 50% of EfW emissions have been assumed to be biogenic⁴⁴, and have been assumed to be counted towards Government ambition for greenhouse gas removals.
- CCC targets for EfW with CCUS have been mapped to the CCC estimated requirement for industrial carbon capture.

Interpretation of ambitions and estimated requirements

In some instances, for example where UK Government ambitions or estimated requirements are stated as a range, we have had to make additional assumptions. We have made assumptions which reflect a high level of ambition for decarbonisation of UK; while taking a balanced view on the role of CCUS-enabled technology versus other technology sources.

- The UK Government has stated in the British Energy Security Strategy that at least half of the 10GW target for hydrogen production will be electrolytic. We have assumed the upper-end value of 5GW for non-electrolytic low carbon hydrogen for this report. This was converted to 11.5 MtCO₂/yr, as described earlier in this section.
- The upper-end value of 20GW has been used for this report, with half assumed to be non-electrolytic low carbon hydrogen. This was converted to 23 MtCO₂/yr, as described earlier in this section.
- An indicative figure of 2 MtCO₂/yr has been used to approximate the captured and stored emissions of one large scale Power CCUS project
- The upper-end value of 10GW for Power CCUS has been used for this report. This was converted to 18.2 MtCO₂/yr, as described earlier in this section.

^{†††} Both efficiency and plant load factor values assumed the midpoint of ranges provided by the respective sources.

⁵⁵⁵ Capture rate inferred from the difference between the carbon intensity of hydrogen produced via natural gas and the carbon intensity of hydrogen produced by natural gas with CCS



Figure 21: Government and CCC figures used from comparison against known pipeline of projects

Sector	Body	Type	Value	Year	Relevant figures	Source
Industrial Carbon Capture	UK Government	Ambition	6 MtCO ₂ /yr	2030	4, 5, 13	HM Government (October 2021) Net Zero Strategy: Build Back Greener ⁴⁵
Industrial Carbon Capture	UK Government	Ambition	9 MtCO ₂ /yr	2035	4, 5, 13	HM Government (October 2021) Net Zero Strategy: Build Back Greener
Industrial Carbon Capture	CCC	Estimated requirement	24 MtCO ₂ /yr	2050	13	CCC (December 2021) Sixth Carbon Budget – Dataset (version 2) ⁴⁶
Hydrogen	UK Government	Ambition	10 GW ⁱ	2030	4, 5, 15	HM Government (April 2022) British Energy Security Strategy ⁴⁷
Hydrogen	UK Government	Estimated production capacity requirement	7 – 20 GW ⁱⁱ	2035	4, 5, 15	HM Government (August 2021) UK Hydrogen Strategy ⁴⁸
Hydrogen	CCC	Estimated requirement	16 MtCO ₂ /yr	2050	15	CCC (December 2021) Sixth Carbon Budget – Dataset (version 2)
Power CCUS	UK Government	Ambition	At least 1 power CCUS project ⁱⁱⁱ	Mid 2020s	4, 5, 16	DESNZ (August 2023) The future policy framework for the delivery of power with CCUS: government response ⁴⁹
Power CCUS	UK Government	Estimated requirement for Sixth Carbon Budget	Up to 10 GW ^{iv}	2035	4, 5, 16	DESNZ (August 2023) The future policy framework for the delivery of power with CCUS: government response
Power CCUS	CCC	Estimated requirement	15 MtCO ₂ /yr	2050	16	CCC (December 2021) Sixth Carbon Budget – Dataset (version 2)
Greenhouse Gas Removals	UK Government	Ambition	5 MtCO ₂ /yr	2030	4, 5, 17	DESNZ (June 2023) Government response to the consultation on a GGR Business Model ⁵⁰
Greenhouse Gas Removals	UK Government	Ambition	23 MtCO ₂ /yr	2035	4, 5, 17	DESNZ (June 2023) Government response to the consultation on a GGR Business Model
Greenhouse Gas Removals	CCC	Estimated requirement	44 MtCO ₂ /yr	2050	17	CCC (December 2021) Sixth Carbon Budget – Dataset (version 2)



Abbreviations

BECCS	Bioenergy with CCS
CBAM	Carbon border adjustment mechanism
CCC	The Climate Change Committee
CCS	Carbon capture and storage
CCSA	The Carbon Capture and Storage Association
CCUS	Carbon capture, utilisation and storage
CfD	Contract for Difference
CO₂	Carbon dioxide
DAC	Direct air capture
DESNZ	Department for Energy Security and Net Zero
DPA	Dispatchable Power Agreement
EfW	Energy from waste
ETS	Emissions Trading Scheme
FEED	Front-end engineering and design
FID	Final investment decision
GGR	Greenhouse gas removal
ICC	Industrial Carbon Capture
LCHA	Low Carbon Hydrogen Agreement
NGO	Non-governmental organisation
NPT	Non-pipeline transport
NSTA	North Sea Transition Authority
SAF	Sustainable aviation fuel
T&S	Transport and storage
TRI	T&S Regulatory Investment
GW	Gigawatt
Mt	Megatonne
m	Million
bn	Billion
Gt	Gigatonne
kWh	Kilowatt hour
MtCO₂	Megatonnes of carbon dioxide
MtCO₂/yr	Megatonnes of carbon dioxide per year



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