Exploring the impacts of the adopted carbon capture approach to the Scottish chemical industry and the wider Scottish economy

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Summary

The UK's ambition to reach net zero by 2050 will require the decarbonisation of a number of economic activities. The UK Climate Change Committee (CCC) has identified carbon capture as an essential technology to decarbonise industrial production, especially for those industries where electrification or alternative production processes are not viable options. Carbon capture can be implemented in different ways, either post-combustion (or post-production, more generally) or pre-combustion with a substitution of current fuels for low-carbon alternatives. However, not every production facility can implement either approach and there are different capital and energy input requirements depending on which carbon capture approach is adopted.

As part of the Industrial Decarbonisation Research and Innovation Centre, the Centre for Energy Policy (CEP) developed the project titled 'The wider economy and competitiveness impacts of employing pre- and post-combustion carbon capture in UK industries (ECONCC)'. The project focused on the Scottish chemical industry, exploring how the adoption of pre- or post-combustion carbon capture can impact the industry itself and, by extension, the wider Scottish economy. Three key findings emerge that not only highlight the potential implications of the adoption of different carbon capture approaches on the Scottish chemical industry but also the role of government interventions in addressing some of the negative impacts:

1. **Carbon capture introduction could pose competitiveness and price challenges for the Scottish chemical industry and wider economy.**
   The additional capital and energy requirements associated with the introduction and operation of carbon capture technologies introduce more costs for the industry, pushing prices upwards and negatively affecting the sector's competitiveness and the Scottish economy as a whole. The capital requirements drive most of the costs, making the more capital-intensive pre-combustion carbon capture the approach that may lead to the least favourable outcomes. For example, introducing pre-combustion carbon capture to Scottish Petrochemicals could increase their output price by 3.12%, whereas the price would increase by 2.19% if post-combustion carbon capture is used.

2. **A decarbonisation approach across the UK chemical industry can protect against disproportionate losses at the devolved level.**
   An approach where the entire UK chemical industry adopts CCS, and therefore faces similar costs, leads to better sectoral and Scottish economy outcomes. Specifically, a UK-wide decarbonisation approach would limit the Scottish GDP impacts to up to -0.12% (£203.55 million) instead of up to -0.15% (£261.88 million) when the Scottish chemical industry makes unilateral decisions. This is because a common approach levels the field across the UK, allowing Scottish chemicals to retain their exports to the rest of the UK (RUK), while being protected against imports of and substitutions for less expensive RUK-produced chemicals.

3. **Government subsidies can help protect against economy-wide losses.**
   A broader subsidy, in line with the CCUS Business Models provisions, can help ease the negative pressures emerging from the introduction of carbon capture. Easing the chemical industry price impacts might be more expensive when pre-combustion

carbon capture is used, but government support to level the field between the less expensive post- and the more expensive pre-combustion carbon capture can actually lead to better economy-wide outcomes if the latter is adopted. This still comes with implications for the government budget, which, however, need to be considered in a broader net zero context, e.g., a fuel switch in the chemical industry could be the basis to develop a hydrogen economy and facilitate decarbonisation in other sectors.

Carbon capture introduction in the Scottish chemical sectors

The UK's Climate Change Committee (CCC) has identified carbon capture utilisation and storage as an essential technology to support the decarbonisation of UK industries and this applies to chemical industries across the UK. The Scottish chemical industry has indicated that it will employ carbon capture to decarbonise its production.[i] However, carbon capture can take place post-combustion, or more generally post-production, or pre-combustion with a substitution of current fuels for low- or zero-carbon alternatives. Not all production facilities are suitable to introduce either approach due to factors such as the inherent variability in their emissions, procedures, and operational needs, while depending on which approach is adopted there are different capital and energy requirement implications.

Our review of existing technoeconomic analyses of the different carbon capture approaches has revealed that post-combustion carbon capture generally requires less capital and more energy to operate, while pre-combustion carbon capture is more capital intensive, owing to the need to introduce new equipment and replace or retrofit existing equipment to operate with new fuel, but overall leads to smaller energy requirements. Table 1 summarises our high-level findings.

Table 1: Post and pre-combustion additional capture capital and energy inputs requirement for chemical industries

Capture technology	CAPEX relative to industry Core Asset Value	Additional Energy Requirements (Additional relative to combustion energy input)	
		Natural Gas (Feedstock or heat)	Electricity
Post- combustion CCS	+40%	+30%	+4%
Pre-combustion CCS	+50%	+20%	+3%

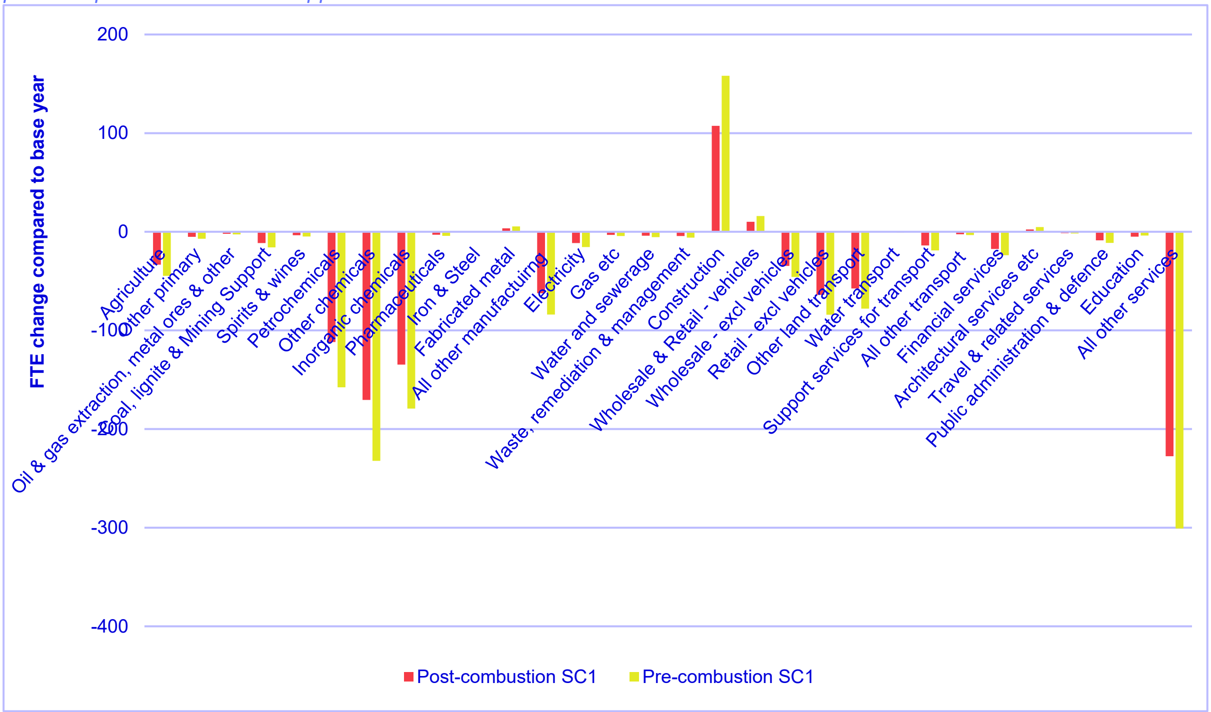
Analysing the impacts of introducing carbon capture to the Scottish chemical sectors, we found that in the petrochemicals sector, for instance, the adoption of post-combustion carbon capture could drive the sector's output price upwards by 2.19%. On the other hand, the adoption of pre-combustion carbon capture could lead to a price increase of 3.12%, indicating that capital requirements are more important in determining the price impacts at the sector level; crucially, these results are echoed across the Scottish chemical sectors. Due to the higher prices, the Scottish chemical sectors lose some of their competitiveness and as a result, we observe losses in output, ranging between 4.24% and 20.48% depending on the specific sector and the carbon capture approach used, value-added and employment. On employment, we find that in petrochemicals, the larger chemical sector in Scotland, there can be direct employment losses of around 100 full-time equivalent (FTE) jobs, -3.62%, when post-combustion carbon capture is used, increasing to 140 FTE direct job losses (-5.11%) when using pre-combustion carbon capture.

The impact on the Scottish economy and the effect of UK-wide action

As is commonly the case, the negative pressures are not isolated to the chemical industries that introduce carbon capture; instead, there is some degree of spillover across the entire Scottish economy manifesting in the form of negative economy-wide impacts. A key driver of these impacts is that chemical industries produce a significant share of outputs used by other sectors as part of their production processes. Therefore, an increase in the cost of chemicals pushes up the production cost and, by extension, the output price of most Scottish industries. This is reflected by a sustained increase in the consumer price index (CPI) between 0.02% and 0.03%, depending on the carbon capture approach used. The economy-wide price increases negatively affect the competitiveness of most Scottish industries, leading to reduced demand for their output, including export losses between -0.24% and -0.33%.

Overall, the introduction of carbon capture to Scottish chemical industries contributes to sustained Scottish GDP losses between -0.11% (£196.24 million) and -0.15% (£261.88 million), alongside net employment losses of -0.04% (871 FTE) and -0.05% (1,152 FTE). Most of the employment losses are concentrated in the chemical industries, which are mostly affected by the introduction of carbon capture, but we observe losses across most sectors. The only exception is 'Construction', which benefits from additional activity associated with maintaining the new infrastructure required for carbon capture.

Figure 1. 2050 changes (relative to base year) in sectoral employment when Scotland is the sole adopter for the case of post-and pre-combustion CCS application.



In that sense, some of the negative impacts to the Scottish economy could be avoided if there was action to protect the Scottish chemical industries. One way that this could be achieved would be if the UK Government co-ordinated and/or mandated the roll out of carbon capture approach across the entire UK chemical sector. In practice, this would involve the use of different approaches for different production facilities, driven by their individual characteristics. However, in the absence of sufficiently detailed representation of the chemical sector in our model, we have focused on the illustrative example that all the UK chemical industries will use the same carbon capture approach.

In doing so, this would level the field within the UK, meaning that Scottish chemicals would not lose their export capacity to the rest of the UK (RUK), their major export partner, while other Scottish industries would not substitute Scottish chemicals for cheaper ones produced elsewhere in the UK. Indeed, if for instance a UK-wide pre-combustion carbon capture approach is adopted for the chemical industries, we find that the net employment losses in the Scottish economy are restricted to -0.02% (567 FTE) instead of -0.05% if the Scottish chemical industries adopt pre-combustion carbon capture unilaterally.

Similarly, the total export losses are eased to -0.26% (instead of -0.33%), largely due to the chemical industries being able to continue exporting to RUK without being in a disadvantaged position compared to their RUK competitors. This would still be the case even if the RUK chemical industry were to predominantly use less expensive post-combustion carbon capture. In that case, the field would not be entirely level, favouring the less impacted RUK chemical industries and driving some substitution away from Scottish chemicals and towards imported RUK chemicals. However, the substitution would be smaller compared to the scenario where Scottish chemical industries act unilaterally and therefore their RUK counterparts do not face any carbon capture related costs. Thus, co-ordination at the UK level will still help protect the Scottish chemicals industries and the wider Scottish economy.

Specifically, UK co-ordination on the rollout of carbon capture in the chemicals industries could mean that the Scottish GDP losses are mitigated to -0.12% (£203.55 million). However, it should not be overlooked that these improved economy-wide outcomes emerge because of identically high prices of chemicals across the UK. Therefore, there could be negative impacts on the broader UK economy, not captured by our analysis. At the same time, the prices of the Scottish sectors are becoming marginally higher as there is no longer the option to keep their production cost lower by importing less expensive chemicals from the rest of the UK. In that sense, the competitiveness impacts of Scottish sectors persist, with only the chemical industries being protected in the UK market.

Government supporting the introduction of carbon capture

Alternatively to mandating a UK-wide carbon capture approach for the chemical industry, there could be government support to help ease the impacts of introducing carbon capture in different industries. We explored the illustrative case where this support is offered only to the Scottish chemical industries, with a view to ease the price impacts of carbon capture by 25%. Similarly to what we found in relation to the case where a UK-wide carbon capture approach is adopted, easing the price impacts in the Scottish chemical industries helps restore some of their competitiveness in Scottish, UK and international markets, mitigating the employment and export impacts both within the chemical industries and in the economy as a whole, and ultimately leading to smaller GDP losses.

Specifically, government support directed to ease 25% of the carbon capture price impacts limits the net employment losses to approximately -0.02%, with small differences between the two carbon capture approaches, instead of -0.04% and -0.05% in the absence of any government support. The export losses are restricted to -0.18% and -0.25% for post- and pre-combustion carbon capture respectively, as opposed to -0.24% and -0.33% when no support is provided. This is supported by the fact that the prices of Scottish chemicals are reduced for all users, meaning that the impact on economy-wide prices is also smaller, helping restore some of the competitiveness of Scottish sectors. As a result, more activity is retained within the Scottish economy, mitigating the GDP losses to -0.8% under post-combustion carbon capture and -0.11% under pre-combustion, as opposed to -0.11% and -0.15% for post and pre-combustion respectively for the case without government support.

Besides supporting both carbon capture approaches, a different option for the government could be to bridge the price impacts between post- and pre-combustion carbon capture. This would allow the different chemical industries to use the carbon capture approach most suitable for their needs, without being less competitive to their counterparts that are able to use the less expensive post-combustion carbon capture. Interestingly, levelling the price impacts of pre- and post-combustion carbon capture does not necessarily mean that the economy-wide impacts are also on the same level. In fact, due to the greater reliance on construction and the smaller reliance on the import-intensive natural gas, a supported pre-combustion carbon capture leads to smaller economy-wide impacts compared to the unsupported post-combustion carbon capture. Specifically, supporting the implementation of pre-combustion carbon capture limits the net employment losses to -0.01% (331 FTE) as opposed to -0.04% (871 FTE) under the unsupported post-combustion approach, while the GDP losses are limited to approximately -0.11%, marginally smaller than the unsupported post-combustion.

However, it is important to emphasise that the improved outcomes come with a bill that needs to be covered by the government, which will be higher for the more expensive pre-combustion carbon capture, and which will have implications of its own depending on how the government will cover the costs.

Policy implications

The findings from our research as part of the ECONCC project suggest two key considerations for policy.

First, there needs to be careful consideration as to whether different industries should act unilaterally. Our analysis demonstrates that there can be significant impacts to the devolved national economies, in the event that industries - here Scottish chemical industries - adopt a different decarbonisation approach to the rest of the UK. Especially when this involves industries with strong links to the rest of the devolved economy, the impacts can spill across the entire economy, negatively affecting sectors that are not adopting the considered decarbonisation measures. This is particularly relevant in a 'Just Transition' and 'Levelling-up' context, which can be the driver as to why there may be a need for co-ordinated action across the UK (for example managed by the UK Department for Energy Strategy and Net Zero). However, it should not be overlooked that, while co-ordinated action can protect 'at risk' industries in parts of the UK, it can also lead to increased prices across the UK economy with negative implications for the competitiveness of the UK sectors. Thus, any decisions for co-ordinated action at the central UK level will need to take into consideration the UK economy-wide implications of said decisions.

Linked to the aforementioned consideration, there can be government support measures to help mitigate the price pressures associated with the introduction of carbon capture in different industries. However, any form of subsidy is likely to come with a bill that needs to be covered by the government and with additional implications associated with the approach used to raise the necessary subsidy funds.

The second policy implication then is that the government needs to clearly define what are the objectives associated with introducing and supporting specific carbon capture approaches. The cost implications are an immediate consideration, but as our analysis shows, there can be different outcomes emerging by choosing to support different carbon capture approaches. Opting to support post-combustion carbon capture might be the least costly choice. At the same time, supporting pre-combustion carbon capture can ultimately lead to better economy-wide outcomes, albeit at a higher cost, while also potentially acting as a basis for a hydrogen economy within the UK. Assigning then specific objectives and targets against any support provided, will be essential for policymakers to determine where subsidies should be provided.

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[i] Major operators of chemical production facilities such as INEOS, Exxon-Mobil, Shell and Calachem are part of the supporters of the Scottish Cluster as indicated in the cluster's website: https://www.thescottishcluster.co.uk/our-partners

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