Briefing
Greenhouse gas removals

July 2022

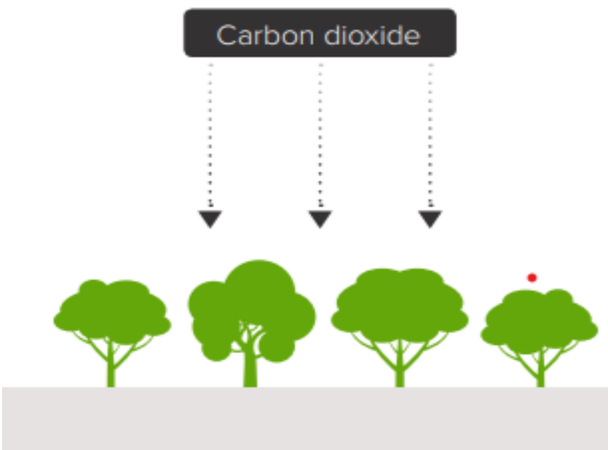
Methods of removal

To reach a net zero carbon economy by 2050, the UK needs to remove greenhouse gases from the atmosphere, since some sectors, such as aviation and agriculture, will struggle to cut their emissions to zero.

Greenhouse gas removals (GGR) are the 'net' in net zero. They are either nature-based or engineered:

Nature-based approaches store carbon in soils, plants and trees. In 2019, existing land carbon sinks removed four per cent of emissions from the atmosphere. This capacity could grow with the creation of more natural habitat, primarily woodland.

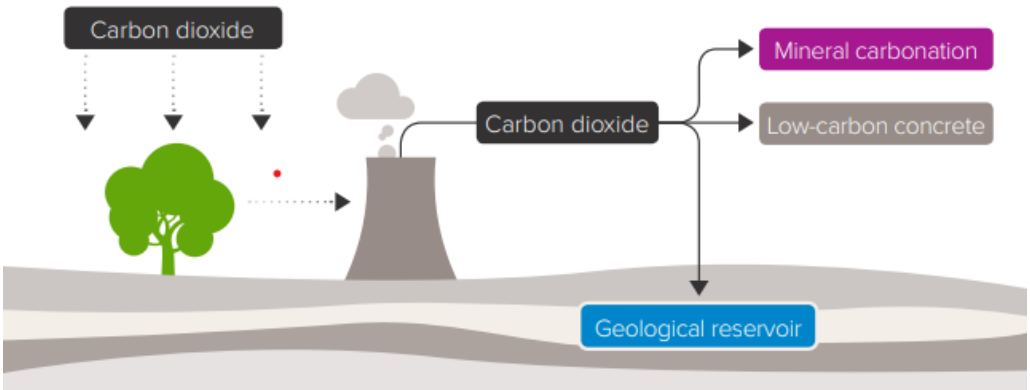
Nature-based carbon dioxide removal[1]



Engineered approaches are not yet fully operational. The two main approaches in the Climate Change Committee's (CCC's) UK government plans are bioenergy with carbon capture and storage (BECCS) and direct air capture of CO_2 with storage (DACCS):

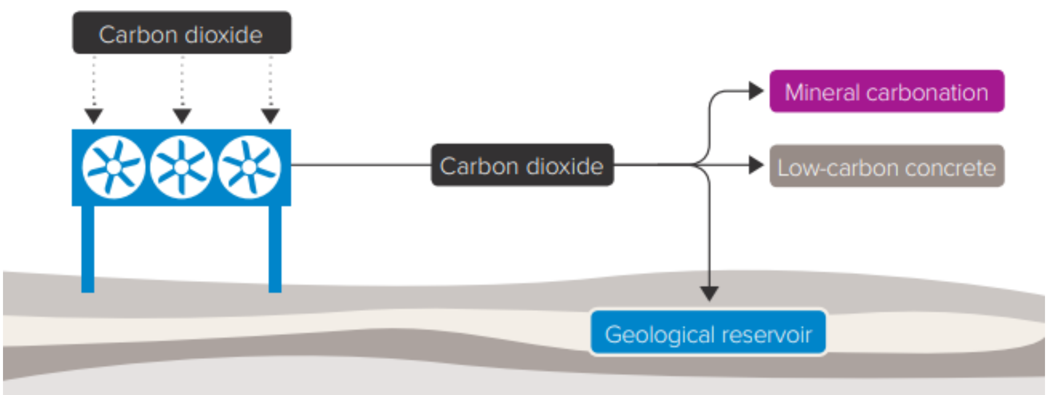
- **BECCS** uses technology to capture the CO_2 released when biomass (organic matter) is burnt. This biomass removed CO_2 from the atmosphere as it grew, so capturing it on burning generates power while delivering a net removal of CO_2. Captured CO_2 must be stored, probably in depleted oilfields and saltwater aquifers under the North Sea.

Bioenergy with carbon capture and storage (BECCS)[2]



- **DACCS** removes CO_2 directly from the air using heat, electricity and chemicals. As for BECCS, the captured gases must be stored.

Direct air capture of CO2 with storage (DACCS)[3]



Risks and benefits

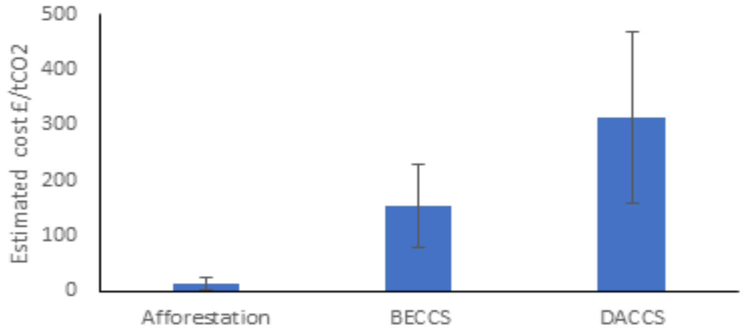
These options come with different risks and benefits.

Nature-based approaches can start now. They are inexpensive and provide co-benefits for nature, provided biodiverse habitats are created with native species. However, capacity is limited by the area available to restore them and there is uncertainty about long term carbon storage in nature because it fluctuates over time, for example due to fire or disease in trees.

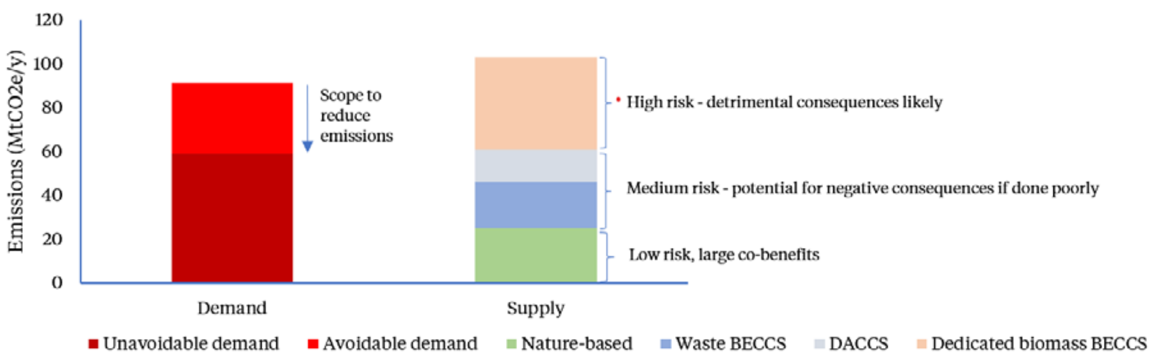
Engineered approaches can remove CO_2 more quickly and provide a more certain long term store than nature-based approaches. As developing technologies, there is significant uncertainty over their impacts, scale and timeline. In particular, BECCS could cause deforestation because of its large land footprint, which would result in net emissions, not removals. Using biomass from existing forests will not achieve net zero because removal occurs not when the biomass is burnt, but when the forest has regrown, which may take decades or even centuries, and which is too late to meet the 2050 net zero goal. Using biomass crops avoids this problem, but this puts BECCS in competition with food production, with similar food security risks to crop-based biofuels.

Engineered solutions are expensive, though future costs are very uncertain. Per unit of CO_2 removed, BECCS is estimated to cost between 3.5-115 times more than afforestation. DACCS might cost 7-235 times more (see below).

The estimated cost of afforestation, BECCS and DACCS[4]



Demand and supply of engineered and nature-based GGR under the UK Government's Net Zero Strategy[5]



Anticipated demand and supply of GGR

The scale at which GGR options are deployed affects their negative impacts. Higher demand for GGRs, caused by higher residual emissions from aviation and agriculture, for example, increases the risk that the UK will have to rely on environmentally riskier GGRs. The graph above shows that limiting demand for GGRs would make the riskiest types of GGR unnecessary. The effect of each type of GGR on environmental risks is outlined below.

Nature-based solutions
The capacity for nature-based GGR, such as tree planting, is limited by the availability of land. Agriculture covers over 70 per cent of the UK land surface, but tree planting can be done at very little cost to food production if located on the 20 per cent of farmland that produces only three per cent of calories, and could remove between 15-25MtCO_2e per year from the atmosphere by 2050.

BECCS
The sustainability of BECCS largely depends on the input biomass. Using waste biomass as an input would avoid competition for land but could remove only 21-32MtCO_2e per year by 2050.[6]

Scaling BECCS beyond this could see three million hectares of land (17 per cent of the UK's agricultural area) dedicated to growing biomass for BECCS.[7]

Unlike nature-based solutions, dedicated biomass requires land suitable for cropping, meaning crop-based BECCS will compete with food production.

DACCS
DACCS requires the input of electricity and heat. At worst, large scale DACCS would increase electricity demand by 18 per cent. At best, it would use waste heat from industrial or nuclear power plants, which could limit DACCS' demand to 0.5 to five per cent of annual electricity use.[8]

If demand for DACCS is lower, it could be run intermittently, drawing energy from the grid in times when there is excess supply of renewable energy.

Recommendations

It is likely that the UK will require a mixture of nature-based and engineered GGR, but limiting the need for GGR will reduce the deployment of riskier options like crop-based BECCS. Therefore, to deliver net zero, the government should:

- **Establish an Office for Carbon Removal.** Regulating the credibility and integrity of GGRs is essential to a functioning private carbon removals market that limits environmental and food security risks.

- **Set separate targets for greenhouse gas reductions and removals.** This will limit the risk that residual emissions are so high that environmentally risky GGRs are used to hit net zero. The need for GGRs could be as low as 59MtCO_2e per year, which is similar to the upper estimate of low risk GGRs, like nature-based solutions and waste-based BECCS.[9]
- **Maximise the deployment of nature-based solutions.** Allocating a third of Defra's Environmental Land Management budget to the Landscape Recovery scheme has most potential to deliver large scale nature-based GGR. It could support sufficient tree planting to capture an additional 25MtCO_2e per year, with minimal impact on food production.[10]
- **Use only sustainable engineered options to deliver the remaining required removals.** Standards must limit biomass inputs for BECCS to only waste products, eg from agriculture, forestry or industrial processes.

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Endnotes

[1] Image from: Royal Society and Royal Academy of Engineering, 2018, Greenhouse Gas Removal, page 26
[2] Image from: Royal Society and Royal Academy of Engineering, 2018, Greenhouse Gas Removal, page 39
[3] Image from: Royal Society and Royal Academy of Engineering, 2018, Greenhouse Gas Removal, page 59
[4] Vivid Economics, 2019, Greenhouse Gas Removal (GGR) policy options – Final Report, table 2 (based on Royal Society and Royal Academy of Engineering, 2018, Greenhouse Gas Removal)
[5] Analysis based on: The Climate Change Committee, 2020, *The sixth carbon budget: the UK's path to net zero; Ricardo Energy and Environment*, *2017*, The UK and Global Bioenergy Resource Model (2017)
[6] Lower bound taken from *Ricardo Energy and Environment*, *2017*, The UK and Global Bioenergy Resource Model (2017); upper bound taken from BNZP in The Climate Change Committee, 2020, *The sixth carbon budget: the UK's path to net zero*
[7] Analysis based on: *Ricardo Energy and Environment*, *2017*, The UK and Global Bioenergy Resource Model (2017)
[8] Analysis based on: UK Energy Research Centre, 2019, Bioenergy with carbon capture and storage, and direct air carbon capture and storage: Examining the evidence on deployment potential and costs in the UK
[9] The Climate Change Committee, 2020, *The sixth carbon budget: the UK's path to net zero*, figure 2.13
[10] Centre for Ecology and Hydrology, 2021, 'Updated quantification of the impact of future land use scenarios to 2050 and beyond', table 4