Submission to the UN 6.4 Supervisory Body on Challenges for Carbon Removal under the UN Standard from Marginal Carbon.

Introduction

This submission addresses the imbalanced perspective on carbon removal presented in the information note prepared by the UNFCCC Secretariat for the 5th meeting of the Article 6.4 Supervisory Body. We aim to highlight the problems with the note and provide recommendations for addressing them. It is crucial to ensure a fair and scientifically informed approach to carbon removals under the Article 6.4 mechanism of the Paris Agreement.

Identified problems in comparing temporary and permanent carbon removal

Using a too-short time horizon, and combining a time horizon with further discounting

A discount rate can be used to set a de-facto time horizon. For example, using a discount rate of 1% makes 500-year storage about 99,5% as valuable as permanent storage. **But such a <u>time horizon cannot be combined with discounting again</u> as is done in the information note** (page 26-27) since this would be double-discounting. It is permissible to use a conservative discount rate to compare time-limited storage to permanent storage, but not to first set a time horizon (which necessitates directly or indirectly using discounting even if not done explicitly) and then use discounting **again** to justify even shorter storage times.

The note seems to argue for 100 years being an acceptable time horizon for carbon storage. But a high discount rate would need to be used to equate 100-year storage to permanent storage. On page 26 the note says "economic valuation means applying a non-zero discount rate which takes time value into consideration. Under this valuation, mitigation resulting from 300 years storage and 100 years storage turns out to be comparable." But this implies a discount rate of 2-3%, which can be argued to be too high.

Tonne-year accounting

A large part of the note consists of a discussion of tonne-year accounting but fails to differentiate between horizontal and vertical tonne-year crediting. Horizontal meaning that credits are renewed as soon as removal ends. Vertical meaning that a larger number of tonne-year credits are stacked to equate it to long-term storage. While horizontal tonne-year accounting is a scientifically sound method, vertical stacking is not, especially not when using a short minimum activity period. Unless you renew them, temporary carbon removal credits stored for a very short time (such as ten years) do not help solve the climate crisis. It does temporarily create a slightly less warm world which can, in theory, avoid some current harm from global heating. The effect of this is very low and there are arguably much more cost-effective ways of reducing current harm from warming. (See appendix for sources and further details)

Many calculations of the value of carbon storage also disregard that harm from warming is non-linear. In the short to medium-term, harm from warming will increase - as the negative effects of warming are nonlinear. Going from 2°C-3°C is much more disruptive than going from

1°C-2°C. When temperatures rise, the value of carbon storage increases with time. Very temporary storage has a very low value if not replaced, since it avoids a smaller level of harm per tonne-year of storage than carbon stored when the temperatures are higher. If the storage you do is for only ten years, it actually makes sense **to delay** deployment until we're near peak temperatures.

It is shocking to read some of the answers to the concerns brought up on tonne-year accounting. For example on page 33 in paragraph 1.a the concern that tonne-years are physically inconsistent with the Paris Agreement's goal of temperature stabilization is brought up. The answer given in paragraph 2.a basically invalidates the Paris Agreement and temperature targets.

Recommendation

The adoption of like-for-like removals

The "Like-for-Like" principle in carbon removals should be introduced in the note instead of tonne-year accounting. It is an approach that matches the nature and timescale of carbon emissions with corresponding removal techniques. This principle appreciates the fact that not all emissions are equal in their impact and permanence. Short carbon cycle emissions, such as those from land-use changes, could be effectively offset by biosphere-based carbon removal methods, such as reforestation. In contrast, long-lived emissions, such as those from burning fossil fuels, demand more enduring carbon removal strategies, such as direct air capture with geological storage.

The "Like-for-Like" principle thus brings in an element of specificity and appropriateness in carbon removal strategies, making them more effective and targeted. We believe that the adoption of this principle would better align our carbon removal efforts with the actual challenges and nuances of atmospheric carbon dynamics. This has also been adopted by several actors, such as the UNFCCC Race to Zero campaign.

The definition of what constitutes long-lived storage under like-for-like removals can be set using a time horizon and a conservative discount rate. The exact period chosen will always be arbitrary. For example, using a 1% discount rate makes 200-year storage about 90% as valuable as permanent storage and 500-year storage 99,5% as valuable as permanent.

The like-for-like principle means tonne-year accounting with vertical stacking cannot be used. Restoring carbon to the short carbon cycle should never be used to offset emissions from fossil fuels.

Problems with how "engineered" removals are treated in the note

All removals serve the objective of Article 6.4:

Contrary to the note's claims, “engineered” removals do serve the objectives of the Article 6.4 mechanism. The integration of removals into climate change mitigation activities is essential for achieving the goals of the Paris Agreement. The information note mentions that engineered removals are not suited for developing countries, which is false, but regardless, Article 6.4 is not restricted to developing countries. As the latest large purchases of durable carbon removal have shown (for example Microsofts purchase from a danish BECCS facility), actors like the US and the the EU could become exporters of durable carbon removal tonnes such as from BECCS or DACCS. Dismissing “engineered” removals undermines the potential of Article 6.4 and contradicts its intended purpose.

“Engineered removals” is not a good classification.
The Information Note puts some carbon removal methods into a group called "engineering-based activities". We think this isn't the best way to describe them because almost all methods of removing carbon involve a mix of nature and engineering. Instead of listing and sorting each carbon removal method, we suggest that the Supervisory Body should set out clear rules that a carbon removal project needs to meet to be part of the Article 6.4 mechanism. This approach would allow scientific innovation, market forces, and competitive spirit to drive the development of solutions that yield the highest climate impact and additional co-benefits.

Not presenting a balanced overview of different removal methods
Instead of presenting a balanced overview of different carbon removal methods, the note selectively highlights pros and cons, failing to provide a scientifically informed and comprehensive analysis. A more balanced comparison, as seen in reports such as the IPCC AR6 WG3 and the State of CDR report, should be considered to ensure a fair assessment of different removal methods.

Disregarding stakeholder input on removals:
The note disregards substantial stakeholder input on “engineered” removals, which has been submitted in multiple instances. Judging all engineered removals as technologically and economically unproven and suggesting their exclusion from the scope of Article 6.4 undermines the value of stakeholder perspectives. All relevant stakeholder input should be thoroughly considered to develop effective recommendations.

Countries' Climate Targets:
An increasing number of countries rely on engineered removals to achieve their climate targets. Excluding such removals from the scope of Article 6.4 makes it more challenging for countries to meet their ambitious NDCs. Article 6.4 is an essential tool for global climate change mitigation, and removals will become increasingly important in countries' efforts to combat climate change.

Global Methodologies for Removals:
Article 6.4 is expected to establish global standards for methodologies in carbon removal activities, particularly for emerging removal methods. By excluding “engineered” removals from the scope, an opportunity to develop robust methodologies on a global level is missed. Other

carbon markets are closely observing these developments, emphasizing the need to establish comprehensive standards.

We hope that these points are taken into consideration and implemented in forthcoming iterations of the information note and in the final rules.

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Appendix

In the appendix are two of my articles on the topic of temporary versus permanent carbon storage and tonne-year accounting, annotated with sources.

Are temporary and permanent carbon stores interchangeable?

https://marginalcarbon.substack.com/p/are-temporary-and-permanent-carbon

7 February 2023

Are three trees worth one rock? Permanent storage is always best, but given realistic assumptions on discounting of future damages, as well as long-term climate adaptation - carbon storage lasting centuries could be made comparable to permanent storage. However, carbon re-released before peak warming needs to be replaced and cannot be equalized to permanent CDR.

Does CO_2 always need to be removed permanently? Carbon insecurely or temporarily stored - such as in forests & soils - are cheaper and more scalable than permanent storage, such as direct air capture with storage. But since CO_2 lasts in the atmosphere for millennia, temporary CDR only postpones emissions - and very short-term storage does little or nothing to control peak warming.

Given this, how can temporary and permanent storage be accurately compared? This article explores this in detail. (See my earlier article Carbon can be temporarily stored for a long time for a classification of different storage methods.)

Although deploying temporary carbon storage instead of permanent leads to higher future temperatures, this could be acceptable if:

1. Expired storage is replaced
2. The harm from warming decreases with time.
3. Future harm is discounted.

If none of these applies**, harm from warming is enduring, and no amount of temporary sequestration could offset long-term damages.**

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I expand on these three points below:

1) Expired storage is replaced

Reforestation carbon credits could be bought today, and replaced with permanent storage when the carbon is re-released (this practice is also described as horizontal stacking). Cost may favour temporary storage followed by future replacement if the sum of the cost of temporary storage and replacement is lower than the one-time cost of permanent storage today. Such scenarios can be explored using The Carbon Plan permanence calculator.

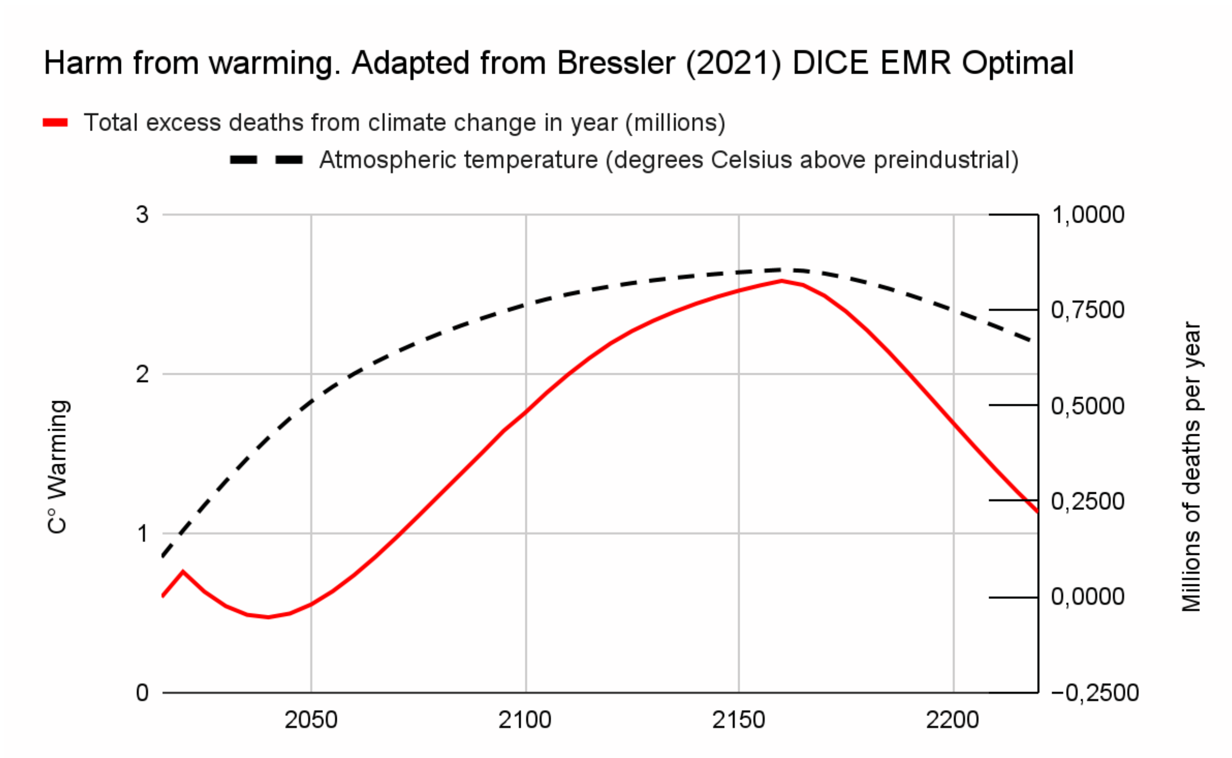
Choosing temporary storage might rely on the expectation that **durable carbon removal prices will fall with time.** However, if no one buys permanent CDR today, the absence of learning curve effects may mean costs do not fall.

Future *costs* of removal can also be discounted. Imagine you plan to replace temporary storage with permanent in 100 years. At $100/t with a nominal interest rate of 2%, $14 banked today pays the entire future replacement cost. This effect is unrelated to learning-curve cost reductions; it's purely based on the investment return made. However, if no one buys permanent storage today, it might not just fail to become cheaper but not be available at scale at all.

In either case, if used as an offsetting strategy, it could be difficult to ensure that temporary storage is actually replaced in the future - even if this strategy would be the most cost-effective. A company buying or deploying temporary removal today might not be around when it needs replacement. But there are theoretical solutions to this problem; trusts or foundations could be used, or responsibility could be shifted to governments.

2) The harm from warming decreases with time

In the short to medium-term, **harm from warming will *increase* -** as the negative effects of warming is nonlinear. Going from 2°C-3°C is much more disruptive than going from 1°C-2°C. When temperatures rise, the value of carbon storage increases with time. Very temporary storage is, therefore, almost useless if not replaced, since it avoids a smaller level of harm per tonne-year of storage than carbon stored when the temperatures are higher. If the storage you do is for only ten years, it actually makes sense to delay deployment until we're near peak temperatures.



The graph above shows how increased mortality from warming can follow an inverted U-shape. Here, harm becomes significant after 2°C warming and drops due to negative emissions after 2.65°C (2160). Data adapted from R. Daniel Bressler's paper [The mortality cost of carbon](#)

But what happens if temperatures plateau? A reasonable assumption is harm decreases due to adaptation. Rising incomes and learning curve effects spread adaptation technologies: storm-proof houses, air conditioning, drought-resistant seeds, early weather warning systems, etc. This effect is real: the number of weather-related disasters in the world has increased five times in 50 years, but fatalities fell by two-thirds. However, economic damages could increase even if fatalities fall; - fancy homes cost more to rebuild than tin shacks. This is not a law of nature, however; such adaptation progress may stop.

If temperatures start to go down, then harm from warming and the value of carbon storage decrease too. Temperatures could decrease for reasons unrelated to carbon removal, e.g. lower methane levels or increased albedo.

It should be kept in mind that estimates of future harm decreases have huge uncertainties. Current estimates likely underestimate future harm since there are more potential sources of harm than what we can put into models today. Climate sensitivity is also uncertain - i.e. how much warming a given amount of emissions leads to. The **harms of any specific emission trajectory might be far worse than expected.** Additional warming may come from unanticipated sensitivity, or from unexpected feedbacks (e.g. permafrost methane release).

3) Future harm is discounted

The harm future warming causes can also be discounted. This is standard economic practice. We most highly value immediate benefits and avoided harm. Partly, this reflects uncertainty. We understand near-time harm avoidance better than future effects. We might, for example, reach a technological breakthrough that addresses climate change, or an AI apocalypse wiping out humanity might make it irrelevant. Nevertheless, the opposite may apply - larger, poorer future populations could gravely suffer from climate change.

Even a low discount rate makes differences in avoided harm between long-term and permanent storage small. Using a discount rate of 1% equates carbon storage for around 500 years to permanent storage, and 2% would make 200-year storage almost as valuable as permanent. (A typical discount rate is 1-4%.) Another discounting approach uses an arbitrary time limit, like 1000 years. After this, you ignore all damages.

Discounting future harm at some rate seems reasonable. Without discounting, you spend as much to save a life in a million years as you are to save someone today. However, determining a rate is difficult, and involves balancing moral and practical considerations.

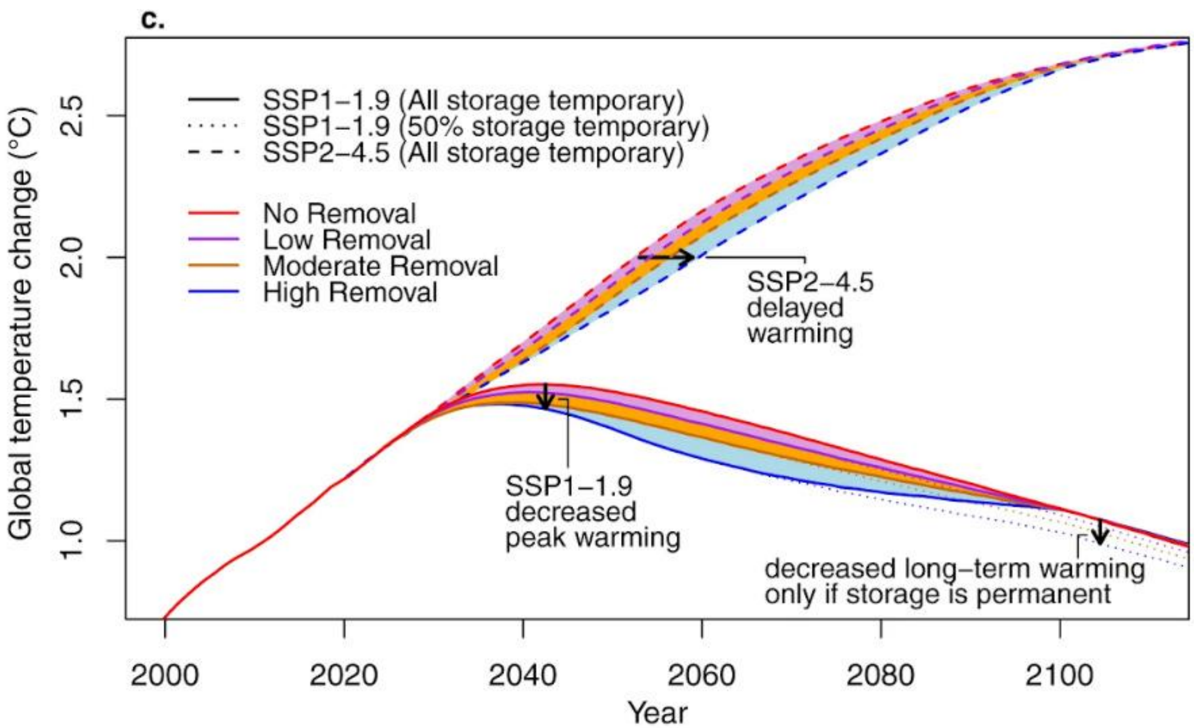
Equate short and long-term storage.
Economically discounting future harm, or anticipating adaption improvements makes it possible to equate permanent storage with a larger amount of temporary storage (also called vertical stacking).

Economists have proposed various approaches. Groom & Venman's paper *The social value of offsets*, equates 2.5 tonnes stored for 50 years to 1 ton removed permanently using a 3,2% discount rate.

However, equating short-term and long-term carbon storage **does not help reach the climate targets set in the Paris agreement or reduce**

peak temperatures. 50-year carbon storage would avoid short-term harm, but retain peak temperatures and associated tail risks including tipping points. These are thresholds of irreversible change such as Amazon dieback, gulf stream collapse, or glacier loss. Median estimates for the first two effects are that they happen at ~4°C, but they could occur at 2°C. **Constraining temperature is crucial; harm is not fungible over time.**

Longer storage suffers the same theoretical problem. Even millennial storage would not automatically reduce peak temperatures, but it would *delay* the peak. That would allow time for non-CDR mechanisms (e.g. reduction of other greenhouse gases) to lower temperatures, keeping the peak down. It could also shorten the peak, limiting harms such as glacier melt.



This graph from the paper [Temporary nature-based carbon removal can lower peak warming in a well-below 2 °C scenario] shows how peak warming can be delayed with temporary storage. The top (dotted lines) show the effect of short-term carbon storage in the SSP2-4.5 scenario where the world is headed today with peak warming after 2150. The bottom shows the SSP1-1.9 scenario, where the peak is reached in 2050. Decadal carbon storage would delay the peak in the latter, more optimistic, scenario but not in the former.

Conclusion

Given the above assumptions, time-limited carbon storage can be equated with long-term storage under some circumstances. Discounting future harm at some rate seems warranted, and harm from warming will likely decrease over time due to adaptation (after first increasing, due to temperature excesses). But it matters how time-limited storage is.

Using time-limited carbon storage to equate to permanent storage could be viable for deposits that last well beyond peak warming. Examples include biochar, biomass burial, and deep ocean storage. For example, if biochar retains 80% storage after 100y, and 25% after 1000y, around 1.25 tonnes of biochar CO_2 storage equates to 1t permanent storage using a 1% discount rate

[2]. The practice would not be suitable for decadal storage - since that neither reduces nor delays peak temperatures[3]. Discounting should be set conservatively (i.e. a low rate) - erring on the side of caution, considering future uncertainties.

Permanently replacing expiring short-term storage can be viable. If companies are temporarily offsetting, money for replacement should be set aside today. A conservative (low) discount rate should be used when budgeting for storage replacement, as well as using conservative (high) replacement costs. It should be kept in mind that early under-investment in permanent CDR will result in an immature market - causing high prices and constrained supply. Nature-based solutions such as forestation also have limited scaling potential and will not fill the needs of CDR, so new carbon removal solutions are needed in any case.

For **offsetting, like-for-like removal** is a good principle. Short carbon cycle emissions (e.g. land-use change) could be offset with biosphere carbon, whereas fossil fuel emissions from the long carbon cycle should be offset with long-lived removals.

Permanent storage is, however, always best since it removes future uncertainties and forever keeps peak temperatures down.

What is the value of temporary carbon removal?

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https://illuminem.com/energyvoices/295b520b-8b18-4a42-bc5e-67d9861b9c74

Unless you renew them, temporary carbon removal credits do not help solve the climate crisis, and they are likely not a cost-efficient way to reduce warming-induced harm today.

There are ways to store carbon that are very temporary. Storing carbon in soil where contracts are short and the risk of reversal high is one way. Paying someone to push their timber harvest forward with one or a few years is another.

Several companies are selling temporary carbon removal credits, storing the CO_2 for as little as one year. NCX (formerly Silvia Terra) pays forest owners to wait with cutting down their trees, using what is known as ton-year accounting. NCX argues* that buying several 1-year credits can make up for the release of 1 tonne of CO_2 that stays in the atmosphere for hundreds of years. Nori that sells 10-year credits from soil carbon projects has put forward similar reasoning.

Waiting to cut down trees. Image by me using Open AIs Dall-e 2

But carbon that is removed and stored for a very short time (1–10 years) does not help solve the climate crisis. It does temporarily create a slightly less warm world which can in theory avoid some current harm from global heating. The effect of this is however likely very low and there are arguably much more cost-effective ways of reducing current harm from warming.

Temporarily stored carbon does not help to solve the climate crisis.

Temporary carbon removal does nearly nothing to affect temperatures after the carbon is re-released again. Therefore it does not help to keep warming below 1.5C (which primarily happens after 2030). If there were very strong feedback loops at work today, even temporary removal would have value but this does not seem to be the case. And since the carbon is released again in just a few years, temporary carbon removal does not affect the carbon budget positively or help stop future tipping points either.

Temporarily stored carbon is likely not a cost-efficient way of reducing current harm from global heating compared to the alternatives.

Very importantly, the harm caused by global heating is non-linear. For example, going from 2 to 2.5C warming almost certainly creates more harm than going from 1 to 1.5C. In models, excess deaths from warming happen predominantly at the end of the century. This paper calculates that 1 million tonnes of CO_2 released in 2020 would cause 5 deaths between 2046 and 2050, but 40 deaths between 2096 and 2100 (assuming warming rises to 4 degrees). Based on this, temporary removal of 1 million tonnes between 2021 and 2031 could end up saving 0 lives. Temporarily avoiding a temperature rise now is not equal to avoiding it when temperatures are higher.

Temporarily removing and storing carbon today could help alleviate some other, mainly non-fatal damages of climate change, such as material costs from extreme weather, but there are likely much more cost-efficient ways of doing so. Climate adaptation measures such as storm protecting, early warning systems and more resilient crops will almost surely create more impact per dollar spent. If you are just looking to alleviate harm in general, measures such as disease prevention in low-income countries are very likely even more cost-effective.

This is not to say that temporary credits such as those that NCX or Nori* sell are worthless. A different approach from overbuying 1-year credits would be to renew the carbon removed each year or decade. Instead of purchasing 17 credits with 1-year storage to offset your 1 ton CO_2 emission as NCX suggests, you would purchase a 1-year storage credit every year to offset your original emission. This is a much more sound approach in theory, but in practice, it's obvious that it would be very difficult to guarantee that an actor will continue renewing carbon credits each year for a century.

A more feasible approach could be to pay for temporary storage for a few years or a decade and then buy permanent carbon removal, such as with DACCS once the credit expires. This could be an option for when the supply of permanent credits is low, or for a cash-strapped company that wants to make a net-zero claim today. But that would also require the buyer to keep track of old commitments. Will a company in 2031 remember that previous employees bought 10-year temporary credits in 2021 to offset 2020's emissions? Carbon plan has developed a calculator to assess the cost of renewing temporary credits.

Another option is to use temporary credits to offset short-lived emissions that match the storage time. Soil carbon with contracts for 10 years could perhaps be used to partially offset methane emissions with a half-life of 9 years. But the global warming potential of methane would then need to be calculated to match the temporary storage of CO_2.

Generally, I believe that the best approach for individuals and companies that want to counter the damages their emissions are doing is to find and fund highly effective climate projects that help solve the climate crisis (without necessarily making any offset or net-zero claims). That could for example be funding new nascent carbon removal methods, fund decarbonization efforts that have a high green premium, or funding advocacy to help decision-makers get off fossil fuels and protect forests. This is the approach that we are taking with the Milkywire climate transformation portfolio. As global emissions are reduced and permanent carbon removal solutions are scaled up this can be transitioned into a carbon removal-only strategy.

(Making a commitment to permanently remove all historic emissions at a future date is yet another option but doesn't include temporary storage. For example, saying that by 2040 company X will have permanently removed all carbon emitted 2000–2040.)

Temporary credits can have their place if used right, but that's not what we are seeing right now.