CARBON MARKET WATCH

MORTGAGING THE ATMOSPHERE

Why temporary carbon storage is risky and cannot replace emission reductions

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SUMMARY FOR POLICYMAKERS

This report provides a scientifically grounded framework for assessing the climate value of temporary carbon dioxide (CO_2) storage, with applications for carbon dioxide removal (CDR) and carbon capture, utilisation, and storage (CCU/CCS) policies.

Because CO_2 emissions have effectively permanent impacts on the atmosphere and the oceans, any carbon storage that does not last for many thousands of years is not physically equivalent to CO_2 emissions and should only be considered temporary. This is especially true for land-sector applications involving forests and soils, where typical carbon storage commitments are made on the order of one to one hundred years in duration.

Temporarily storing CO_2 only provides limited benefit to humanity's efforts to tackle the climate crisis and can actually fuel further temperature rises if used to offset CO_2 emissions. This means that, at best, temporary carbon storage is a supplementary tool that can be pursued in addition to deep, rapid and sustained emissions reductions. If used incorrectly it can burden future generations with higher warming.

Even when temporary storage is used as a supplementary tool, rather than a carbon offset, its climate effectiveness still depends on keeping CO_2 out of the atmosphere at least until the point at which planetary temperatures have peaked. Although there is no way to know for certain how long the world will take to fully decarbonise and halt peak heating, the gap between current global climate policies and the Paris Agreement's temperature limit suggests that temperature stabilisation might not occur for 100 years or longer — a timeframe that depends not just on one country's climate policies, but on the sufficiency of global efforts.

Temporary carbon storage that expires too early does not reduce peak warming. Because the timing of peak warming depends on global choices and currently looks to be far in the future, the precautionary principle suggests that policymakers should only recognise climate mitigation benefits from carbon that is temporarily stored for a minimum of 100 years.

Temporary carbon storage cannot offset CO_2 emissions

Storing carbon for less than several millennia is not physically equivalent to CO_2 emissions because those emissions have effectively permanent atmospheric consequences that stretch into geologic time frames. Even after 10,000 years, about 20% of the mass of the original emission remains in the atmosphere and contributes to higher temperatures. Most of the rest is absorbed in forests and especially the oceans, where it contributes to ocean acidification.

As a result of these dynamics, global temperatures depend primarily on cumulative CO_2 emissions, not on their timing. Since temporary carbon storage only delays emissions, it does not have a cooling effect on the planet's long-run equilibrium temperature. Due to the mismatch between the effectively permanent impacts of CO_2 emissions and the limited benefits of temporary storage, using temporary carbon storage to offset, neutralise, or otherwise compensate for emissions leads to higher long-term temperatures. This combination directly undermines the Paris Agreement's warming limits.

Temporary carbon storage can contribute marginally to the Paris Agreement's warming limits and help reduce peak global temperatures, but only when used alongside deep, rapid and substantial CO_2 emission reductions — and not as a substitute for them.

Differentiating economic and physical claims

Perhaps because the effectively permanent physical effects of CO_2 emissions are well understood in the scientific community, many carbon market standards and some academic publications make a subtly distinct claim: that temporary storage is *economically* equivalent to CO_2 emissions. Although carbon offsets based on temporary carbon storage inevitably lead to higher temperatures, some argue that the short-term benefits they provide are worth more than the damage that eventually occurs, especially when economic analysis uses discount rates that make future damages look smaller.

These claims are based on assumptions that conflict with the Paris Agreement's primary goal of limiting global warming. Economic equivalence is not the same thing as physical equivalence and is largely irrelevant when assessing the effectiveness of temporary storage as a climate mitigation tool. Instead of taking the goal of temperature stabilisation as a given, economic equivalence methods optimise theoretical cost-benefit calculations and can end up justifying outcomes with higher warming levels. When someone claims that 2 or 3 tonnes of temporary CO_2 storage are equivalent to a tonne of permanent CO_2 storage or CO_2 emissions, for example, they are asserting that the economic benefits of temporarily avoiding emissions are more valuable than the social, economic and environmental harm of higher warming in the future. Setting aside concerns about our ability to accurately project expected climate damages, this framework is incompatible with the Paris Agreement, which commits its signatories to limiting global warming — a physical target, not an economic one.

Stored to last

In order for temporary carbon storage to support the Paris Agreement's warming limits, it also has to stay out of the atmosphere for at least as long as it takes to stabilise global temperatures. Intuitively, if planetary temperatures do not peak until 2100, a commitment to keep CO_2 out of the atmosphere for 30 years will not reduce the temperatures experienced in 2100. A 100-year commitment would contribute to temperature reductions in 2100, though it would lead to additional warming in 2150.

Because the timing of peak warming depends on the choices made by governments, companies, and individuals around the world, it is inherently uncertain. While a number of factors control the timing of peak temperature, its timing is closely related to the point at which global greenhouse gas emissions fall to net-zero levels.

The IPCC's Sixth Assessment Report scenario database includes information on the timing of net-zero greenhouse gas emissions for each scenario. Scenarios that limit warming to 1.5°C are associated with achieving net-zero emissions toward the end of the 21st century; 2°C scenarios generally do not achieve net-zero emissions until the 22nd century; and scenarios for 2.5°C and 3°C take longer still. Because current climate policy is not yet sufficient to put the world on track to limit warming below 2°C, storing carbon for at least a century may be necessary to contribute to reducing peak planetary temperatures.

Unfortunately, there is an inverse relationship between global climate mitigation policy ambition and minimum carbon storage needs. The more successful the world is at cutting emissions, the shorter the minimum storage required to contribute to the Paris Agreement's warming limits; the less successful the world is at cutting emissions, the longer the minimum storage requirement would be. Even when a government commits to achieving rapid net-zero greenhouse gas emissions and succeeds, it cannot control whether all of the other countries in the world do the same thing. As a result, policymakers should account for the possibility that global emission reductions do not proceed as quickly as one might like and set longer minimum carbon storage requirements to account for those risks.

Based on current emissions trajectories, which are not yet on track for the Paris Agreement's temperature target, the minimum time frame looks to be on the order of one hundred years. Given the possibility that governments will not increase their climate policy efforts in time, the precautionary principle would justify setting a minimum time frame of substantially more than a century.

However complex temporary carbon storage might seem, one simple insight is clear: the most important thing policymakers can do is permanently reduce and avoid CO_2 emissions in the first place. Temporary carbon storage can play only a limited role in climate mitigation.

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FURTHER READING

A framework for assessing the climate value of temporary carbon storage