



Research Brief

How do the characteristics of a new CO₂ Transport and Storage industry compare to those of the current Oil and Gas sector?

Understanding the implications for the economy-wide impacts of deploying Carbon Capture, Utilisation and Storage (CCUS) in Scotland and the wider UK economy

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Summary and key findings

As the first stage in CEP's work on Scotland's Net Zero Infrastructure (SNZI) programme, our research to understand the wider socioeconomic impacts of Carbon Capture, Utilisation and Storage (CCUS) in the UK has explored how a CO₂ Transport and Storage (T&S) industry is likely to evolve. Our starting point there was to make the benchmark/starting assumption that the T&S industry would have the same upstream supply chain structure as the existing Oil and Gas (O&G) industry. This was on the basis that taking CO₂ for offshore storage will involve the reverse of many processes to bringing oil and gas out. However, there is now a need to examine whether this basic assumption needs to be refined in order to generate more accurate and informative insight from our economy-wide scenario simulation analyses.

Thus, the next stage in our SNZI work is to refine our analysis drawing on evidence emerging from interviews with industry and policy experts to fully understand the differences between the T&S and O&G sectors. We focus specifically on the operational costs and supply chain requirements as a new T&S industry emerges. This research brief summarises insights emerging from this process that are relevant both to current CCUS decision-making and our ongoing research as part of SNZI, summarised under five headings:

- 1. Levels of investment and sources of funding:** The UK financial sector is likely to play a similar role in supporting the operation of T&S as it has for O&G, but with the substantial upfront investment and capital expenditure (CAPEX) involving a range of actors with more direct stakes in UK CCUS, including Government and potential operators and users of the new T&S industry. Just how the funds are used, particularly in terms of activity within the UK economy, as well as how costs of Government intervention are recovered, will have important consequences for GDP, jobs, international competitiveness, and economic development in different UK regions.
- 2. Labour requirements, location, and the potential implications on wages:** While the roll-out of a new UK T&S industry will provide opportunities to transition current O&G workers, a range of challenges arise via retraining requirements, the likely employment status, wage rates and working location of employees and wider labour market implications. The compensation of many current O&G workers working offshore on extraction and drilling platforms involves a wage premium within an industry-specific international labour market. The T&S industry is likely to involve more employment activity onshore within the regions/nations of the UK, which may have important implications in terms of both industry wage rates and spill over impacts on wage determination in the wider UK labour market.
- 3. Reliance on electricity:** The current UK O&G industry relies heavily on on-site generation to power equipment. A UK T&S industry is likely to rely more on the national electricity grid, where a relatively strong domestic supply chain may deliver net wider economy gains. However, where this adds to the network capacity demands of increased electrification, there will be costs spread across all bill-payers, with associated cost-of-living/doing business and fuel poverty pressures. However, much will depend on the counterfactual, where, particularly if CCUS aids deployment of hydrogen solutions, a path of reduced or delayed reliance on electrification as an industrial decarbonisation solution may be enabled.
- 4. The potential role of shipping:** Shipping is central to O&G. For T&S, transportation of CO₂ using ships will be reserved for long distance transportation and clusters where storage is not in close enough proximity to utilise pipelines and may offer limited domestic gains. Shipping services are likely to be largely provided by the existing (international) marine transportation sector. As a result, relative to the central pipeline case, a combination of lower CAPEX but higher OPEX costs are likely to be set against gains associated with required economic activity be located and recorded in other countries.
- 5. The export capacity of T&S:** A key difference between O&G and T&S is the destination of output, where the former is export-intensive while the latter is initially domestically focussed. Nonetheless, exporting T&S services ('importing' CO₂ captured in other countries) could become an important revenue source, depending on the design of the CCUS networks at different industrial sites in the UK. Moreover, the export capacity of UK T&S is likely to change the economic transition as domestic demand for T&S services decreases, providing revenue sources that may reduce domestic funding requirements.



1. Introduction

Through research undertaken initially via funding from the Children's Investment Fund Foundation and now via the UKRI Industrial Decarbonisation SNZI project, CEP has been developing an understanding around the potential characteristics of a new CO₂ Transport and Storage (T&S) Industry.ⁱ This knowledge - alongside understanding of how engaging in carbon capture will impact cost and activity levels in, and the competitiveness of, regional clustered industriesⁱⁱ - will be critical to building a more detailed picture of how the deployment of Carbon Capture, Utilisation and Storage (CCUS) will impact across the UK wider economy.

The first challenge in our research – involving development of a UK computable general equilibrium (CGE) model for use in scenario simulation analyses – has been conceptualising a new activity like T&S in economic terms. Crucially, as a completely new industry, is not currently included in the Input-Output (IO) tables, published as part of UK national statistics, that we use to calibrate our scenario simulation models. More generally, the absence of formal accounting data means that there is very limited information on how the industry links with other sectors and markets in the UK economy.

Here we should note that the picture is further complicated by that fact that, despite common characteristics of CCUS across different regional/industry contexts, key features – such as how storage is operated or where the captured CO₂ is going to come from – are unique for each CCUS project. Thus, like any diverse national industry, economy-wide research will always come with the 'health warning' that the average picture captured may not always be the most useful where granular level insight is needed.

Here, in our previous researchⁱⁱⁱ, as a benchmark assumption, we have used the UK Oil and Gas (O&G) industry as a proxy for T&S, based on the consideration that T&S will operate in some ways as a reverse O&G activity. That is, by instead of extracting crude oil and natural gas and transporting it via pipelines and ships, T&S will use pipelines and other transportation options, such as shipping, to move captured CO₂ to permanent storage sites (often depleted oil and gas reservoirs).

Furthermore, in both a national and, particularly, the devolved Scottish policy context, a key role of T&S and the broader CCUS activity is its potential to enable the ongoing use of existing infrastructure and labour, skills and expertise from established carbon intensive sectors. That is, sustaining but evolving the wider economic (including employment) contribution of the offshore O&G industry and its onshore supply chains.

However, it is important to examine whether this basic assumption needs to be refined in order to generate more accurate and informative insight from our economy-wide scenario simulation analyses. Thus, a central element of our initial work on the SNZI project has involved interviews with a range of partners working across the UK industrial clusters, to understand what the T&S sector may look like, and the potential similarities and differences compared with the initial benchmark of the O&G industry.

The outcomes are essential to progress our economy-wide modelling. Moreover, a better understanding of the differences and similarities between T&S and O&G can help policy makers and other key stakeholders make more informed decisions regarding the development, deployment, and operation of T&S in the evolving CCUS and wider net zero transition landscape. Going forward, this mix of benchmarking and consultation is likely to be useful approach in a wider range of contexts, such as considering how growing marine sector activity – particularly offshore renewables and hydrogen – may develop and diverge from the existing industrial base established through the UK O&G industry.^{iv}

2. The key characteristics of Oil and Gas as a proxy of CO₂ Transport and Storage sector

As with all sectors of the economy, O&G relies on a combination of intermediate goods and services (both domestically produced and imported), along with labour and capital inputs in order to produce its output. Examining the structure of the current UK O&G industry (see Figure 1), as represented in the latest UK IO tables⁴, we see that labour and capital, i.e., the value-added component of the upstream supply chain, contribute 63% of the total value of inputs. Breaking this down further we find that 8% of the value of inputs are linked to payments to workers, while 55% is associated with payments to capital.

O&G is a highly capital-intensive sector, with the greatest share of input value relating to not only extraction platforms, but also to any O&G industry-owned and operated pipelines and ships used to transport the extracted oil and natural gas. Here, any changes in the operational requirements, and the ownership of capital equipment in shifting to T&S activity would mean changes in the value and importance of capital inputs (e.g., external shipping services will be recorded as a service rather than capital requirement).

The number of people directly employed by the sector (with O&G recording 13,338 full-time equivalent, FTE, employees in 2018), are also a key input to production. When valued in terms of the wages paid, labour becomes the second most important input used by the O&G industry. Crucially, the O&G sector provides high quality employment to the economy, associated with the skills requirements and reliance within its supply chain which increase the value contributed to the supported average wage, involving a range of wage premiums associated with offshore working.

Given the substantial value of capital and skilled labour employed by the O&G sector, it is understandable that there is policy, public and industry appetite to ensure the ongoing use of these valuable physical and human assets, even operating in a different environment. However, while the ongoing employment of skilled labour is crucial in ‘Just Transition’ terms, there are a range of issues in terms of how the employment profile of a new T&S industry may differ from the current offshore O&G industry. A fundamental issue is where (on or offshore) employment may be concentrated and what industry-specific/international vs. regional/national labour market activity may be involved. We return to this issue below, but note that there is an interaction with the intermediate input requirements, where some labour provision services are provided via the UK ‘Mining and mining support sector’.

Figure 1a: Breakdown of UK oil and gas total inputs

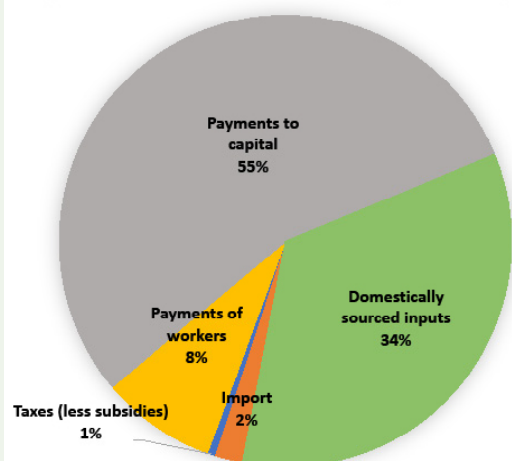
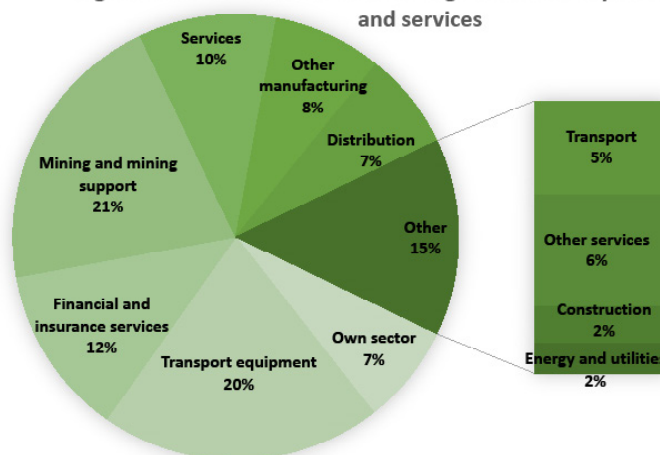


Figure 1b : Breakdown of UK oil and gas domestically sourced goods and services



More generally considering the intermediate (produced by other domestic or external sectors) goods and services required by the O&G industry, we see from Figure 1a that only 2% of them are imported (i.e., sourced from outside the UK). That is, the UK O&G predominantly and heavily relies on domestic supply chains to support its production (34% of the total value of inputs).

Out of all the domestic industries that provide input to the UK O&G sector, some of the most significant contributions/purchases are made from the ‘Transportation equipment’ sector (20% of total domestic inputs). Among other things this covers both the building and maintenance of drilling and oil extraction platforms, a crucial equipment requirement for an oil extraction sector mainly operating offshore. We can also observe that there is a close interaction between O&G and the wider financial industry (12% of domestic inputs), a key source of funding for the necessary maintenance and further investment required for the ongoing operation of the sector.

There are also substantial interactions with the ‘Mining and mining support’ sector (21% of the value of domestic inputs), which reflects the fact that some part of equipment required for the operation of O&G industry are not directly owned by firms within the O&G sector rather provided by subcontractors. Similarly, and some recruitment/provision of labour involves subcontracting activity. Much of both involves activity recorded in UK IO tables via the ‘Mining and mining support’ sector.

Finally, a key point to highlight is that the O&G sector is characterised by what are classified as ‘own sector’ inputs (i.e., inputs produced within the sector itself), accounting for 7% of the total value of domestic inputs. This may include a range of different interactions between firms within the O&G sector, but a key activity recorded here is the electricity generated on-site for use on oil platforms, where the value is recorded within the industry rather than via interaction with the UK electricity industry.

3. Similarities and differences between O&G and T&S sectors and key implications arising

In considering the similarities and differences between the O&G and T&S sectors via discussions with our expert stakeholders, some interesting findings emerge. Our questions focussed on the status of industry and how it is developed, maintained, and invested in that cut across the following categories:

1. Value of the products/outputs and how the industry is considered by the financial sector
2. Labour requirements and whether they are based on or offshore
3. Operational inputs in terms of the energy required and its source
4. Transportation options for O&G and captured CO₂
5. Export/value potential

A broad observation was the level of similar consensus, responses, and opinions across most of the areas that we discussed with the interviewees. This was partly expected, given our focus on understanding some of the general features and characteristics of the emerging T&S industry, which are likely to be common across sub-sectors/regionally based T&S industries within the UK. However, some divergences emerged that are attributable to differences in the main users and design properties of each T&S or wider CCUS network. Table 1 provides a brief summary of the headline findings.

Similarities and differences between O&G and T&S			
	O&G	T&S	Implications
Currently included in National Accounts	Yes	No	The T&S sector needs to be introduced with limited information on its potential structure
Value of product/output	Value of extracted oil incentivises operation and investment in sector	Captured CO ₂ has no value at present but there is an expectation that there will be value in the service of transporting and storing captured CO ₂	The value of the T&S services needs to be ensured, otherwise this could jeopardise private investment in the sector
Established industry	Mature and evolving industry	New and evolving industry	Most of the investment of O&G is embedded in the operation of the sector, while for T&S substantial upfront investment will be necessary



Cost impacts	Established demand but sensitive to global market and costs directly passed on to consumers, policy interventions may include fuel subsidies and windfall tax	Upfront funding with government potentially guaranteeing demand for services and recovering costs from emitters or UK households	Depending on how the funds required for public support are raised, this can have implications on different parts of the economy (e.g., taxpayers or industries using the T&S services)
Labour requirements	Substantial share of workforce located offshore in drilling and extraction platforms	Workforce requirement concentrated at onshore facilities, although some storage units might require workers to be operational offshore	Working onshore could have implications for the wages of T&S workers compared to those of O&G. Precise impacts are not straightforward to predict as skills/occupations involved will also impact wage rates.
Operational inputs	In terms of where energy is sourced, most platforms generate their own electricity, which is considered part of the sector's activity	Significant reliance on the electricity grid for its energy needs, therefore interacting more with the relevant UK sector	Greater reliance from the UK Electricity sector could introduce the need for upgrade/expansion of the network to cope with the additional demand. Increased demand could introduce upward pressure on electricity prices with knock-on effects on the cost of energy for households and businesses across the economy. Net impact depends on counterfactual (i.e., does availability of CCUS limit other electrification requirements?)
Operational inputs Transport options	Pipelines and oil tankers are most commonly used. For bulk transportation of oil and refined products, pipelines are cheapest and most efficient options.	Pipelines will be dominant option for distances of up to 100 miles. Shipping reserved for longer distances or where pipelines are not viable. Also, there is the option of tanker trucks being used by smaller units without access to central CCS systems.	Depending on which transportation method is mainly used and who owns and operates the pipelines and ships, there could be greater or smaller differences in the capital input requirements (and capital intensity) of T&S relative to O&G.
Export value	Exports constitute 87% of the industry's supply chains activity (ONS, 2022)	Some CCS networks are designed to service both the domestic and exports market, but others are exclusively focussing on a single industrial cluster	Exports of T&S services are possible, but the overall export potential is not yet clearly defined. Export capacity could increase as domestic demand for T&S services decreases and offset domestic funding requirements.



3.1 Value of product/output and investment

The key difference between O&G and T&S as economically defined industries is that the extracted oil and natural gas have a market value. Captured CO₂ that will flow through the T&S systems, on the other hand, currently has no market value beyond enabling emitting industries to reduce exposure to various carbon price mechanisms. However, that this constitutes a service, one that may be demanded on the basis of reducing exposure to costs of emitting CO₂ into the atmosphere, underpins the expectation that T&S has the potential to generate value, as reflected in movement within the financial sector to support the T&S industry. The involvement of the financial sector (reflected in the intermediate input requirements in Figure 1b) is crucial for O&G as it facilitates the maintenance and replacement of capital. Similarly, the financial sector's involvement with T&S is not expected to be limited to upfront investment/capital expenditure (CAPEX), rather extending to the operational phase and lifetime of the new industry.

However, as with any projected new industry activity, and particularly a capital and infrastructure-intensive one like T&S, significant investments are necessary ahead of the sector becoming operational, including likely development of initial excess capacity. In this case, the level of contributions coming from external investors is uncertain, with the expectation being that a significant part of the necessary infrastructure will be self-funded by actors within the T&S sector; firms across different sectors, including O&G, that are actively involved in the development of CCUS networks. As most UK CCUS networks are, at this stage, linked to the existing industrial cluster(s), it is also possible that funding for the T&S infrastructure will come from those industries that will engage in carbon capture (and, thus, require T&S services) within the cluster(s), as part of a wider investment in the development of the cluster. Additionally, for the Track 1 and 2 clusters, the UK Government is expected to provide some level of support in infrastructure development.

Our research around the implications of whether the government internalises the cost or opts to pass it to other parts of the economy, as well as the impacts of an 'industry pays' model, highlights the potential positive and negative knock-on effects for industrial competitiveness, GDP, jobs and regional economies. These must be considered in the continued evolution of T&S as part of a wider carbon management industry, and in terms of wider regional 'Levelling-Up' and 'Just Transition' considerations.

3.2 Labour requirements, location of employment activity, and the potential implications on wages

Consensus emerged from our stakeholder discussions that the labour and skills requirements of T&S will be similar to what is currently observed for O&G, and likely with a focus on utilising and developing UK workforce capability. A key difference though is that for T&S most workers are expected to be employed onshore, whereas O&G mainly employs people offshore. This could have implications for the wage intensity of T&S compared to O&G that will require further investigation. Crucially, the nature of the O&G activity involves drawing on an industry-specific but international labour market. Consensus emerged across the interviews conducted that a transition of part of the O&G workforce to T&S is likely to involve changes in this regard, potentially with more reliance on UK regional and national labour markets, and with challenges in terms of recruiting, retaining, and growing skills, all of which could further affect relative wage rates in T&S.

It is also important to emphasise that the operation of T&S will not necessarily signal the O&G sector ceasing production. This being the case, O&G, T&S and perhaps other emerging sectors, such as offshore renewables (and linked green hydrogen production), may end up competing for a limited number of workers with the necessary skills via UK regional and national as well as international labour markets on both a transitory and more permanent basis. Thus, the evolution of T&S employment and wage rates depends on a multitude of factors, as do consequent impacts on incomes accruing within the UK economy, and on wage rates within different labour markets. This is a critical area for further research and analysis.

However, a fundamental and key factor to highlight here is that labour market conditions will govern, influence, and potentially constrain how the economy responds to any new or substantial change in activity and industry composition. This becomes increasingly important in the context of both transitory and lasting UK labour supply constraint challenges, where competition for appropriately skilled labour and/or cross-sector (i.e., between O&G, T&S and Offshore renewables) skills overlap could exacerbate shortages and wage costs in the labour market. The latter is what could give rise to displacement of jobs/employment across a wide range of sectors not directly linked to the roll-out of T&S and/or transition from current O&G activity.



3.3 Operational input and dependence on electricity sector

Consensus also emerged via interview responses regarding shifts between 'own sector' production of electricity and transactions with/demands on the UK electricity network. Currently, the electricity used on offshore platforms is produced on-site and recorded in the input-output accounts as part of the O&G activity. Interviewees advised that the T&S industry is not expected to generate electricity on-site, at least not to the same extent, and will instead rely on the UK Electricity industry (encompassing generation, network and supply activity) to power the transportation and storage facilities.

Both opportunities and challenges arise from the greater reliance on the domestic Electricity industry. On one hand, the UK Electricity industry has a strong domestic supply chain. This could trigger greater economy-wide 'multiplier' effects relative to what is associated with own-sector electricity generation within the current O&G industry.

However, this needs to be set in the context of increased electrification across the economy, where T&S requirements may add to other needs - such as the electrification of private and much commercial transportation, and residential heating - to the extent costly electricity network upgrades requirements must be undertaken to ensure that the network can cope with the additional demand. Depending on how the upgrade costs are covered, this could introduce upward pressures on the energy bills of electricity users. This will add to the demand pressures on the price of electricity, with implications for fuel poverty, the wider cost of living and doing business in the UK and consequent inflationary pressure.

On the other hand, where the deployment of UK CCUS enables reduced electrification demands in decarbonising UK industry (even if only for a transitory period), particularly if linked to the deployment of hydrogen as a low carbon substitute for current fossil fuel use, the net impacts in terms of network pressure and upgrade costs may be limited. Thus, as with so many aspects of scenario-dependent analyses, much depends on the counterfactual.

3.4 The potential impacts of how captured CO₂ will be transported

The other key element of the T&S sector is how the captured CO₂ will be transported to the storage sites. O&G uses a combination of pipelines and tanker ships to transport extracted crude oil and natural gas. For T&S, the expectation is that when CO₂ needs to be transported within a distance of up to 100 miles, pipelines will be the main option used. These pipelines could be new, purpose built, or repurposed existing infrastructure. When there are transportation requirements over significantly longer distances, especially when there are no sufficiently proximate storage sites that can be reached at reasonable cost via pipelines, then shipping will be required for transportation of CO₂.

The interviews also revealed that there is another possible T&S transportation option; that is using tanker trucks, but this will be reserved for isolated production units that cannot link to any major T&S network or for smaller facilities that do not capture sufficient CO₂ to justify an ongoing connection to a CCUS network.

Another important point raised by the interviewees is that the existing marine transportation sector is expected to provide shipping services. However, a significant part of the sector providing shipping services, and its supply chain, is operated and owned by shipping companies located in other countries. This suggests that, on one hand, if shipping becomes a dominant mode of transporting captured CO₂, then some of the value associated with pipeline ownership operation will be offshored to wherever the shipping vessels are registered. On the other hand, if T&S uses a similar mix of pipelines and shipping as the one used by the O&G sector, then it is fair to assume that there will be minimal differences in the capital requirements and returns of the T&S sector.



3.5 Is there potential to export T&S services?

A final but important consideration relates to the potential users of T&S services. O&G is highly export-intensive (over 87% of its output). UK T&S also has some export potential (where actors in other countries may pay the UK T&S sector to take CO₂ captured in external industries and store it in UK sites), but this is not currently the case across all CCUS networks. Some of the networks have been designed to service exclusively their adjacent industrial clusters, with no capacity available to be exported. For other networks, such as in the Scottish case, exports are an integral part of the design.

In the cases where there is potential to export T&S services, this will mainly be to mainland Europe, but the magnitude is uncertain. Our previous analyses have shown that accessing international markets can help mitigate the T&S development cost that domestic actors, such as the government and carbon intensive industries, could face. Overall though it is likely that the export capacity may vary over time, especially if technological advancements (e.g., the use of alternative fuels, new less carbon-intensive production processes) help to decarbonise UK industries, reducing their need for T&S services and freeing up storage capacity to enable the export of T&S services to other users.

4. Conclusions and next steps

It is clear that numerous complexities exist around the nature and specific characteristics of the O&G and T&S industries that impact their comparability, both in terms of interaction with other sectors of the economy, and with the UK labour market. This not only gives rise to implications for CEP's economy-wide modelling on the SNZI project, but also raises some crucial questions and challenges for policymakers as the CCUS and wider net zero landscape evolves. Of these questions and challenges, there are three that require particular attention. First, labour market and 'Just Transition' considerations; second, the potential reliance of T&S on the UK electricity sector and third, the impact of CO₂ transportation options on potential economic gains that can be derived from this activity.

In terms of the labour market, potentially important differences exist between O&G and T&S in the location and nature of jobs/skills/employment transition opportunities. Expectations are strong in terms of how T&S may offer crucial and relatively smooth transition opportunities for workers currently employed in O&G. However, these expectations need to be examined in the wider socioeconomic and political context of a constrained labour market and multiple net zero and other activities competing for workers. These could have important implications for both project delivery and economy-wide outcomes. In relation to energy demand and the potential greater reliance of T&S on the electricity sector in comparison to O&G which generates its power needs on-site, much will depend on whether the availability of CCUS can limit the electrification requirements of industrial activities looking to decarbonise, at least in some timeframes. If not the operation of T&S activity will put further costly demands on capacity which could in turn have an impact on increased levels of investment in the electricity network and consumer bills.

Finally, regarding transportation of CO₂, particularly the potential role of shipping, a key factor is that this service will be largely provided by the existing (international) marine transportation sector. This could have important implications for where economic activity is recorded and incomes accrue, with the potential risk of 'offshoring' the value contribution of this activity. These critical questions and challenges will be explored in more detail in a forthcoming brief. They will also inform our economy-wide modelling and analytical work going forward in SNZI and help us refine the supply chain structure of the new T&S industry in our scenario simulation framework, around which we will continue to engage with CCS stakeholders.



Endnotes

ⁱ We have explored the potential impacts to the UK economy of introducing a new CO₂ transport and storage (T&S) sector, servicing either the [Scottish cluster](#) or [all 4 clusters](#) that submitted proposals for consideration as part of Track 1 of CCUS rollout. Furthermore, we have produced policy briefings of the work focusing on the [Scottish cluster](#) and [all 4 clusters](#), while we have produced a further briefing exploring the implications of the T&S sector servicing the Scottish cluster being able to [export a large share of its services abroad](#).

ⁱⁱ We have explored the impacts of introducing carbon capture in the Scottish Chemicals industry on the Scottish economy. We have also considered the implications of carbon capture introduction on the UK chemical industry, especially under difference conditions regarding the use of carbon capture across the world. Our work focusing on Scotland is also available in a policy [briefing format here](#), while we consider the broader economy-wide impacts of CCUS in [an extensive report](#) published by CEP

ⁱⁱⁱ We have further applied the approaches developed through our peer reviewed work in considering the potential impacts across the UK economy, and the emerging trade-offs linked to the implementation of Track 1 of CCUS rollout in a policy brief available at <https://strathprints.strath.ac.uk/79477/>. A further application involves examining the impacts of exporting T&S capacity developing in the Scottish cluster, in the brief available at <https://strathprints.strath.ac.uk/79716/>.

^{iv} For example, we are currently embarking on a similar process via our work on the [EPSRC Ocean-REFuel project](#).

^v The [latest \(2018\) UK Input-Output tables](#) were published by the Office for National Statistics in April 2022