Carbon removal will cost as much annually as the NHS budget, but research shows polluters could pay

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Professor Jim Hall, Professor of Climate and Environmental Risk, and Johannes Bednar, Oxford University Centre for the Environment and the

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Before most countries have decarbonised their economies, even if they deliver on their ambitious net-zero pledges, global warming will likely exceed 1.5 degrees Celsius in the early 2030s. It is not a good outlook. But all is not lost.

Even if this threshold is passed, climate researchers believe long term warming can still be stabilized at 1.5 degrees Celsius if, in the second half of the century, more CO_2 is removed from the atmosphere than is emitted. This is so-called net-negative carbon emissions—a global Manhattan Project—and it would lead to subsequent cooling of the planet.

The trouble is, there is no political or economic mechanism to establish responsibility for large-scale removal of CO_2 and it will not be cheap.

Atmospheric carbon removal can be as simple (and relatively inexpensive) as planting trees. But to remove sufficient carbon to meet the target, new technologies will be needed. Some are currently being piloted, including potentially expensive and/or environmentally-invasive technologies. Costs are estimated to range up to $600 per ton of sequestered CO_2, although no one really knows for sure.

For restoring the atmosphere, the IPCC's 2018 Special Report envisages at least the equivalent of 2-18 years' global pre-COVID CO_2 emissions will have to be removed and safely stored on a net basis. This could mean as much as 100-800 gigatons of CO_2 will need to be removed. Gross CO_2 removal, which partly compensates residual fossil emissions, will need to be even larger, 190-1200 $GtCO_2$ or 5-28 years.

Under current arrangements, the costs and risks for net emission removal will have to be borne by future generations. Few people currently realize

a carbon price on net-negative emissions leads to a subsidy for sucking carbon out of the atmosphere. If we can trust the long-term projections of carbon prices, this subsidy will be massive—probably as high as the annual NHS budget (£150 billion in 2019/20). And that's just for the UK.

Higher temperatures will see climate damages peak; funds for repairing damages, for adaptive measures and for CO_2 removal all happen in the second half of the century. It becomes very unlikely, in this scenario, that there will be any spare cash for CO_2 removal, which would simultaneously be needed—ultimately locking the planet into much higher warming.

An international team of researchers, led by the University of Oxford and the International Institute for Applied Systems Analysis (IIASA), has come up with a solution to this intergenerational dilemma.

In a *Nature* paper, Operationalizing the net-negative carbon economy, they argue that, when the remaining quantity of carbon emissions compatible with 1.5 degrees Celsius warming has been consumed, emitters should no longer pay to store carbon in the atmosphere until the end of time, as they conveniently do under current carbon taxes and emission trading schemes (ETS). Instead, emitting parties should pay a fee to temporarily store CO_2 in the atmosphere. In other words, emitters become 'carbon debtors', responsible for subsequent CO_2 removal and obliged to pay interest on their debt to account for the implied risks, such as the potential default of carbon debtors.

A financial instrument, a 'carbon removal obligation', could be used to apply the 'polluter pays principle' to financing CO_2 removal, and it could be neatly integrated into existing emission trading architectures.

The good news is, as soon as emitters become responsible for removing

their future share of CO_2, it seems likely, fewer emissions will be produced in the first place. Under this scenario, the paper envisages a faster transformation to carbon-neutral practices. Importantly, if carbon removal is cheap and scalable, such technologies would be rolled-out at large scale in the near term, to achieve net-zero more quickly.

Carbon removing technologies then no longer serve as an excuse to delay mitigation at the expense of future generations, instead they become essential components of the near-term mitigation mix helping to reduce the amount of global carbon debt. The researchers argue that this is key to promote learning and reveal costs, socioenvironmental co-benefits and hazards; and to lift the promising options for carbon removal out of the pilot phase.

More information: Johannes Bednar et al, Operationalizing the net-negative carbon economy, *Nature* (2021). DOI: 10.1038/s41586-021-03723-9

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