



CCUS Delivery Plan 2035

March 2022

CCUS Delivery Plan – 2035

© 2022 CCSA. All rights reserved.

The Carbon Capture and Storage Association (CCSA) is the trade association promoting the commercial deployment of Carbon Capture, Utilisation and Storage (CCUS), an essential solution to help tackle climate change.

We work with 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.

CCSA members are drawn from across the CCUS value chain – from capture, transport and storage developers – to power & industrial users, engineering, legal, insurance, finance, academia and other supporting sectors

Document last updated on: 25th March 2022

Contents

Foreword	4
Executive Summary	5
Key findings	5
Urgent recommended actions	7
Introduction	8
Context	8
Guide to this report	9
Summary of Analysis	11
Build out rate analysis	11
Building blocks for a successful CCUS industry	12
 Actions needed to achieve the 2035 ambition	 12
A) Attractive Investment Framework	13
B) Timely Cluster Delivery	17
C) Healthy Supply Chain & Skills	20
D) Mature CO ₂ Transport Networks	26
E) Sufficient Storage	31
F) Supportive Public	34
G) Investing in Innovation	38
Action Timeline	41
 Appendix	 44
Appendix 1 : CCUS Deployment Scenarios	44
Appendix 2: Scenario Methodology & Supplementary tables/analysis	51
Appendix 3: Required Funding Envelope	53
Glossary	55
End Notes	56



Foreword

“The next five years is a crucial period for CCUS in the UK and will lay the foundations for the rapid scale up that will be required over the coming decade.”

In November 2021, the UK Government published its Net Zero Strategy aimed at delivering reductions in UK Greenhouse Gas emissions to 78% below 1990 levels by 2035 – the 6th Carbon Budget. The strategy sets out pathways for the deployment of clean energy and other technologies that can deliver the deep cuts in emissions required over the coming decades.

A key tool in the box is Carbon Capture – a technology that has been around for decades, which when combined with permanent storage can be used to abate emissions at source or remove greenhouse gases directly from the atmosphere. The Net Zero strategy envisages that the UK will need to store up to 30 million tonnes of carbon dioxide (CO₂) a year by 2030, rising to at least 50 million tonnes a year by 2035.

It sets out envisaged pathways for capture and storage of emissions from power, industrial and hydrogen production plants, as well as for greenhouse gas removals through Bioenergy with CCS (BECCS) and Direct Air Capture with Storage (DACS). The Net Zero Strategy also requires the UK power sector to be fully decarbonised by 2035, subject to security of supply, which requires carbon capture on gas-fired power stations and switching to CCUS-enabled (blue) hydrogen.

This CCUS Delivery Plan 2035 is the industry’s response to these ambitions.

What is strikingly clear from this work is that only by building all the major projects currently under consideration in CCUS clusters and deploying CO₂ shipping and other non-pipeline transport solutions alongside rapid CO₂ pipeline network development, can we meet the UK Government 2035 ambition. Given the long lead in times for this infrastructure, the message from the industry is that ‘2035’ is essentially ‘now’ in terms of the urgent need to plan the roll-out of CCUS across all regions in the UK.

CCUS is also crucial for the competitiveness of the UK. Deploying CCUS in all of our industrial heartlands provides an opportunity to lead the global green industrial revolution and reduce our reliance on imports with new UK products, such as clean steel and cement, and attract inward investment through our offer of a clear route to decarbonisation for heavy industries. As one of the first-movers on CCUS, there is a huge opportunity to exploit our skills and plentiful offshore storage capacity to offer decarbonisation services to Europe.

Providing there is more clarity on greenhouse gas removals and non-pipeline transport, the UK Government work on business models looks set to deliver a viable investment framework. What is now required to unlock that investment, and further develop the project pipeline, is a UK Government commitment to a steady build-out rate through a multi-year programme of contract allocation rounds, similar to the 2013 Electricity Market Reform (EMR) Delivery Plan that enabled the scale up and cost reduction seen in offshore wind over the last decade.

The CCSA stands ready to work with members, the UK Government and other stakeholders to make this vision a reality. I would like to thank all of the many contributors to this work. It’s great to see our collective knowledge brought together clearly in one place. Now it’s time to deliver!

- Ruth Herbert, CCSA CEO



Executive Summary

In this report, we set out industry's view of the recommended pathway and key actions needed to achieve the UK Government's ambition to capture and permanently store at least 50 million tonnes of CO₂ per annum by 2035.

Key findings

A summary of our analysis from looking at three scenarios for potential build-out rates for CCUS in the UK in the period 2025–2035, based on data from known clusters and major emitters across the UK, is provided on page 11. The key findings from this analysis are:



The UK's ambition of storing over **50MtCO₂/yr** by 2035 can be significantly exceeded by the industry's capture project pipeline, which represents over **70MtCO₂/yr** of current emissions that could be avoided using CCUS



All of the UK's 2027 and 2030 **technology-specific CO₂ capture targets*** can be delivered and, in some cases, exceeded threefold, with industry investing and ready to deliver:

- A total of over **500MtCO₂** captured and stored by 2035
- Over **7GW** of **low carbon and carbon negative generation capacity**
- Over **15GW** of **low carbon hydrogen production**



The majority of this capture project pipeline is at risk, waiting for the next opportunity to secure a contract from Government

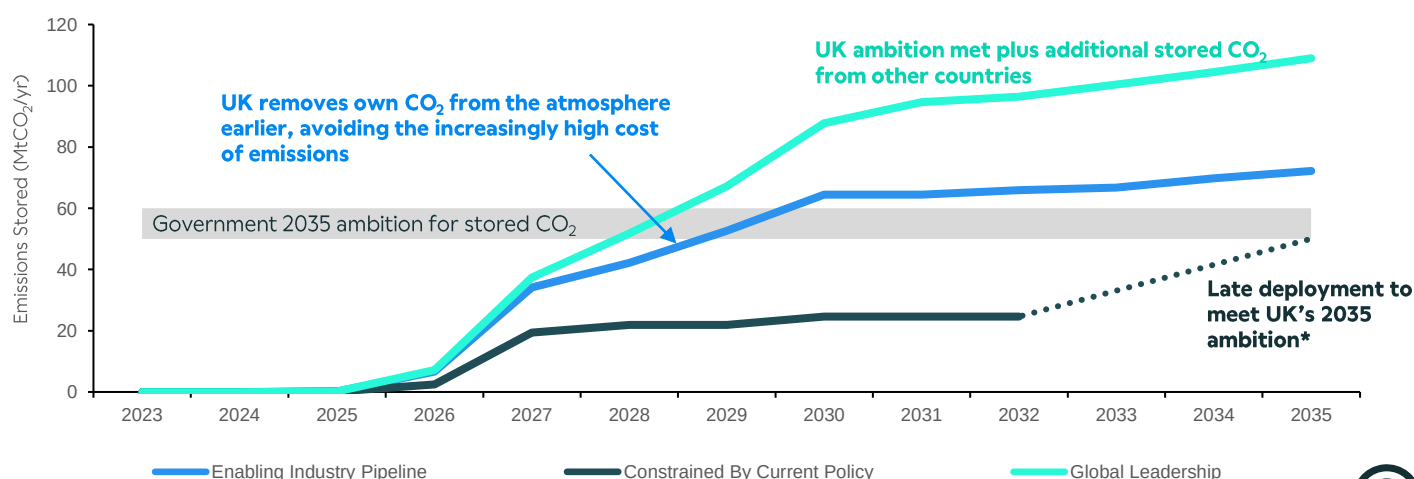


More development of storage and CO₂ pipeline capacity is needed to accommodate the current capture project pipeline, and **CO₂ shipping will be needed in the 2030s** for capture sites not close to stores



Domestic capture projects using **shipping and other non-pipeline transport infrastructure** are able to contribute **~15MtCO₂/yr** by 2035, and the UK has sufficient storage, if developed, to import a further **~20MtCO₂/yr** from neighbouring countries (where international shipped volumes are assumed to be accepted only after domestic UK shipped volumes have been captured and stored)

Figure 1: Emissions captured to 2035 by CCSA scenario



Note: *The UK Government's 2027 and 2030 technology specific targets refer to the capture and storage targets as featured in the Net Zero Strategy. The UK Government's targets for the mid 2020's, as featured in the Net Zero Strategy, are referred to in this report as having a 2027 deadline. Refer to Appendix 2 Table 1 for details.



Conclusions

From the three scenarios presented in Figure 1, the (blue) *Enabling industry pipeline* scenario enables the UK to achieve its 2035 ambition earlier, which considerably reduces the cost of meeting the target, due to the avoided cost of emissions from 2025 onwards (~£250/t¹).

- This *Enabling industry pipeline* scenario entails total expected construction and operation funding costs of **£69bn** (real 2020) through to 2035 to build and operate those projects.

In the *Constrained by current policy* scenario, a majority of the current pipeline will not be deployed before 2032, and without visibility on the scale and frequency of government contracts, many projects will fall away. The dotted line is therefore not based on the known project pipeline, which is likely to be unavailable in the future. Instead it assumes Government doesn't allocate further capture contracts until much later in the decade, since new projects would need an attractive framework and several years to get to the readiness of the current pipeline. Any emitters still operating would then need to deploy capture rapidly from 2032.

- The reduced build-out rate in the *Constrained by current policy* scenario has total costs of **£111bn** (accounting for funding through to 2035, plus societal carbon costs corresponding to emissions from projects that could have been built).

This scenario is considered to be undesirable for several reasons: it is more costly; its stop-start deployment pattern would frustrate the development of a strong domestic supply chain; and delayed deployment of retrofits may result in the loss of heavy industry as ETS prices rise.

Our conclusion is that by constraining CCUS deployment now, the UK will incur higher costs overall. If instead, we pursue the *Enabling the industry pipeline* pathway, the costs will be lower and the UK will develop shipping solutions before 2030, offering a route to decarbonisation for all of the UK's major industrial regions. This pathway would also create optionality for the UK to pursue the *Global leadership* scenario, with volumes of CO₂ coming from additional capture projects on domestic dispersed sites and infrastructure costs potentially offset by subsequent CO₂ imports. We have therefore also included actions to enable the *Global leadership* pathway within the report.

More information on the scenario analysis is provided in Appendices 1 and 2.



Our Recommendations:

The UK should pursue an **accelerated capture and storage build-out rate to significantly reduce total costs of deployment** and ensure it can stay on a pathway to storing 50MtCO₂/yr by 2035

To enable this, the **government must implement a set of urgent actions in the next 12 months** to create the necessary environment for industry to continue their planned investments (see next page)



We believe this approach will **maximise the benefits from UK leadership on CCUS, providing:**

Certainty to enable UK's domestic supply chain to grow

Reduced reliance on imported commodities, with low carbon products made in UK

Creation of a new export industry and attracting inward investment

Development of skills and the safeguarding of jobs

Enhanced competitiveness of UK manufacturing



Urgent recommended actions

Out of the 29 actions identified in this report, industry recommend that the **10 most urgent actions are need to be prioritised by Government, industry and wider stakeholders over the next 12 months to enable the rapid scaling needed to achieve the 2035 ambition.**



Attractive
Investment
Framework

1) Hold regular funded contract allocation rounds

Government must provide certainty on frequency and volume of future contract awards for further Transport & Storage and capture projects to enable industry to continue to invest in developing a pipeline of projects that can meet the UK Government's 2030 and 2035 ambitions (*Action A1, page 16*)

2) Finalise business models across the value chain

Significant progress has been made towards business models that are financeable and attract investment. Government must now finalise contract terms for industrial and power capture projects, hydrogen, and Transport & Storage, with urgent attention on Greenhouse Gas Removals (GGRs) and recognition of shipping (*Action A2, page 16*)



Timely Cluster
Delivery

3) Launch of the next cluster selection process in the first half of 2022

Government should continue building confidence for deployment of further clusters by providing the process and timeline for Track-2 cluster selection; and on the basis of this, industry to continue to invest in developing further clusters (*Action B1, page 19*)

4) Legislate a policy framework to enable projects to develop at pace

Government must provide timely legislation to ensure; all delivery bodies have the necessary powers and funding to deal with projects in a timely way, permitting is streamlined and there is a legislative basis to execute business models, including GGRs valued in an evolved UK Emissions Trading System (ETS) (*Action B2, page 19*)



Healthy Supply
Chain & Skills

5) Gain consensus on UK strengths in product and skill areas to prioritise for investment

Government and industry must agree the areas of the supply chain to target for investment to establish a strong competitive advantage in the supply chain, to ensure timely project delivery and develop an export base (*Action C1, page 24*)

6) Set policy and regulation to incentivise UK content

Government must develop an approach in 2022 for defining and measuring UK content, providing certainty for the supply chain to invest in new capabilities and attract inward investment (*Action C2, page 24*)

7) Accelerate entry into the workforce to meet demand

Government needs to build on existing skills mapping work from several industry organisations to focus training and investment in the right areas to develop additional jobs and training in the UK and avoid a bottleneck in skilled labour, which could delay onshore construction (*see Action C3, page 25*)



Mature CO₂
Transport
Networks

8) Accelerate permitting and construction of the infrastructure

Government must ensure that a clear permitting regime is outlined and communicated to project developers, to ensure timely project delivery and maximisation of deliverability of the pipeline (*Action D1, page 29*)



Sufficient Storage

9) Rapidly bring additional storage capacity to a commercial level of readiness

Government to coordinate with all stakeholders to launch a licensing round for new storage acreage, and provide clarity on the future market framework and how expansions of storage will work within the Transport & Storage license to drive industry investment in new store development (*Action E1, page 33*)



Supportive Public

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

Industry must create a communications strategy (building on existing Government plans) that will aid the success of communication with local projects, clusters and at the national level (*Action F1, page 36*)

Value chain focus

● Capture projects and Transport & Storage

● Transport & Storage

● CCUS ecosystem



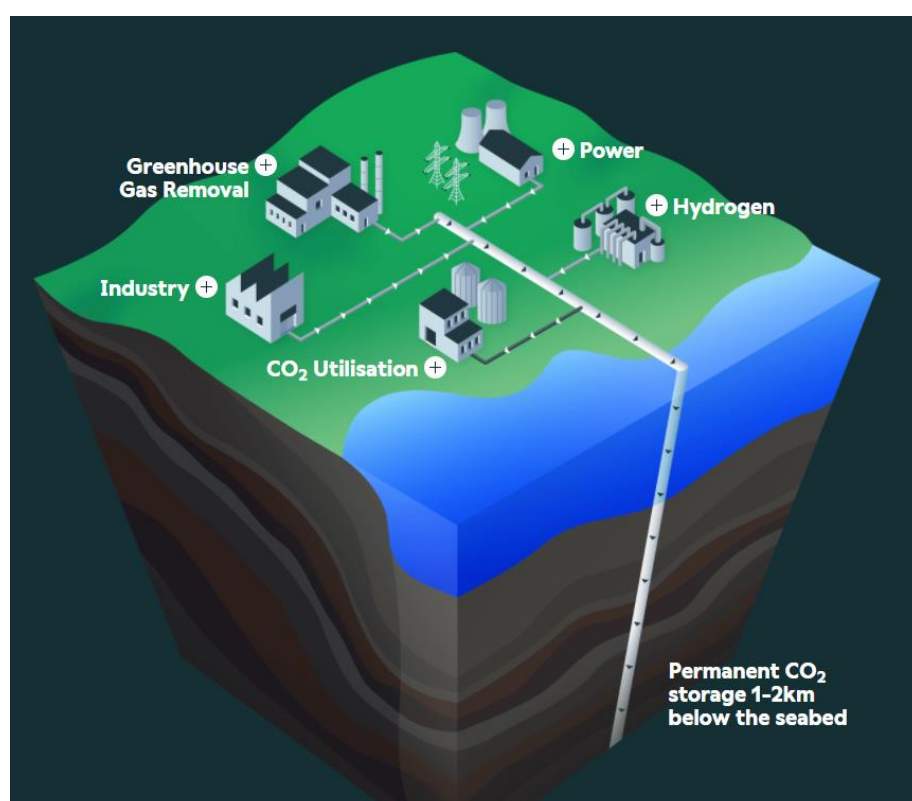
Introduction

Context

In June 2021, the UK Government adopted the Climate Change Committee's Sixth Carbon Budget Advice, setting in legislation a target of 78% Greenhouse Gas (GHG) emissions reductions by 2035. This was followed later that year with a Net Zero Strategy setting out the UK Government's view of how reductions could be made across the economy to deliver this. The Net Zero Strategy requires deep reductions in industrial emissions alongside a power sector that is net zero by 2035. The strategy states the UK Government ambition to capture 20-30 million tonnes of carbon dioxide a year (MtCO_2/yr) by 2030, and an indicative pathway rising to over $50\text{MtCO}_2/\text{yr}$ stored by 2035. It also includes 2030 targets for capture from different sectors, to be achieved by delivery of four CCUS clusters, with at least two operating by the mid-2020s ("Track-1" clusters) and another two by 2030² ("Track-2" clusters)*.

In May 2021, the government launched phase 1 of the Cluster Sequencing programme, a process that allows CCUS clusters to apply for infrastructure support for the first Track-1 projects to be operational by the mid-2020s. In October 2021, it provisionally allocated two clusters (HyNet North West and East Coast Cluster) as Track-1 clusters to negotiate with the UK Government for a license and government support to operate a CO_2 Transport & Storage network, with the Scottish Cluster held as a reserve cluster. The Phase 2 competition that is currently underway until May 2022 will allocate the first wave of emitter projects that will connect to the two Track-1 clusters. Industry is ready and is already investing in projects to bring them forward. At the time of writing there is no clarity on the timing for selection of further clusters to receive Transport & Storage support, nor on the timing for further phases of emitters to decarbonise either as part of Track-1 or Track-2 (see page 41 for our assumed fastest possible cluster selection timeline). It is within this context that the industry has come together to form its own view of what is needed to ensure that it can deliver the UK Government's CCUS ambition for 2035.

Figure 2: Illustration of a notional CCUS cluster



*Track-1 Clusters: The HyNet North West and East Coast Clusters have been selected as Track-1 clusters for the mid-2020s

*Track-2 Clusters: Clusters to be operational by 2030; these clusters have not yet been selected



Guide to this report

In this report, we set out the actions that industry recommend are needed to achieve the UK Government ambition of capturing and storing at least 50 million tonnes of CO₂ per annum by 2035 (this will be referred to as “the 2035 ambition”) that may be needed to deliver the Net Zero Strategy, which is aligned with the Sixth Carbon Budget. The rest of the report is structured as follows:

Summary of Analysis

The “Summary of Analysis” section describes the two workstreams that this report is based on (“Analysis of potential build out rate” and “Building blocks and actions needed to achieve the 2035 ambition”). It gives an overview of the methodologies, the scenarios employed, and the “building blocks” used to structure the recommended actions needed to achieve the 2035 ambition.

Actions needed to achieve the 2035 ambition by the *Enabling industry pipeline* scenario

The “Actions needed to achieve the 2035 ambition” section describes each recommended action in more detail, presented in sub-chapters of the “building blocks” used to categorise them. Additionally, they are divided into:

1. **Urgent actions:** a set of 10 urgent actions that industry recommend must be completed in the next 12 months if the 2035 ambition is to be achieved. These are presented in the Executive Summary, and tagged in **blue** in the next section.
2. **Enabling actions:** additional actions that industry recommend must be completed to remain on track for 2035, which are subsidiary to the urgent actions in time sensitivity or in priority. They are tagged with **green** in the next section.

Each action has an alphanumeric reference code e.g. “A1”; the letter refers to the building block to which it belongs (e.g. “A – Attractive Investment Framework”), and the number denotes its numerical place within that building block. At the end of each section, there is a table summarising:

1. The list of actions and sub-actions
2. A recommended timescale for each action to deliver the *Enabling industry pipeline* scenario
3. A recommendation for the organisation(s) considered well placed to deliver the action
4. A “RAG” rating based on the progress that has been made on that action to date
5. Any dependencies each action has with the other actions or building blocks identified in this report

Finally, a timeline of all the recommended actions and deadlines is provided.

Appendix

The Appendix describes the three CCUS Deployment Scenarios; the scenario methodology; the scale and frequency of allocation rounds required to deliver the scenarios; and the funding envelope required. It also provides a glossary of key terms, and end notes for the report’s references.



Summary of Analysis

Our findings are based on two workstreams:

1. **Analysis of potential build-out rate:** Data was collected from clusters and capture projects to identify the current and potential build-out rate, and how this compares with the UK Government ambition of capturing and storing at least 50 MtCO₂ per annum by 2035

Outcome: A recommended pathway for the UK Government to deploy CCUS between now and 2035 (see page 11)

2. **Building blocks and actions needed to achieve the 2035 ambition:** Prioritisation of actions through workshops with industry stakeholders, market research and Workstream 1

Outcome: A recommended set of 29 critical actions across 7 key building blocks for a successful industry, 10 of which are required in the next 12 months (see pages 7, and 13–40)

Analysis of potential build-out rate

Data was collected from clusters and capture projects to identify the current and potential build-out rates, and how they compare with the UK Government ambition of storing at least 50 MtCO₂/yr by 2035. This data was anonymised and aggregated to generate three scenarios for CCUS deployment in the UK (key insights described in Executive Summary). A detailed description of the methodology used in analysis and scenario creation are described in Appendices 1 & 2.

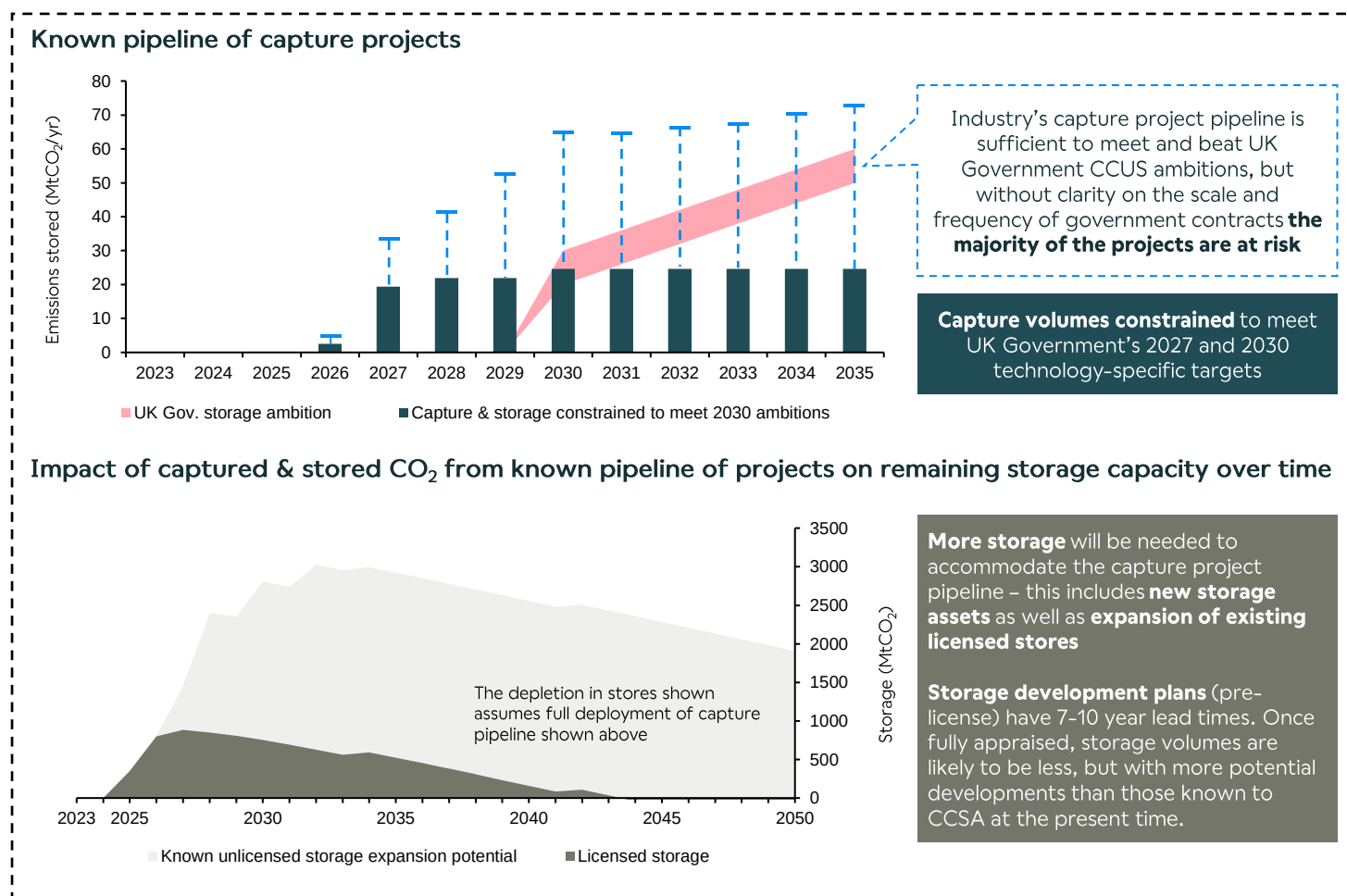
Scenarios

The 2035 Delivery Plan draws on three modelled scenarios for CCUS deployment in the UK, demonstrating a range of possible outcomes under varying levels of UK Government support. For all scenarios storage and capture data is based on project information provided by cluster leads and supplemented by publicly-available sources, with differing assumptions for regulatory timetables and the inclusion of shipped emissions. These three scenarios are:

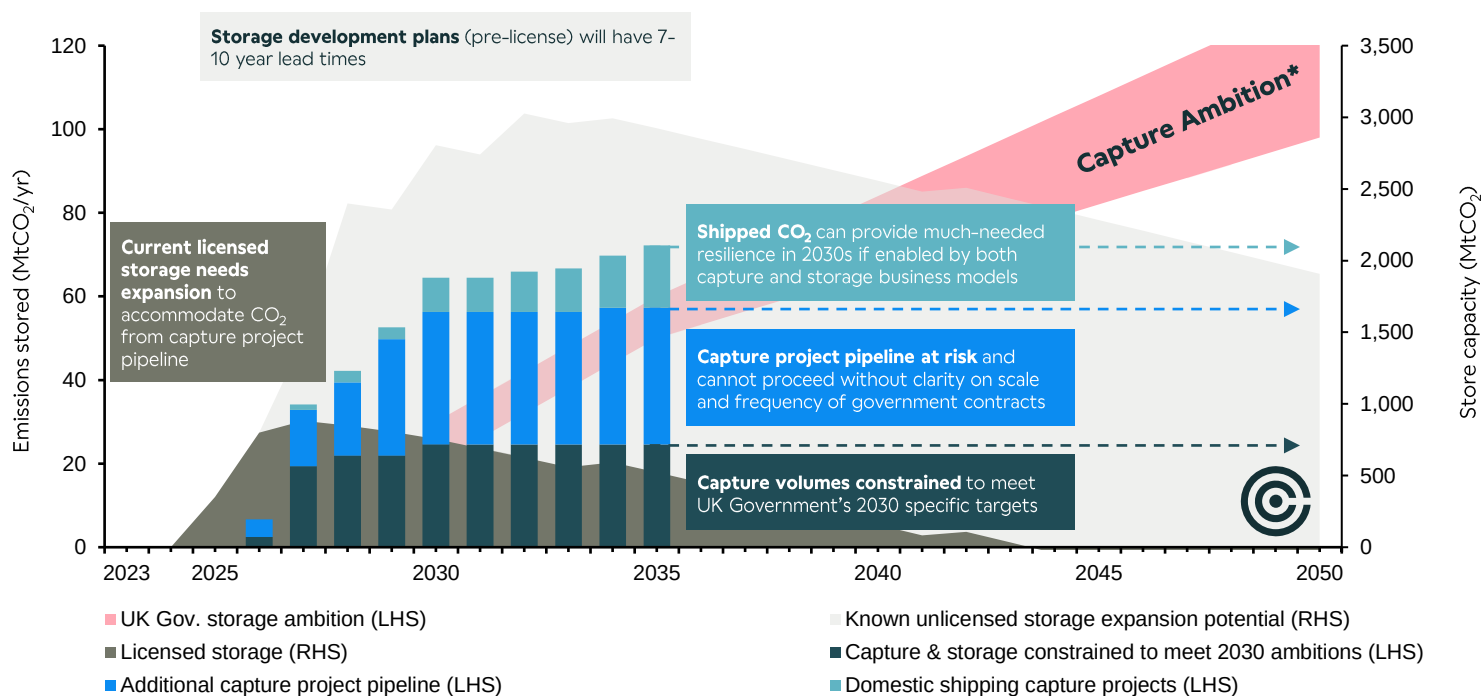
1. **Constrained by current policy:** Industry is constrained by the UK Government's 2030 technology-specific targets. Industry's current pipeline of capture projects is brought forward, but only to the extent that it meets 2030 Government targets for individual capture technologies and Track-1 and Track-2 clusters. There is then a further scramble to allocate projects later in the decade, by which point some of the pipeline has fallen away.
2. **Enabling industry pipeline:** Industry is able to implement the full pipeline of capture and storage projects currently under development in the UK, including domestic shipped CO₂. This scenario meets and exceeds the UK Government's 2030 and 2035 capture ambitions whilst providing certainty for development of the UK supply chain.
3. **Global Leadership:** The UK takes a leading role in the deployment of CCUS globally, through storing further volumes of CO₂ coming from additional capture projects on domestic dispersed sites, as well as European CO₂ imported by shipping. This scenario assumes domestic CO₂ storage requirements are prioritised and a commercial model to utilise excess storage is permitted.

Enabling industry pipeline is highlighted on the next page, as it provides particular insight into what industry recommend will be required to meet the 2035 ambition.



Figure 3: CCSA Delivery Plan 2035 – *Enabling industry pipeline* scenario

Capture and storage volumes over time – *Enabling industry pipeline* scenario



Note: Detailed assumptions employed in the creation of the *Enabling industry pipeline* scenario are listed in the Appendix. *Capture ambition in 2030 and 2035 based on Net Zero Strategy; for 2050 targets refer to CCC targets, showing a range between the 'Tailwinds' and 'Widespread Innovation' scenarios.



Building blocks for a successful CCUS industry

The recommended actions in this report are the output of workshops with industry stakeholders, market research and the analysis of potential build out scenarios. The actions have been presented within 7 outcome-focused building blocks for a “successful UK CCUS industry” – defined as an industry able to deliver the scale up required to meet the UK’s domestic targets and subsequently help Europe to decarbonise through storing CO₂ imports. *Attractive Investment Framework* and *Timely Cluster Delivery* are described as cross-cutting foundations, underpinning the success of all other building blocks.

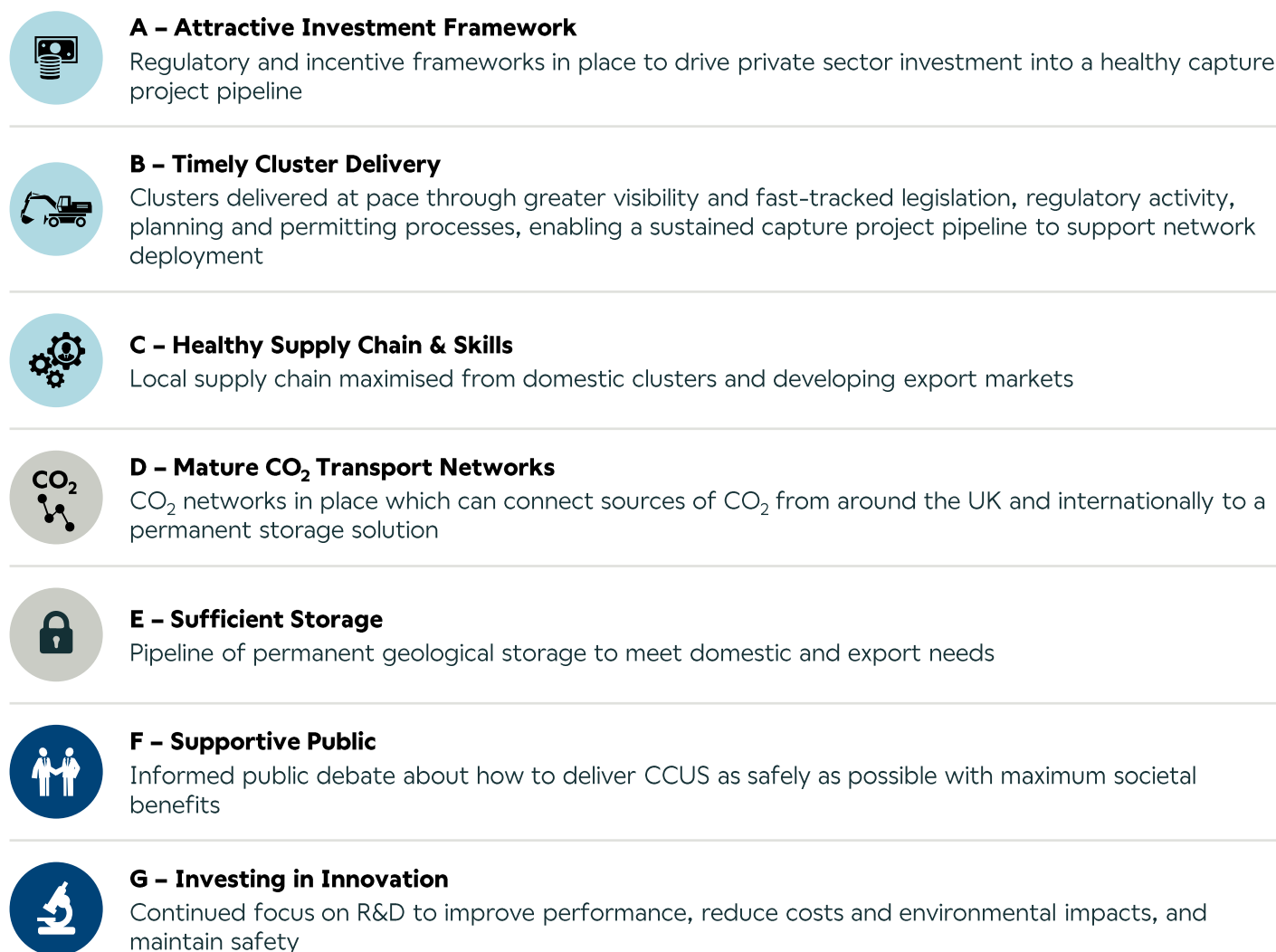
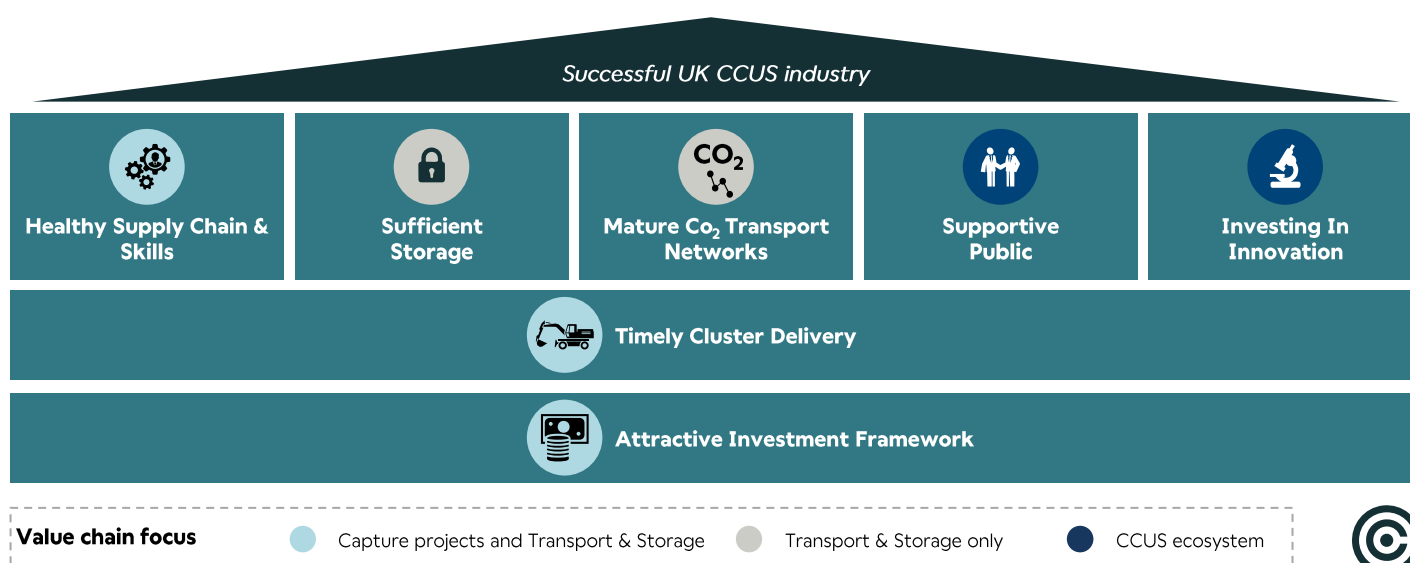


Figure 4: The “building blocks” for a successful CCUS industry





A) Attractive Investment Framework

Regulatory and incentive frameworks in place to drive private sector investment into a healthy capture project pipeline

Overview

Although there is a capture project pipeline that can meet the 2035 ambition, there is currently limited visibility on commercial incentives for CCUS in the UK. These projects will need access to low-cost capital to be successful, but in order to make the sector attractive to private investors, public funding support for CCUS business models is needed to build confidence and reduce risks. Once this is in place, there is no shortage of interested investors with private capital to channel into the sector.

Why Attractive Investment Framework is Needed

The Track-1 Phase-2 selection process, which closed in January 2022, has created a world-first competition for public funding between a range of power, hydrogen and industrial capture projects. However, there is currently a lack of visibility for capture project developers and funders on the projects that can expect to receive UK Government support, the timelines for this, and what the next opportunity is if they are unsuccessful. As demonstrated in the data analysis (see Appendices 1 & 2), there is a strong pipeline of capture projects ready to grow the UK CCUS industry, but visibility of funding and contract allocation is critical for that pipeline to be fulfilled. There are similar challenges for Transport & Storage networks that have not been selected in the Track-1 process; these networks have long lead times, but are unable to plan without a clear view of the timelines and process to receive an economic license and Government Support Package. The Attractive Investment Framework building block aims to provide visibility on funding, project capacity and contract allocation timelines.

Existing activity

While progress already has been made on some actions, it is important to accelerate their completion if sufficient clarity and confidence is to be achieved:

- UK Government has committed over £1.5bn to support CCUS, including the £1bn CCUS Infrastructure Fund (CIF)³
- The draft Transport & Storage operator licence has been published, and the Track-1 Phase-2 cluster sequencing submission evaluation period is underway until May 2022
- BEIS is developing the detailed structures and mechanisms with industry, with the objective of finalising the Transport & Storage Regulatory Investment ("TRI") model in 2022⁴
- The Industrial Carbon Capture (ICC) and Dispatchable Power Agreement (DPA) are close to being finalised and published by BEIS
- BEIS is developing a low carbon hydrogen business model, and has committed to develop the GGR business model, both due in 2022⁵

Key Stakeholders

BEIS

HMT



Urgent actions for an Attractive Investment Framework

A1 Hold regular funded contract allocation rounds

A2 Finalise business models across the value chain

Enabling actions

A3 Establish long term carbon removal market

A1 Hold regular funded contract allocation rounds

Capital and revenue support must be agreed within the UK Government, and project developers must have sight of this, in order to develop the confidence needed to invest; without this, there is a risk that project development stalls. UK Government needs to set out its funding policy providing clarity on areas including; allocation process, timing, funding envelope, eligibility, and funding mechanisms.

This policy will need to be underpinned by legislation as soon as practicable. Legislative cycles limit the frequency with which primary legislation can be laid, requiring a strategic approach from the UK Government and industry in structuring a funded policy framework that provides clarity in the near term and until legislation is enacted. Understanding the pipeline of projects supported by UK Government contracts is critical for project developers and owners to understand realistic deployment timelines and plan their operations in a cost efficient manner (for both networks and capture projects). Equally, investors and lenders need sight of the volume of projects that will require funding and financing.

A2 Finalise business models across the value chain

Business models are yet to be fully defined for both capture projects and clusters. Progress has been made in the development of the business models to underpin investment across individual CCUS sectors. However, significant market engagement will be required as the first projects are progressed, to ensure those models are financeable and the projects they support are able to attract investment.

CCUS-enabled businesses have domestic and international competitors that are not as of yet paying material carbon taxes. There is an existing view that capture projects will be able to pass carbon prices to their customers, however given the uncertainty of timing around this, some projects may struggle to raise finance on that presumption. As a result, early projects may require a greater level of government support to address this issue, which is expected to fall away as the ability to pass through carbon prices becomes clearer.

While the TRI model is expected to be finalised in 2022, core network investment decisions require clarity on key questions such as how clusters fund expansion and how the TRI model interfaces with non-pipeline transport (“NPT”) of CO₂. The business model needs to formulate ownership/operating model for the shipping part of NPT in a way that incentivises capture projects or Transport & Storage companies to invest in shipping.

UK Government’s 2030 ambition of capturing 5MtCO₂ /yr from engineered GGRs requires deployment of these technologies as soon as possible, but a business model is not yet defined, which holds back investment decisions.

It is important to note that the finalisation of investable business models is also required for DPA, ICC and hydrogen. All of the above technologies and business models are inter-related and progress will be most effective, and encourage fair competition, if made across all of them simultaneously. To this end all of the business models must be synchronised.



Enabling actions

A3 Long term carbon removal market

Lack of a formal market structure limits valuation and price discovery for carbon removal units, preventing investment for future projects. Establishing a clear pricing mechanism for negative emissions is crucial. Given the long lead times required to introduce or amend existing long term market mechanisms, such as reforming the UK ETS (and any CBAM where it emerges), a decision on integration of carbon removal technologies will need to be taken by the end of 2022 and be supported by primary legislation (see Action B2). The enabling of voluntary carbon markets could play an important early role in accelerating price discovery and allow Government to access revenue, reducing the funding burden on the Treasury. The Coalition for Negative Emissions, a membership organisation advancing policy on negative emissions technologies, is developing a negative emissions standard with work expected to be released later in 2022 which may serve as a starting point to explore standards for negative emissions. As other markets take actions to develop global carbon removal markets, early action in the UK will be important to maintain a position of global leadership.



Attractive Investment Framework: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
A1) Hold regular funded contract allocation rounds			
A1.1) Provide clarity and visibility agreement on funding commitment and timelines:			
a) Provide clarity and visibility to industry on funding envelope and timelines for award of hydrogen and ICC Contract for Difference (CfD) as part of the Phase 2 process.	BEIS HMT	Timely Cluster Delivery: B2 ✓✓✓	End 2022 Target to publish funding envelope, however if only covers Phase 2, could see unsuccessful projects fall away.
b) Publish funding envelope and contract award process for business models that don't have confirmed funding (including hydrogen and ICC CfD beyond Phase 2, DPA funding beyond the current Levy Control Framework (LCF), funding committed to engineered GGRs under its new business model, and expansion investments for existing Transport & Storage projects)	BEIS HMT		2023 Funding certainty needed for DPA contracts operational after 2026 (when LCF expires), post-Phase 2, and GGR contracts
A1.2) Communicate the project pipeline and requirements of that pipeline to UK Government and financial sector			
a) Communicate to UK Government; to understand the potential for projects to deliver on storage and emissions capacity ambitions	CCSA Project Developers	N/A	End 2022 Developing existing fora and dialogues with the finance sector is needed in 2022. This will further familiarise commercial lenders and insurers, as demand for financing and funding grows as Phase 2 projects move to FID in 2023
b) Communicate to financial sector; to enable a coordinated understanding between project funders, financiers, developers and owners (for example through confirmation around the role of the UK Infrastructure Bank (UKIB) in unlocking deployment of CCUS)	CCSA Project Developers		
A2) Finalise a business models across the value chain			
A2.1) Refine and finalise TRI business model – ensure it is designed for longevity, fit for purpose and agile for future network expansion. This includes ensuring transparency over capacity planning, sizing, and charges included in the model.	BEIS	Timely Cluster Delivery: B2 ✓✓✓	End 2022 TRI should be published in 2022, and expected to be iterated through negotiations
A2.2) Refine capture project business models – ensure ongoing development of capture project business models to account for capture project requirements (for example with shipping costs, through providing clarity on cost pass through for CfD contract holders for these costs), industrial sectors, and the nascency of linked low carbon markets (e.g. supporting hydrogen demand among offtakers)	BEIS	Timely Cluster Delivery: B2 ✓✓✓	2023+ Additional consultation with industry will be needed following award of Phase 2 contracts
A2.3) Establish short term carbon removal market and price through GGR business model – there is currently no support for GGR technologies nor a market for engineered removal certificates in the UK. Timely development and deployment of the GGR business model will be critical to reach UK Government's 2030 target of 5Mtpa of removals. The anticipated BEIS consultation on a GGR business model in Q2 2022 should be swiftly acted upon	HMT BEIS	N/A	End 2022 UK Government target consultation on engineered GGRs in 2022, and business model ready for FID in 2023
A2.4) Clarification of Non-Pipeline Transport (NPT) business model	BEIS	N/A	2022 Industry seeking clarity on Track-2 and the role of NPT this year
a. Identifying how NPT will interface with the TRI and capture business models (i.e. what are the interfaces, and how are these considered by the regulator)			
b. What elements of a shipping NPT model can map across to other modalities and what are the distinct elements of a road/rail model which need to be addressed by 2035			
c. Clarify ownership and accountability for CO ₂ liabilities for Transport & Storage operators, particularly as stores accepting shipping volumes may accept both domestic and international CO ₂ volumes (with liabilities for international volumes unlikely to be underwritten by a Government Support Package (GSP) arrangement)			
A3) Establish long term carbon removal market			
A3.1) Confirm decision on integration of GGRs into the ETS (and any Cross Border Adjustment Mechanism, where it emerges) by 2025 for the 2026 – 2030 allocation period	BEIS HMT	N/A	2023 Requirement to complete ahead of the 2026-2030 ETS (and any CBAM) allocation period, however industry expects signposting as soon as possible

Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned





B) Timely Cluster Delivery

Clusters delivered at pace through greater visibility and fast-tracked legislation, regulatory activity, planning and permitting processes, enabling a sustained capture project pipeline to support network deployment

Overview

The ability to deliver clusters (which we define as Transport & Storage networks and connected capture projects) at pace will require a confluence of regulation, planning and other measures to streamline the issues faced by project developers. As initial cluster projects move to take final investment decision (FID) in early 2023 and capture projects to begin taking FID later that year, there are several areas of regulation and policy in which action is needed to build in the flexibility required to deliver a series of projects toward ambitious timelines. A general presumption of the Delivery Plan is that the enabling legislation and regulation required to deliver the TRI model is in place to enable the financing of the first two Transport & Storage networks.

Why Timely Cluster Delivery Is Needed

The UK Government has set robust long-term ambitions for carbon capture, and while Track-1 clusters have been selected and industry and Government have been engaged in extensive constructive discussions, there is still a process to navigate to bring these initial projects to FID. Stakeholders have consistently noted how crucial it will be to effectively deliver on the early Transport & Storage networks; while these projects are on track, their business models must be finalised and these must undertake a complex task of sequencing multiple capture projects into their networks. Early capture projects face challenges including planning and permitting processes (e.g. environmental permitting), which could lead to project delays.

Beyond Track-1 clusters, there are several potential cluster projects pursuing an investable project development concept but lack the clarity on timelines for deployment through the Track-2 process, which is typically required for similar infrastructure projects with such high capital expenditure commitments. The need for greater visibility and coordination around legislation, regulatory activity and permitting processes has led some stakeholders to call for coordination through a national roadmap. This coordination is also critical for ongoing issues such as resolving seabed co-location issues for CCUS acreage, familiarising the finance sector with CCUS, and coordinating port activity and regulations related to CO₂ shipping operations.

Existing activity

Progress is underway on some recommendations, however it is critical to address barriers to the permitting process and accelerate the finalisation of these activities, in line with the urgent actions of this building block:

- BEIS is progressing the initial framework for Track-1 cluster deployment (Phase 1 and 2 processes)
- Projects are submitting DCO and environmental permit applications

Key Stakeholders

BEIS	HMT	North Sea Transition Authority (NSTA)	Ofgem	Environment Agency
Department for Environment, Food and Rural Affairs	Department for Levelling Up, Housing & Communities	Planning Inspectorate		



Urgent actions

- B1** Launch the next cluster selection process in the first half of 2022
- B2** Legislate a policy framework to enable projects to develop at pace

Enabling actions

- B3** Build capability for the finance and insurance sectors to support cluster delivery

Urgent actions

B1 Launch the next cluster selection process in the first half of 2022

Continued engagement from the UK Government with Track-1 clusters will be critical as they convert their storage licenses to permits, complete a front end engineering and design (FEED) and move through construction. Delivering on the UK Government's 2030 and 2035 ambitions will require the development of Track-2 clusters, but clusters not selected in Track-1 currently have no certainty on potential timelines. While BEIS guidance suggests they could take FID as early as 2024- just one year behind Track-1 clusters - therefore urgent clarity is required on Track-2 to keep investors and partners engaged.

B2 Legislate a policy framework to enable projects to develop at pace

A key gap in coordinating project delivery in the UK is around the legislation required – several stakeholders outlined the urgent need to map out the legislation that is needed to deliver a full-chain CCUS network in the UK. Stakeholders flagged the requirement for additional primary legislation that would be needed for Government to cover the whole CCUS chain. This includes: the legislative basis to execute business models, including GGRs valued in an evolved UK ETS (and any CBAM where it emerges); the legislative underpinnings to implement the long-term funding framework (i.e. allocation rounds for capture project CfDs); and ensuring all regulators and delivery bodies have the necessary powers and funding.

This action extends to streamlining the permitting and approvals process. Given the challenges faced by the offshore wind industry in managing the consenting process, there is a perception that early action to streamline the permitting and approvals process for CCUS will be key to ensure that projects remain on track for their ambitious ambitions. However, permitting challenges may be even more acute in CCUS compared to offshore wind – cluster networks are not responsible for managing the consenting and permitting process for their capture projects. The inclusion of several parallel processes for each network creates interface and timing risks multiplied across a range of parties. The absence of an existing regime for managing COMAH and HSE engagement processes for capture projects was flagged by some stakeholders as a potential blocker, while others sought clarity on the planning regimes for different projects (e.g. town and country planning versus Development Consent Order (DCO) processes for the different types of projects). Other capture projects noted a lack of clarity on how to engage in the permitting process as they moved through FEED phase.

Enabling Actions

B3 Build capability for the finance and insurance sectors to support project delivery

The UK Government expects that private capital will provide the majority of the funding for capture project and cluster networks, but investors, lenders and insurers view CCUS as a novel technology class given the absence of large-scale network deployments, particularly in the UK. Early projects will need to test lending markets and industry should accelerate use of existing dialogues and fora to educate the financial sector on CCUS project profiles to help establish industry consensus around lending costs, project risks and insurability before a large series of projects are brought forward.



Timely Cluster Delivery: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
B1) Launch the next cluster selection process in the first half of 2022			
B1.1) Confirm Track-2 sequencing process, including timing, eligibility and allocation	BEIS	Attractive Investment Framework A1 ✓✓✓	Mid 2022 Essential to occur in H1 22 to ensure continued investment in industry pipeline
B1.2) Develop clear, concise value for money case for CCUS – industry must outline the national and regional value of CCUS in decarbonisation, jobs and economic benefits across the UK	CCSA	Mature CO ₂ Transport Networks ✓✓✓	End 2022 Update previous work from 2021
B2) Legislate a policy framework to enable projects to develop at pace			
B2.1) Develop legislation, with a focus on whole CCUS chain including: funding, business model execution (including GGRs), governance, delivery body, and future allocation process	BEIS CCSA	Attractive Investment Framework A2 ✓✓✓	End of 2022 To enable FID in 2023, primary legislation should be developed this year, and enacted as soon as possible
B2.2) Ensure that all regulators and delivery bodies have the necessary powers and funding to respond to CCUS projects in a timely way and that the CCUS-related actions of all public bodies are managed under a single programme and are accountable to a single decision-making authority	UK Government UK Parliament	Attractive Investment Framework A2 ✓✓✓	2023 Many regulators are now on the critical path for clusters being operational mid-2020s; this action will be needed to enable FID in 2023
B2.3) Support the growth of CCUS, clearly setting out regulatory requirements , to ensure that they support innovations and good environmental and public health standards	OPRED DEFRA BEIS Environment Agency	N/A	End of 2022
B2.4) Provide clarity on the planning regimes for different projects (e.g. town and country planning vs DCO for the different types of projects)	Department for Levelling Up, Housing & Communities COMAH	N/A	End 2022 Feedback received from industry
B3) Build capability for the finance and insurance sectors to support project delivery			
a) Communicate to UK Government; to understand the potential for projects to deliver on storage and emissions capacity ambitions	CCSA Project Developers	N/A	End 2022 Accelerating existing fora with the finance sector will further familiarise lenders as demand for financing grows alongside Phase 2 FID in 2023
b) Work with financial sector; to enable a coordinated understanding between project funders, financiers, developers and owners (for example through confirmation around the role of the UK Infrastructure Bank (UKIB) in unlocking deployment of CCUS	CCSA Project Developers UK Infrastructure Bank		

Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned





C) Healthy Supply Chain & Skills

Local supply chain maximised from domestic clusters and developing export markets

Overview

The scale of the supply chain opportunity for the UK CCUS is tremendous (the 2019 CCUS EINA study predicts the Engineering Procurement Construction (EPC) sector alone has an exportable value of £2.1bn per annum by 2050), given the manufactured goods and services required to deliver a new industry. Simultaneously, there are risks in the UK supply chain landscape (in particular skills) that must be mitigated if the 2035 ambition is to be realised. The Supply Chain and Skills building block covers the required steps to maximise UK supply chain benefits and competitively position the UK to seize the opportunity, while mitigating the potential risks. This building block is divided into two sections: one focusing on the Supply Chain, and one on Skills.

Why a Healthy Supply Chain Is Needed

1. Failure to activate a viable supply chain would impact both industry and the UK Government. For industry, this may lead to a combination of higher costs for imported goods and/or labour, delays in project pipelines and potential cancellation of projects if the supply chain capacity and capability cannot align with project timelines. For the UK Government, a failure of the supply chain delivering will risk its 2030 and 2035 deployment ambition.
2. There is huge opportunity to provide significant economic benefits to the UK economy and levelling-up if the supply chain receives targeted investment and focus. This should be maximised given the role taxpayer funding will play in CCUS deployment, and timely government action and commitment will enable this. Clear signals around visibility of funding rounds for Transportation & Storage and capture projects will do more than activate project pipelines, they will provide confidence for supply chain development as well. Several stakeholders flagged supply chain development as a specific risk given the UK's experience with early support for offshore wind failing to spur a large domestic supply chain, and the industry is intent to secure the most economic benefits for and within the UK as possible.
3. Close collaboration between developers, supply chain companies and Government to advance the CCUS supply chain is imperative. While progress already has been made on some actions, it is important to expedite their completion.

Existing activity

- BEIS has published a CCUS Supply Chain roadmap that sets out the initial activities both the UK Government and industry need to take to realise the world-class potential of the UK CCUS supply chain⁶
- BEIS has commissioned a supply chain mapping report that will be available in the Spring of 2022 to gather evidence about the current and potential future capabilities of the UK supply chain in delivering industrial CCUS and match those capabilities to the pipeline of industrial decarbonisation projects up to 2030
- CCSA published a Supply Chain Excellence report that outlines how to maximise the benefits of CCUS through a strong UK supply chain⁷
- NAMRC report for the CCUS Council on "Supply Chain Intervention Strategy for CCUS" and Fit4CCUS programme to assess supply chain readiness levels⁸

Key Stakeholders

BEIS	Department of International Trade	NAMRC	CCSA	Project Developers
------	-----------------------------------	-------	------	--------------------





Skills

Why a focus on Skills is needed

The need to address a design and EPC skills bottleneck was a priority item identified by nearly all stakeholders engaged in the process. Ensuring a sufficient supply of adequate skilled workers to deliver on CCUS projects is a critical precondition for meeting the 2035 ambition, but this is at risk. While the UK has a strong base of skilled workers in construction and design services across a range of complex infrastructure classes, there were significant concerns among capture project developers about a lack of skilled labour to meet the demand of projects required to achieve the CCUS 2035 ambition. This is not only due to competition between CCUS projects, but also against other infrastructure projects occurring over the same timeframe.

Existing activity

The scale of the problem is well acknowledged, with progress made in skills supply mapping and efforts are underway to train new and existing workers:

- ECITB: March 2020 “Towards Net Zero” report on engineering and construction skills needed to meet net zero; they have completed occupational skills mapping, but trying to generate demand mapping⁹
- “People and Skills Plan” delivered to BEIS by OPITO under North Sea Transition Deal, which covers supply & demand, safety & technical standards, apprenticeship development and STEM. Likewise, the All Energy Apprenticeship Scheme has created modules specific for CCUS¹⁰
- Department for Education has established apprenticeships, skills bootcamps, traineeships, and T Levels – to grow future talent pipelines
- Green Jobs Taskforce (Taskforce of 17 individuals) published a report in July 2021, sharing evidence on the skills needed for our transition to net zero¹¹

However, the rate of training is currently insufficient to meet the demand for skilled labour that will occur in the mid-2020s and industry operating model preclude training new entrants at the scale required in advance of firm project orders.

Key Stakeholders

ECITB	OPITO	BEIS	CATCH UK	OEUK	CCSA
-------	-------	------	----------	------	------

Urgent actions to drive a healthy supply chain & skills

- C1** Gain consensus on UK strengths in product and skill areas to prioritise for investment
- C2** Set policy and regulation to incentivise UK content
- C3** Accelerate entry into the workforce needed to meet demand

Enabling actions

- C4** Optimise standardisation & modularisation
- C5** Build engagement between project owners and industry with supply chain
- C6** Incentivise suppliers to move manufacturing sites to the UK



Enabling actions (cont.)

- C7** Future skills demand mapping & modelling
- C8** Established and standardised competence assurance

Urgent Actions

C1 Gain consensus on UK strengths in product and skill areas to prioritise for investment

If the UK is to establish a strong competitive advantage in its CCUS supply chain, the UK Government and industry must finalise identification of potential areas where there is a significant gap to achieve the required future UK capability and capacity. Once this has been achieved, mobilising investment to fill gaps in a targeted way will be crucial to catalyse a strong supply chain. Another precursor engaging with suppliers and potential suppliers to gauge potential and desire to move into the space. This will require ‘boots on the ground’ engagement with these suppliers – an existing forum to engage with suppliers is the Fit for CCUS (F4CCUS) initiative, which can be engaged to reach out to more suppliers without creating additional organisational structures.

C2 Set policy and regulation to incentivise UK content

As part of the North Sea Transition Deal, the offshore oil and gas sector is voluntarily committing to achieve 50% local UK content across project lifecycles. There is also an opportunity to align greater UK content in the CCUS supply chain with the country’s ambitious Net Zero targets through the deployment of novel technologies including GGRs. However, there has not been clear definition of a UK content methodology, as well as a commitment established to a longer-term move towards increased transparency for the CCUS sector. As a result, the sector must develop a more holistic approach of defining and reporting UK content, particularly in supply chain procurement.

C3 Accelerate entry into the workforce needed to meet demand

Achieving the 2035 ambition will require multiple clusters to complete development in quick succession. This creates a significant demand for engineering and construction skills, with the risk of a skills bottleneck preventing delivery. While centres such as CATCH-UK are supporting training new skilled workers, currently there is still a significant gap in qualified available workers. Easing and accelerating entry into the workforce is needed in order to fill this gap. This includes not only accelerated pathways for new workers, but facilitating upskilling of semi-skilled workers, and transfer of workers from other sectors.

C4 Optimise standardisation & modularisation

Techniques for modularising technologies, standardising components, and increasing the efficiency of fabrication facilities suitable for manufacturing activity are key enablers for a healthy UK Supply Chain. Success here enables rapid deployment of the sector, triggers competition within the supply chain, provides a platform for export opportunities, and provides a global blueprint for deployment. Many of these points are critical for the sector’s growth beyond the often bespoke First of a Kind (FOAK) projects, into the medium/smaller emitters which are more suited to a modular, standardised engineering solution. Standardisation of specifications for equipment, including development of a standard taxonomy and tier 1 contractor toolkit (including for example open specification guidance) will be aid industry’s deployment and procurement.

C5 Build engagement between project owners and industry with the supply chain

The industry has highlighted the need to develop a CCUS Supply Chain Database that could be built through existing industry databases such as the Achilles and North Sea Transition Authority (NSTA) – previously OGA – pathfinder databases. This allows stakeholders to have greater visibility of the UK’s project pipeline and supply chain to make strategic investments and get involved earlier in the design process. To make opportunities more accessible, project developers and tier 1 contractors need to guard against unnecessarily over-specifying requirements. This could be supported by the development of an open specification guide for key equipment.



C6 Incentivise suppliers to move manufacturing sites to the UK

There is an opportunity to attract new, modular capture manufacturing sites to the UK given its competitive manufacturing environment, but investors and project developers view CCUS as a novel technology class given the absence of large-scale network deployments. Early incentives to attract and retain suppliers to the UK market are critical to seize the first mover advantage and boost the supply chain's export potential.

C7 Future skills demand mapping & modelling

In order to properly plan for the location and timing of skills requirements across CCUS and other infrastructure projects, it is important to complete a thorough skills demand mapping and modelling exercise. This will identify priority areas for intervention, and facilitate mitigation planning. One of the barriers for demand mapping is the fact that the detailed skills information from the clusters is not publicly available, yet this information does exist and is held by BEIS.

C8 Establish and standardise competence assurance

The engineering and construction skills required for CCUS, such as welding and mechanical engineering, are not just common across energy transition sectors but also “traditional” engineering and construction projects. While this emphasises the risk of a skills bottleneck, it also highlights a potential opportunity to leverage existing skilled workers. If competence assurance can be standardised, it would streamline workers moving between projects.



Healthy Supply Chain & Skills: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
C1) Gain consensus on UK strengths in product and skill areas to prioritise for investment			
C1.1) Confirm prioritised supply chain areas for investment which maximise UK value add (where minimal investment is required, and where investment will require coordination). Component actions here include:	BEIS CCSA NAMRC Catapult OEUK	N/A	First Half of 2022 Need consolidation of published reports
a) Supply chain mapping			Q1 2023
b) Cross reference the supply chain mapping output with competing sectors; investigate synergies and tensions with other supply chains or infrastructure (e.g. existing O&G supply chain)			
c) Logistics assessment required for transportation of CO ₂	CCSA		End 2023 Work should conclude next year otherwise the window of opportunity may close
d) Detail and understand the gaps to set out an investment programme and strategy for engagement with potential UK suppliers (for example through the Fit for CCUS ("F4CCUS") initiative)	CCSA NAMRC		End 2023 Pilot is complete, but work should conclude next year otherwise the window of opportunity may close
C2) Set policy and regulation to incentivise UK content			
C2.1) Clarify definition and transparent reporting process for UK and local content – UK content must be defined (e.g. lifetime £ value of project spend) before it can be measured	CCSA / BEIS	N/A	End 2022 Early projects need to establish this upfront
C2.2) Form an open and stable dialogue with the private sector to enable feedback on key enablers for the UK supply chain and help build export capability	CCSA UKEF Department of International Trade	Attractive Investment Framework A1.2	End 2022 To align all parties in the market
C2.3) Establish long-term incentives to be attractive to investors , with new and innovative approaches required to meet the industry demand and help realise export potential	BEIS UKEF	Attractive Investment Framework A1	End 2022 To capture first mover advantage
C2.4) Provide support UK businesses to generate additional UK Intellectual Property (e.g. Focused development funds and targeted finance, trade / export finance) and for companies' export business development, and operational support for attracting investors/investment	Department of International Trade UKEF	Attractive Investment Framework A1	End 2022 Stakeholders expect the incentives this year

Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned



	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
C3) Accelerate entry into the workforce needed to meet demand			
C3.1) Confirm approach to leverage semi-skilled workers, and have on-project training across projects. Learn lessons from Hinkley Power Project and identify what actions are required to leverage these personnel and improve their skills over time	CCSA	N/A	2023 To be able to match the increasing demand of skilled workers to undertake construction as Track-1 projects moves to FID stage
a) Identify regional organisations capable and willing to provide training at local level	CATCH-UK		
b) Align apprenticeships with project needs e.g. through flexible curriculum, matching service	CCSA		
c) Introduce more flexibility in recruitment process for apprenticeship schemes, enabling potential & aptitude to be considered over grades. We also need to develop the skills required at scale ahead of project demand.	DWP		
d) There is a need for funding mechanisms to enable skills development at scale, particularly for new entrants, ahead of companies having project orders.	CCSA UK Government		
C4) Optimise Standardisation & Modularisation			
C4.1) Align on standardisation of specifications for equipment, including development of a standard taxonomy and tier 1 contractor toolkit (including for example open specification guidance)	BEIS CCSA Infrastructure and Project Authority	Mature CO2 Transport Networks: D6 ✓	End of 2024 Requires coordinated action across the whole supply chain
C4.2) Review and identify which technologies would benefit from modularisation	NAMRC		
C5) Build engagement between project owners and industry with supply chain			
C5.1) Create dialogue or forum to enable feedback flow between project owners, industry, and supply chain	CCSA	N/A	Q1 2023 Build on existing industry databases like Achilles
C5.2) Establish a stable framework to monitor progress and enable feedback	BEIS CCSA	N/A	Q3 2023 To allow stakeholders to work collaboratively to minimise duplication of work
C6) Incentivise suppliers to move manufacturing sites to the UK			
C6.1) Launch long-term incentive packages (including Freeports) for attracting high-skilled manufacturing facilities to locate in the UK	BEIS Department of International Trade HMT	Timely Cluster Delivery: B2 ✓✓✓	End 2022 Feedback received by industry to accelerate incentives needed for suppliers
C7) Future skills demand mapping & modelling			
C7.1) Map supply of skills	ECITB OPITO	N/A	2022 Build on existing work to date
C7.2) Model future demand of skills, including consolidated view across strategic Infrastructure	ECITB OEUK OGUK	Timely Cluster Delivery B1 ✓	2022 To build a plan to identify and mitigate biggest skills bottlenecks across infrastructure projects
C8) Establish and standardise competence assurance			
C8.1) Standardise competence assurance framework to facilitate transfer of skilled workers between projects and sectors	OEUK ECITB UK Government North Sea Transiiton Authority OPITO		2023 To enable adequate assurance framework in place in time for demand surge

Key

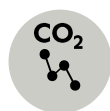
RAG status based on industry confidence rating:

■ Not Started / Not moving quickly enough
■ In Progress / Risk of Delay
■ On track

■ Urgent Actions
■ Enabling Actions

✓ Low dependency
 ✓✓ Moderate dependency
 ✓✓✓ High dependency





D) Mature CO₂ Transport Networks

CO₂ networks in place which can connect sources of CO₂ from around the UK and internationally to a permanent storage solution

Overview

Mature CO₂ Transport Networks covers pipeline infrastructure and non-pipeline transport (“NPT”) such as shipping, road and rail, which can connect dispersed sources of CO₂ from around the UK primarily, and subsequently from Europe if the *Global leadership* scenario pathway is chosen. This creates the opportunity for clusters to operate on a connected basis, resulting in resilience for individual clusters. Given how crucial a well-planned network evolution is to scale up CCUS, this building block has several actions for achieving the 2035 ambition, which have been confirmed through stakeholder engagement.

Why Mature CO₂ Transport Networks Are Needed

There is currently a lack of visibility for capture project developers, funders, and Transport & Storage players on the CO₂ networks, its regulators, and funding mechanisms. Carbon dioxide networks have long lead times and are critical for the deployment of future clusters and expansion of early clusters. However, they are unable to plan without clarity on the timelines and process to receive an economic license and UK Government grant support. The Mature CO₂ Transport Networks theme seeks to provide clarity on regulatory, investment, and governance for future networks and future transport solutions. Furthermore, it proposes actions to establish a framework for a diverse ecosystem of solutions to be able to connect all major UK sources of CO₂ to a permanent storage solution. (Note that a key requirement in this building block is the finalisation of business models – this is covered in the Attractive Investment Framework building block).

Existing activity

Progress has been driven by BEIS to develop the TRI model and formulate incentive mechanisms for NPT. Accelerating and building on the work done to date and finalising the details will be valuable if the network is to be built sustainably.

- BEIS has recently updated the business model for Transport & Storage as of January 2022¹²
- BEIS is developing the detailed structures and mechanisms with the objective of finalising the TRI model in 2022
- BEIS is engaging with the UK Government and industry stakeholders on how to accommodate NPT within the Transport & Storage business model as of January 2022.¹³ This is an area of expertise where we expect industry to propose a clear process, where progress on first projects can be made swiftly if Government allows for those models to interface with the existing TRI and capture business models.

Key Stakeholders

BEIS	Planning Inspectorate	Welsh Devolved Government	Department for Transport	Crown Estate Scotland
European Commission	North Sea Transition Authority	Department of Environment Food & Rural Affairs	Marine Management Organisation	The Crown Estate



Urgent actions to get mature CO₂ Transport Networks

- D1** Accelerate permitting and construction of the infrastructure

Enabling actions

- D2** Early access to Transport & Storage network from within UK for non-cluster projects
- D3** Degree of interoperability confirmed for future networks
- D4** Enable road and rail CO₂ transport infrastructure
- D5** Catalyse shipping supply chain
- D6** Align with international regulatory framework

Urgent actions

- D1** **Accelerate permitting and construction of the infrastructure**

Having a clear line of site of all permits required will be critical to project timelines. There is wide agreement across stakeholder groups that a clear permitting process should be understood within UK Government and communicated to stakeholders. Expediting the permitting process is not sufficient without providing an upper timeline limit and greater visibility on the process. This will then allow industry players to ensure appropriate and efficient planning is implemented.

Enabling actions

- D2** **Early access to Transport & Storage network from within UK for non-cluster projects**

The UK ports sector currently operates in a free market with a limited role for the state. Failure to facilitate early access to Transport & Storage networks for UK imports will discourage investment in the capability for accepting imports and risks hampering the UK's potential to capture first mover advantage. A clear framework for import and shipping and coordinated communication of the import potential to prospective non-domestic shippers is needed. Therefore, policy levers that provide long-term market confidence in CCUS, and give earlier certainty of CCUS project will be critical for ports to develop appropriate additional capacity to match the industry needs.

- D3** **Degree of interoperability confirmed for future networks**

Feedback suggested that having a degree of interoperability confirmed before CO₂ networks are constructed in 2023 would be highly valued by industry. It allows stakeholders to gain clarity on how network codes will be developed between different networks of the energy market (e.g. electricity, gas, hydrogen and CO₂). CO₂ network regulation was expected by some stakeholders to be less complex and simpler than gas network regulation – taking the opportunity to develop a dedicated framework for network regulation and interoperability was expected to ensure efficiency and deliver value.

- D4** **Enable road and rail CO₂ transport infrastructure**

Stakeholders stated expectations of clarity on the role of onshore transport modalities (e.g. truck, rail) as part of the decarbonisation plan for dispersed sites. Providing detail on these flexible onshore transport solutions is seen as pivotal to mobilise green investment in isolated or inland capture projects and clusters that are generally excluded from the main pipeline network but have a large share of emissions.



D5 Catalyse shipping supply chain

Wide consensus is seen on the importance to have shipping supply chain capacity and capability ready by 2023 as some Track-2 clusters have a large potential for shipped-CO₂. Government should encourage submission of competitive shipping offers as part of future bids from capturer projects supported through the capture business model at remote sites in the event of any future contract allocation rounds.

D6 Align with international regulatory framework

The UK and European Union have taken several initial actions to establish regulatory frameworks that facilitate trans-boundary import/export of CO₂ to be stored. The next step is to extend on this initiative in wider areas, for example with alignment between the UK ETS and EU ETS (and any associated CBAMs where they emerge). With the London Protocol already signed, bilateral national agreements are needed to supplement this.



Mature CO₂ Transport Networks: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
D1) Accelerate permitting and construction of the infrastructure			
D1.1) Establish coordinated tendering and permits procedure	Planning Inspectorate Devolved Government: Scotland Devolved Government: Wales	Attractive Investment Framework A3 ✓✓✓ Sufficient Storage	2022 Expediting permitting and construction process in 2022 will further incentivise continuous pipeline of projects to move forward
D1.2) Expedite permitting process and provide an upper timeline limit and greater visibility in the process	Planning Inspectorate		
D1.3) Create a cross-border forum to share lessons learnt and streamline the permitting process (as an enabler for international shipping market, this is a key action for the <i>Global Leadership</i> scenario)	BEIS	E1.2	
D1.4) Understand the interaction of permitting with other seabed users and time implications involved	BEIS		
D2) Early access to Transport & Storage network from within UK for non-cluster projects			
D2.1) Ensure access to port facilities by providing clear plan and process	Maritime Management Organisation The UK Major Ports Group	N/A	2023 Additional coordination needed between ports, industry as end users, and local government
D2.2) Establish mechanisms for ports to be provided with long-term market confidence in shipping	Department for Transport The UK Major Ports Group		
D2.3) Ensure health and safety framework for port facilities is appropriate	HSE Department for Transport BEIS		
D3) Degree of interoperability confirmed for future networks			
D3.1) Assess level of operability between clusters and networks	CCSA BEIS / Future Regulator	N/A	2023 Important to have degree of interoperability confirmed before CO ₂ network is constructed in 2023
D3.2) Confirm timelines for when interoperability may be required and long-term implications of lacking it			
D3.3) Ensure any degree of interoperability is flexible: striking a balance between speed and longevity			
D3.4) Confirm approach for interoperability of regulators in light of net zero as part of the network code development			
D4) Enable road and rail CO ₂ transport infrastructure			
D4.1) Mobilise funds to optimise the design, construction and operation of road and rail CO ₂ to become cost competitive in future	BEIS	Attractive Investment Framework ✓✓✓	2023 Stakeholders desire clarity on Non-shopping NPT (e.g. rail, truck) decarbonisation plan to mobilise investment in dispersed sites
D4.2) Establish initial non-shopping NPT demonstration (e.g. rail project) to create momentum and confidence	BEIS Department for Transport Network Rail		

Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned



	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
D5) Catalyse shipping supply chain			
D5.1) Clarify sizing for CO ₂ transport ships and ensure offloading facilities can receive a range of CO ₂ ships	Shipping sector Clusters reliant on shipping	Healthy Supply Chain C5 ✓✓✓	2023 Important to have shipping supply chain ready by 2023 as some Track-2 clusters have a large potential for shipped-CO ₂
D5.2) Build coordination between ship operators, industry, and builders to pursue market-led technological routes	The UK Major Ports Group Maritime and Coastguard Agency		
D5.3) Consider network codes on CO ₂ specification	BEIS / Future Regulator		
D5.4) Ensure appropriate interface with the landside of the infrastructure	Department for Transport The UK Major Ports Group		

D6) Align with international regulatory framework (as an enabler for international shipping market, this is a key action for the <i>Global Leadership scenario</i>)			
D6.1) Complete ratification of amendment of London Protocol by parties who wish to import CO ₂	BEIS	N/A	2024 Need wider member states participation and consensus
D6.2) Clarify ownership and accountability of trans-boundary shipped CO ₂	EU		
D6.3) Clarify alignment of UK ETS/EU ETS (and any associated CBAMs where they emerge) for cross border CO ₂ storage	BEIS		

Key

RAG status based on industry confidence rating:



Not Started / Not moving quickly enough
In Progress / Risk of Delay
On track



Urgent Actions
Enabling Actions

✓ Low dependency
✓✓ Moderate dependency
✓✓✓ High dependency



Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned



E) Sufficient Storage

Pipeline of permanent geological storage to meet domestic and export needs

Overview

Sufficient storage covers the regulatory frameworks required to drive investment in the exploration and appraisal of potential offshore storage sites, in order to ensure that the demand of storage from the pipeline of capture projects can be met. It is crucial that sufficient commercially-appraised storage is developed at the required pace. This building block therefore has several actions for achieving the 2035 ambition, which has been confirmed through stakeholder engagement

Why Sufficient Storage is Needed

Permanent storage is the lynchpin of a full chain CCUS network. With four storage licenses currently held by operators, there is the potential for substantial growth in the storage capacity of CO₂ licenses in the Offshore UK Continental Shelf ("UKCS"). However, developing this involves significant upfront risk (similar to upstream oil/gas exploration), long lead times (on average around 10 years), significant operational complexity and administrative challenges in securing a license. There are additional challenges related to the licensing process - while the NSTA generally requires a lease option from The Crown Estate ("TCE") within two years of an appraisal license, current TCE and The Crown Estate Scotland ("TCEs") policy is for lease options only to be granted to store operators which have a direct link to an industrial cluster designated in the 2018 CCUS Cost Challenge Taskforce Report.

Additionally, TCE lease options are in force for up to 10 years, requiring stores to come online within 10 years of the grant of a lease. As NSTA plan an open licensing round for storage sites, the limited number of potential industrial clusters and the 10 year time limit on seabed lease options have resulted in uncertainty for private investors concerning their strategy to apply for and secure expansion acreage (which may only be required beyond a 10 year period), and the ability of new storage developers to access industrial clusters. Developing sufficient storage in a timely manner is needed to meet the UK's ambition.

Existing activity

Progress is underway on some recommendations, however it is critical to accelerate the finalisation of these activities, in line with the priority recommendations of this building block:

- The NSTA has awarded four CO₂ appraisal and storage licences to Pale Blue Dot Energy (PBD) – Acorn CCS Project, Eni – Liverpool Bay Area and Harbour Energy – V Net Zero project ¹⁴
- The NSTA has also consented to a licence transfer for a CO₂ appraisal and storage licence to Northern Endurance Partnership ¹⁵

Key Stakeholders

BEIS

North Sea Transition
Authority

The Crown Estate
Scotland

The Crown Estate



Urgent actions to ensure sufficient storage

- E1** Rapidly bring additional storage capacity to a commercial level of readiness

Enabling actions

- E2** Identify the end-of life oil and gas assets suitable for repurposing to CCUS

Urgent actions

- E1** **Rapidly bring additional storage capacity to a commercial level of readiness**

Industry has made clear that given ~10 year end-to-end lead times for new storage sites, licensing new acreage through a new NSTA leasing process should begin as soon as possible, with the round launched in 2022 and licenses issued as soon as possible. Several stakeholders have noted that resilience in UK storage capacity will be important, which may require development of multiple stores in proximity of each other. Incentivising development of a larger set of potential stores will require significant additional private investment. Coordination with TCE, CES, and BEIS is also seen as a vital enabler in this, as the UK Government is crucial in setting the cadence for this leasing and an interface with seabed leases is critical to licensing new acreage.

Enabling actions

- E2** **Identify the end-of life oil and gas assets suitable for repurposing to CCUS**

Re-purposing existing oil and gas assets for CCUS can save time and costs. However, challenges to maximising the benefits of repurposing include a) decommissioning requirements do not currently guarantee that fields are left suitable for storage, and b) significant lead times and cost are still seen as deterrent factors to repurpose oil and gas assets for CCUS.

It can be easier to decommission a site rather than maintain it with little certainty it will be operated as a future storage site. Therefore, identifying which assets are suitable is an important part of achieving the maximum storage capacity possible. .



Sufficient Storage: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
E1) Rapidly bring additional storage capacity to a commercial level of readiness			
E1.1) Expedite the identification, development, and permitting of CO₂ storage a) Hold a licensing round for new offshore CO ₂ storage sites coordinated with offshore acreage leasing process	BEIS The Crown Estate Scotland North Sea Transition Authority The Crown Estate Marine Scotland	Timely Cluster Delivery B2 ✓✓	2022 Moving towards more coordinated carbon storage licence and lease rounds in 2022 or 2023
b) Develop a detailed understanding of future storage capacity beyond initial cluster plans, by pairing potential storage acreage with areas of high expected capture volumes	North Sea Transition Authority XTF (Exploration Task Force) CCSA		2022 Completion before NSTA licensing round assists targeted exploration
c) Support for the initial oversizing of capacity. The availability of excess capacity can substantially reduce lead times for future CCUS facilities	BEIS Exploration Taskforce Marine Scotland		2022 This should be run alongside the licensing round in coordination with a range of stakeholders
d) Ensure incentives for the next phase of exploration and appraisal are in place and agreed between the UK Government and regulators, since timely development of expansion storage sites will require appropriate funding mechanisms within the TRI. This should include consideration of whether permitted stores (including those not economically regulated) should be enabled to contract or transact with any CO ₂ network	Currently unassigned, but likely to involve: CCSA NSTA XTF BEIS The Future Regulator		2022
E1.2) Coordinated approach to offshore net zero technology in long term – with: a) multiple competing users for seabed (oil/gas, offshore wind, CCUS) make ensuring access protocols critical b) Ensure ongoing use of the Colocation Forum to head off emerging issues and proactively guide offshore leasing policy	The Crown Estate Scotland The Crown Estate CCSA North Sea Transition Authority	N/A	2022 This should be run alongside the licensing round in coordination with a range of stakeholders
E2) Identify the end-of life oil and gas assets suitable for repurposing to CCUS			
E2.1) Map and review the integrity and suitability of legacy wells in prospective CO ₂ storage reservoirs. Crucial to ensure legacy wells (old plugged and abandoned wells) are compatible with interaction with CO ₂ rich fluids and pressure fluctuations, and ultimately do not impact the integrity of the CO ₂ storage reservoir	OEUK CCSA BEIS XTF	N/A	2022 Integration with NSTA - licensing round to determine applicable acreage for round
E2.2) Joint discussion with the oil/gas sector on infrastructure suitability for re-purposing – use of existing infrastructure (primarily pipelines) can significantly reduce the development time of Transport and Storage infrastructure, so encouraging optimal re-use of these assets through a joint forum with oil and gas operators can help select the most advantaged cluster network locations	OEUK BEIS XTF CCSA North Sea Transition Authority OGUK	N/A	2022 Alignment around geographic distribution of assets for potential re-use can inform bidders strategies in future NSTA CO ₂ storage licensing round

Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned





F) Supportive Public

Informed public debate about how to deliver CCUS as safely as possible with maximum societal benefits

Overview

Successful delivery of the 2035 ambition will depend on positive public sentiment for CCUS. The Supportive Public building block captures actions that are needed to engage with the public and build support for CCUS projects through evidence-based communication.

Why a Supportive Public Is Needed

The transition to net zero represents a tremendous opportunity to build national pride and a sense of ownership amongst the public for the UK's green revolution. By building strong communication and informed public debate on the collective need to tackle climate change, we can ensure that the public are involved in the journey to net zero right from the start. This will in turn help to foster broader understanding and support for CCUS – both in terms of its essential role as part of the portfolio of solutions that will be needed to meet net zero, as well as the value that CCUS delivers across the entire economy.

Conversely, without public support for CCUS, progress towards the CCUS 2035 ambition is threatened at both national and local levels – this in turn threatens the delivery of the overarching net zero target. At a national level, widespread antipathy towards CCUS as a viable part of achieving net-zero could result in withdrawal of UK Government funding and legislative support, while at a local level, public opposition to CCUS projects could delay planning processes or project development. These risks can be mitigated by building on the public engagement already being carried by clusters, actively engaging with the public and building a coherent communications strategy to build support and listen to and address criticisms.

Existing activity

Work is already underway by organisations like CCSA, BEIS, and ALIGN-CCUS, and the individual projects and clusters, to assemble evidence in support of CCUS and engage the public on the topic. Building on the work done to date, and assembling a coherent strategy to support communication at national, cluster and project level, will be needed if positive momentum is to be built and maintained. Work done to date:

- CCSA assembly of evidence for CCUS communications, and existing communications activities
- BEIS Evaluation of a public dialogue on Carbon Capture Utilisation and Storage (CCUS) in December 2021¹⁶
- BEIS Carbon Capture Usage and Storage Public Dialogue in July 2021¹⁷
- ALIGN-CCUS WP6 work on surveying public perception towards CCUS

Key Stakeholders

BEIS	CCSA	ALIGN CCUS	UKRI	CCC
------	------	------------	------	-----



Urgent actions

- F1** Establish strategy to support national, cluster and project-level communications

Enabling actions

- F2** Evidence base for CCUS communications developed
- F3** Dialogue and participation with critics and citizens established
- F4** Framework to monitor public sentiment

Urgent actions

- F1** **Establish strategy to support national, cluster and project-level communications**

A communications strategy will aid the success of each level of CCUS communications, whether at local project level, cluster level or national level. An ‘umbrella strategy’ would provide access to a common evidence base to support communications. It would also give access to a planned network of stakeholders and organisations to help amplify positive messaging and provide a feedback loop to identify and support responses to risks and issues. In addition, it would aid alignment of messaging among industry members on key points, increasing the effectiveness for all.

Enabling Actions

- F2** **Evidence base for CCUS communications developed**

Building and maintaining public support will depend on a strong base of evidence to highlight the potential benefits and address concerns of potential risks of CCUS. The existing work of the CCSA and other organisations should be added to in line with the priority areas identified in the table of actions, and supplemented by additional public engagement and dialogue to identify areas of public concern (see enabling action 3).

- F3** **Dialogue and participation with critics and citizens established**

For any communications strategy to be aligned with genuine public cares and concerns, it must be based on engagement and dialogue with the public. This critical path item is designed to achieve that engagement. Furthermore, it includes engagement and discussion with potential critics of CCUS, to understand their concerns, in order to address them and provide a coherent response. Engaging a network of trusted stakeholders who are independent from the industry and who can provide positive messaging on CCUS would increase the dialogue and help build public trust. Finally, ensuring there is an explicit feedback loop in place so that this public dialogue can influence the evidence assembled, the content of communications, and the overall communications strategy, will maximise the benefits of this item.

- F4** **Framework to monitor public sentiment**

As CCUS delivery progresses and more projects move into the development phase, it will be important to monitor public sentiment in order to plan the next communications steps. It will be necessary once again to make sure there is an adequate feedback loop to ensure such monitoring feeds into the communications strategy. There is currently an open question regarding the role of the CCSA in this monitoring (versus the role of government and clusters), so an initial baseline exercise to confirm government plans is needed.



Supportive Public: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
F1) Establish strategy to support national, cluster and project-level communications			
F1.1) Identify critical timelines for public engagement for clusters and local projects. Refine list of common public concerns and questions, and responses needed	CCSA	Timely Cluster Delivery B2 ✓	End 2022
F1.2) Map existing UK Government plans for public engagement on CCUS and decarbonisation ambitions	CCSA		End 2022
F1.3) Create an “umbrella” national communications strategy to support clusters and local projects	CCSA		End 2022
F1.4) Agree process and information flow to enable cohesive narrative if risks or delays experienced	CCSA		End 2022
F1.5) Engage with key stakeholders on communications strategy	CCSA		End 2022
F1.6) Execute communications strategy (at national, cluster and local level)	CCSA		End 2022
F2) Evidence base for CCUS communications developed			
F2.1) Assemble evidence base for CCUS communications, with initial focus points of: a) Benefits of CCUS for gross value added (GVA) and job creation & retention b) Wider benefits of CCUS, including its criticality for Net Zero and its enabler as a “soft landing” for the energy transition (e.g. supporting security of supply, jobs and industrial activity through the transition, while effecting real action on climate change) c) Safety and reliability of CCUS d) Effectiveness and timely delivery of CCUS e) Lessons learnt from other nations and projects	CCSA	Timely Cluster Delivery B1 ✓✓	End 2022
F3) Dialogue and participation with critics and citizens established			
F3.1) Utilise existing public engagement fora (e.g. local councils, town halls, etc) to increase dialogue with the public	CCSA	N/A	Q1 2023
F3.2) Create expert engagement forum with key CCUS critics (e.g. NGOs)	CCSA	N/A	Q1 2023
F3.3) Build network of trusted messengers to share learnings and disseminate evidence-based message of CCUS	CCSA NGOs	N/A	Q1 2023
F3.4) Establish feedback loop and process to update national communications strategy in light of dialogue with critics and citizens	CCSA	N/A	Q1 2023

Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned



Supportive Public: Sub-Actions, Owners, Deadlines, Dependencies

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
F3) Dialogue and participation with critics and citizens established			
F4.1) Baseline what monitoring mechanism is in place with the UK Government	BEIS	N/A	End of 2022
F4.2) Create monitoring mechanism and cadence to measure public perception of CCUS , filling any gaps from existing UK Government monitoring activities	CCSA	N/A	End of 2022
F4.3) Create feedback loop for monitoring information to update and inform the communications strategy and content	CCSA members	N/A	End of 2022

Key

RAG status based on industry confidence rating:



Not Started / Not moving quickly enough
In Progress / Risk of Delay
On track



Urgent Actions
Enabling Actions

✓ Low dependency
✓✓ Moderate dependency
✓✓✓ High dependency





G) Investing in Innovation

Continued focus on R&D to improve performance, reduce costs and environmental impacts, and maintain safety

Overview

Investing in Innovation covers how research in capture technologies and Transport & Storage can be improved and aligned to industry needs in order to reduce costs and support the delivery of deployment ambitions. This “building block” has several actions for achieving the 2035 ambition which have been confirmed through stakeholder engagement.

Why Investing in Innovation is needed

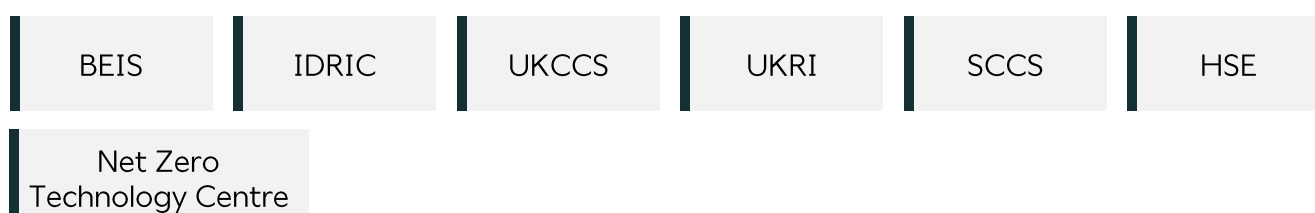
Novel, innovative, and evidence-based research can support continuous development of CCUS in the UK, while also spurring innovation in the UK economy and potentially providing the UK with a base for innovative technology exports. With dedicated funds for CCUS innovation, there is the potential for substantial growth in the research and innovation space of CCUS. There are competing demands for innovative solutions in the value chain as industry focuses on more near-term pinch points in deployment and innovators look at longer-term step changes in technology. Balancing focus in innovation efforts requires a determined approach to ensure the UK economy delivers the greatest long term value in CCUS given its strong skills base and research institutions. Additionally, improving existing solutions for CO₂ treatment and aligning research with the emerging needs in the industry involves long lead times (on average around 5 years), significant operational complexity and administrative challenges in producing the research.

Existing activity

There is already academia and industry coordination on research activities in the CCUS sector, but maximising collaboration and establishing the ownership to monitor research progresses into commercialisation stage should be the key focus in the upcoming years. Existing work includes:

- BEIS launched a call for CCUS Innovation 1.0 and 2.0 to offer grant funding for world-leading research and innovation in CCUS¹⁸
- BEIS Carbon Capture Utilisation Demonstration (CCUD) programme¹⁹
- The UK Industrial Decarbonisation Research and Innovation Centre (IDRIC) funding²⁰
- The UKCCSRC is funded until September 2025 and CCS research projects will continue to be funded through the flexible funded programme²¹
- Horizon Europe, the European Commission key funding programme for research and innovation, has funded a number of CCUS research projects²²
- HSE has conducted scientific research to help reduce both the risks and costs of any future development of industrial-scale CCS²³

Key Stakeholders



Enabling actions

- G1** Capture: Develop and improve technologies for CO₂ capture, compression and treatment
- G2** Transport & Storage: Develop research on Transport & Storage, software, and storage monitoring technologies
- G3** Improve process with needs of the industry

G1 Capture: Develop and improve technologies for CO₂ capture, compression and treatment

There is wide consensus on the importance to develop and improve technologies for CO₂ capture, compression and treatment to achieve cost reduction of capture solutions in the long run. Furthermore, a thriving R&I sector could help establish the UK as a global centre for excellence in CCUS technology, and showcase the UK's leading role in climate mitigation technologies.

G2 Transport & Storage: Develop research on Transport & Storage, software, and storage monitoring technologies

Stakeholders suggested that conducting more research in Transport & Storage space and drawing on best practice from other basins who have stored CO₂, are valuable to de-risk early projects, reduce cost, and spur innovation for future clusters. One area for potential innovation is in storage monitoring and verification (M&V) processes.

G3 Improve process with needs of the industry

Feedback suggested that aligning research activity with CCUS industry needs (including addressing any gaps in industry knowledge) and establishing the governance model to run this initiative will be important for the longevity of a CCUS economy in the UK. By aligning industrial innovation needs with a research and innovation programme, the UK can create a more attractive environment for investment in world leading CCUS technologies.



Investing in Innovation: Detail of Actions

Recommended owners and timelines to achieve the *Enabling industry pipeline* scenario

	Recommended Owner(s)*	Dependent on:	Proposed Dates necessary to achieve Recommended Pathway, and RAG Status
G1) Capture: Develop and improve technologies for CO ₂ capture, compression and treatment			
G1.1) Identify and confirm capture technologies for targeted R&D spending	UKCCSRC IDRIC CCSA	N/A	2025 Expectations by stakeholders to have visibility from the commissioning of Track-1 projects, to be able to improve on existing research methodology
G1.2) Establish ongoing collaboration forum between industry lead key developers, EPC contractor organisations and relevant UK Government departments to explore substances for CO ₂ capture and maximise engagement	CCSA IDRIC Net Zero Technology Centre	N/A	
G1.3) Incentivise data and information sharing from leading CCUS projects such as Track-1 cluster and existing oil & gas data, knowledge, models, and safe and secure operation ²⁴	BEIS North Sea Transition Authority XTF	Attractive Investment Framework A1.3 ✓✓	
G2) Transport & Storage: Develop research on Transport & Storage, software, and storage monitoring technologies			
G2.1) Establish funding for FEED study	BEIS CCSA	Attractive Investment Framework ✓✓	2027 The target is set to de-risk early projects, reduce cost, and spur innovation in the long run
G2.2) Establish forum between industry and academic institutions to align on most valuable CCUS research	CCSA	N/A	
G2.3) Draw on best practices from other basins who have already stored CO ₂ successfully, including a focus on secure operation	BEIS CCSA	N/A	
G3) Improve process with needs of the industry			
G3.1) Establish forum between industry and academic institutions to align on most valuable CCUS research, including the review of best practices from world leading projects actively storing CO ₂ securely in the subsurface	CCSA SCCS IDRIC UKCCSRC Net Zero Technology Centre UKRI	N/A	2023 Important to have an ongoing forum established to maximise UK research and innovation contribution to the development of Track-2, Track-3, and future clusters

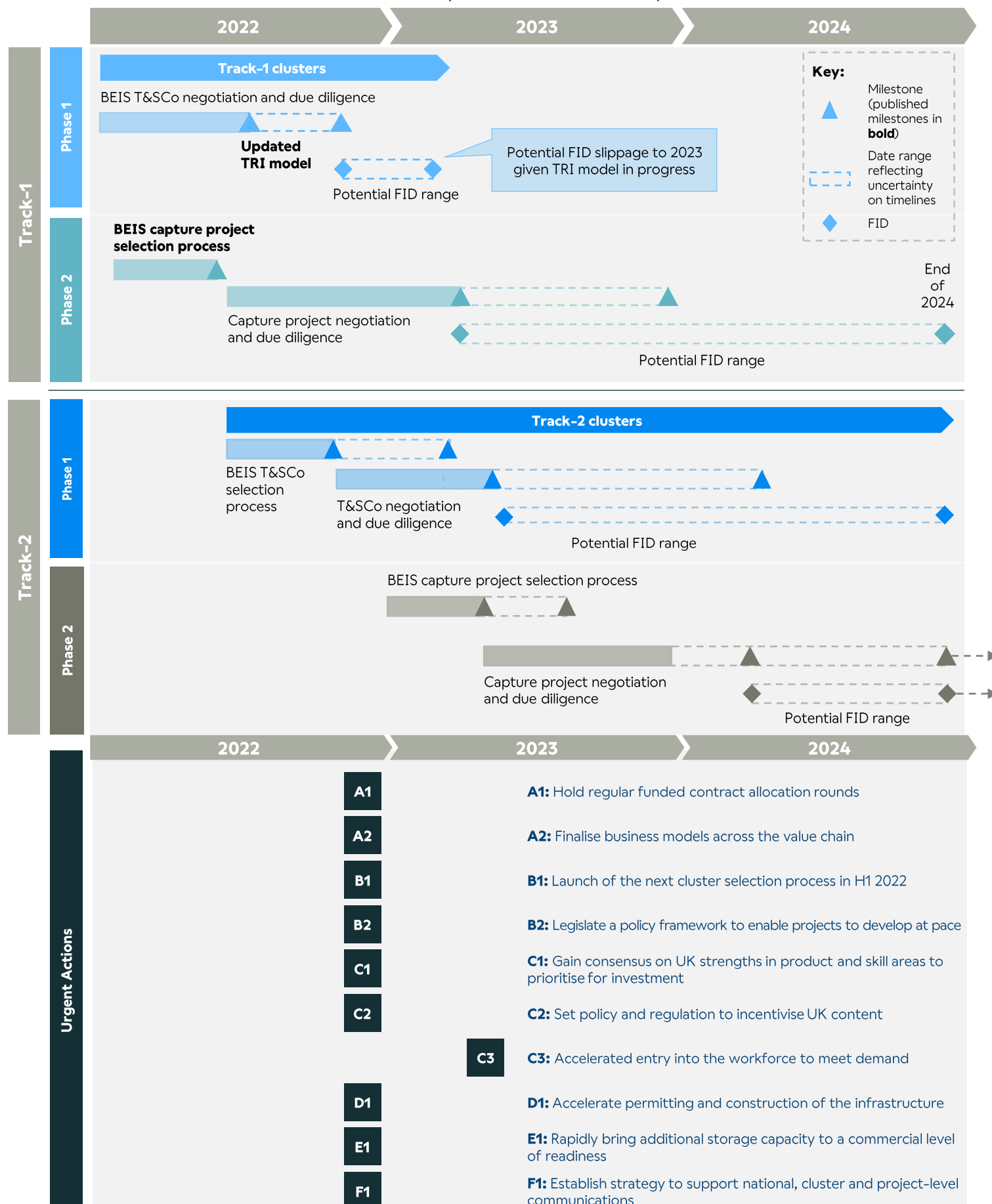
Key	RAG status based on industry confidence rating:	Not Started / Not moving quickly enough	Urgent Actions	✓ Low dependency
		In Progress / Risk of Delay	Enabling Actions	✓✓ Moderate dependency
		On track		✓✓✓ High dependency

Note: *Most organisations listed have been consulted during the project however the assigned organisations have been allocated on the basis of member and stakeholder feedback and do not represent commitments by those named organisations to deliver the actions assigned



Milestone Timeline with 10 Urgent Actions

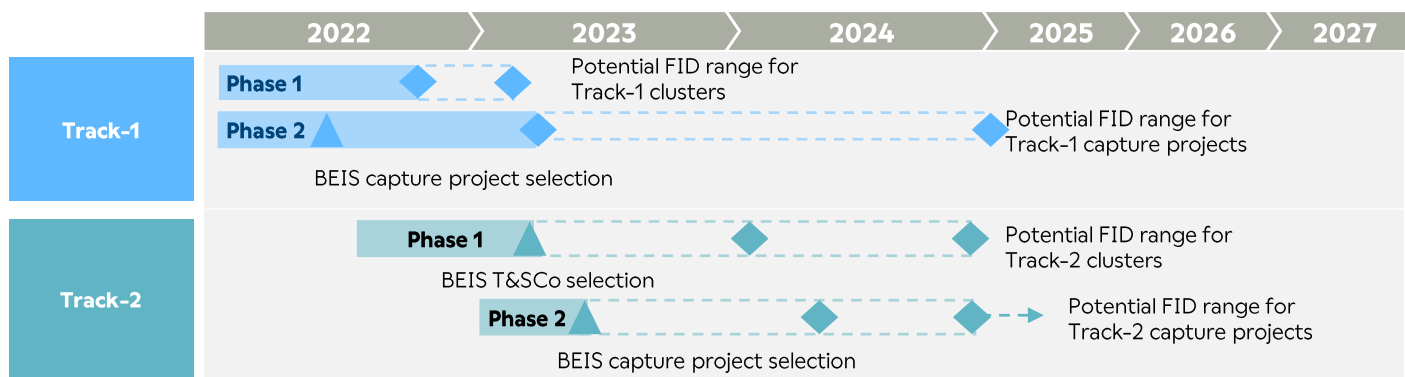
CCSA's view of an achievable timeline, based on published material and experience to date



Key: ▲ Milestone □ Date range ◆ FID



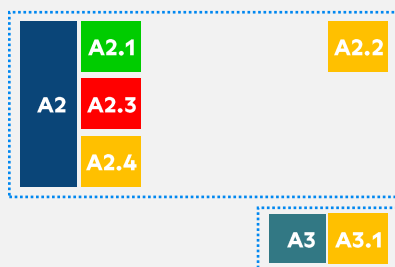
CCSA's view of an achievable timeline, alongside all 29 actions (part 1)



A: Attractive investment framework



A1: Hold regular funded contract allocation rounds



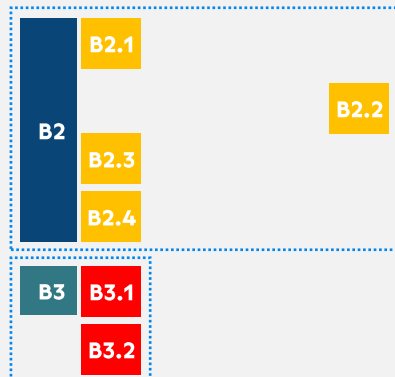
A2: Finalise business models across the value chain



B: Timely cluster delivery



B1: Launch of the next cluster selection process in H1 2022



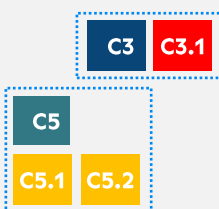
B2: Legislate a policy framework to enable projects to develop at pace



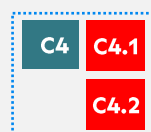
C: Healthy supply chain & skills



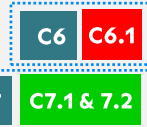
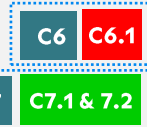
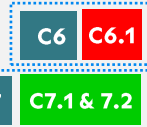
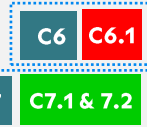
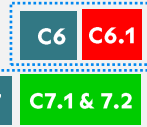
C1: Gain consensus on UK strengths in product and skill areas to prioritise for investment



C2: Set policy and regulation to incentivise UK content



C3: Accelerated entry into the workforce to meet demand



Key

Not Started

In Progress/ Risk of Delay

On track

Urgent actions

Enabling actions

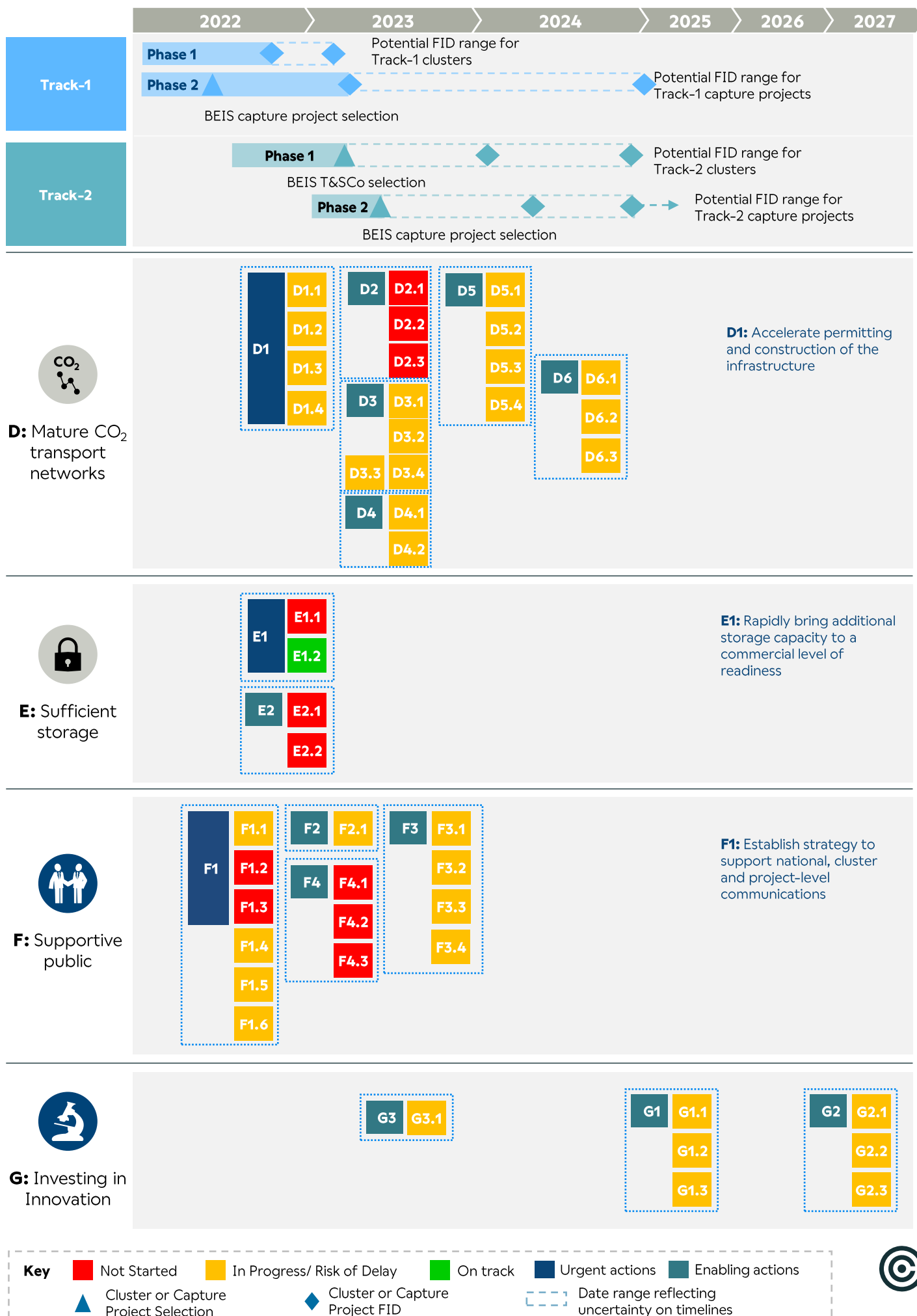
Cluster or Capture Project Selection

Cluster or Capture Project FID

Date range reflecting uncertainty on timelines



CCSA's view of an achievable timeline, alongside all 29 actions (part 2)



Appendix

Appendix 1: CCUS Deployment Scenarios

As part of the 2035 Delivery Plan, the CCSA has developed 3 scenarios for CCUS deployment in the UK.

The scenarios have been designed based on information acquired through a series of workshops with key industry stakeholders, information provided by cluster leads and the UK Government's CO₂ capture ambitions. They aim to indicate a range of possible outcomes, assuming varying levels of UK Government support.

The assumptions used in creating the scenarios are listed in Appendix 1 Table 1.



Scenario 1: *Constrained by Current Policy*

In this scenario, industry is constrained by the UK Government's 2030 technology specific targets.

- Capture volumes are allocated through Phase-2 competitions to meet the 2027* and 2030 targets
- Any clusters, capture projects, or unlicensed potential store expansion opportunities not required to meet the 2030 targets are assumed to be at risk, due to lack of funding clarity from the UK Government
- The scenario is designed not to reflect an anticipated or desired outcome of CCUS deployment in the UK, but to show the size of the potential pipeline of projects that could be at risk if action is not taken by the UK Government



Scenario 2: *Enabling Industry Pipeline*

In this scenario, industry is unconstrained by 2027 and 2030 targets, and is enabled to deploy the full pipeline of 'ready/known' projects identified by cluster leads to meet and exceed the UK Governments capture ambitions:

- The timing and volume of cluster, capture and storage projects is based on a combination of information provided by cluster leads and publicly available information
- This is the scenario featured in the Executive Summary of the report. It is aimed to show the potential pipeline of projects that industry can be ready to deliver with adequate levels of Government support

This scenario is used to illustrate the scale and frequency of UK Government allocation rounds required to activate the full pipeline (see Appendix 2 Table 2).



Scenario 3: *Global Leadership*

In this scenario, similarly to *Enabling industry pipeline*, industry is enabled to activate a full pipeline of projects to exceed capture ambitions. *Global leadership* builds on this further, and assumes the UK takes a leading role in the deployment of CCUS globally. This includes:

- The phasing in of dispersed domestic capture projects via NPT
 - Dispersed sites** are classified as sites with no immediate access to proposed clusters Transport & Storage networks, via shipping or planned pipelines
 - The UK is a major sink for European shipped CO₂
 - Additional potential capture projects, identified by cluster leads, are include in the plan

This scenario is used to assess the ability of the project pipeline to meet the requirements of a net zero power system by 2035.

Note: *The UK Government's ambitions for the mid 2020's, as featured in the Net Zero Strategy, are referred to in this report as having a 2027 deadline

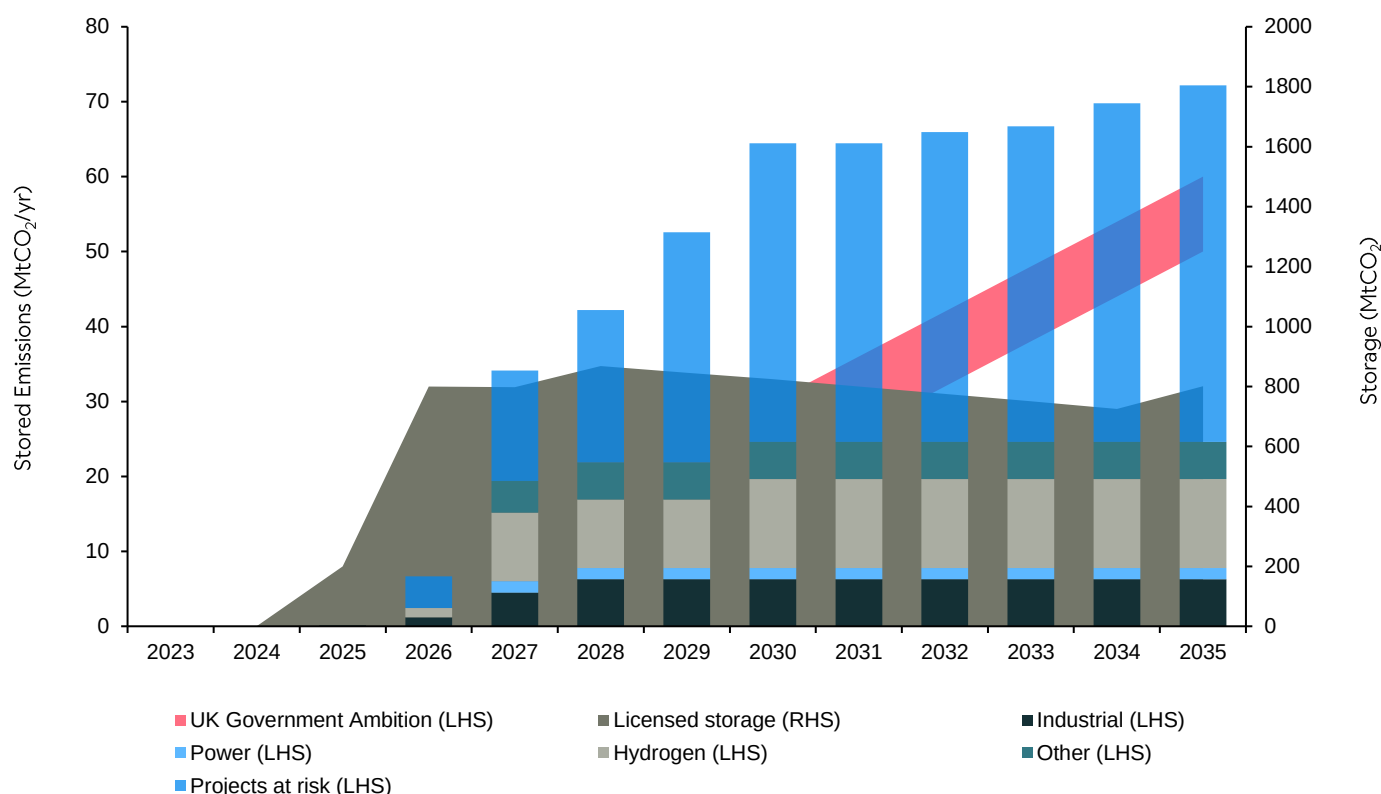
** Dispersed Sites defined as capture projects not located in large clusters, without access to pipeline or shipping Transport & Storage networks





Scenario 1: Constrained by current policy

Appendix 1 Chart 1: Constrained by current policy – Industry is constrained by the UK Government’s 2030 technology specific targets



Key Takeaways:

In adhering to the UK Government’s 2027 and 2030 technology specific targets...

- Almost **40MtCO₂/yr of capture projects are at risk due to no certainty on a route to market**
 - Any capture projects not selected as part of Phase-2 processes are at risk
 - Clusters without any licensed storage, and their capture projects, are at risk
 - Any clusters, and their capture projects, which rely on a shipping business model are at risk
- Potential to **miss out on capturing and storing an additional 90MtCO₂ by 2030**
- Potential to **miss out on developing around 2Gt in additional carbon storage capacity**
- The **UK’s 2035 ambition of 50MtCO₂/yr is in serious doubt**, with the majority of potential capture projects at risk due to lack of funding certainty

Key Assumptions:

- The **Track-1 Phase-2 process takes 12 months for selection** and doesn’t conclude until late 2022. This process procures emitter projects to meet UK Government 2027 targets, as well as volumes from ‘Other’** technologies to meet to contribute towards 2030 GGR targets
- The winners of the **Track-2 Phase-1 process are not announced until 2023**, resulting in a **one year delay to emitter timelines***
- The Track-2 Phase-2 process, to select Track-2 emitters, is concluded in 2023
- Any storage that does not currently have a carbon storage license is unable to obtain one due to there being no process in place

Note: *The UK Government’s ambitions for the mid 2020’s, as featured in the Net Zero Strategy, are referred to in this report as having a 2027 deadline

** ‘Other’ technologies includes GGRs, as well as other capture technologies unspecified by cluster leads

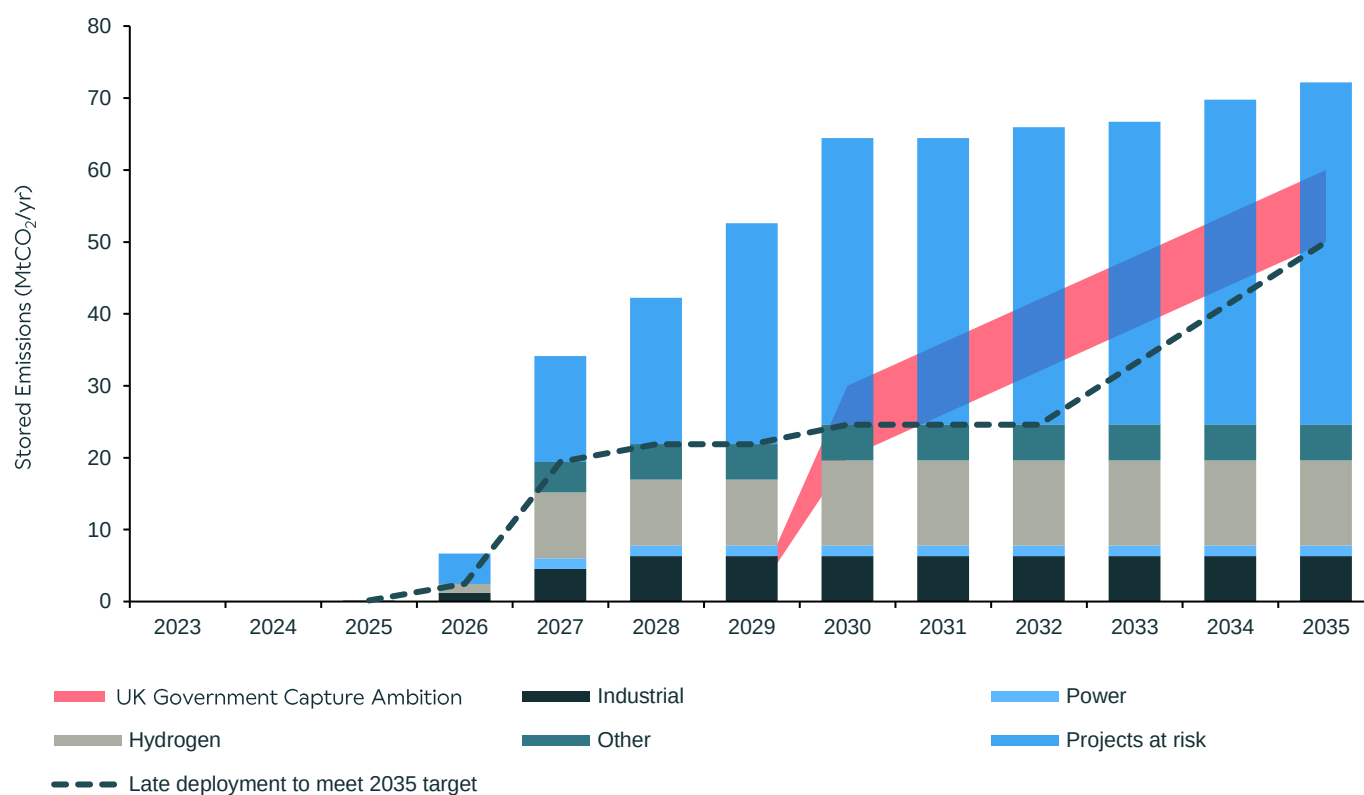


Sensitivity analysis: Deployment trajectory needed under the *Constrained by current policy* scenario to meet the UK Government's 2035 capture ambition:

- In addition to meeting the 2030 technology specific targets, the UK Government will need to incentivise further deployment to meet the 2035 capture ambition of at least 50MtCO₂/yr
- In the *Constrained by current policy* scenario, the majority of the current project pipeline is at risk due to lack of clarity on funding and contract allocation
 - If these projects are not progressed in due course, many will fall away as development concepts do not receive investment in planning or because unabated operations are financially unsustainable
- In this sensitivity, to meet the 2035 ambition, we assume the UK Government runs additional allocation processes for capture projects in the late 2020s
- Due to the length of time since previous allocations, the process takes a similar length of time to the Track-1 process, and additional capture projects do not commission until after 2032
 - This longer lead time is impacted by the negative effects on the supply chain from discontinuous, uneven deployment, as well as the time taken to revive the mothballed capture project pipeline or generate new projects
- We have assumed the gap to the 2035 ambition is met by theoretical capture volumes (this differs from the project methodology, where capture volumes are based on the project pipeline submitted to the CCSA by industry). There is no evidence that suitable projects would be available

In this sensitivity we have assumed capture volumes are allocated evenly between industrial, power, 'Other' technologies and hydrogen

Appendix 1 Chart 2: Deployment trajectory needed under the *Constrained by current policy* scenario to meet the UK Government's 2035 capture ambition:



- This sensitivity is used to explore the potential consequences of delayed and uneven deployment.
 - In Appendix 3, we use this sensitivity to analyse the difference in the economic impact of deploying CCUS just in time, as in this sensitivity, rather than incentivising the current pipeline to press forward, as in the *Enabling industry pipeline* case

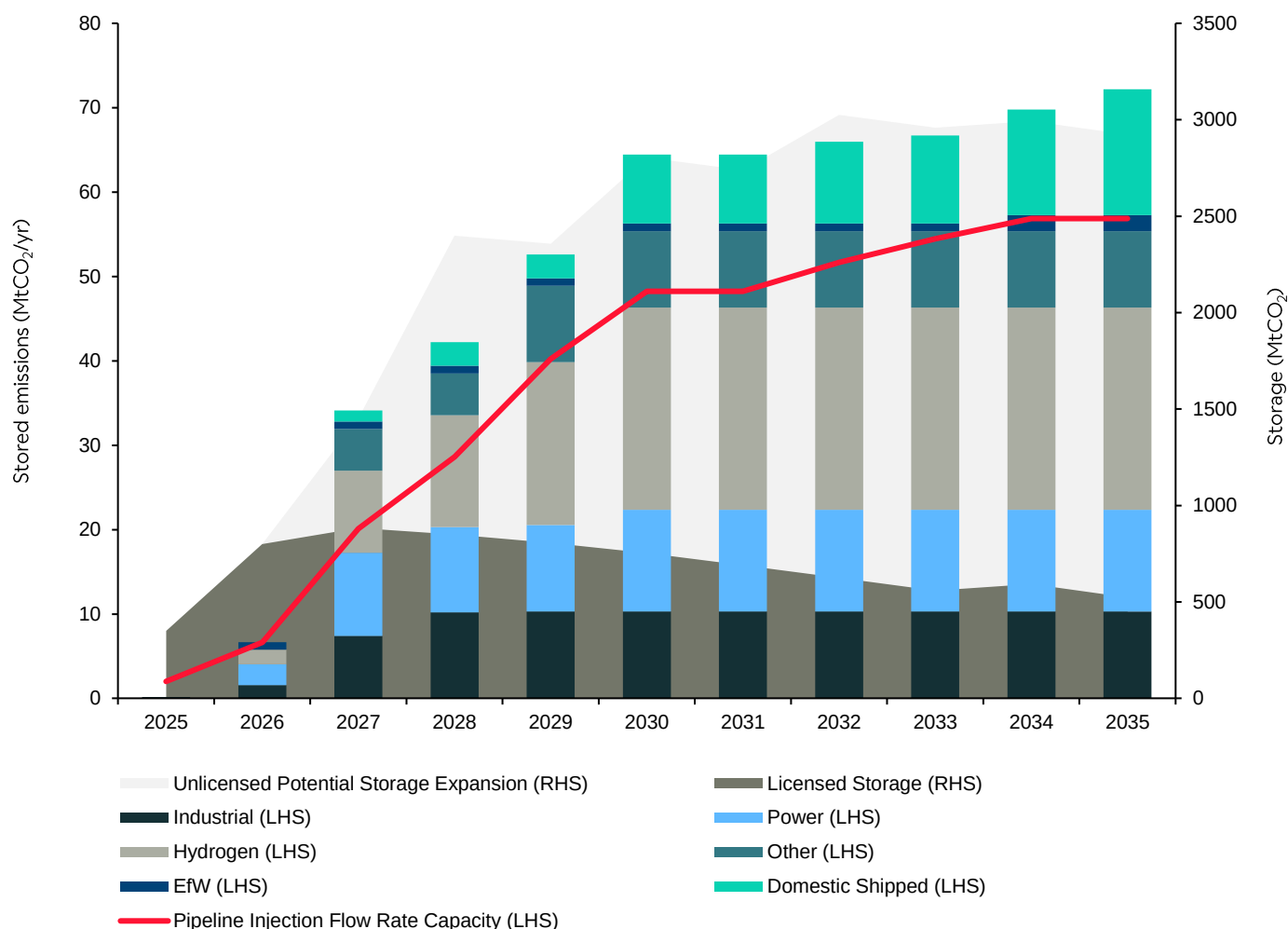
Note: *Cluster timelines, including emitter project timelines, may experience more than a one year delay to proposed timelines if Track-2 does not launch in 2022.. The one year figure is indicative and not based on information provided by cluster leads.





Scenario 2: *Enabling Industry Pipeline*

Appendix 1 Chart 3: *Enabling industry pipeline* – Industry is unconstrained by policy, and is enabled to activate a full pipeline of projects to meet and exceed the UK Government’s capture ambitions



Key Takeaways:

With the correct policy and sufficient, timely allocation competitions, industry is able to deliver:

- The **UK's 2035 ambition of 50MtCO₂/yr is exceeded, with over 70MtCO₂/yr of capture projects by 2035**
- Industry can meet and exceed all of the UK's 2027 and 2030 technology specific capture targets
- **Over 500MtCO₂ captured and stored by 2035**
- Over 7GW of low carbon or carbon negative power generation capacity*. It is important to note that investment decisions in power CCUS are more complex as decisions are closely tied to investor views on the future of the electricity market. Given the requirement for firm, low carbon power needed to support a system with high wind penetration, additional capacity beyond this figure could be developed by the industry, if incentivised
- Over **15GW of low carbon hydrogen production**
- While cluster based capture projects provide the majority of the captured emissions, domestic capture projects using shipping infrastructure to transport CO₂ contribute around 15MtCO₂/yr of emission reduction by 2035

Note: * Generation capacity is likely to be higher than this. Some clusters chose not to disclose the generation capacity of assets involved in their plans



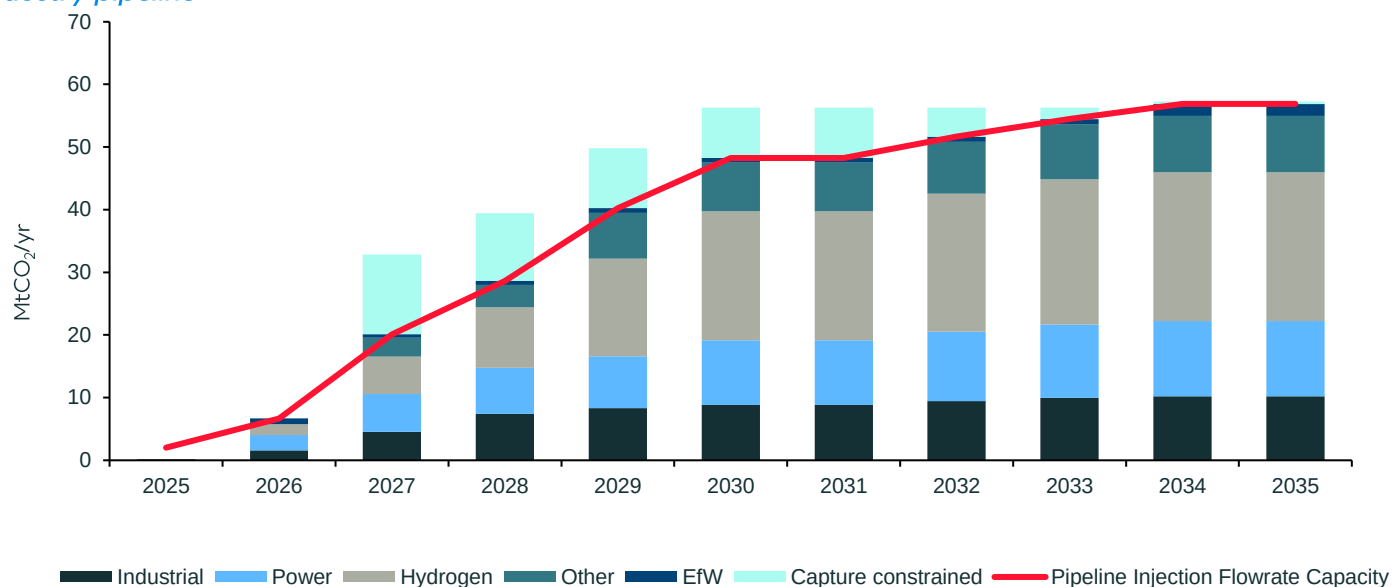
Key Assumptions:

- The full pipeline of projects identified by cluster leads, and sourced through publicly available information, are able to progress. This will depend on:
 - The Track-1 Phase-2 and Track-2 Phase-1 processes being concluded in 2022
 - A Track-2 Phase-2 process being carried out in early 2023
 - Clarity on the future of offshore licensing rounds for additional carbon stores provided in 2022
 - Clarification on shipping business models provided in 2022
- For a full list of requirements of the size and allocation of funding rounds, see Appendix 2 Table 2
- While there is additional capture potential in the UK through dispersed sites, these are not considered in this case

Identified Constraint: Pipeline injection flowrate capacity

- In some of the timelines sent by cluster leads, pipeline injection capacity was shown to be a constraint (i.e. the captured emissions were greater than the maximum pipeline injection flowrate)
- For the purposes of modelling the *Enabling industry pipeline* scenario, captured and stored volumes were not curtailed based on any constraints in pipeline injection capacity
- In the chart below, we explore the volume of capture that may have to be curtailed to accommodate for this constraint

Appendix 1 Chart 4: Impact of pipeline injection capacity on captured & stored emissions to 2035 in *Enabling industry pipeline*



Key Takeaways:

- The pipeline injection flowrate capacity constraint is most prevalent in the late 2020s – in 2027, where the constraint is greatest, ~13MtCO₂/yr out of a total of ~33MtCO₂/yr captured emissions could be constrained
- Whilst it should not inhibit industry's ability to deliver the UK Government's capture ambitions, it could result in over 50Mt of potentially captured and stored CO₂ being emitted
 - This assumes that capture projects operate as normal, even if their ability to capture and store CO₂ through the T&S network is restricted
- It could also impact the project pipeline, with capture projects unable to come online due to concerns about inadequate Transport & Storage capacity
- By 2035, the scale up of pipeline injection flowrate capacity is sufficient to accommodate the entire pipeline of capture projects, not accounting for shipped CO₂ volumes*

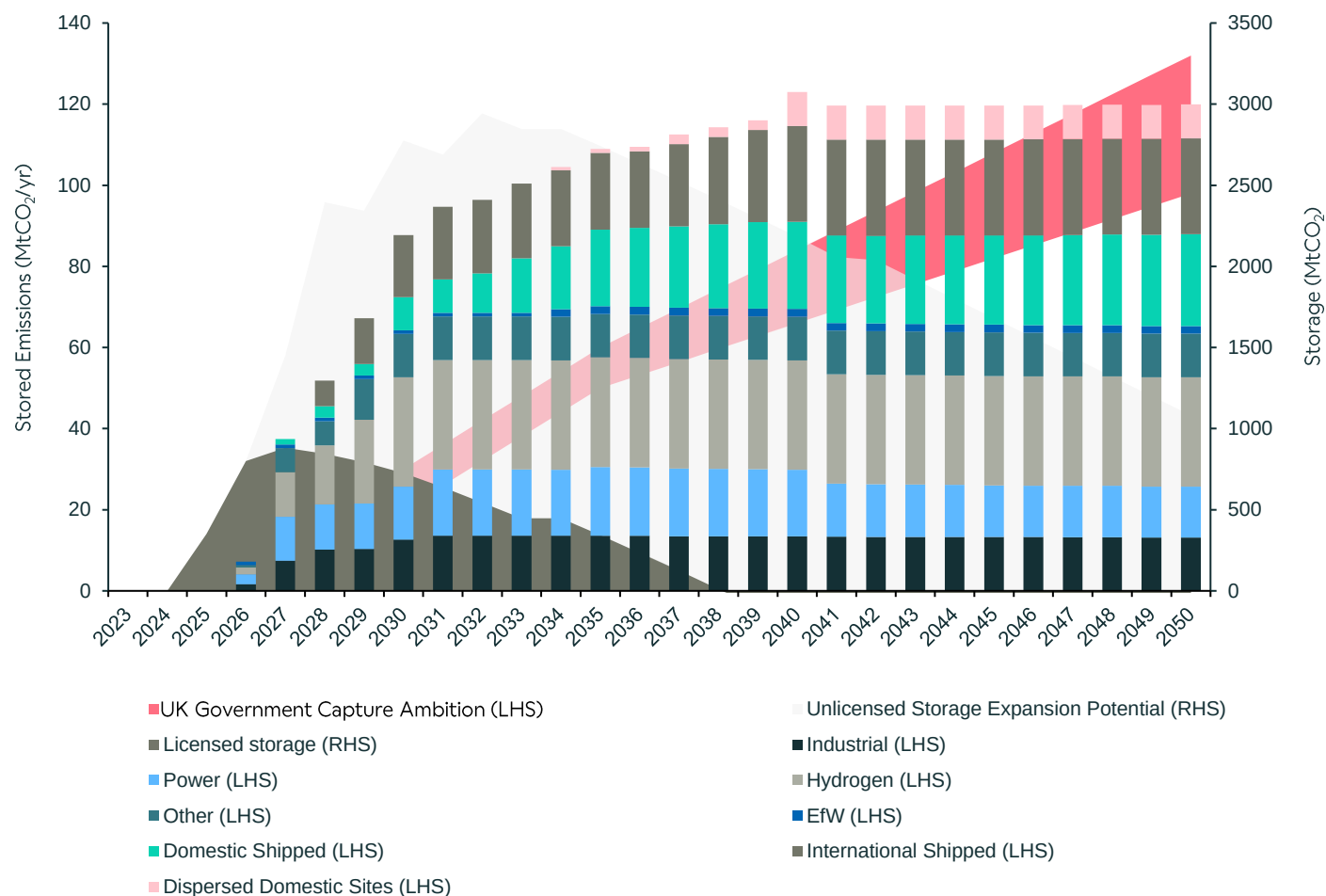
Note: * The data provided by cluster leads suggests there is expected to be sufficient injection capacity for domestic capture projects relying on shipping as a means of transporting CO₂ (should these plans go ahead)





Scenario 3: *Global Leadership*

Appendix 1 Chart 5: *Global Leadership* - The UK assumes a leadership role in CCUS, activating a full pipeline of projects. The UK builds on this further, utilising its extensive storage potential to store emissions from dispersed domestic sites and European emitters



Key Takeaways:

With the enabling policy and sufficient, timely allocation competitions, industry has the potential to deliver:

- **Around 110MtCO₂/yr stored by 2035** (of which almost 20MtCO₂/yr comes from other European capture projects) **considerably exceeding the UK's 2035 ambition of 50MtCO₂/yr**
- **Domestic dispersed sites and shipped emissions** account for **30MtCO₂/yr** of capture projects by 2040
- **Over 750MtCO₂ captured and stored by 2035**, of which 125MtCO₂ comes from European capture projects with no local Transport & Storage infrastructure
 - The UK, as a first mover, is a major sink for European emitters
 - In doing this, the UK helps to unlock the decarbonisation potential of other European countries
 - Over 10GW of Power CCS capacity by 2035, resulting in 17MtCO₂/yr of captured and stored emissions, significantly greater than the 5-9 MtCO₂/yr required for a decarbonised power system^{26*}

Key Assumptions

In addition to the assumptions made for the *Enabling industry pipeline* scenario, *Global Leadership* includes dispersed sites and European shipped volumes. The scenario also accounts for additional potential capture projects that were identified by cluster leads and shared with the CCSA for inclusion in this case.

Notes: *The 5-9MtCO₂/yr refers to the range of electricity supply CCS demand across all scenarios in the CCC's sixth carbon budget.



Appendix 1 Table 1: Scenario Methodology – The following table lays out the key assumptions that were made in developing the CCSA's CCUS Deployment Scenarios

Variable assumption	Scenario 1 – Constrained By Current Policy 	Scenario 2 – Enabling Industry Pipeline 	Scenario 3 – Global Leadership 
Licensed storage	Assigned for clusters with existing carbon storage licences. Only stores covered by the licenses accounted for Doesn't include expansion opportunities in nearby areas		
Unlicensed storage expansion potential	Not included	Assigned based on storage sites with pending applications submitted, high confidence storage with a licence pending, or high confidence storage where approvals for licence expansion are required. This is based on a mixture of publicly available information and information provided by cluster leads	
Existing emitter sites with retrofit capture	Where capture information was not provided in the public domain, emissions taken from the 'Defra Facility Search' database. Capture rates of 90% CO ₂ assumed based on BEIS published targets for industrial emitters		
New build emitters	Emissions captured based on a mixture of publicly available information and information provided by cluster leads		
Curtailment of capture projects based on identified constraints	In order to maintain the anonymity of project data, captured cluster emissions are not curtailed if the local stores are exhausted. Equally, stored emissions are not constrained by pipeline injection capacity		
Timeline and extent of domestic emitter projects, connected via pipeline to Transport and Storage infrastructure	Constrained by UK Government's current technology specific capture targets (2027 and 2030) (for more detail, please see Appendix 2 Table 1&2)	Assigned based on a mixture of publicly available information and information provided by cluster leads	Assigned based on a mixture of publicly available information and information provided by cluster leads. This scenario also includes additional potential capture projects for expansion beyond original development concepts, that were submitted to the CCSA by cluster leads
Domestic shipped emitter volumes	Not included		
Dispersed domestic emitters		Not included	Identified based on reports by BEIS ²⁷ and Scottish Enterprise ²⁸ . The timeline of capture projects, where not provided in the reference report, was expected to come online after 2035
International / European shipped emissions			Identified based on published analysis ²⁹
Timelines	Timelines of cluster and capture projects identified from a combination of publicly available data and data provided by cluster leads. Timelines for Track-2 clusters delayed based on a delay in receiving Track-2 funding commitment (see Table-2)	Timelines of cluster and capture projects, unless stated otherwise, identified from a combination of publicly available data and data provided by cluster leads	
Supply chain constraints	All scenarios assume that there is sufficient workforce and supply chain availability/capability to deliver at the scale/timescales suggested. We do not account for any delays due to supply chain constraints.		



Note: ²⁹Analysis carried out for the referenced report, identifying European emitters that could require a shipping model for CCS. This analysis assumes 50% of the identified e captured emissions come to the UK from 2028 onwards

Appendix 2: Scenario Methodology & Supplementary tables/analysis

Appendix 2 Table 1: UK Government technology specific targets

Target	2027*	2030
Industrial	3 MtCO ₂ /yr	6 MtCO ₂ /yr
Power (DPA)		1 project
Hydrogen	-	5 GW
GGRs (other)	-	5 MtCO ₂ /yr
Energy from Waste (EfW)	-	-
Clusters	2	4

Appendix 2 Table 2: Scale and frequency of allocation rounds required to deliver Scenarios

Competition	Scenario 1 – Constrained By Current Policy 	Scenario 2 – Enabling Industry Pipeline 	Scenario 3 – Global Leadership 
Confirmation of TRI and emitter business models	Not confirmed until 2023 – putting strain on current clusters development plans and emitter timelines	Confirmed in 2022	
Additional offshore licensing round	Not announced – putting additional carbon stores at risk	Held in 2022, licensing nearly 2Gt of additional potential storage for development. This will give developers the 8-10 year lead time to develop the stores needed for widescale CCUS deployment	
Confirmation of integration of shipping business models	Not given – putting any cluster and emitter projects that rely on shipping at risk	Confirmed in 2022, giving CCUS shippers and emitters relying on shipping to access stores at least a year to finalise bids for a 2023 competition, exclusively for shipping business models	
Track-2 Phase-1 – the selection process for Track-2 clusters	Cluster projects selected in 2023, awarding contracts to 2 additional clusters thereafter. The 2023 conclusion leads to a delay of at least one year in Track-2 cluster development plans	Cluster projects selected in 2022, awarding contracts to 4 additional clusters thereafter. This allows Track-2 clusters the 2-4 year lead time to develop infrastructure for a 2026-28 start date, maintaining the planned delivery date as submitted to BEIS in the Track-1 Phase-1 process	
Track-1 Phase-2 – the selection process for capture projects in Track-1 clusters	Capture projects selected in 2023, only awarding contracts thereafter for enough: - industrial capture to meet 2027 targets (3MtCO₂/yr) - some GGR capture to contribute towards 2030 targets (5MtCO₂/yr) - Some H₂ production capacity to contribute towards 2030 targets (5GW)	Capture projects selected in 2022, awarding contracts (ICC, DPA, Hydrogen CfD and to be determined GGR funding contracts) thereafter to all projects submitted by cluster leads in the Track-1 Phase-1 plan submission	
Track-2 Phase-2 – the selection process for capture projects in Track-2 clusters	Capture projects selected in 2024, only awarding additional contracts thereafter for enough: - industrial capture to meet 2030 targets (additional 3MtCO₂/yr, resulting in 6MtCO₂/yr total industrial capture) - GGR capture capacity to meet 2030 targets (5MtCO₂/yr) - H₂ production capacity to meet 2030 targets (5GW)	Capture projects selected in 2023, awarding contracts (ICC, DPA, Hydrogen CfD and to be determined GGR funding contracts) thereafter to all projects submitted by cluster leads in the Track-1 Phase-1 plan submission	
Track-1 Phase-3 – the selection process for additional capture projects in Track-1 clusters		Not needed – as all high confidence capture projects procured in the Track-1 Phase-2 process	



Competition	Scenario 1 – Constrained By Current Policy 	Scenario 2 – Enabling Industry Pipeline 	Scenario 3 – Global Leadership 
Track-3 Phase-1 & 2 – the selection process for an additional cluster, along with capture projects within the cluster	Not utilised		Projects selected in 2023, awarding contracts to an additional cluster and various capture projects thereafter. This gives the additional cluster 3-4 year development time for initial operation in 2027
Processes for emitters requiring shipping to access CCUS infrastructure	Not utilised	First round carried out in 2023, giving early CCUS shippers and emitters relying on shipping a 3-4 year lead time before initial emissions are captured and stored in late 2026. Additional rounds carried out throughout 2020s and early 2030s	
Policy in place to facilitate capture and storage of emissions from dispersed sites	No policy in place		UK Government policy in place to facilitate the awarding of support/contracts to dispersed sites from the early to mid 2030s
Policy in place to facilitate capture and storage of emissions from international emitters	No policy in place		Decarbonisations policy in regional and international jurisdictions drives global demand for CCUS stores, which UK captures as first mover in CCUS

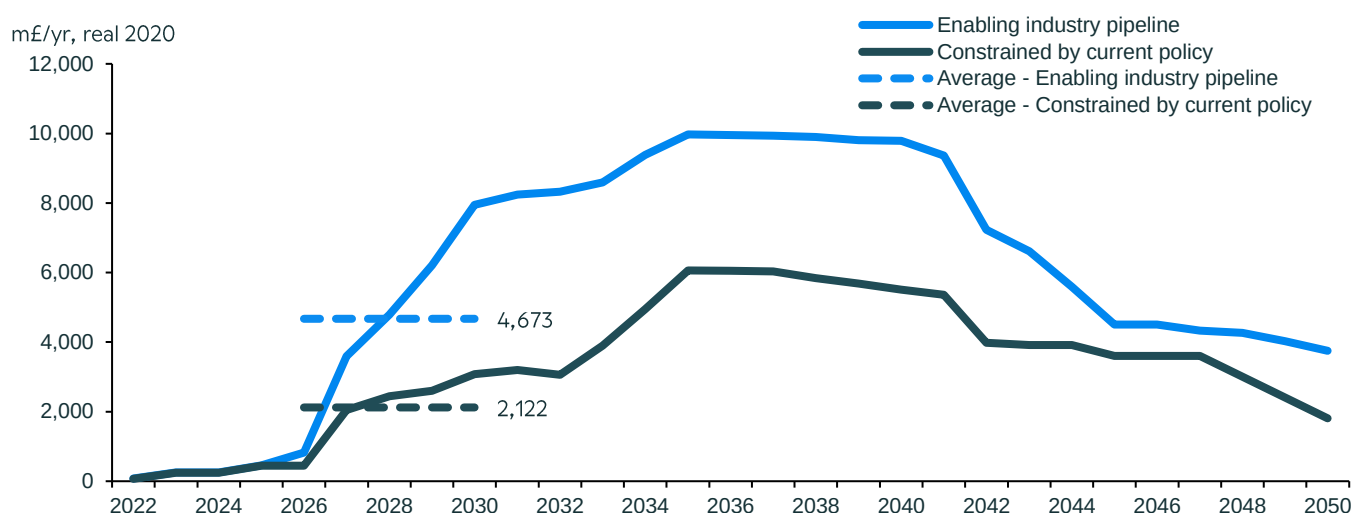


Appendix 3: Required funding envelope

In 2021, the CCSA commissioned Afry Management Consulting to produce ‘Economic analysis of UK CCUS’, a report which explores the economic impact of deploying CCUS in the UK. As part of the CCSA’s Delivery Plan 2035, the CCSA approached Afry Management Consulting to repeat this analysis*, however this time, using the data provided by cluster leads, according to the CCSA’s *Enabling industry pipeline* and *Constrained by current policy* scenarios. For the purposes of this report, we calculate:

- The funding envelope required to achieve the levels of deployment in the two scenarios (based on Afry Management Consulting analysis)
- The societal cost of carbon, when not deploying CCUS at pace, according to the Treasury’s Green Book¹ (based on CCSA analysis)

Appendix 3 Chart 1: Annual funding envelope required to deploy CCUS by scenario



Key Takeaways:

- The required funding envelope, from now until 2035, is greater for the *Enabling industry pipeline* scenario (£69bn), than the *Constrained by current policy* scenario (£33bn)
 - This is predominantly due to the greater capture volumes, and the ‘front-loading’ of deployment
- However, the average cost of capture is marginally lower for the *Enabling industry pipeline* scenario (£117/tonne), than the *Constrained by current policy* scenario (£118/tonne)**
 - This is predominantly driven by the saving incurred (£/tonne) as a greater deployment of Transport & Storage capacity reduces Transport & Storage fees, as economies of scale develop***
 - It is also worth noting that the average cost estimates are conservative, as they do not account for:
 - learning benefits that are expected to be achieved as CCUS is deployed at scale
 - recent increases in UK ETS price that decrease the funding commitment from HMT for future deployment

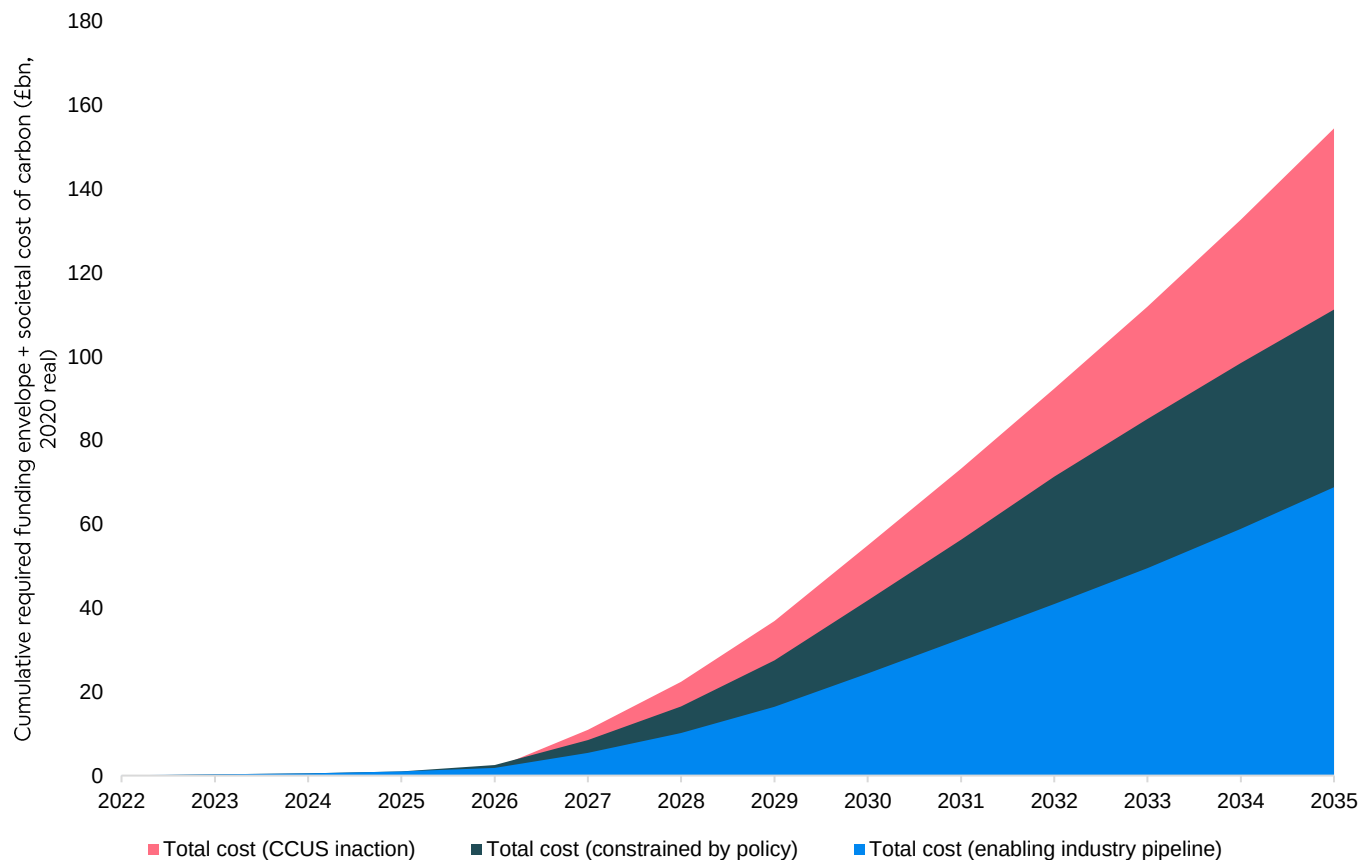
Cost of emitting

- Costs for greater volumes and front-loaded deployment in the *Enabling industry pipeline* scenario are comparatively high on an absolute basis, however this is before factoring in the societal cost of carbon emissions as estimated by HMT
- In Appendix 3 Chart 2, the total costs of the two scenarios above, plus the total costs of deploying no CCUS (“CCUS inaction”) through 2035, are assessed
 - For all scenarios compared, the volumes of CO₂ captured under the *Enabling industry pipeline* scenario are set as a baseline of potential emissions captured by industry through 2035. Costs associated with deployment are calculated, as are the societal carbon costs (according to the Treasury Green Book’s central case) for volumes of carbon not captured that could have been within a given year (i.e. the gap of capturable emissions up to the potential of the *Enabling industry pipeline* scenario). For reference, the current price in 2022 of one tonne of CO₂ emissions is estimated at nearly £250, which is significantly above estimated capture and storage support costs

Notes: *Funding envelope calculated as support costs for projects commissioned by 2035. Detailed capex and opex assumptions by technology type in original Afry Management Consulting analysis. Electricity and gas prices are based on the Reference Scenario of BEIS’ 2019 Updated Energy & Emissions Projections. For consistency, the BEIS Reference scenario for carbon prices in the power sector is applied to both the power and non-power sectors. For hydrogen, the calculation assumes 50% of the H₂ sells at a price equivalent to the natural gas price + avoided CO₂ cost, and the remaining 50% sells at the natural gas price, with the shortfall made up by the subsidy scheme. **Average cost of capture values calculated from 2026 to 2030. *** The average cost per tonne is also driven by the capture technology mix in each scenario. There is a wide range of variation in the funding envelope requirement for different capture technologies



Appendix 3 Chart 2: Combining the required funding envelope with the societal cost of carbon emissions



Key Takeaways:

- The cost of inaction in deploying CCUS (not capturing and storing any CO₂ until 2035) is significantly higher than the cost of deploying CCUS
- The *Enabling industry pipeline* scenario entails total expected construction and operation costs of £69bn (real 2020) through to 2035 to build and operate those projects, which compares to total costs for the reduced build-out rate in the *Constrained by current policy* scenario of £111bn (accounting for funding through to 2035, plus societal carbon costs corresponding to emissions from projects that could have been built). The societal cost of CCUS inaction is significantly higher than this
- The high societal cost of carbon means that, even when taking into account the increased funding envelope required in the *Enabling industry pipeline* scenario, ensuring a healthy, front-loaded capture pipeline leads to significant savings across the UK economy
- An earlier deployment schedule has the critical benefits of activating the UK supply chain in value-added manufacturing, creating new jobs and protecting existing industries and ensuring that existing capture and storage projects remain 'in play' and have the confidence to move forward



Glossary

BECCS	Bioenergy with Carbon Capture and Storage
BEIS	Department of Business, Energy, and Industrial Strategy
CES	Crown Estate Scotland
CfD	Contract for Difference
CIF	CCUS Infrastructure Fund
COMAH	Control of Major Accident Hazards
DACS	Direct Air Capture with Storage
DCO	Development consent order
DPA	Dispatchable Power Agreement
ECITB	Engineering Construction Industry Training Board
EMR	Electricity Market Reform
EPC	Energy Performance Certificate
ETS	Emissions Trading System
FEED	Front End Engineering Design
FID	Final Investment Decision
GGR	Greenhouse Gas Removals
GHG	Greenhouse Gas
GVA	Gross Value Added
HSE	Health and Safety Executive
ICC	Industrial Carbon Capture
IDRIC	Industrial Decarbonisation Research and Innovation Centre
NAMRC	Nuclear Advanced Manufacturing Research Centre
NPT	Non Pipeline Transport
NSTA	North Sea Transition Authority (Previously OGA)
OFGEM	Office of Gas and Electricity Markets
O&G	Oil and Gas
TCE	The Crown Estate
TRI	Transport & Storage Regulatory Investment
T&SCo	A company licensed to provide transport and storage services



End Notes

- 1) HMT (2020), Treasury Green Book
- 2) BEIS (2021), [Net Zero Strategy: Build Back Greener](#)
- 3) Ibid.
- 4) BEIS (2022), [Carbon Capture, Usage and Storage: An update on the business model for Transport and Storage](#)
- 5) BEIS (2021), [Greenhouse Gas Removals](#)
- 6) BEIS (2021), [CCUS Supply Chains: a roadmap to maximise the UK's potential](#)
- 7) CCSA (2021), [CCUS Supply Chain Report Showcases Major UK Opportunity](#)
- 8) NAMRC (2022), [CCUS Supply Chain Intervention Strategy](#)
- 9) ECITB (2020), [Towards Net Zero](#)
- 10) OPITO (2021), [North Sea Transition Deal](#)
- 11) Green Jobs Taskforce (2021), [Green Jobs Taskforce Report](#)
- 12) BEIS (2022), [Carbon Capture, Usage and Storage: An update on the business model for Transport and Storage](#)
- 13) BEIS (2020), [CCS Deployment at Dispersed Industrial Sites](#)
- 14) North Sea Transition Authority (formerly Oil & Gas Authority) (2021), [Carbon Capture and Storage](#)
- 15) North Sea Transition Authority (2021), [UK Carbon Dioxide Storage](#)
- 16) BEIS (2021), [Evaluation of a public dialogue on Carbon Capture Utilisation and Storage \(CCUS\)](#)
- 17) BEIS (2021), [Carbon Capture Usage and Storage Public Dialogue](#)
- 18) BEIS (2020), [CCUS Innovation Programme](#)
- 19) BEIS (2019), [Carbon Capture and Utilisation Demonstration \(CCUD\) innovation programme](#)
- 20) IDRIC (2022) [Industrial Decarbonisation Challenge](#)
- 21) UKCCSRC (2022), [Research](#)
- 22) European Commission (2021), [Horizon Europe: Work Programme 2021- 2022](#)
- 23) HSE (2021), [Overview of carbon capture and storage \(CCS\) projects at HSE's Buxton Laboratory](#)
- 24) DECC (2015), [Onshore Oil and Gas Exploration in the UK: Regulation and Best Practice](#)
- 25) AFRY and Cambridge Econometrics (2021), [Economic Analysis of UK CCUS](#)
- 26) The CCC (2020), [Sixth Carbon Budget](#)
- 27) BEIS (2020), [CCS deployment at dispersed industrial sites](#)
- 28) Scottish Enterprise (2021), [CCUS Economics Impacts Study](#)
- 29) Norwegian Ministry of Petroleum and Energy (2020), [Longship – Carbon capture and storage](#)



List of Figures

Figures

Figure 1: Emissions captured to 2035 by CCSA scenario	5
Figure 2: Illustration of a notional CCUS cluster	8
Figure 3: CCSA Delivery Plan 2035 – <i>Enabling industry pipeline</i> scenario	11
Figure 4: The “building blocks” for a successful CCUS industry	12

Appendix 1

Chart 1 : <i>Constrained by current policy</i>	45
Chart 2: Deployment trajectory needed under the <i>Constrained by current policy</i> scenario	46
Chart 3: <i>Enabling industry pipeline</i>	47
Chart 4: Impact of pipeline injection capacity on captured & stored emissions to 2035 in <i>Enabling industry pipeline</i>	48
Chart 5: <i>Global Leadership</i>	49
Table 1: Scenario Methodology	50

Appendix 2

Table 1 : UK Government technology specific targets	51
Table 2: Scale and frequency of allocation rounds required to deliver Scenarios	51

Appendix 3

Chart 1 : Annual funding envelope required to deploy CCS by scenario	53
Chart 2: Combining the required funding envelope with the societal cost of carbon emissions	54

