Grantham Research Institute on Climate Change and the Environment

Centre for Climate Change Economics and Policy

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Policy brief

Seizing sustainable growth opportunities from CCUS in the United Kingdom

Centre for Economic Performance

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Headline issues

- Carbon capture usage and storage (CCUS) needs to be deployed urgently to bring greenhouse gas emissions to net-zero.
- The potential contribution of CCUS to sustainable growth in the UK is high, through jobs and supply chains.
- CCUS could present a levelling-up opportunity if support is directed strategically to address the unequal distribution of innovative performance across the country.

This policy brief has been written by **Esin Serin, Anna Valero, Ralf Martin, Arjun Shah, Pia Andres and Penny Mealy.** It summarises a longer report, *Seizing sustainable growth opportunities from carbon capture, usage and storage in the UK*, available at www.lse.ac.uk/GranthamInstitute/publications.

Summary

CCUS is necessary for the UK to reach net-zero by 2050. The more aligned CCUS deployment in the UK can be with net-zero over this decade, the higher the potential for job creation. Construction activities will be the main driver of jobs in the short to medium run. Estimates suggest up to 31,000 jobs could be created by 2030.

Existing export capabilities for CCUS-related products put the UK at a slight disadvantage but plentiful opportunity remains. Many of the CCUS-related products the UK already exports competitively or could do so in the future are in the measuring, monitoring and verification instrument category and these will be the backbone of any commercial framework for CCUS. The UK also has strengths in innovation in some technologies that are 'adjacent' to CCUS, including those relating to physical or chemical separation, liquefaction and solidification of gases.

The UK cannot afford any further policy failure or delays deterring investment in CCUS, given the urgency of net-zero, and because investor confidence is already fragile due to past experience. A consistent, long-term policy, institutional and regulatory framework, underpinned by multi-year funding, is now needed to improve coordination across stakeholders at the national and local levels on the entire portfolio of net-zero solutions and technologies, including CCUS.

"The use of CCUS is key for enabling a net-zero-aligned growth path, given its role in decarbonising hard-to-abate industries such as steel and cement, producing low-carbon hydrogen and delivering negative emissions."

Why is CCUS needed – globally and in the UK?

Limiting global temperature rise to around 1.5°C above pre-industrial levels to limit the worst impacts of climate change implies net-zero emissions of CO_2 by 2050 (IPCC, 2018). The UK has responded with an economy-wide net-zero target for mid-century. The current decade is critical to ensure coordinated investments in infrastructure, innovation and skills reorient the UK economy towards a net-zero-aligned growth path.

The use of carbon capture, usage and storage (CCUS) is key for enabling this growth path, given its role in decarbonising hard-to-abate industries such as steel and cement, producing low-carbon hydrogen and delivering negative emissions. As such, the International Energy Agency (IEA) has concluded that reaching net-zero globally will be virtually impossible without CCUS (IEA, 2020). In its recent *Net-Zero by 2050 Roadmap* the IEA recommends that 10 heavy industrial plants should be equipped with carbon capture technology every month from 2030 onwards (IEA, 2021). Progress in the energy sector to date does not reflect this level of activity and there is a need to urgently ramp up investment in CCUS research, development, demonstration and deployment over this decade globally.

There is now wide acceptance that CCUS is a necessity rather than an option for the UK if it is to meet its net-zero target (CCC, 2019). The Government's current stated ambition is to capture 10 million tonnes of carbon dioxide ($MtCO_2$) a year by 2030. To meet net-zero, this needs to be ramped up significantly. There are projects already in early development stages across the UK that together could deliver double that capacity in the 2020s.

An inconsistent policy environment, including two failed major demonstration competitions, has been the primary setback against CCUS development in the UK to date. Now is the time to make up for years of stalled progress in deploying this essential technology. What's more, fast, strategic action can unlock growth opportunities along the way. Focus should be on areas where the UK has or can build comparative advantage, crucially by capitalising on its existing capabilities in the oil and gas sector, to deliver significant emissions abatement while generating export opportunities and wider economic benefits from CCUS.

CCUS as an enabler of sustainable growth in the UK

Investment in CCUS can:

1. Create net-zero aligned jobs. Jobs can start emerging in the short term from the construction of CCUS projects with the potential to feed into a net-zero-aligned recovery. Two carbon capture clusters are planned for construction by the mid-2020s and a further two clusters by 2030 in the UK. Many of these jobs will be concentrated in the UK's industrial heartlands. CCUS can also help to avoid potential job losses from the restructuring of the economy under net-zero as it is a sector demanding skills similar to those currently found in some of the high-emitting industries.

2. Unlock export opportunities from the supply chain. Ambitious climate targets coming from around the world imply that demand for CCUS-related products and services will rapidly increase globally as well as in the UK. Early action to develop manufacturing and innovation capability of CCUS-related products could create

significant export opportunities given the immature state of the market for these, in turn supporting jobs into the long term. Arguably, the UK is in a stronger position to capture export opportunities from CCUS-related services than from products, given it currently successfully exports relevant expertise in related industries, notably in the oil and gas sector.

3. Enable net-zero-aligned industrial growth. In the presence of strong competition, low-cost decarbonisation is crucial for the continuation of existing UK industries and the many jobs they support. CCUS can act as a 'bridge' for addressing industrial emissions quickly where renewables-based solutions either do not yet exist or are prohibitively expensive. And it is an enabler of low-cost, low-carbon hydrogen and electricity production, which can replace fossil fuel use in industry. For some industries, CCUS is currently the only technically feasible way to abate process emissions.

4. Deliver negative emissions. The two main engineered ways of removing CO_2 from the atmosphere, bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS), share a technological foundation with CCUS. Both are currently prohibitively expensive, therefore CCUS investments made today are crucial for bringing costs down through shared infrastructure, economies of scale and learning by doing. CO_2 removal technologies need to be up and running in the UK by 2030, according to existing studies, and will continue to play an essential role even beyond 2050. However, even purely from a cost perspective in a potential future of very high demand for negative emissions, the focus on removals should be to complement, not to replace, greenhouse gas mitigation.

Our findings

We have assessed:

- National and local economic opportunities from CCUS in the UK – both direct and indirect via supply chains
- Potential employment and implications for skills needs
- Transferability of existing strengths and capabilities from other sectors
- Barriers and enablers of growth, and implications for both national and local policy.

Economic opportunities and jobs

Job creation opportunities lie along the highly complex and fragmented value chain for CCUS. Overall, the studies we reviewed suggest that CCUS investments can generate significant gross value added (GVA) benefits and a substantial number of jobs in the short, medium and long terms. Studies that explicitly quantify these aspects suggest more jobs will lie in the construction than in the operation phase of CCUS projects, and that potentially higher economic benefits both in terms of jobs and GVA will come from export rather than domestic markets. According to Energy Innovation Needs Assessment analysis commissioned by the Department for Business, Energy & Industrial Strategy (BEIS), CCUS as an export industry could create almost 50,000 direct jobs for the UK in 2050 (Vivid Economics, 2019).

As well as creating new jobs, CCUS is crucial for helping retain existing jobs in energy-intensive industries. Estimates of job retention in the UK through CCUS vary; examples include: between 35% and 70% of existing manufacturing jobs supported and safeguarded in the Tees Valley; 60% of direct jobs retained in the iron and steel industry by 2060 in the East

What is CCUS?

CCUS covers a suite of technologies. These include those that enable the capture of CO_2 from large point sources, including power generation or industrial facilities that involve the combustion of either fossil fuels or biomass, as well as facilities such as cement plants that release CO_2 as a direct by-product of industrial processes (IEA, 2020).

The CO_2 can also be captured directly from the atmosphere. Captured CO_2 is then compressed and transported by pipeline, ship, rail or road to a destination where it is injected into deep geological formations (e.g. depleted oil and gas reservoirs), which trap the CO_2 for permanent storage. The captured CO_2 can also be used in a range of industrial applications.

CCUS can be used for multiple purposes, from decarbonising industry to mitigate new emissions to removing existing CO_2 from the atmosphere.

There are other solutions to these problems too, such as fuel switching and nature-based solutions, which means the ultimate level of CCUS that will be deployed is uncertain. This uncertainty is illustrated in the vastly different CCUS deployment scenarios found in various models of the UK's pathway to meeting net-zero, for instance by the National Grid (2020) and the Climate Change Committee (2020).

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Coast region; and up to 53,000 jobs protected by 2030 in the UK's refineries, steel and cement industries, and parts of the chemicals sector.

Multiple estimates for the number of jobs created by CCUS by 2030 cluster between 22,000 and 31,000. This is unsurprising given these studies consider unambiguous deployment scenarios designed to be consistent with the UK's climate targets. Studies that look beyond 2030 are mixed in terms of both the number and type of jobs they consider, which makes comparisons challenging.

For CCUS to contribute to a just workforce transition under net-zero, policies need to account for not only the number but also the place-related and social dimensions of the jobs created. Having the skills in place locally will be a prerequisite for retaining economic value from CCUS investments within regions, contributing towards the 'levelling-up' agenda. The extent of skills transfer from other industries into CCUS will be a crucial determinant of local skills availability.

The UK's productive strengths in CCUS

We observe that CCUS-related products tend to be somewhat higher in complexity relative to the universe of all traded products. This suggests that on average, CCUS-related products tend to be more technologically sophisticated, requiring more knowledge-intensive skills and capabilities for their production. These products are also likely to have greater opportunities for knowledge spillovers into other areas.

The UK's export share in CCUS-related product categories tends to be low (around or below 5%) and declined over the period 1995–2019. The US and Germany historically have been dominant in CCUS-related exports but increasingly are being overtaken by China. This partly reflects China's dominance in global manufacturing exports more generally.

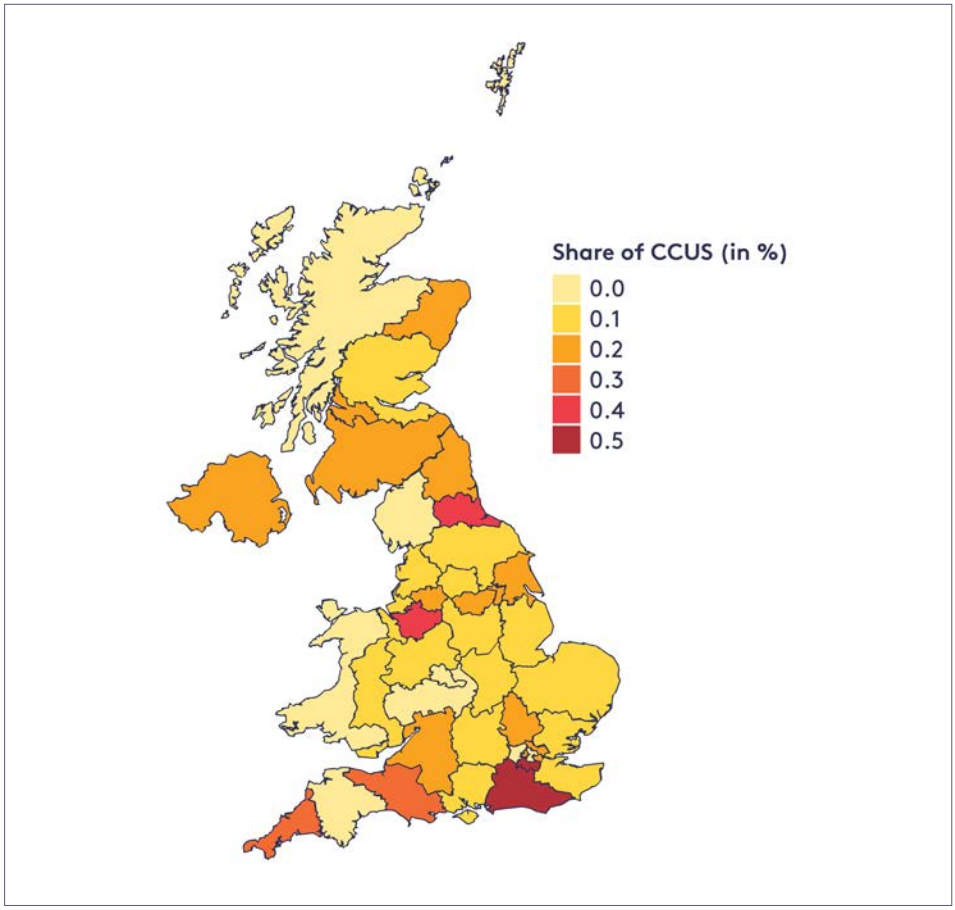
Nevertheless, the UK has revealed comparative advantage (RCA) in some key CCUS-related products, and a mix of strengths and opportunities, especially in mechanical machinery and measuring, monitoring and verification (MMV) instruments. RCA is defined as a given product's share in a country's exports, divided by the product's share in global trade volume.

The UK's innovative strengths in CCUS

A more forward-looking indicator of the UK's comparative advantage in CCUS is its innovative capability. Our analysis of CCUS-related patenting shows global CCUS innovation has been growing rapidly over the last 20 years but experienced a decline following the financial crisis. Just 4% of global CCUS patent applicants over the period 2000–2015 were made in the UK but the country demonstrates a comparative advantage in this area – which also exceeds other broad categories of 'clean' innovation. Previous analyses have shown that the UK exhibits strong comparative advantage in specific technologies within these broad categories of 'clean' innovation, including wind and ocean energy.

Looking at patenting at a regional level (Figure 1), we find a relatively high share of CCUS-related innovation activity in the South East of England. Industrial areas in the North East and North West also appear to have a relatively high share of CCUS-related patents compared with other regions. Regional dimensions and transferability of R&D capability require further attention to ensure

Figure 1. Share of CCUS innovation out of total innovation in the UK, 2000—2015 (share of patents at NUTS2 regional level)



Source: Authors' estimates based on PATSTAT – 2018 Spring Edition

Note: "The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU and the UK"; NUTS 2 regions are "basic regions for the application of regional policies" (Eurostat).

CCUS-driven growth is regionally balanced. In the context of uneven economic performance across the country, it is important to understand where technological strengths are located, and the extent to which different parts of the UK could be well positioned to act as R&D hubs for CCUS in the coming years. While CCUS has the potential to contribute to future growth and employment in the UK's industrial heartlands, the extent to which this is the case will depend on where new knowledge is generated, patterns of knowledge spillovers, the structure of supply chains and the skills base.

A positive correlation between CCUS innovation and areas that have traditionally patented more intensively in oil and gas extraction technologies is also shown by our analysis. This suggests that places that have specialised in these technologies might be well-placed to benefit from the transition to CCUS. Regions such as North Eastern and Eastern Scotland have a large share of innovation in oil and gas extraction but quite a low share in CCUS-related technology, whereas inner London and parts of South East England including Surrey, East and West Sussex display a large share of patenting in oil and gas extraction as well as CCUS-related technologies.

We also conducted preliminary analysis on innovation in technologies that appear to be 'adjacent' to CCUS technologies, to shed light on potential sources of indirect comparative advantage and knowledge spillovers for CCUS innovation. We find that patents

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that are classified as CCUS are also often classified under some other related technology classes, in particular, 'physical or chemical processes of separation' and 'liquefaction, solidification or separation of gases by pressure and cold treatment'. There is evidence to suggest that the UK could capitalise on its strengths in these CCUS-adjacent technologies to improve its position as a global leader in CCUS innovation.

Conclusions and recommendations

Recent policy frameworks and funding committed to CCUS have set a clear deployment pathway for initial CCUS projects in the UK but more needs to be done to stimulate investment at the required scale and pace. In light of our analyses of the data on economic impacts, trade and innovation relating to CCUS, and the current barriers to CCUS development that we identify, we present policy recommendations that span national and local levels, and relate to the investments across infrastructure, innovation, human, natural and social capital that are required for sustainable and inclusive growth.

Policy risk operates across these five types of capital and therefore needs to be carefully managed to avoid policy failures that can deter investment. Holistic thinking across the types of capital can attract much needed investment into CCUS supply chains and innovation to underpin the target levels of deployment in the short term and drive further ambition in the longer term. Maximising opportunities from a holistic approach requires a consistent, long-term policy, institutional and regulatory framework to improve coordination across stakeholders at the national and local levels on the entire portfolio of net-zero solutions and technologies. The UK government should urgently embed its ambitions for CCUS into this framework, crucially through the upcoming Net Zero Strategy, and in doing so demonstrate globally, ahead of COP26, that it is leading the race to net-zero.

1. Infrastructure/physical capital

Recommendations

1.1. Finalise CCUS business models as an immediate priority, underpinned by long-term funding to support deployment in the 2020s, and with a coordinated approach across interrelated energy systems including hydrogen and greenhouse gas removal technologies.

Action leads: Department for Business, Energy and Industrial Strategy (BEIS) and HM Treasury

1.2. Link CCUS investment with a robust, net-zero-aligned carbon price.

Action lead: BEIS, in close consultation with HM Treasury

1.3. Leverage the role of the UK Infrastructure Bank to create the conditions to crowd much-needed private sector investment into CCUS while ensuring support for CCUS is not at the expense of necessary investment in other net-zero-enabling technologies.

Action leads: UK Infrastructure Bank and HM Treasury

1.4. Develop CCUS as part of a holistic infrastructure programme considering infrastructure that will be shared across various technologies (e.g. greenhouse gas removal) as well as complementary assets (e.g. broadband) required for net-zero-aligned regional growth.

Action lead: HM Treasury, in close consultation with local government, and by extension communities, across the UK

2. Knowledge capital and innovation

Recommendations

2.1. Draw on diverse economic evidence to align domestic CCUS supply chain ambitions with a proper understanding of the UK's comparative advantage in production, services and innovation, with early coordination between CCUS project developers and supply chain companies, and considering an outcome-based approach that brings in international supply chains where necessary.

Action leads: BEIS and Department for International Trade (DIT), in close consultation with businesses

2.2. Ensure that support for innovation in net-zero-enabling technologies, including CCUS, is ambitious, considering enhanced R&D tax credits where applicable, and that it is channelled in a way that addresses regional disparities as well as the current gaps in thinking across path-dependent innovation systems.

Action leads: BEIS and UK Research and Innovation (UKRI)

2.3. Explicitly link domestic CCUS policy with the ambitions to play an international leadership role on climate action, especially in the context of COP26, considering further collaboration in R&D.

Action lead: COP26 Team within the Cabinet Office, in close consultation with a range of other government departments including BEIS, Foreign and Commonwealth and Development Office (FCDO), and DIT

2.4. Inform industrial and innovation strategy at national and local levels by creating a robust evidence base on what works that draws upon enhanced collaboration and co-creation between higher education institutions and industry as well as lessons shared across projects by capitalising on the cluster sequencing agenda.

Action leads: BEIS, Department for Education (DfE) and UKRI, in close consultation with local government, businesses and education institutions

3. Human capital

Recommendations

3.1. Complement CCUS investments with a special emphasis on skills as part of a holistic, proactive net-zero skills programme, designing targeted re- and upskilling for those displaced in the COVID-19 crisis and who will be displaced by ongoing structural change towards net-zero, using human capital tax credits to incentivise firms to play an enhanced role in the programme.

Action leads: BEIS, DfE and Department for Work and Pensions (DWP), in close consultation with local government

3.2. Ensure collaboration across departments on the net-zero skills agenda, including skills required for the successful delivery of CCUS, and embedding necessary frameworks in overarching policies underway, such as the Skills and Post-16 Education Bill.

Action lead: Cross-government

3.3. Ensure joint effort between government, industry and education providers to take a place-based approach to map and quantify the existing skills base that is transferable into CCUS, identify skills gaps, and develop education/training curricula accordingly.

Action leads: BEIS, DfE and DWP, in close consultation with local government, businesses and education institutions

"Maximising opportunities from a holistic approach requires a consistent, long-term policy, institutional and regulatory framework to improve coordination across stakeholders at the national and local levels."

4. Natural capital

Recommendations

4.1. Ensure environmental regulation and legislation keep pace with developments in CCUS in an agile way, and that the drive to support faster deployment does not compromise on environmental scrutiny.

Action leads: BEIS, Department for Environment, Food & Rural Affairs (Defra) and the Oil & Gas Authority

4.2. Take a holistic view of all energy systems to minimise environmental disruption from investments in CCUS and related economies at both the national and local levels, respecting local ecosystems and natural resource constraints.

Action leads: BEIS, Defra and the Oil & Gas Authority, in close consultation with local government

5. Social capital

Recommendations

5.1. Create an awareness and information programme to ensure social acceptability of CCUS, using a positive but realistic narrative that positions CCUS within the wider portfolio of essential net-zero technologies, while emphasising the role of CCUS as an enabler of just workforce transitions towards net-zero.

Action leads: BEIS, DfE and Department for Digital, Culture, Media & Sport (DCMS)

5.2. Rebuild pride and sense of community within regions around a shared purpose for clean growth that includes CCUS, in particular through participatory decision-making processes at a local level, to ensure community buy-in and just outcomes.

Action leads: BEIS, in close consultation with local government, and by extension communities, across the UK

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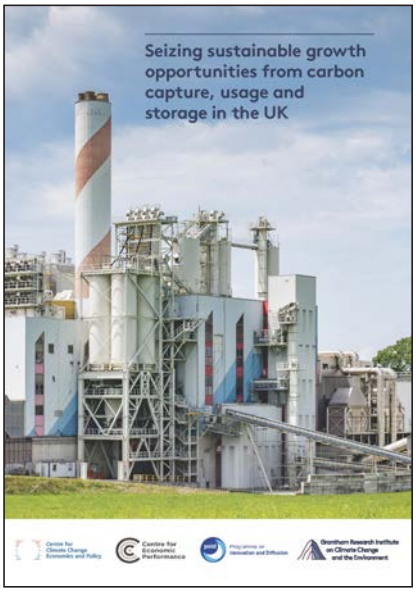

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