UK CLUSTER POTENTIAL - HOW THE UK CAN LEAD THE WORLD IN CARBON CAPTURE AND STORAGE

Development Economics Ltd

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EXECUTIVE SUMMARY

1) The need for Carbon Capture & Storage (CCS) and the UK's advantage

Scientists from across the globe are in agreement that carbon capture and storage (CCS) will be crucial to global efforts to reach net zero. Here in the UK, the Climate Change Committee (CCC) has emphasised the importance of CCS to meeting our 2030 and 2035 decarbonisation targets, calling it '*a necessity, not an option'*; while the UK Government regards CCS as essential to achieving net zero emissions by 2050.

Analysis from the CCC indicates that scenarios for achieving net zero by 2050 require an aggregate annual carbon capture and storage of between 75 and 175 million tonnes of CO_2 by 2050.

To achieve this, the UK Government has recognised the need to develop major CO_2 transport and storage infrastructure to enable the deployment of CCS technologies. They are progressing plans for a minimum of two industrial clusters that will deploy CCS by the mid-2020s, and four by 2030, with some CO_2 transported by ships or heavy goods vehicles to address industrial emissions occurring outside major industrial hubs.

The UK has a number of natural advantages that puts it in a unique position to realise the potential of carbon capture and storage. First, the UK possesses 25% of Europe's geological storage opportunities for carbon, located in the UK Continental Shelf[1]. With other countries, who do not have this storage potential, increasingly looking to address their own emissions, the UK finds itself in a unique position to export this storage capacity to others, presenting a significant opportunity to be a global leader in this space. With the right policies, ambition, and partnerships, the UK can leverage this geological feature to its advantage.

The UK also holds an infrastructure, skills, and engineering advantage due to the legacy associated with the oil and gas industry in the country, along with the relevant expertise which the country already possesses.

These factors indicate a significant economic and environmental opportunity for the UK and could be transformative for regions like the Humber and other major industrial centres, allowing them to thrive for decades to come.

The right policy and commercial approach are now needed to unlock this opportunity.

There is significant enthusiasm from the private sector, with businesses welcoming the Government's confirmation of £20bn funding for the UK's CCS programme at the Spring Budget of March 2023. This funding has the potential to unlock private investment and job creation across the UK.

This report examines the economic opportunity of carbon capture and storage for the UK, dependent upon the decisions and level of ambition demonstrated by the UK Government in the coming years.

[1] Department for Business & Trade, *Carbon capture, usage and storage.* Available at: https://www.great.gov.uk/international/content/investment/sectors/carbon-capture-usage-and-storage/

2) The Prize to be Won

If the UK commits to becoming a leader in CCS, it has the opportunity to unlock substantial employment and economic benefits. These benefits are outlined below, with the methodology used to calculate this found on Page 23 of the report.

Scenario 1: Positive Economic Benefits of Domestic CCS Development

In a scenario where the UK Government follows current policy commitments, the potential outcomes are as follows:

- Approximately 310,000 jobs could be created and supported by 2050. [2]
- Out of these, around 210,000 jobs could be created in the North of England by 2050, with over 33,000 of these located in the Humber.
- An additional GVA worth nearly £23 billion per year is projected for the UK by 2050.
- Of this figure, around £15.5 billion per year would be expected to be concentrated in the North of England, with just over £2.4 billion located in the Humber.

Scenario 2: The Opportunity the UK Can Grasp with High Ambitions and Fast Delivery on CCS

In a more aspirational scenario, where the UK aims to develop the CCS resource in a faster and more expanded format, such as becoming an exporter of CCS storage services, the potential outcomes are as follows:

- Approximately 489,000 jobs could be created and supported by 2050.
- Out of these, around 330,000 are expected to be created in the North of England, with over 42,000 of these expected to be located in the Humber.
- Additional GVA worth around £32 billion per year is projected for the UK by 2050.
- Of this figure, just under £22 billion per year is expected to be concentrated in the North of England, with just over £3.4 billion of this located in the Humber.

3) How the UK Can Lead the World in CCS – A Roadmap

With a combination of geological, infrastructure, and skills advantages, the UK is well-placed to become a world leader in CCS. However, due to the progress being made elsewhere, there is only a narrow window for the UK to establish a competitive advantage over its international counterparts and ensure private sector investment in CCS technologies is prioritised in the UK.

In order for the UK to succeed, action is required from the government, businesses and the investment community across the following areas:

- **Creating the conditions for investment in infrastructure -** including accelerating the cluster sequencing process; finalising CCS business and financial models; confirming the role of the UK ETS scheme and voluntary carbon markets in supporting investment in CCS; and expanding the role of the UK Infrastructure Bank in relation to facilitating private investment in CCS.
- **Ensure greater clarity over cluster development** – including greater government co-ordination of cluster activities, creation of roadmaps for the decarbonisation of each cluster, providing a near-term incentive for prospective storage operators to appraise storage

[2] The scale of industry assumptions by 2050 are based on Development Economics analysis including figures from CCSA (2021): *Supply Chain Excellence for CCUS*

locations building on recent North Sea Transition Authority licencing rounds, and de-coupling onshore transport from offshore transportation and storage.
- **Supply chain development** – providing certainty and details on the scale and timing of the UK CCS industry, thereby supporting the development of a supply chain by removing uncertainty as a barrier to investment.
- **Investment in innovation –** including additional government measures to boost R&D, such as enhanced R&D tax credits.
- **Skills and recruitment** – support in the recruitment and training of a sizeable workforce through the development of apprenticeship programmes and raising the profile of CCS as a career pathway.

4) The Consequence of Inaction

The prize to be won is clear. However, without focusing on the outlined priorities, the UK may find that higher-emitting industries have limited options to decarbonise and businesses ready to invest in the UK might prioritise investment elsewhere. This could lead to a de-industrialisation and a loss of economic opportunities for the UK, making carbon targets even more challenging to achieve.

There are concerns about the UK falling behind. The CCC Progress Report to Parliament has warned that, despite the UK Government's ambition for a significant scaling up of CCS and engineered removals in this decade, there have been delays and the rollout is behind schedule. Therefore, any further unforeseen delays or complications, or a reduction in scope or ambition, could further jeopardise the UK's ability to become a global leader in carbon capture and storage. In addition, there are also concerns that the UK is falling behind the US and the EU in its efforts to provide the right investment environment to encourage CCS development. The US, through its Inflation Reduction Act, has provided generous tax credits and financial incentives to support the green transition. The European Commission's Communication on A Green Deal Industrial Plan for the Net Zero Age recognises the vital role of CCS, with two of the plan's four key pillars having a direct impact on accelerating the technology, including faster access to sufficient funding and a predictable and simplified regulatory environment.

Scenario 3: The Dangers of the UK Government Not Delivering on Its Current Policy Ambitions

In a scenario where a sufficient domestic CCS resource is not developed and other countries successfully position themselves ahead of the UK as global leaders in CCS, the UK economy is likely to be negatively impacted. Besides the fact that, under this scenario, the UK cannot meet its decarbonisation targets, including net zero by 2050, there is also a significant risk to jobs. Industries may be forced to close due to the UK's stringent carbon targets. It is estimated that, in the absence of suitable CCS infrastructure, 15% of business activity in heavy-emitting industrial sectors could be lost to the UK by 2050. Potential outcomes are as follows:

- Over 136,000 jobs lost in the UK by 2050 in heavy-emitting sectors within manufacturing.
- Out of these, approximately 43,000 jobs are at risk of being lost in the North of England regions 2050, with 4,100 of them located in the Humber.
- GVA worth just over £9 billion per year is at risk of being lost across the UK by 2050.
- Overall GVA worth over £2.8 billion per year is at risk of being lost in the North of England, with over £250 million of this loss located in the Humber.

SECTION ONE: THE NEED FOR CARBON CAPTURE AND STORAGE AND THE UK'S ADVANTAGE

Carbon capture and storage (CCS) is an intrinsic part of the UK's overall decarbonisation strategy.

This has been recognised by the UK Government, which has stated that CCS is essential to achieving the national target of net zero emissions by 2050.[3] The Committee for Climate Change (CCC) say CCS is '*a necessity, not an option*'.[4]

There are several routeways available for carbon capture, each of which could play a part in the overall solution:

- **Power (gas) and industrial carbon capture, use and storage (CCS) involve** capturing carbon dioxide (CO_2) emissions from fossil power generation and industrial processes for storage deep underground or re-use.
- **Bioenergy with carbon capture and storage (BECCS)** is a process of capturing and permanently storing carbon dioxide (CO_2) generated during the production of energy from sustainable biomass. This process removes more CO_2 than it generates, resulting in "negative emissions" or "carbon removal". When used to produce electricity, this is the only carbon removal technology that also generates low carbon renewable power.
- **Direct air capture and storage (DACCS)** extracts CO_2 directly from the atmosphere using either liquid or solid sorbents, resulting in net-negative emissions. While this technology holds significant potential, it is still in its infancy and requires substantial investment to become more widespread. It also demands vast amounts of low carbon power to operate.
- **Blue hydrogen production** involves producing hydrogen from natural gas through steam reforming and storing the resulting carbon dioxide emissions.

CCS, BECCS and DACCS are methods that require capturing and then locking away carbon in geological storage sites near the coast.

The UK has Geological Advantages for Storing Carbon

The UK has geological advantages for storing carbon. Given CCS' role as a major component of decarbonisation strategies worldwide, there is significant competition among international players, including the UK, for technology, skills and resources.

The UK possesses an estimated 25% of Europe's geological storage opportunity, primarily found in the UK's continental shelf.[5] This offshore resource is concentrated in major offshore sedimentary basins, including the southern, central and northern North Sea and the east Irish Sea. The overall storage capacity of this resource is estimated to be 78 Gt, with most of this capacity located in saline aquifer units.[6]

[3] UK Government (2023): *CCS Investment Opportunities in extent*
[4] Committee for Climate Change (2021). *Net Zero: the UK's contribution to stopping global warning*, page 23

This resource has been assessed as capable of meeting the UK's storage needs for hundreds of years. The scale of the resource potentially allows the UK to support European countries with more limited storage opportunities in their territories. [7]

A 2016 study by the Energy Technologies Institute confirmed that there were no major technical hurdles to storing industrial scale CO_2 emissions offshore in the UK, with the resource sufficient to meet all the UK's needs.[8]

Apart from the unique geological advantages the UK possesses for CCS to emerge as a leading routeway, there is also:

- **An infrastructure advantage** with legacy pipelines and other legacy infrastructure associated with the natural gas distribution network.
- **A skills and engineering advantage** from the oil and gas industry.

The role of CCS in reducing industrial emissions directly

Industrial processes are currently responsible for just over 15% of the UK's greenhouse gas emissions.[9] Many of the industries involved in these emissions produce important materials and products, such as steel, building materials, and chemicals vital to food production and other downstream uses. These industries are also important sources of jobs and prosperity to many of the UK's industrialized areas.

Achieving net zero emissions from these industries necessarily involves capturing CO_2 emissions and storing them underground, preventing them from re-entering the atmosphere.

To the UK's advantage, a substantial proportion of storage resources is in close proximity to several of the country's most important concentrations of carbon-intensive industrial activities, including the Teesside and Humber areas and in the Merseyside-Greater Manchester corridor.

The role that CCS could play in producing negative emissions via GGRs, indirectly abating hard-to-abate sectors and, eventually, compensating for historic emissions (net carbon negativity)

In addition to CCS being used in direct decarbonisation of industrial processes like the production of steel, chemicals, or food, there is also a need to support the decarbonisation of other sectors which will struggle to decarbonise completely by 2050.[10]

This includes sectors such as agriculture and aviation, which are often referred to as 'hard-to-abate' sectors. CCS can help these sectors to decarbonise, albeit indirectly, through the capture and permanent storage of carbon through technologies grouped as greenhouse gas removals (GGRS). These captured emissions can be considered negative emissions, as the overall process removes carbon from the atmosphere.

The importance of greenhouse gas removals is two-fold: first, to mitigate emissions from hard to abate sectors, and second, to drive sectors and even economies to achieve net negativity, compensating for historic CO_2 emissions.

[9] Office for National Statistics (2023): Greenhouse gas emissions in the UK, 1990-2021 data series
[10] UK Government: *Net Zero Strategy: Build Back Greener* (2022), page 184

Progress on CCS Cluster Development in the UK

Latest Progress on Track-1 and Track-2

In November 2021, the Government selected the HyNet and East Coast Cluster as Track-1 clusters to be taken forward to negotiations and capture project selection. In March 2023, the government announced the first successful CCS projects to be taken forward into the negotiation phase. These eight projects were selected across the Teesside and Merseyside region.

However, in the same announcement, the Government made it clear that the list of eight selected projects did not 'represent the extent of our ambition', and announced a process referred to as 'Track-1 expansion', which would allow further expansion of the Track-1 clusters beyond the announced projects, potentially operational by 2030. It is anticipated that a selection process for Track-1 expansion CCS projects will take place in early 2024.

In July 2023, following a review of Expression of Interest (EoI) applications against the Track-2 eligibility criteria, the Government concluded that Acorn and Viking T&S systems were considered to be best placed to deliver objectives for Track-2. Specific projects will be selected in due course. These projects will follow a similar deployment schedule to Track-1 expansion projects.

SECTION TWO: THE PRIZE TO BE WON

This chapter focuses on estimating the potential future value of the emerging carbon capture and storage (CCS) industry for the UK economy. Should the UK take action to become a global leader in the CCS industry, significant positive economic benefits that could be realised.

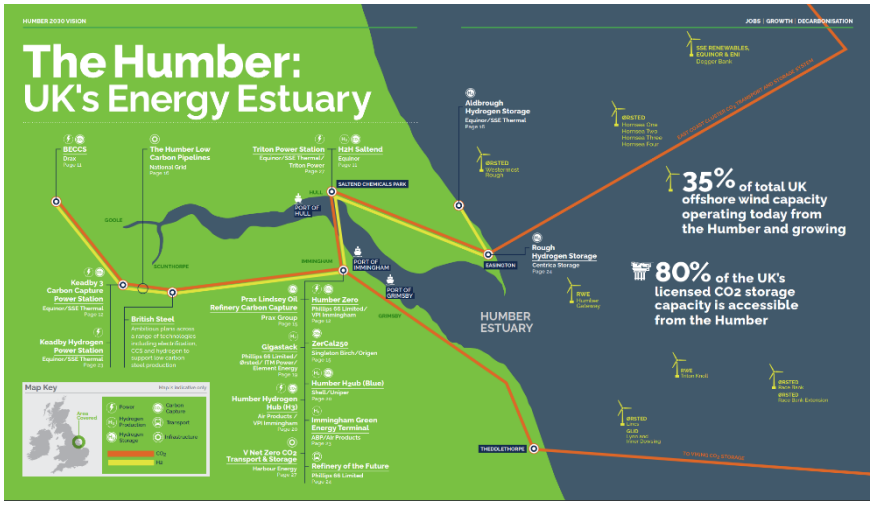
Two future scenarios were assessed, as follows:

- **Scenario 1**: Explores the potential implications of the development of a domestic CCS resource under relatively conservative assumptions. This scenario assumes the Government is on track for its current policy commitments.
- **Scenario 2**: Explores the potential implications of a more aspirational scenario where the UK has the ambition to develop the CCS resource in a faster and more expanded format. This could include developing the potential to become an exporter of CCS storage services to other countries.

Through estimating the total of the direct/indirect workforce, in the Capex and Opex Phase, alongside the overall investment that would be required to build new CCS and allied infrastructure, this research has found the following impact to the UK (The methodology used to calculate this may be found on Page 23 of the report):

Scenario 1	• Approximately 310,000 jobs created and supported by 2050. • Out of these, around 210,000 jobs could be created in the North of England by 2050 under Scenario 1, with over 33,000 of these located in the Humber • Additional GVA worth nearly £23 billion per year gained for the UK by 2050 • Of this figure, around £15.5 billion per year would accrue in the North of England, of which just over £2.4 billion would occur in the Humber
Scenario 2	• Approximately 489,000 jobs created and supported in the UK by 2050 • Out of these, around 330,000 would be located in the North of England, with over 42,000 of these located in the Humber • Additional GVA worth around £32 billion per year gained for the UK by 2050 • Of this figure, just under £22 billion per year would occur in the North of England, with just over £3.4 billion of this located in the Humber

Spotlight on the Humber – What CCS Deployment Can Bring to a Region
[11]



Source: CBI, Humber 2030 Vision (2022), p.8 & 9.

The Humber has significant potential for supporting the UK Government in reaching its net zero target and is considered by some to be the best place to deploy CCS:

- Due to the nature of the area, with a large tidal estuary, the Humber is an industrial manufacturing centre.
- It is home to 25% of the UK's seaborne trade as well as receiving around 25% of the UK's natural gas coming ashore.
- The Humber has 20% of the UK's electricity generation assets and a third of all refined petroleum goods come from the region. Deploying CCS at scale in the Humber would, therefore, support the decarbonisation of the energy system more significantly than in other UK regions.

As an industrial heartland, the region has already begun working towards decarbonisation. There are abundant opportunities to continue the trajectory to net zero and become the world's first carbon negative region.

Jorgen Sandstrom, Head of Energy, Materials, Infrastructure Program – Industrial Transformation at the World Economic Forum said: *"There are few places around the world more crucial to net zero and industrial decarbonisation than the Humber – it is a location from which so much can be learned and achieved."*

The Humber will play a critical role in reaching Government's decarbonisation targets:

- The Humber has access to 80% of the UK's licenced CO_2 storage capacity.
- The Humber can meet 50% of the UK's renewable power needs, enough to power 25 million homes.
- To realise the potential, there is already £15bn of private investment ready for the energy transition, presenting tangible possibilities for the region as a whole.

[11] CBI, Humber 2030 Vision (2022), p.8 & 9.

If the Humber is able, and enabled, to move quickly to adopt CCS technologies, either through Track 1 or Track 2 cluster processes, it will offer growth opportunities for the region, as well as benefits for industries, communities and consumers that will reverberate around the UK.

If the Government makes the UK a global first mover, then it will spell economic success for regions across the nation. Areas like the Humber will see significant benefits through investment and the creation and safeguarding of jobs for those who have worked in the region for generations.

SECTION THREE: HOW THE UK CAN LEAD THE WORLD IN CARBON CAPTURE AND STORAGE – A ROADMAP

Given the UK's significant advantages, it is well-placed to take a world-leading role in CCS and greenhouse gas removal technologies. However, there is a need for accelerated and sustained action to seize the opportunity due to the faster progress being made elsewhere. There is a narrow window available for the UK to establish a comparative advantage over international competitors and to secure sufficient private investment to help the UK reach net zero, preventing this capital from flowing to other international projects.

If the UK wants to be at the forefront of this new industry and capture potential export opportunities, it needs to capitalise on its advantages and initiate early action. This section assesses what actions are required by Government, businesses and the investment community for the UK to succeed as a world-leader in the emerging CCS sector. It covers:

- **Creating the conditions for investment in infrastructure**
- **Ensuring greater clarity over cluster development**
- **Supply chain development**
- **Investment in innovation**
- **Skills and recruitment**

Creating the Conditions for Investment in Infrastructure

The legislative framework for the development of the UK's carbon capture and storage industry is to be established by the Energy Bill currently before Parliament. This legislation will provide for the economic regulation of CO_2 transport and storage, industrial carbon capture, and the low carbon and hydrogen business models. The framework is intended to provide a predictable and certain environment to encourage and attract private investment.

Developing CCS infrastructure will require a large commitment by the private sector. The International Energy Agency (IEA) anticipates that the average annual total energy sector investment required to address the net zero transition will be equivalent to around 1% of GDP over the 2021-2050 period. Although the private sector has indicated a strong interest in investing in clean energy technologies, turning interest into investment will require policy support from the public sector.[12]

The UK Government is working closely with industry and the financial services sector to establish the business models required to underpin investment, but these are still at various stages of development.

For greenhouse gas removals (GGRs), the Government's ambition is to develop a market for carbon removals, possibly modelled on the UK's Emissions Trading Scheme (ETS) or supporting the growth of Voluntary Carbon Markets (VCMs). Such a market would create mechanisms for producers of carbon to invest in GGRs to compensate for their residual emissions. However, the Government recognises that markets for GGRs will take time to become established, and, in the meantime, there will need to be a continued role for the public sector to provide financial support and de-risking for early projects.[13]

[12] International Energy Agency (2021): *Net Zero by 2050*, p154

[13] UK Government: *Net Zero Strategy: Build Back Greener* (2022), page 193

The priorities for action in this area are as follows:

- Government to finalise and confirm the CCS business and financial models as soon as possible, underpinned by continuing public funding support for early projects and expansion projects under the Track-1 and Track-2 initiatives.
- Government to confirm the role of the UK's ETS scheme and voluntary carbon markets in supporting investment, including how it will incorporate incentives for private companies to invest in GGRs.
- Expansion of the role of the UK Infrastructure Bank in facilitating private investment in CCS.

Ensuring Greater Clarity Over Cluster Development

A key aspect of the UK's efforts to deploy CCS technologies is the development and deployment of CO_2 transportation and storage (T&S) networks which provide a route to take captured CO_2 for secure and safe storage in geological storage sites. These routes are often, but not exclusively, pipeline based. CCS capture projects require visibility of access to a T&S network, in a cluster, as a critical part of their project development programme.

The UK has made a sensible decision to 'decouple' capture projects from T&S solutions in an attempt to de-risk CCS projects, enabling developers to focus on either developing a capture project, or developing a T&S solution for a cluster. While this has been successful in de-risking initial CCS projects and supporting investment in CCS, it has had the unintended consequence of reducing CCS capture projects visibility of available storage in initial CO_2 stores and increasing the reliance on the Government's cluster sequencing process to provide direction to both T&S projects and capture projects.

This has meant the CCS industry has become faced with a 'chicken and egg' scenario whereby potential T&S networks have been reticent to invest in T&S development and storage site appraisal in absence of clarity from Government that they will be able to recover this investment via T&S fees charged to capture projects. At the same time, capture projects do not have sufficient clarity on T&S storage options available to them in absence of T&S development spend. The Government has a role here to break this cycle and facilitate the rapid development of T&S networks under the cluster approach.

Therefore, it is recommended that the Government should take the following actions to provide greater clarity over cluster deployment:

- **Greater Government role in the co-ordination of cluster activities** – at present the cluster sequencing process is the primary mechanism by which cluster development is coordinated. This competitive approach means that cooperative cluster development can sometimes be limited, and prospective capture projects are 'competing' to participate for access to a T&S network. While cluster sequencing is a necessary part of the development of CCS projects, the Government could play a stronger role in facilitating a collaborative approach to cluster development.
- **Creation of roadmaps for each cluster** – with a greater role for Government in facilitating the co-ordination of cluster activities, clusters in conjunction with Government should look to develop clear roadmaps for the development of T&S networks including clear timelines for pipeline and storage expansion as well as estimated connection dates for CCS capture projects.

- **Provide a near-term incentive for prospective storage operators to appraise storage locations building on recent North Sea Transition Authority licencing rounds** – the lack of clarity on specific storage site characteristics, such as the amount of CO_2 that can be injected into these stores, is a significant barrier to ensuring clarity for CCS project developers. The Government should provide a clear direction for CO_2 storage operators to undertake this appraisal working, including financial support for doing so.
- **De-coupling onshore transport from offshore transportation and storage** – CCS capture projects will require access to an onshore CO_2 transportation solution to take captured CO_2 away for storage (such as a pipeline) and will have limited visibility of the offshore CO_2 storage options for this captured CO_2. These offshore storage options may benefit from a competitive approach whereby the best value for money storage options are selected to receive CO_2 volumes captured in onshore projects. Therefore, the Government could explore the possibility of supporting offshore competition for storage sites and decouple this from the onshore transportation network, where competition is not feasible, and a regulated monopoly is more appropriate. Doing so may increase the co-ordination of the cluster approach.

Supply Chain Development

The UK's CCS Supply Chain Strategy is being developed by industry through the CCS Council. The UK possesses a key advantage in the form of an offshore oil and gas industry supply chain that has technological experience and skills that could be adapted to the needs of the emerging CCS industry. This 'project content' presents the UK with an opportunity to utilise these skills in the development of CCS projects.

However, the UK's offshore oil and gas industry is currently shrinking. Moreover, the industry's skills and experience are also potentially relevant to other forms of clean energy, such as offshore renewables and hydrogen. Hence, there could be considerable competition for these resources and skills, and there is potentially a narrowing window during which the existing offshore supply chain could be available to benefit the emerging CCS sector.

For example, it appears that there is limited time available to meet the demand for project content that is likely to be generated by the Track-1 cluster and its constituent projects. With respect to the timelines that the Government has published, 2023-26 is likely to be the critical period for the UK supply chain to participate in the bulk of the fabrication, construction and installation opportunities associated with these projects.

The lack of certainty regarding the scale and timing of the UK's emerging CCS industry is also a barrier for potential investment in a domestic supply chain. Without a strong and capable domestic supply chain, it is likely that a larger proportion of project content will be sourced from non-UK suppliers. As a consequence, a significant proportion of potential business and employment opportunities will be lost to overseas suppliers. A key priority, therefore, is the development of a robust and broadly-based domestic supply chain for the UK's emerging CCS industry.

It is also the case that there are gaps in the existing offshore supply chain that may need to be filled if the CCS opportunity is to be met in full by UK-supplied project content. An assessment by OEUK in

2022 identified the following as areas where there were potential supply constraints or where further action may be required to allow domestic supply potential to be realised:[14]

Table 3-1: CCS Supply Chain key segments, capacity, and actions likely to be required

Segment	Assessment of current UK capability	Conclusion and action required
Carbon capture: Plant design & engineering	The UK can supply all of the required content.	• UK supply chain is very strong and is already delivering front end engineering for UK projects. • Clarity and commitment needed from government for expansion of CCS and ongoing funding for early-stage projects.
Carbon capture: Major plant fabrication	The UK has moderate coverage of the required capability and content.	• UK capabilities have declined in some major plant fabrication areas. • There are barriers to UK competitiveness from labour costs, productivity challenges and the ability to produce the largest components at home. • There may be specific opportunities for major fabricators, including mini-modules and specialised pressure vehicles. • Additional production facilities may be needed to meet CCS technical requirements and future demand. • The Government should consider targeted support for investment in UK fabrication capacity, tied to incentives for developers to use the UK supply chain. • Industry to investigate greater use of modular components to cut costs.
Carbon capture: Equipment design & manufacture	The UK has limited coverage of the required capability and content.	• Most components are available from global markets. • There is limited opportunity for the UK supply chain to develop capacity where it does not already exist. • Government to consider measures to attract international investment to address gaps in UK capacity.
Carbon capture: Construction & commissioning	The UK can supply most of the required content.	• UK capacity is strong and can make a major contribution to local content ambitions. • Competition from other clean energy sectors might mean that further actions might be needed to ensure that supply-side constraints do not hinder UK participation in supplying project content.
Carbon transport: Pipework	The UK has moderate coverage of the required capability and content.	• The UK can install plant onshore and offshore but lacks a competitive capability for the fabrication of pipework to the right specification. • Government to consider measures to attract international investment to address gaps in UK capacity.
Carbon transport: Marine transport	The UK has minimal coverage of the required capability and content.	• This is a new industry, and the UK has no domestic capacity. It would take a significant effort to capture the opportunity from shipping.
Carbon transport: Marine loading	The UK has moderate coverage of the required capability and content.	• Government would need to assess the capacity of existing national port infrastructure to offload CO_2 shipments.
Carbon storage: Wells & reservoir design & engineering	The UK can supply all of the required content.	• UK has a strong storage development capability through the oil & gas supply chain. Companies are already providing engineering services to the early Track-1 projects.
Carbon storage: Marine & subsea contractors	The UK can supply all of the required content.	• Opportunities depend on access to globally optimized equipment and services. • Regulators to develop clear views on future storage development requirements and a progressive approach.

Source: Based on OEUK (2022), *Carbon Capture and Storage and the opportunity for the oil and gas supply chain*

[14] OEUK (2022), *Carbon Capture and Storage and the opportunity for the oil and gas supply chain*

Investment in Innovation

The supply chain mapping exercise highlights a number of supplier segments where UK capability may be insufficient to fully meet the likely demand for project content. In some cases, this results from the historical evolution of the offshore sector in the UK, while, in other instances, it reflects the emergence of a new industry. In such cases, there may be opportunities for the UK to develop new capacity, but this is likely to require investment in research and development (R&D) or other types of innovation by established companies or new market entrants.

Several ongoing initiatives have the potential to address current gaps in industrial and technological expertise:

- The Industrial Strategy Challenge Fund, which includes the Industrial Decarbonisation Challenge, offers government funding of £170 million (with a target of £261 million match funding provided by industry) to support low-carbon technology development in UK industrial clusters.
- The Net Zero Innovation Portfolio is providing up to £115 million in grants to support R&D in CCS and GGR technologies.

To encourage and address key gaps in capability, there may be a case for additional Government measures to boost R&D activity in the sector, particularly to address gaps in domestic capacity that could realistically be filled. Such measures could include enhanced R&D tax credits.

There may also be a case for enhanced industrial support targeting supply chain enhancement in areas that host CCS clusters to help these areas retain a greater share of project content. Such measures could be designed to align with the Government's Levelling Up agenda and other spatial regeneration policies.

Skills and Recruitment

The emergence of the CCS industry has the potential to create tens of thousands of new jobs. In some cases, these new roles will require a highly skilled workforce that could potentially help offset job losses that may be experienced due to the expected continuing decline of the UK's offshore oil and gas industry.

Given the need for the newly emerging CCS sector to achieve a lot in a comparatively brief period and from a relatively standing start, it will also be necessary to recruit and train a sizeable workforce with appropriate skills. To secure sustainable growth in the CCS sector, it will be important to raise the profile of the sector among the younger generations to attract new, skilled workers.[15]

This issue is particularly acute because the UK's existing workforce in sectors such as energy production and energy transmission are ageing. The CCS sector will face stiff competition for new talent graduating from the UK's universities and technical courses over the next 5-7 years and beyond.

Despite the widespread confidence that the oil and gas industry workforce will have many of the skills and experience needed, there has been little detailed mapping of the precise skills that the new CCS sector's workforce will be expected to possess. However, a review suggested that around 90% of the

[15] Green Jobs Taskforce (2021), page 22

UK's oil and gas workforce has medium to high skills transferability and are well-positioned to work in adjacent energy sectors such as CCS.[16]

It is also worth noting that the review predicts that there will need to be an overall increase of around 40,000 in the UK's offshore energy workforce over the period 2021-2030. Representing an increase of 25% compared to 2021 levels. Although the oil and gas sector is expected to decline (and therefore be a source of workforce for other segments), there will still be the need for a residual oil and gas workforce amounting to around 35,000 workers in 2030.

This reinforces the need to raise the profile of the CCS sector and market it as a career destination among young people with diverse backgrounds, especially those considering enrolling on university engineering courses and other relevant disciplines. Likewise, it will also be necessary to ensure the recruitment of sufficient numbers of people into relevant skilled trades courses, and for the CCS industry to develop apprenticeship programmes to ensure a sufficient supply of trade and vocational skills.

Additional investment in workforce will need to be developed in coordination with businesses operating in the CCS supply chain in collaboration with private sector training providers, with relevant sector skills councils and industry training boards, and with universities and colleges.

[16] Energy Transition Institute, *UK Offshore Workforce Transferability Review* (May 2021)

SECTION FOUR: THE CONSEQUENCES OF INACTION

Section two of this report sets out the potential prize to be won should the Government meet its policy commitments, or go beyond them, and what this means for regions and nations of the UK. Section three sets out the areas which Government and industry should focus on, in order to get there.

However, in the scenario where the Government make slower or less ambitious progress towards its policy commitments, there's a potential scenario (Scenario 3) where jobs and economic value are lost and the UK's manufacturing activities are adversely affected as a result of a UK CCS resource not being developed at scale.

The risk of failing to develop a sufficient domestic CCS resource may be that existing high-emitting industries that have few options to decarbonise and remain exposed to measures which incentivise decarbonisation such as carbon pricing, could be lured away from the UK by other countries, resulting in significant job losses to overseas and the decline of long-standing industrial regions.

In the UK, there are 315 large businesses (250 employees or over) operating in the heavy GHG emitting sectors, with a collective turnover of £115.5 billion.[17] The potential loss of these businesses would have a significant impact to the UK if they faced a decision to relocate their businesses to countries with further developed carbon capture facilities.

Industrial sub-sector	Number of large businesses	Aggregate turnover (£m)	Aggregate employment ('000s)
Wood & wood products	25	2,564	13
Paper & paper products	40	8,685	27
Fuels	10	56,805	8
Chemicals	80	21,862	47
Rubber & plastics	90	9,139	48
Non-metallic mineral products	40	9,781	38
Basic metals (Inc Steel)	30	6,735	26
Total	**315**	**115,571**	**207**

[18]

This concern is heightened when we look at Europe's progress on CCS. Europe already has some CCS projects in operation and the EU has taken recent actions to accelerate this further. Whereas the UK only has projects in planning and development stages, and there are concerns about Government support compared to the US or Europe.

The outcome of such a scenario where the Government does not deliver on its policy commitments is outlined below. This is based on an assumption that 15% of the jobs in heavy emitting industrial sectors that would otherwise be expected to be in place by 2050 would be lost. The job losses would be a combination of plant closures, reductions in the size of some retained plants, and the failure of new

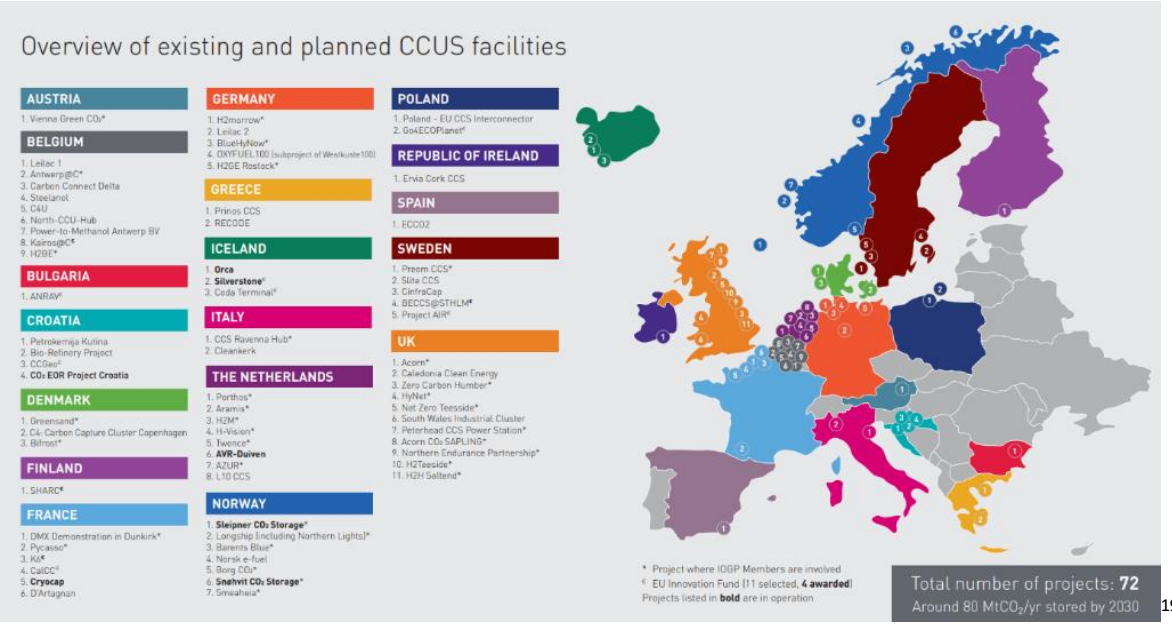
[17] Office for National Statistics, Business Population Estimates for the UK (2022), Table 6.
[18] Office for National Statistics, Business Population Estimates for the UK (2022), Table 6.

plants in heavy emitting industries to be developed (compared to a counterfactual scenario where underlying employment trends continue to occur over the period to 2050). The estimates for this scenario are as follows:

Overview of Scenario 3

Scenario 3	• Over 136,000 jobs lost in the UK by 2050 • Of these, around 43,000 jobs at risk of being lost in the North of England regions by 2050, with around 4,100 of these located in the Humber • GVA worth just over £9 billion per year is at risk of being lost in the UK by 2050 • Overall GVA worth over £2.8 billion per year is at risk of being lost in the North of England, with over £250 million of this located in the Humber

Europe's CCS development



[19]

Source: IOGP, CCUS projects in Europe (2022)

It is clear that the EU sees the critical importance of CCS for decarbonising Europe's industrial base and moving closer to their 2050 target of climate neutrality.

Following the US' Inflation Reduction Act, which provides generous tax credits and financial incentives to support the green transition, the EU expressed concern. However, in February 2023, the European Commission presented its Communication on A Green Deal Industrial Plan for the Net Zero Age, of which Carbon Capture and Storage plays a vital role. Two of the plan's four pillars have direct impact on the acceleration of CCS:

- Faster access to sufficient funding, which includes both national and EU level funding for key sectors, and a proposal for a European Sovereignty Fund.
- A predictable and simplified regulatory environment to allow for the growth of net zero industries reflected by a Net Zero Industry Act.

[19] IOGP, CCUS projects in Europe (2022)

The NZIA sets a target for storage in the EU of 50 million tonnes of CO_2 in annual injection capacity by 2030.

Europe already has several projects in advanced development and seven projects in operation, creating jobs and opportunities. Europe is also progressing towards coordination, a key development in cluster development, and is accelerating the development of CO_2 storage sites.

At this moment, the UK has CCS projects in planning or early development stages; none of them operational. The UK has work to do to ensure that it doesn't fall further behind Europe and other international competitors in CCS development.

List of European projects already operational

In operation: ***7***

- *CO_2 EOR Project Croatia, Croatia – n/a*
- *Cryocap, France – 100,000 tonnes per annum*
- *Orca, Iceland – 4,000 tonnes per annum*
- *Silverstone, Iceland – 37,000 tonnes per annum*
- *Duiven CO_2 Plant, The Netherlands – 100,000 tonnes per annum*
- *Sleipner CO_2 Storage, Norway – 1 million tonnes per annum*
- *Snohvit CO_2 Storage, Norway – 700,000 tonnes per annum*

List of European projects in advanced development

Advanced development: ***10***

- *Steelanol, Belgium*
- *C4U, Belgium*
- *Power-to-Methanol, Belgium*
- *CCGeo, Croatia*
- *Demonstration in Dunkirk, France*
- *Leilac 2, Germany*
- *Twence CO_2 Capture Plant, The Netherlands*
- *Longship, Norway*
- *Norsk e-Fuel, Norway*
- *ECCO$_2$, Spain*

CONCLUSION

Carbon capture and storage will play an instrumental role in efforts to reach net zero. This viewpoint is shared globally and illustrated by organisations such as the Climate Change Committee, which deems it *'a necessity, not an option'.* Countries have the opportunity to position themselves as global leaders and take advantage of the significant economic and environmental benefits presented by the development of a domestic CCS resource.

The UK is well positioned to embrace this role. The UK has a substantial geological advantage for storing carbon and possesses infrastructure, skills, and engineering expertise thanks to the legacy of the oil and gas industry.

In light of these advantages, the UK currently stands at a crossroads, with Government decisions on policy and ambition setting the direction for the future. Within this context, several potential scenarios emerge.

In a more conservative scenario where the Government follows current policy commitments (Scenario 1) approximately **310,000 jobs could be created and supported by 2050 as well as additional GVA worth nearly £23 billion per year gained for the UK by 2050.**

Should the Government decide to pursue a more aspirational scenario (Scenario 2), there could be approximately **489,000 jobs could be created and supported by 2050 and additional GVA worth around £32 billion per year gained for the UK by 2050.**

To realise these transformative economic opportunities and position itself as a world-leader, the UK requires action from the Government, businesses, and the investment community. This involves creating the conditions for investment in infrastructure, ensuring greater clarity regarding cluster development, supporting the development of a supply chain, investing in innovation, and developing and recruiting the required workforce.

Should the Government fail to capitalise on the UK's numerous advantages and neglect to create a sufficient domestic CCS resource, there exists a scenario where jobs and economic value are lost (Scenario 3). Under this scenario there could be **over 136,000 jobs lost in the UK by 2050 and GVA worth just over £9 billion per year at risk of being lost UK wide by 2050.**

With significant support from the private sector and widespread industry backing, CCS has the potential to deliver economic and environmental benefits across the UK while simultaneously positioning the country as a world leader in this field. However, enthusiasm and support alone are not sufficient. The Government must take action to bring the potential benefits to fruition and avoid missing this opportunity.

APPENDIX – METHOLODY AND FURTHER DETAIL FOR SCENARIO 1 AND SCENARIO 2

Explanation of derivation of estimates for jobs and GVA

The key metrics used to assess the economic impact of developing CCUS are employment and Gross Value Added. Two phases of activity are considered:

- a capital investment (Capex) phase, driven by the expected scale of expenditure on the design, fabrication, installation, and commissioning of new infrastructure and facilities used in the various processes relevant to CCUS and related activities.
- consideration of the operational (Opex) phase of CCUS plants and related activities once newly built and commissioned CCUS infrastructure and facilities commence operations.

For both the Capex and Opex stages, the approach is to estimate jobs and GVA created through linked supply chains (and additional related activity stimulated through multiplier effects) as well as CCUS business activities themselves.

Quantification of the potential employment and GVA impacts of investment in CCUS resource is based on anticipated levels of business expenditure during each of the Capex and Opex stages. The approach taken here is to utilise estimates of installed CCUS capacity and associated expenditure identified in a report entitled *Supply Chain Excellence for CCUS*, which was published by the Carbon Capture and Storage Association (CCSA) in 2021.[20] This report identified potential cumulative Capex on various CCUS and related technologies that could occur by 2035 and 2050, respectively. The report also identified potential levels of annual Opex for each technology for the same two years (2035 and 2050).

Estimates of respective Capex and Opex expenditure were converted into estimates for employment and GVA using benchmark data for relevant business sectors published by the Office for National Statistics in various annual datasets.

Summary table of key effects for the United Kingdom

Indicator	Scenario 1	Scenario 2
Capex phase jobs (cumulative occurring by 2050)	198,400	331,440
Capex phase jobs (average p.a., 2022-2050)	6,840	11,429
Capex phase GVA (cumulative occurring by 2050	£14.04 billion	£23.46 billion
Capex phase GVA (average p.a., 2022-2050)	£484 million	£809 million
Opex phase jobs (total in place by 2050)	111,500	157,300
Opex phase GVA (per annum, by 2050)	£22.92 billion	£32.32 billon

Spotlight On: Economic Benefits of Exporting

Scenario 2 explores the potential implications of a more ambitious strategy to develop and expand the UK's CCS resource compared to Scenario 1 . This includes the introduction of specific types of technology – such as Direct Air Capture Carbon (DACCS) – plus expansion of the use of energy generation technologies that are linked to a gas capture and storage resource.

[20] Carbon Capture and Storage Association (July 2021): *Supply Chain Excellence for CCUS*

Under Scenario 2 it is also assumed that the UK develops its significant potential to become an exporter of CCS services to industries in other countries.

In the modelling of Scenario 2 , it is therefore assumed that the development of the UK's carbon capture export service potential (i.e., the importing of CO_2 produced by other countries) would require additional investment in:

- the ability to berth ships transporting CO_2 from other countries in UK harbors and transfer their cargoes to the UK's domestic CO_2 distribution and storage network of pipelines and other apparatus; and
- additional offshore carbon storage capacity (i.e., above and beyond the storage capacity that would be needed to handle domestic output from carbon intensive industries and other domestic sources (such as aviation) over the same timeframe.

Apart from business activity and employment associated with developing the additional infrastructure needed to handle carbon imports, there would also be additional jobs in maintaining and operating the infrastructure once it is commissioned.

The estimates of jobs and GVA associated with the exporting components of Scenario 2 during the Capex phase (2022-2050) are as follows:

- Employment: around 54,000 person-years of employment from direct/indirect effects and a further 13,700 from multiplier effects, amounting to around 67,700 in total.
- GVA: aggregate economic output worth around £2.58 billion in total.

The estimates of jobs and GVA associated with the exporting components of Scenario 2 during the Opex phase are as follows:

- Employment: around 12,800 permanent direct/indirect jobs in place by 2050, plus a further 3,300 jobs created through multiplier effects, amounting to 16,100 jobs in total.
- GVA: a total of around £4.85 billion of GVA generated annually by 2050.