

Engineered greenhouse gas removals: impact and costing note

Introduction

This note reviews the recommendations in the Commission's Engineered greenhouse gas removals study that could have material spending implications.

It assesses:

- the impact of the recommendations on the Commission's objectives to support sustainable economic growth across all regions of the UK, improve competitiveness and improve quality of life
- the expected costs of the recommendations, and their impact on the Commission's fiscal and economic remits
- uncertainty, distributional effects and risks around these estimates and the balance of evidence behind recommendations, as far as it has been possible to make these assessments.

The impact and costing note records the Commission's assessment of these factors in a standard format.

The core of each impact and costing note is how the cost of the recommendations affect the Commission's fiscal and economic remits. These were set out by government in the 'Remit Letter to the National Infrastructure Commission'.¹

Recommendations in the engineered greenhouse gas removals study

In the engineered greenhouse gas removals study, the Commission makes eight recommendations covering the strategic case for engineered greenhouse gas removals, the policy needed to incentivise their rollout and the enabling infrastructure needed to support engineered greenhouse gas removals.

To satisfy its obligations to the fiscal and economic remits, the Commission has assessed direct impact of these recommendations on public capital expenditure (fiscal remit) and other sources of infrastructure funding including consumer bills (economic remit).

These recommendations are:

- **Recommendation 1:** Government must make a clear commitment to deploy a range of different engineered removals at megatonne scale in the UK no later than 2030 and must publish a detailed plan to deliver this by the end of 2022. This should form the basis for an enduring policy regime which will maximise the likelihood of the UK playing a leading role in the development of engineered removals.
- **Recommendation 2:** Action on deploying engineered removals must not reduce effort from emissions reduction, which should be used to cut most of the country's emissions. Government's net zero strategy should set this out clearly.
- **Recommendation 3:** By 2024, and before any engineered removals are deployed at scale in the UK, government must put in a place an independent monitoring regime. This must:

- be robust, transparent and instil public and investor confidence
- ensure that any removals are genuine and verifiable, including putting in place a monitoring, reporting and verification regime
- account for the full lifecycle emissions of technologies, regardless of whether those emissions occurred inside or outside the UK
- be consistent with the principles to protect the natural environment set out in the Environment Bill.
- **Recommendation 4:** A market for engineered removals, whereby government support can gradually fall away, should be created by obligating polluting sectors to offset their emissions. Obligations on polluting sectors should cover a growing proportion of emissions over time, reaching 100 per cent no later than 2050.
- **Recommendation 5:** Government should support a portfolio of engineered removals and deploy a range of first of a kind plants at scale no later than 2030. To support deployment, government should use a combination of:
 - staged competitions, focused on pulling through early stage technologies to commercial readiness
 - direct investment, with the option for the involvement of the UK Infrastructure Bank
 - contracts for revenue with government using competitive auctions where possible, and consider the feasibility of linking the contracts to a market-based mechanism, such as the newly established UK Emission Trading Scheme.
- **Recommendation 6:** Government should aim to have polluting sectors pay for removals they need to reach carbon targets. Sectors that do not require removals to achieve net zero should not be obligated to pay for them. However, in some instances there may be adverse consequences that require intervention. To account for this, by 2024, government must:
 - undertake and publish detailed analysis on the range of adverse distributional consequences that could occur from the proposed policy approach
 - set out which sectors it is open to providing subsidy for removals to
 - consider the risks of offshoring emitting activities to other countries, and how these can be mitigated.
- **Recommendation 7:** Government and regulators, in particular Ofgem for electricity and Ofwat and the Environment Agency for water, must work with operators of infrastructure networks to ensure any demands from engineered removals are planned for from the late 2020s.
- **Recommendation 8:** Government must ensure that the required carbon transport and storage infrastructure is delivered and that additional demand from engineered removals deployment is accounted for in its plans. To do this government must:
 - finalise its regulatory regime and policy frameworks for carbon transport and storage and facilitate deployment at scale over the 2020s
 - consider how engineered removals in dispersed locations not near the UK's industrial clusters, for example small energy from waste or biomass plants with carbon capture and storage, can be integrated into carbon transport and storage networks over the next decade

- ensure adequate carbon dioxide storage capacity is explored and characterised in time to deploy engineered removals.

Assessing the impact on the Commission’s objectives

The table below reviews how the Commission’s recommendations contribute towards its objectives: to support sustainable economic growth across all regions of the UK; improve competitiveness; and improve quality of life.

Objective	Description
Sustainable growth	<p>Reducing carbon emissions, and the impact of climate change is vital for economic growth. The effects of climate change pose large risks to economic activity. In meeting targets that have a greater likelihood of limiting global warming to 1.5 degrees, and not 2 degrees, the global risk of heatwaves is one to three times lower, risk of species extinction halved and risk of extreme weather heavily reduced.² The scale of the productivity impacts of these risks is likely to be in the order of £billions per year.³</p> <p>Engineered removals will support the UK meet its legally binding climate targets, which are consistent with lower levels of global warming. The Commission’s recommendations are designed to put the strategic, policy and enabling infrastructure frameworks in place to support deployment of engineered removals.</p>
Balance across regions	<p>The benefits from mitigating climate change will be felt across all regions. There are also likely to be some economic benefits to the areas where engineered removals plants are located. These will be through jobs created in the construction and operation of plants and in the services needed to support sites and their employees.</p> <p>The exact location of engineered removals infrastructure will be driven by access to the essential inputs and infrastructure requirements of the plants. They could be situated in many areas across the UK. However, it is likely, particularly in the near term that engineered removals will be located within industrial areas in order to access carbon transport infrastructure that is expected to first be developed in these areas.</p>
Competitiveness	<p>Engineered removals will be a new infrastructure sector and the UK has an opportunity to gain a comparative advantage in the skills, services and the manufacturing of parts that will be needed to support the sector both domestically and globally.</p> <p>The Commission’s recommendations – to get ahead and support this nascent sector with stable policy and a long term view – could help the UK to build an early advantage. It may allow the</p>

	<p>UK to develop a globally significant cluster with expertise in engineered removals. This supports agglomeration and trade in the UK's industrial areas.</p> <p>A global market for the negative emissions produced by engineered removals could develop. The Commission's recommendations will support the UK playing a role in developing this future market through the skills and regulatory regime developed and may allow the UK to provide negative emissions in this future market or purchase negative emissions from other countries.</p>
Quality of life	<p>Reducing the levels of greenhouse gas emissions in the atmosphere is expected to limit the impacts of climate change. The impacts of climate change have significant impacts on quality of life in the UK and globally.⁴ The largest impacts are likely to be on health and availability (and therefore affordability) of food. It will also impact on quality of life through affecting infrastructure and access to infrastructure services, for example from flooding or overheated train tracks. Engineered removals can support the many other actions that are needed to limit the level of greenhouse gases in the atmosphere.</p> <p>How investment in greenhouse gas removals is funded is likely to have implications on disposable income, and/or affordability of household bills for different groups. This is discussed in more detail in the 'distributional impacts' section of this note.</p>

Assessing the impact on the Commission's fiscal remit

Recommendation 5 requires public capital on delivering staged competitions to support development of engineered removals and direct investment in deploying engineered removals. This funding is required to get the sector established and will therefore fall from the mid-2020s to the mid-2030s. In total, government should expect to spend £200-400 million as shown in table 1.

Table 1: Fiscal remit impact 2020 to 2050

Average annual public capital (£billion, 2020 prices)						
	2021-25	2026-30	2031-35	2036-40	2041-45	2046-50
Low estimate	0.01	0.02	0.01	-	-	-
High estimate	0.02	0.04	0.02	-	-	-

Assessing the impact on the Commission’s economic remit

The Commission’s recommendations will have an impact on the economic remit through their potential impact on public sector resource expenditure, the indirect impact on consumer bills and a smaller impact on government administrative costs.

The most significant impact will come from the funding needed to support contracts for engineered removals as per recommendation 5. The Commission estimates that by 2030 the sector will require about £2 billion in revenues per year to remove 5-10 MtCO₂e (megatonnes of carbon dioxide equivalent) annually.

As the volume of engineered removals grows over time, all else held equal, this revenue requirement will grow over time. However, the cost of engineered removals is expected to reduce over time. Costs of new technologies reduce over time due to reductions in construction costs through learning by doing; realisation of economies of scale as the supply chain develops; lower finance costs as the risks associated with building first of a kind plants reduce; and improved efficiencies in the process leading to a reduction in inputs required. Additionally, if costs do not fall as expected there is a choice for government on the volume of engineered removals that is delivered versus alternative actions to mitigate emissions.

Low and high estimates for the total cost, in terms of the revenue needed to support the sector, over time is provided in table 2. This is based on a trajectory towards a 2050 cost of between £100 and £200 million per MtCO₂e removed and the volume delivered being a function of the price. The lower the cost of engineered removals the more they will be used if the cost falls below the cost of other mitigation activities. Some plants are assumed to start operating in the late 2020s.

Table 2: Revenue to support the sector 2020 to 2050

Average annual revenue for the sector (£billion, 2020 prices)						
	2021-25	2026-30	2031-35	2036-40	2041-45	2046-50
Low estimate	-	1	3	5	6	8
High estimate	-	1	4	9	13	16

There is uncertainty on the share of this revenue recovered from different sources. Central government may fund some of this revenue through public sector resource expenditure. Some, or all, will be paid by polluting industries and the consumers of the goods and services produced, as per recommendation 4. The share of revenue recovered from these sources is a choice for government, as noted in recommendation 6.

The costs are expected to increasingly fall on polluting industries allowing government support to fall away. Recommendation 4 proposes that over time an increasing proportion of residual emissions (i.e. those that cannot be mitigated) be offset through the use of engineered removals, reaching 100 per cent no later than 2050. As obligations and therefore costs are gradually placed with polluting industries the cost to government will reduce and could reach zero.

But, government may choose to protect certain vulnerable or disadvantaged groups following evaluation of distributional impacts as per recommendation 6. Protection of these groups would require government to provide the resource expenditure on an ongoing basis.

There will also be smaller administrative costs associated with government delivering recommendations 1, 2, 3, 4, 5, 6 and 8. The most significant of these costs will be to establish and operate an independent monitoring regime (recommendation 3). The Commission previously estimated that the combined cost of the regulatory bodies Ofcom, Ofgem and Ofwat is £3 to £4 per household per year.⁵ The activities of these regulators is significantly broader than the role of independent monitoring that is envisaged for the engineered removals sectors and therefore the costs are expected to be a small fraction of this. Costs could be met directly by public sector resource expenditure or regulation could be funded by the industry through a levy.

The cost associated with recommendations 7 and 8 require the infrastructure networks supporting engineered removals to be planned for. The costs of delivering network upgrades or extensions are expected to predominantly fall on engineered removal providers rather than existing users of these networks and are included in the estimates above.

Uncertainty

This section assesses the degree of confidence in the fiscal and economic remit estimates outlined above and the reasons for this judgement.

The above impacts are subject to uncertainty, driven by:

- **Technological and cost uncertainty around the performance of engineered removals** – there is limited deployment of engineered removals globally and therefore the range of estimates for cost and performance is large. Initial deployment to the scale recommended by the Commission (recommendation 1) will produce valuable evidence on the cost and performance of technologies which can support narrowing the current range of uncertainty.
- **Policy uncertainty** – the true scale of costs and impacts on households and businesses will depend on how policies to support the deployment of engineered removals are designed. This is a choice for government. For example, whilst placing obligations on polluting industries (recommendation 4) would impact household bills through their purchasing of goods and services, these could be complemented by policies to support vulnerable or disadvantaged groups in society (recommendation 6).
- **Technological uncertainty around mitigation measures and nature based removals** – continued policy development and action to mitigate greenhouse gas emissions is essential (recommendation 2). There is uncertainty on whether such actions will deliver beyond current expectations or fall short and this creates uncertainty on the volume of engineered removals that will be needed and therefore the overall cost of engineered removals, in supporting the UK meet its climate targets, is uncertain.

Distributional impacts

This section assesses the distributional impacts of the Commission's recommendations across a set of dimensions. The main impact on consumers will be as a result of the additional cost to the goods and services that they purchase. The Commission has evaluated the impact of this cost, based on a set of assumptions, across different income and expenditure groups and across consumers in different regions.⁶

Dimension	Description
Winners and losers	<p>The cost to households related to the deployment of engineered removals is correlated with the carbon dioxide content of the goods and services purchased by a household.</p> <p>Households with higher spending and income levels tend to have a higher carbon footprint and therefore will face more costs from the deployment of engineered removals. The Commission's analysis suggests that costs per household for removals will be higher for households with higher expenditure, with an annual cost of £80 for households in the lowest expenditure decile and £400 for households in the top expenditure decile, based on an average cost of £200 per tonne of carbon dioxide removed.</p> <p>Making the polluter pay for emissions is likely to gradually increase costs for households, particularly those with higher expenditure and a higher carbon footprint, as the offset obligations on polluting industries rise.</p> <p>Consumers can reduce the impact of the additional cost of engineered removals through the choices they make. For example by switching out carbon intensive goods for lower carbon alternatives.</p>
Vulnerable/protected groups	<p>The Commission recommends that government evaluate the impact on vulnerable groups of its policy on polluters paying for engineered removals. Before deployment of the first engineered removals plants it should, based on this evaluation, consider whether to protect vulnerable or disadvantaged groups from any adverse consequences.</p> <p>This evaluation could include consideration of protected groups. The Commission's work has not identified any reason why protected groups would be disproportionately impacted by the cost. It has not identified any drivers of why the consumption of goods and services by protected groups would on average be of a higher carbon content than household consumption driven more generally by levels of income and expenditure.</p>

Regional	<p>The impact across households in different regions of the UK varies to a lesser degree than across income or expenditure groups. Variation across regions is driven by the variation in the carbon dioxide content of purchases across households in different regions, which in turn is driven by the income and expenditure of the average household in some regions being greater than in others. Analysis suggests that households in the South East have the greatest carbon content of the goods and services expected to be purchased in 2050 and would therefore pay the most towards engineered removals. Households in Northern Ireland would pay the least.</p> <p>Additionally, construction and operation of engineered removal plants may yield some local economic benefits in terms of jobs and earnings.</p>

Risks

This section assesses how robust the Commission’s recommendations are to different possible future states of the world based on a set of drivers.

Low = the recommendation is ‘no regrets’ and is robust to a range of future scenarios.
Medium = some future scenarios could affect the optimal choice of variant or timing.
High = some future scenarios could make the recommendation unviable or obsolete.

Driver	Risk	Description
Economic growth	Low	The Commission’s recommendations are robust to economic growth being higher or lower than expected.
Climate change	Low	The Commission’s recommendations are robust to a range of climate change scenarios.
Technology and behaviour change	Medium	<p>There is uncertainty on the scale of engineered removals that will be needed.</p> <p>There are currently no alternative solutions for some sectors, such as aviation and agriculture, to reach net zero emissions without greenhouse gas removals and using nature based solutions alone is not expected to be able to deliver enough removals.</p> <p>However, behaviour change exceeding expectations and driving down demand for carbon intensive goods and services, or new technological solutions being developed could</p>

Driver	Risk	Description
		<p>result in less demand for engineered removals than currently forecast.</p> <p>Equally, some technologies expected to support sectors in getting to net zero may fail or turn out more expensive than expected. This would result in a need for greater volumes of engineered removals.</p> <p>The Commission's recommendations are robust to this as they call for an adaptive approach that reflects this uncertainty.</p>
Population and demography	Low	The Commission's recommendations are robust to a range of future population and demographic scenarios.

Endnotes

¹ HM Treasury (2016), [Remit Letter to the National Infrastructure Commission](#)

² Intergovernmental Panel on Climate Change (2018), [Global warming of 1.5°C](#)

³ Climate Change Committee (2021), [Independent Assessment of UK Climate Risk](#)

⁴ Climate Change Committee (2021), [Independent Assessment of UK Climate Risk](#)

⁵ National Infrastructure Commission (2019), [Regulation study impact and costing note](#)

⁶ University of Leeds and the Grantham Research Institute on Climate Change and the Environment at the London School of Economics (2021), [Distributional impacts analysis of engineered greenhouse gas removals technologies; Report prepared for the National Infrastructure Commission](#)