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Policy Briefing

How is planned public investment to enable CCS likely to impact the wider UK economy?

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Summary of key research questions and findings

The UK has made a binding commitment to reach net zero emissions by 2050 and Carbon Capture and Storage (CCS) is seen as a key component of getting there, as evidenced through the CCUS Action Plan published by BEIS in 2018.[i] In the March 2020 spring budget statement[ii], the UK Government subsequently committed a minimum spend of £800million to promote the development of CCS.

However, there has been limited consideration of how CCS can be deployed in the UK in a fiscally and/or economically sustainable way. What would be the economy-wide implications of developing and operating a complete CCS system? **Here we focus on the wider economic impacts of the UK Government directing funds over a 6-year period to facilitate the development of transport and storage infrastructure.** We find that this does **provide a transitory stimulus to the wider economy with a cumulative GDP gain of £0.2million per £million spent and between 1,700 and 3,850 additional jobs required per year.** This is in addition to establishing the foundations for CCS to play a key role in reducing emissions in key high value industries over the coming decades, and to evolve the role of the oil and gas industry.

1. How will the initial investment impact the wider economy?

We find that both a £800million and larger **£1.75billion investment by Government in critical CO_2 transport and storage** infrastructure over a 6-year period (where the latter amount would be required to fully develop 3-4 storage sites and enable CCS across multiple major UK industry clusters) **results in a transitory wider economy stimulus.** The GDP impact is positive throughout the 6-year investment period, maximised at a 0.01% (£126.4million) gain in the first year (2021) where there is concentrated up-front spending on key administrative and survey activities.

2. What impact does the investment stimulus have on employment?

Importantly given current COVID-19 related circumstances, **the investment can lead to the almost immediate creation of 3,850 full-time equivalent (FTE) jobs in the first year.** Even once substantial upfront activity completes, as projects move through subsequent development phases, employment gains are supported at levels of between **2,250 and 2,670 additional FTE jobs in each of the subsequent 4 years**, and 1,700 in 2026. On average, this maps to the transitory creation of **1.5 additional FTE job per £1million spend across the 6-year time frame.**

3. What are the wider economy impacts on key variables such as the public budget and UK competitiveness?

The investment spending does draw on the public budget in each year but there are **offsetting impacts on the public budget requirement in each of the six years**, given revenues generated as the economy expands. This includes income tax generated through those sectors where employment increases. However, as is the case with any large public or private investment in a constrained economy, the expansion has impacts on prices across the economy. This leads to **some negative impacts to the competitiveness of UK exports, but with no net job losses.**

4. What are the key questions regarding further CCS development?

Moving forward, the question becomes one of whether a large-scale operational CCS sector enabled by this initial investment activity can **constitute a fiscally and economically sustainable return to public and private sector investments**? Could CCS provide a sustained contribution by **helping to sustain activity in several high value industrial activities?** This includes both those manufacturing activities that need to reduce emissions without offshoring value, and those fossil fuel supply activities that need to evolve and use their capacity, skills and infrastructure in different ways in a net zero future.

I. Introduction – the need to understand wider economy impacts

The UK has set in statute binding targets to reach net zero emissions by 2050.[iii] While significant steps forward have been made in reducing emissions from sectors such as electricity generation, significant challenges remain in reducing emissions from heating, transport and key industrial processes. One solution for reducing emissions from industrial processes such as cement and chemicals production (industrial decarbonisation), is Carbon Capture and Storage (CCS).

The International Energy Agency (IEA) and the United Nations Intergovernmental Panel on Climate Change (IPCC) identify CCS as necessary for between 12% and 20% of emissions reduction globally.[iv] In the UK specifically, the UK Committee on Climate Change concur that CCS will be a crucial component of getting to Net Zero.[v] However, the question that has not yet been answered, or even adequately addressed, is **can CCS can be developed and rolled out in the UK in a manner that is fiscally or economically sustainable?** Ideally, CCS should evolve to play a productive as well as emissions reducing role in our net zero economy.

Thus, there is an important research question in terms of **what are the wider economic and fiscal consequences of enabling, operating and realising deep CO_2 emissions reductions through the development of CCS capability and service delivery in the UK?** We have begun to address this question in the context of how CO_2 capture activity could rollout without damaging industry competitiveness.[vi] There, and more generally, we identify a challenge in that building consensus around the feasibility and acceptability of CCS as a decarbonisation and industrial policy solution will require that sufficient economic gains ultimately arise to cover – via policy intervention where required – the costs incurred by different actors in the economy.

In the research reported here, we focus attention on the foundations that could be laid both to enable the transport and storage (T&S) side of CCS and the economic feasibility of a wider CCS industry. That is, we focus on whether taking the first stages in enabling CCS in the UK could generate at least some transitory GDP and employment gains that that could be set against the taxpayer costs involved in initial investment activity as proposed via the UK Government's CCS infrastructure fund (March 2020 Budget).

II. What we have modelled

We use our multi-sector economy-wide computable general equilibrium (CGE) model, UKENVI, to analyse two scenarios, both involving development of pre-identified potential CO_2 storage sites (see Annex A for model details).

The first scenario involves the **development of 4 storage sites (Hamilton, Captain X, Viking A and Bunter 36) with a total estimated cost of £1.75billion** (Strategic UK CCS Storage Appraisal, specifically storage development plans D10, D12, D13 and D14). We assume that all four infrastructure hubs (stores and the CO_2 pipelines needed to transport CO_2 to the stores) are developed concurrently and not sequentially.

The second scenario focusses only on the **development of Captain X and Viking A with a total cost of £755million** (Strategic UK CCS Storage Appraisal, specifically storage development plans D13 and D14). Again, these stores are not chosen because they would necessarily be the first two stores developed in the UK, but because their characteristics and costs are indicative of what could be funded under the government's commitment of an £800m CCS Infrastructure Fund.

In both cases, we assume that just over 80% of the total pre-FEED, FEED and construction investment spending is made within the UK.[vii] We do not model the production of the non-UK imports but we do model the total spending, including both the domestically produced and imported inputs.

Our assumption is that the development will start in 2021 and will last 6 years. Overall, we assume that investment spending is directed to the following activities:

- Seismic surveys, appraisal of wells and engineering analysis (via the existing Mining Support sector) – 3.7% of total spending, concentrated in first year
- Pre-FID (Final Investment Decision) Front End Engineering and Design (FEED) work (carried out by the architectural services sector – 3.58% of total spending, also concentrated in first year
- Securing licencing and permits related activity involving spending within public administration – 1.22% of total spending. This spending is front-loaded (58% of

spending) with the remainder spread over the remaining 5 years

- Design, procurement and fabrication of transport equipment (pipelines etc.) and transport and storage facilities (including repurposing of drilling platforms (from existing fabricated metal and transport equipment manufacturing sectors) – 43.54% of total spending spread equally over 6 years
- Construction and commissioning activity - 47.96% of total spending also spread equally over 6 years

The transitory economy-wide impacts of investment spending in these areas of the economy are simulated as a boost to domestic demand for industry outputs. Here, application of our CGE model allows us to move beyond the conventional multiplier analyses of investment spending to consider how prices and incomes are likely to be impacted in timeframes where public investment may partially 'crowd out' other activity.

Importantly, the analysis purely relates to potential spending under the CCS Infrastructure Fund and therefore does not reflect the full economic impacts of CCS, which would also include investment and activity related to CO_2 capture. In terms of how the spending is funded, in the absence of other information, we assume that spending is funded through the government budget and we therefore introduce it as additional expenditure.

III. Findings

1. How does this initial investment activity to enable CCS impact the wider UK economy?

The outcome is a **transitory but constrained stimulus to the economy.** We focus attention here on the impacts of the larger, £1.75billion, investment programme, but note that the impacts of the more limited £800million investment are roughly half the size of those of the £1.75billion programme, potentially with more limited negative effects given reduced price and 'crowding out' pressures.

Given the relatively small size of the spending stimulus, the annual boost to GDP over and above what it would otherwise be, is small in percentage terms, maximised under the larger £1.75billion spend at 0.01% (£126million) in the first year (2021). The annual GDP boost then settles at around 0.005%-0.006% (£70million - £73million) per annum in the four year period 2022-2025, before tailing off to 0.003% (38million) in 2026, followed by a slight GDP depression as resources reallocate after the stimulus period. **Ultimately, the cumulative long term (30-year) GDP boost (where all positive gains are realised within the 6-year time frame to 2026) equates to around £0.2million of cumulative GDP per £million spent.**

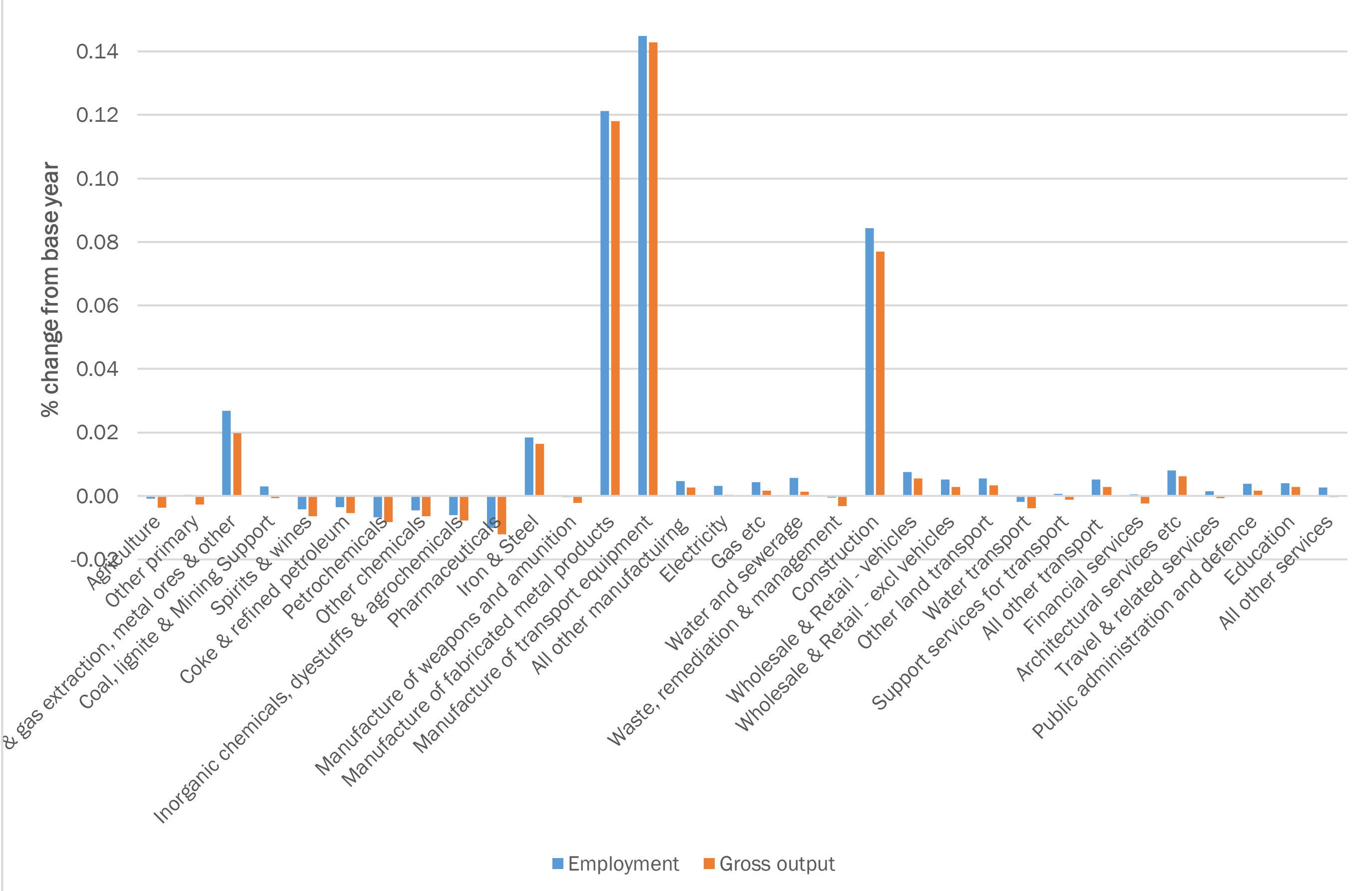
2. What impact does the investment stimulus have on employment?

Additional job creation associated with the expansion (enabled by an existing pool of unemployed labour) is also limited to the 6-year project timeframe, with an additional 3,850 full-time equivalent (FTE) workers required in the first year, between 2,250 and 2,670 additional FTE jobs in each of the subsequent 4 years, and 1,700 in 2026 (see Figure 1). **The cumulative impact is the transitory creation of one additional job per £1million spend (with both spending and job creation limited to the 6-year project timeframe).** Again, it is important to emphasise that these results relate only to the direct investment in the development of T&S infrastructure and don't consider the potential wider direct or indirect employment impacts associated with full-chain CCS projects, e.g. jobs changes directly or indirectly driven by investment in and operation of CO_2 capture.

3. What are the wider economy impacts on key variables such as the public budget and UK competitiveness?

There are notable offsetting impacts on the public budget requirement in each of the six years. This is because the expansion creates revenues generated in those industries that directly or indirectly (through domestic supply chain linkages) enjoy a transitory expansion in activity, and in additional income tax associated with employment (see Figure 1).

Figure 1: Sectoral breakdown of employment and gross output impacts due to UK Government investment in T&S system development in period 3 (4 storage sites)



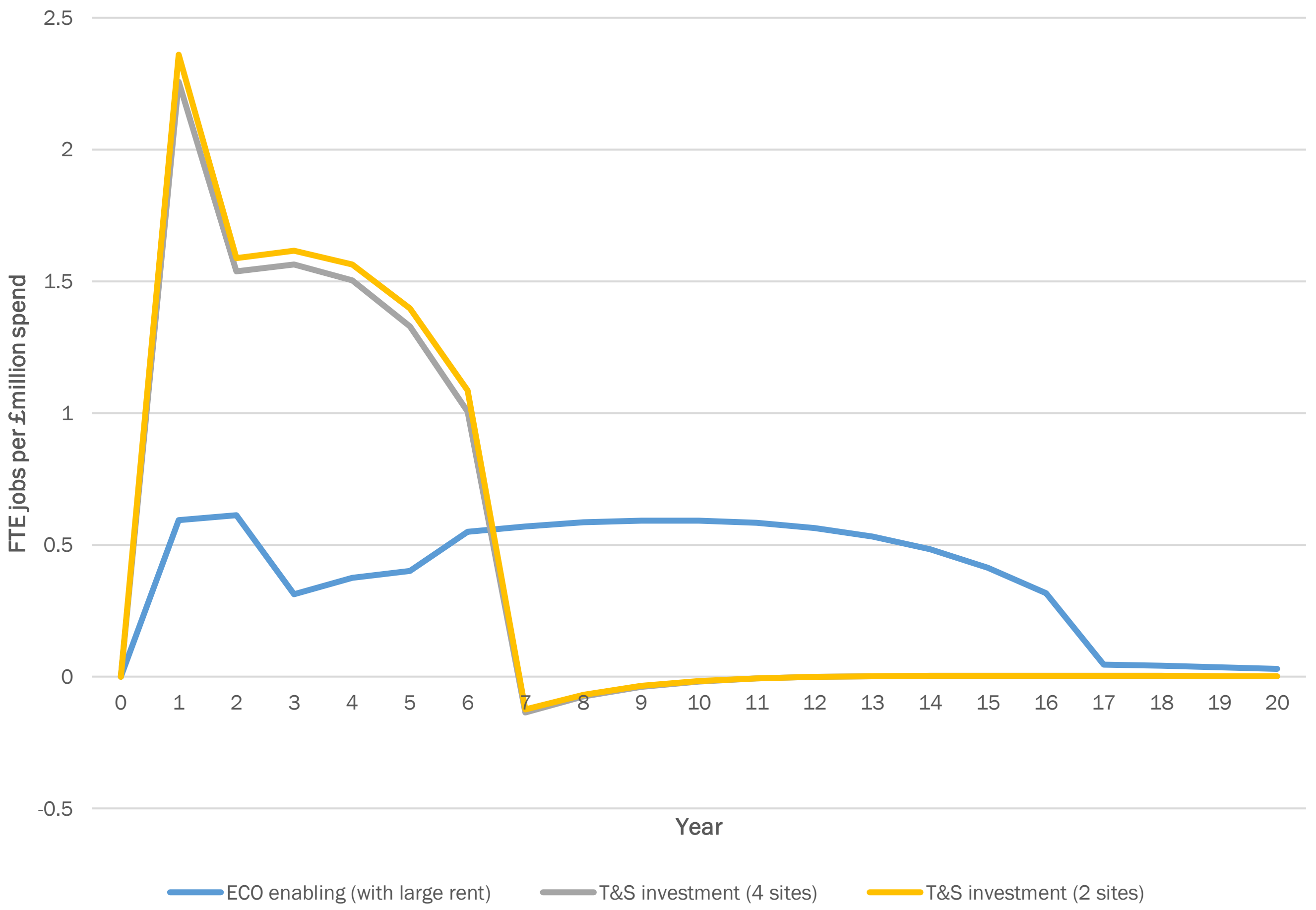
However, as may be expected, the relationship between spending and expansion is not one of a straightforward economic 'multiplier'.

Even spending of the limited scale set out above can be expected to have some 'crowding out' effects on investment and activity elsewhere in the economy. Our simulation results suggest that beyond the first year (where spending is more concentrated in more inward facing service sectors of the economy), the percentage increase in the consumer price index (CPI) will outstrip that of the GDP expansion. This constrains the expansion in two ways. The first is that real earnings growth accruing to UK workers and households is slightly eroded relative to the nominal wages paid by employers. This manifests in small employment gains observed in some sectors being associated with slight real wage contractions (see Figure 1).

Second, the general price pressure acts to reduce the competitiveness of UK exports. In practice, much will depend on the price sensitivity of export demand. Here, our simulation results suggest that the composition of expanding GDP changes in favour of domestic (public and private investment, and household) demand, with the value of total UK exports actually falling (£71.5million) by almost as much as GDP rises (£73.1million) 3 years in to the project activity (2023). This manifests in some contraction in activity in several high-value manufacturing industries that are not direct beneficiaries of the investment spending (including chemicals and pharmaceuticals sectors.

While, the impact in any one sector in this analysis is not sufficient to bring any notable impacts on employment in these sectors, the loss of high-value is reflected in a transitory reduction in labour productivity (GDP per employee) throughout the project timeframe.

Figure 2: Comparison of societal returns of investment to CCUS Transport & Storage (T&S) against the enabling stage of ECO (FTE jobs per £million spend)



It should be emphasised that the type of outcomes discussed here are likely to be typical of any substantial private or public sector investment activity. Indeed, if it is the case that these 'enabling' projects, such as infrastructure development, can be funded from existing government budgets, the lack of pressure for cost recovery through taxation and/or energy bills, prevents the type of net macroeconomic contraction we have observed in other work, for example in the case of electricity network upgrades.

Here, for example, the average societal return of roughly 1.5 FTE jobs per £1million spend over the project timeframe is clearly above the average of 0.5 jobs per £1million we have estimated for other net zero actions, such as the ECO retrofitting programme to enable increased UK residential energy efficiency.[viii] Even considering these societal returns over time, development of T&S returns over 1 FTE job per £million spend across the duration of the programme, which is not achievable through ECO (see Figure 2). On the other hand, a programme like ECO requires that investment costs be recovered through energy bills, which will impact real incomes and consumer spending power. If the CCS infrastructure developments were funded through additional taxation, this would have similar off-setting impacts on the expansionary power of the investment itself.

IV. Policy implications – the challenge of enabling a wider CCS industry

As in other cases of activity to enable emissions reduction, the likelihood of a combination of positive and negative wider economy impacts helps set out a key challenge for CCS. That is,

what an operational CCS system/sector in the UK economy would need to deliver by way of evolving wider economy returns once it is up and running (the 'realising' stage) if it is to constitute a fiscally and economically sustainable return to public and/or supported private sector investment.

Returning to the example of ECO, wider economy benefits accruing from enabling households to become more energy efficient and, thus, free up real consumer spending power in the economy raises the 'jobs per £1million spent' from a maximum of 0.55 FTE jobs in the retrofitting project time frame to 1.8 jobs that are sustained into the longer run. The associated cumulative GDP (by 2040) generated per £1million of spending reaches £2.3million. Our research across a range of net zero actions demonstrates that, depending on how different types of programmes and pathways are designed and delivered, there is real potential for sustained real gains in GDP, jobs and incomes. We have set this argument out via the proposition of a Net Zero Principles Framework[ix] that considers how net zero actions can be challenged to play a role in developing transition pathways that sustain and ideally grow our ability to continue to deliver prosperous and fair outcomes across the economy and society.

The question, then, becomes one of whether using near term investment to lay foundations for a new CCS industry can deliver similarly strong returns and facilitate industrial decarbonisation at home, preventing offshoring of industries, emissions and jobs and, thus, to sustain employment and minimise potential losses in value-added?

In previous work[x], we have identified the UK Oil and Gas industry as a key comparator to the future CCS sector given the similarity in capital intensive activity and the range of linked sectors. For Oil and Gas, we have identified an 'employment multiplier' of 9 or 10 UK-wide jobs per direct industry job that it has supported in recent years, which may be replicable through a wider CCS programme, enabled by investment in this initial infrastructure.

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Annex A: Brief description of the UKENVI CGE model and data for scenarios

Model and scenario data

In this work we use the UKENVI multi-sector computable general equilibrium, CGE, model of the UK economy. The model is fully specified and detailed in previous peer-reviewed papers.[xi] UKENVI is currently calibrated on a 2010 social accounting matrix (SAM) that incorporates an estimated industry-by-industry input-output (IO) table. A benefit of using the specific year it that it reflects the state of the UK economy following the 2008 recession. In that sense, the model can be a good proxy of the state of the UK economy following the COVID-19 pandemic and the associated economic recession. Here we explain some key characteristics of the model that are particularly important for the analysis conducted here.

The data on the cost of development of the carbon storage sites come from the Strategic UK CCS Storage Appraisal, specifically storage development plans D10, D12, D13 and D14. These plans detail the CAPEX and OPEX for the specific storage sites we consider here. As our focus is on the development of the transport and storage (T&S) infrastructure, rather than its operation, we only use the CAPEX figures reported. The spending on T&S infrastructure development is reflected as an exogenous increase to the demand of the sectors involved. A key point is that not the entirety of the activities involved in the development of T&S infrastructure will be delivered by UK industries. We have made assumptions on the UK content of each of the necessary activities as detailed in Table 1. Overall, under our assumptions the total amount directed to the UK economy will be in the region of 80% of the total cost, largely owing to the fact that the UK economy has a developed Oil & Gas industry that can deliver on activities like seismic surveys and manufacture of wells. We also assume that the development cost is covered by the government budget. This means that there is no requirement to adjust the income tax or pass the cost through energy bills, and through that negatively affect the UK households for example, but the total development cost is reflected in the government budget balance.

Which sectors are included?

The general equilibrium framework incorporates all sectors of the UK economy. This allows analysis to capture interactions between the different sectors and markets and identify how changes in one sector can spill across the entire UK economy through changes in prices and incomes generated in different markets and the availability of constrained supplies of labour and capital. We aggregate the 103 sectors reported in ONS IO accounts to 32 sectors. This includes five energy supply sectors: coal extraction, crude oil extraction, refined petroleum, electricity and gas distribution sectors. The aggregation (or not) of the other 27 sectors permits key activities impacting or impacted by the response to the development of T&S infrastructure to be distinguished. Such sectors include 'Manufacture of fabricated metals', 'Manufacture of transport equipment' and 'Architectural and engineering activities'. See Table 1 for the exact spending allocation on each of the different sectors involved in the development of the T&S infrastructure.

How is production activity modelled?

Each industry has a production function that incorporates labour, capital, energy and non-energy intermediate inputs. Capital, labour and intermediates are standard input classification in every CGE model, including the one used by HM Treasury. The key difference is that in our model we distinguish between energy and non-energy intermediates. Capital and labour are combined in one nest of a CES consumption function to produce value added before combining with intermediates, dependent on relative prices. Here, we assume a fixed nominal wage and also a fixed (national) labour supply, meaning there cannot be any migration to cover the excess labour demand. The base year data incorporate a small (6%) pool of unemployed labour that responds to additional employment opportunities and through which the labour demand is covered. We assume perfect mobility of employees to other sectors where increased demand for their output also leads to increased labour demand. Capital is also constrained in that it does not instantly reach the desired level. Instead, the path of the necessary investment to the desired capital stock is calculated so that it maximises the value of the firms, while taking into account the depreciation of existing capital.

Table 1: Summary of data used to inform scenarios (all values in £million)

SIC 2007 codes	Name of sector in UKENVI		1	2	3	4	5	6	
			2021	2022	2023	2024	2025	2026	Total
	Total annual spending (UK and imports)	All 4 sites	396.40	261.90	261.90	261.90	261.90	261.90	1705.9
		Captain X and Viking A	174.73	116.13	116.13	116.13	116.13	116.13	755.4
Spending on UK sectors									
SIC 2007 codes	Name of sector in UKENVI		2021	2022	2023	2024	2025	2026	Total
05, 08-09	Coal, lignite & Mining Support	All 4 sites	56.79	0	0	0	0	0	56.79
		Captain X and Viking A	18.45	0	0	0	0	0	18.45
69.2	Architectural services etc	All 4 sites	54.54	0	0	0	0	0	54.54
		Captain X and Viking A	29.42	0	0	0	0	0	29.42
81	Public administration and defence	All 4 sites	12.13	1.73	1.73	1.73	1.73	1.73	20.80
		Captain X and Viking A	6.07	1.73	1.73	1.73	1.73	1.73	14.73
06-07	Oil & gas extraction, metal ores & other	All 4 sites	20.06	20.06	20.06	20.06	20.06	20.06	120.38
		Captain X and Viking A	5.30	5.30	5.30	5.30	5.30	5.30	31.80
25 excluding 25.4	Manufacture of fabricated metal products	All 4 sites	26.02	26.02	26.02	26.02	26.02	26.02	156.14
		Captain X and Viking A	13.29	13.29	13.29	13.29	13.29	13.29	79.71
30	Manufacture of transport equipment	All 4 sites	31.66	31.66	31.66	31.66	31.66	31.66	189.98
		Captain X and Viking A	16.94	16.94	16.94	16.94	16.94	16.94	101.63
41-43	Construction	All 4 sites	136.38	136.38	136.38	136.38	136.38	136.38	818.30
		Captain X and Viking A	57.23	57.23	57.23	57.23	57.23	57.23	343.40

How is consumption modelled?

Our model includes a number of consumers including the government and households. In our model, the government consumption is treated as exogenous meaning that despite any changes in relative prices the government is assumed to maintain the same level of consumption. This affects the budget balance, but in most simulations the government can accumulate savings or deficit. In our analysis the government is not required to have a balanced budget, while we consider the government expenditure fixed. As such the spending for the T&S infrastructure leads to increased government deficit.

The households are disaggregated into 5 quintiles based on their gross income. This allows us to study how households with varying income levels differ in their consumption of goods and services, including energy goods and services. However, in this work we focus on the total household spending rather than the spending of each income quintile. Household income comes from different sources, including labour income, income from capital and transfers from the government. The marginal propensity to consume is assumed to be constant throughout the duration of our analyses. The initial consumption choices of each quintile are informed by the SAM data used as the basis for this model. However, the households respond to changes in the relative price of goods and services, so that they can maximise their utility; subject to budget constraints that fluctuate with every simulated period.

Are there imports/exports in UKENVI?

UKENVI includes two external regions; Rest of EU (REU) and Rest of the World (ROW). Goods and services from these external regions can be imported for intermediate or final use and similarly UK industries have the option to export their output to these regions. UK goods and services are considered imperfect substitutes to those produced abroad and both import and export demands respond to changes in relative prices. In each simulated period firms can choose to either use domestically produced intermediate inputs or import them from abroad. However, since they are considered as imperfect substitutes, a greater difference in relative prices is required for the UK firms to opt to use imports rather than use domestic goods and services. A similar process applies to consumers, who have the option to meet their needs by using domestic or imported goods and services. The elasticity we assume between domestic and imported goods is in line with the existing literature and is generally accepted as being a reasonable assumption. However, a sensitivity analysis can be conducted by introducing different elasticities to reflect consumers of firms more or less prone to import the goods they need and how export demand does respond to changes in the competitiveness of UK industries.

Annex B: Summary of key results

Table 2: Value changes in key variables due to UK Government investment to T&S

	Base values		Period 1	Period 2	Period 3	Period 4	Period 5	Period 6 (end of investment)
GDP (in £million)	1,306,294	4 storage sites	126.37	70.06	73.13	72.84	62.90	38.22
		2 storage sites	59.12	32.60	33.98	33.90	29.70	19.20
Employment (in FTE)	24,930,573	4 storage sites	3,850	2,625	2,667	2,565	2,267	1,716
		2 storage sites	1,783	1,199	1,221	1,181	1,055	820
Income from Employment (in £million)	801,407	4 storage sites	126.42	81.22	82.42	79.49	70.58	53.80
		2 storage sites	59.12	37.55	38.18	37.00	33.25	26.09
Exports (in £million)	410,158	4 storage sites	-96.03	-69.90	-71.56	-68.01	-63.16	-59.39
		2 storage sites	-38.62	-28.94	-29.66	-28.19	-26.16	-24.56
Government budget (in £million)	-98,224	4 storage sites	-379.33	-262.49	-264.82	-264.54	-265.39	-269.91
		2 storage sites	-166.37	-115.58	-116.36	-116.15	-116.50	-118.49
Household Consumption (in £million)	891,463	4 storage sites	109.71	67.51	65.18	61.55	54.12	40.75
		2 storage sites	49.16	30.09	29.20	27.73	24.61	18.92

Endnotes

[i] The CCUS Action Plan is available here: https://www.gov.uk/government/publications/the-uk-carbon-capture-usage-and-storage-ccus-deployment-pathway-an-action-plan

[ii] See the UK Budget 2020 https://www.gov.uk/government/publications/budget-2020-documents/budget-2020

[iii] The Climate Change Act 2008 (2050 Target Amendment) Order 2019 can be found at www.legislation.gov.uk/uksi/2019/1056/contents/made

[iv]See the 2013 International Energy Agency (IEA) Technology Roadmap Carbon Capture and Storage publication: https://www.iea.org/reports/technology-roadmap-carbon-capture-and-storage-in-industrial-applications

[v] The 2019 report of the UK's Committee for Climate Change is available here: https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

[vi] The policy brief is available at: https://strathprints.strath.ac.uk/72094/

[vii] See the "A UK Vision for Carbon Capture and Storage" report (Orion Innovations for the CCSA and the TUC) available to download here: http://www.ccsassociation.org/index.php/download_file/view/750/76/

[viii] You can find our policy briefing discussing the potential economy-wide impacts of ECO at this address: https://doi.org/10.17868/71454

[ix] You can read about our Net Zero Principles Framework in this briefing document: https://doi.org/10.17868/71580

[x] You can find the report detailing our work in this address: http://www.evaluationsonline.org.uk/evaluations/Search.do?ui=basic&action=showPromoted&id=689

[xi] The 2014 Ecological Economics paper by Lecca et al.: https://doi.org/10.1016/j.ecolecon.2014.01.008 provides a general overview of the model structure. The more recent 2017 Energy Policy paper by Figus et al.: https://doi.org/10.1016/j.enpol.2017.09.028 includes information on investment requirements are calculated and how the households are disaggregated into quintiles based on their gross income.