CLIMATE SOCIAL SCIENCE NETWORK

BROWN
Institute at Brown for
Environment & Society

CSSN Position Paper 2022:1
Net Zero, Carbon Removal and the Limitations of Carbon Offsetting

This position paper provides an overview of key concepts and questions regarding net zero emissions targets and the proposed role of carbon offsets to help meet them. It aims to introduce clarity and nuance to the net zero debate by rejecting the presumption that the achievement of net zero depends on offsetting. It indicates ways in which a focus on offsetting might undermine the pursuit of net zero, highlighting mechanisms through which offsetting can delay or even obstruct climate action, in particular the phasing out of fossil fuels.

The Paris Agreement demands that countries keep global warming to well below 2°C, and do so by achieving a long-term balance between residual emissions and removals, often described as 'net zero' emissions. As a group of researchers who study both the natural and social aspects of climate change mitigation, we are concerned by the increasingly bold and misleading claims about how countries and companies aim to achieve these goals. In particular, we are concerned about the prominent role that is given to offsetting in many net zero pledges. Balancing residual emissions and removals can be achieved in different ways, and at different levels. It does not demand the use of carbon offsets.[1] Yet many net zero targets currently rely heavily on some form of offsetting. A survey by the Corporate Climate Responsibility Monitor revealed that around 60% of emissions 'reductions' committed by the world's largest corporations are in the form of offsets.[2] Moreover, 91% of country targets and 48% of public company targets fail to specify if - and how - offsets will be used.[3]

Reliance on offsetting makes achieving a net zero balance harder. This is because most offsets merely shuffle the sources of emissions around in a 'zero-sum' manner, while a safe carbon budget for 1.5ºC requires accelerated elimination of emissions and early closure of fossil infrastructure. All offsets moreover face social and environmental limits, meaning that the carbon market cannot expand endlessly to compensate for continued emissions. Offsets may also not deliver promised climate benefits if the carbon involved is not permanently captured and stored. Monitoring whether they do or not is challenging, particularly under complex and often uncertain social, ecological and political conditions. Most importantly perhaps, vague, unrealistic and unsubstantiated claims about offsets risk delaying and deterring effective climate policy, and in particular, delaying near-term action to rapidly reduce emissions. All of this means that, in practice, ensuring that carbon markets

[1] The main argument advanced for offsetting markets is that they can direct finance towards otherwise poorly funded, but desirable activities such as restoring ecosystems, developing carbon removal technologies and decommissioning fossil fuel assets. We address the financial arguments in section 2.5.
[2] https://newclimate.org/wp-content/uploads/2022/02/CorporateClimateResponsibilityMonitor2022.pdf
[3] https://zerotracker.net/analysis/pr-post-cop26-snapshot/

offsets (whether 'compliance' or 'voluntary') contribute to rather than obstruct ambitious climate action is a tall order.

In this position paper, we seek to clarify the role of carbon offsetting within net zero targets set by countries and other actors, notably corporations. We differentiate the various approaches to carbon offsetting, explain how they relate to global carbon budgets, and outline the assumptions they rely on. We also highlight a number of consequential issues that should be taken into account when considering the future of carbon offsetting.

To prevent offsetting being used to obstruct and delay climate action in 'net-zero' regimes, we recommend that governments and businesses:

- Completely eliminate the use of avoidance offsets
- Significantly accelerate action to reduce emissions and thereby minimize residual emissions in net zero goals and the need for permanent carbon removal
- Fund any limited carbon removal deemed necessary through other means than carbon offsets
- Treat carbon removal in ecosystems as a co-benefit of targeted efforts to maximize biodiversity protection, restoring degraded ecosystems and climate adaptation

1. Untangling the net zero and carbon offsetting vocabulary

Much of the confusion and ambiguity that pervades the net zero conversation derives from the wide-ranging interpretations that are given to terms such as net zero and offsetting.[4] This is not just an issue of factual accuracy, but a space of deliberate political contestation and debate. Here we therefore examine key definitions and distinctions.

1.1. Net zero, carbon sinks and removals

Net zero describes a balance of anthropogenic sources and removals of greenhouse gases, which at a global scale is necessary to stabilize the rise in temperatures.[5] The ultimate balance between emissions and removals in net zero is ambiguous, but most analysis suggests that global emissions will need to be cut by 90% or more in order to reach a level that can be safely or sustainably balanced by removals.[6] Countries, companies and other entities might also aim to achieve a balance between their residual emissions and removals that they can generate, but global net zero is not necessarily most efficiently or fairly achieved by all smaller entities achieving net zero on the same timescale. Net zero goals only apply to that part of the global emissions balance that is directly attributable to human activity (hence anthropogenic), and do not include CO_2 uptake and release by natural carbon sinks (see below), unless that sink is in some way disturbed or enhanced as a direct result of human intervention (see 'anthropogenic sinks' below).

[4] Fankhauser et al. (2021) 'The meaning of net zero and how to get it right'. *Nature Climate Change.*
[5] Technically, net zero may refer either to a balance of CO2 emissions or to a balance of all greenhouse gas (GHG) emissions. When achieved at the global level, these two scopes (CO2 or all GHGs) lead to different temperature outcomes and the distinction is therefore important: global net zero anthropogenic CO2 emissions lead to stabilising temperatures, while net zero anthropogenic GHG emissions could lead to declining temperatures. See Rogelj et al (2021) 'Net-zero emissions targets are vague: three ways to fix'. *Nature* https://www.nature.com/articles/d41586-021-00662-3
[6] See for example, SBTI: https://sciencebasedtargets.org/net-zero

Residual emissions are those emissions that remain even after all efforts have been made to prevent the production and release of greenhouse gases. In theory, a net zero balance could be achieved at any level of residual emissions, with larger amounts simply demanding a correspondingly larger amount of removals. In practice, however, removing emissions from the atmosphere comes with significant social and environmental limitations, making it inherently uncertain and risky. Emission reductions meanwhile typically have substantial co-benefits for health, biodiversity and other sustainable development goals.[7] This means that emission reductions are the first priority, and that only genuinely 'hard-to-abate' or 'recalcitrant' residual emissions should be left to be counterbalanced by removals. Defining which emissions fall under this category is of necessity a subjective exercise with ample room for creative interpretation, making full transparency and high levels of ambition imperative to avoid mitigation obstruction and greenwashing.

Carbon removal refers to any industrial or ecosystem-based method for removing CO_2 from the atmosphere and storing it either in the biosphere's carbon sinks (e.g. in trees or soils), in oceans, or in the geosphere (e.g. in saline aquifers or depleted oil fields). Depending on the ultimate storage location, carbon removal can be more or less durable. Geologic and ocean storage are likely to be long-term, whereas biological stores are at greater risk of losses (e.g. to wildfires). Carbon removal is distinct from the technology known as carbon capture and storage (CCS), which usually refers to the capture of carbon at the smokestack of a fossil fuel plant. CCS attached to fossil energy production can at best only prevent CO_2 from being emitted in the first place. For CCS to potentially contribute to carbon removal requires that it is connected to the burning of biogenic materials, e.g. wood, straw or soy oil.[8]

Natural carbon sinks describe those parts of the earth's carbon cycle that take carbon dioxide from the atmosphere through natural (meaning non-anthropogenic) bio-geo-chemical processes. The capacity of these natural carbon sinks to absorb CO_2 is limited and moreover often endangered by human activity, in particular through forestry and agricultural practices such as logging and ploughing, the acidification of oceans, and climate change itself. Both the current and future capacity of these existing sinks – in managed and unmanaged ecosystems – to remove carbon dioxide is already included in estimates of the remaining global carbon budget. This means that in their existing state and size, natural carbon sinks cannot be counted in net zero calculations as a way to further expand the carbon budget or offset greenhouse gas emissions. However, the UNFCCC's 'Paris rulebook' effectively allows countries to include them in their nationally determined contributions as long as they happen on land designated as 'managed',[9] in effect, already leading to substantial amounts of double counting.[10]

---

[7] Well designed and managed removals using 'nature based solutions' could also offer co-benefits, but these tend to be difficult or impossible to maintain at large scales or high rates.

[8] The theory here is that the carbon in biogenic material was absorbed from the atmosphere as it grew. So if carbon emitted in combustion of such material is captured and stored, the net effect is a reduction in the amount in the atmosphere. In practice, it is not that simple: the emissions and energy use associated with land management, harvesting, transport, capture processes all need to be accounted for, as does the timescale on which carbon is (re)absorbed by growing biomass. See e.g. Heck, V., D. Gerten, W. Lucht, et al. (2018) 'Biomass-based negative emissions difficult to reconcile with planetary boundaries'. *Nature Climate Change* 8(2).; Hanssen, S. V., V. Daioglou, Z.J.N. Steinmann, et al. (2020) 'The climate change mitigation potential of bioenergy with carbon capture and storage'. *Nature Climate Change.*

[9] Intergovernmental Panel on Climate Change (2006), Vol. 4 p.3.6.Seddon, N., et al.. (2019). Nature-based Solutions in Nationally Determined Contributions: Synthesis and recommendations for enhancing climate ambition and action by 2020. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford.

[10] Grassi G. et al., (2018). Reconciling global-model estimates and country reporting of anthropogenic forest CO2 sinks, *Nature Climate Change* 8: 914–920, Bramley et al. Canada's approach to forest carbon quantification and accounting: key concerns. Nature Canada. https://naturecanada.ca/wp-content/uploads/2021/10/Canadas-Approach-to-Forest-Carbon-Quantification-and-Accounting.pdf

Anthropogenic carbon sinks are those sinks that have been enhanced by human intervention so as to increase the size, rate or durability of their capacity to remove carbon from the atmosphere. This can be done by means of a wide range of biological or chemical methods. Interventions such as afforestation or soil carbon storage enhance natural biological sinks and are sometimes referred to as 'natural climate solutions'. Methods are also being explored to artificially enhance natural chemical and geological sinks, for example by enhancing ocean alkalinity. Anthropogenic carbon sinks can also be created using 'technological carbon removal', such as direct air capture or bioenergy with carbon capture and storage. In these approaches, carbon is extracted from the atmosphere and stored either underground or in the form of stable products.

In summary, all techniques to anthropogenically create or enhance carbon sinks are referred to as '**negative emissions technologies**' or forms of **carbon (dioxide) removal**. Anthropogenic carbon sinks can contribute to net zero goals only if they they are additional to the existing, natural carbon sinks that the IPCC includes in its budgets. In practice, such additionality is difficult to guarantee, particularly when it comes to 'nature-based' techniques. Measures that protect existing ecosystems from being degraded (e.g. 'avoided deforestation') cannot be counted towards the enhanced carbon sink. Although they avoid hypothetical future emissions, they cannot be considered anthropogenic removals in the sense of the net zero concept.

Overshoot is the term used to describe a situation in which global temperature targets are temporarily exceeded, and where carbon removal might be used to reduce atmospheric levels of CO_2 and bring temperatures back down to desired levels by 2100. Most of the climate scenarios assessed by the IPCC allow such overshoot and rely on carbon removal between 2050 and 2100 to achieve ambitious temperature targets. This is made possible by the fact that carbon removal has the theoretical ability to counter the effects of historical CO_2 emissions, enabling the lowering of atmospheric CO_2 concentrations and therefore the reversal of some warming. Relying on carbon removal to compensate for any temperature overshoot however is significantly more risky than avoiding overshoot in the first place. While some warming might in theory be reversible, many climate impacts are not, and the possibility of climate feedbacks means that it is ultimately unlikely that temporary overshoot could be reversed exactly as anticipated.[11]

1.2. Carbon markets and offsets

Carbon credits are permits giving the purchaser either the right to emit or the right to claim that an emission has been 'neutralized' or compensated for. In regulated (or 'compliance') carbon markets a limited quantity of credits (also called permits) might be freely issued by governments or auctioned to regulated companies. In theory, trading of credits between companies ensures economic efficiency in emissions reductions. Companies that cut emissions more than the average required can generate additional credits to sell to others (these constitute 'compliance offsets'). Carbon credits, backed by emissions reductions or removals can also be created and traded in 'voluntary' carbon markets, where they can be purchased by companies or other actors for reasons other than to comply with legal requirements.[12] Either form of market can be subject to 'leakage', if emissions are cut within the market, but the activity (and emissions) are displaced outside the

[11] IPCC (2022). Assesment Report 6, Working Group II. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/.

[12] There are also secondary carbon markets, where credits can be bought and sold among for-profit investors who speculate that the value of permits to emit may increase in the event of stricter regulation of emissions in the future.

market (such as when production is 'offshored', or when logging is shifted out of a territory covered by an offset deal and into an unregulated area).[13]

Carbon offsetting is the practice of purchasing carbon credits on the voluntary or regulated carbon market, as a way to compensate for continued emissions. Within a net zero emissions context, carbon offsetting per definition works as a substitute for direct emission reductions. However, it is important to distinguish between different forms of carbon offsetting. In 'avoidance offsets', the claim is that emissions are 'offset' by reductions achieved or anticipated in another source (calculated against a hypothetical baseline scenario unrelated to the absolute emissions involved).[14] By contrast, in the form of 'removal offsets', continued emissions are balanced against carbon removal. Whereas from the perspective of a smaller entity, these two forms might seem equally valid, in a end-state of a global net zero balance only the latter form of offsets can play any role.[15]

Carbon avoidance offsets allow one entity that emits greenhouse gases to pay another entity to *avoid emitting an equivalent amount of emissions*. This is often done through forest- and peatland protection projects, or by supporting emissions reductions in the energy and waste industries. In theory, the *rate of growth* in emissions is thereby stabilized: Instead of two sites contributing to global warming, only one site does. We say 'in theory' because it is difficult to establish that the financed project would not have avoided emissions regardless, given other drivers of decarbonization (a problem known as 'additionality')[16] or that the anticipated emissions were actually avoided in practice (given challenges of accurate monitoring and verification involved). Because the first entity continues to emit GHGs, these kinds of offsets do not stop the accumulation of greenhouse gases in the atmosphere, and are therefore incompatible with net zero emission targets. Nevertheless, they are often (falsely) portrayed as a means of neutralising the climate impact of carbon intensive activities.

Carbon removal offsets allow one entity that emits GHGs to pay another entity to *remove an equivalent amount from the atmosphere through human means*. Currently, removal offsets primarily take the form of afforestation or other means of artificially enhancing the carbon sequestration potential of ecosystems, although technological methods are also being developed. In theory, the additional amount of GHGs added in one place is removed in another. We say 'in theory' because relying on 'nature-based solutions' assumes that the capacity of the natural carbon sink is actually *enhanced*, and that the carbon originally bound in the form of coal, oil or gas can be bound again to the same degree of permanence.[17]

Because forests and ecosystems change over time and can easily turn from being a carbon sink into being a source of carbon dioxide, offsets based on such biological removals cannot reliably

---

[13] It is debateable to what extent such leakage internationally is triggered by climate policy mechanisms, as opposed to other economic drivers: see https://www.lse.ac.uk/granthaminstitute/news/what-is-carbon-leakage-clarifying-misconceptions-for-a-better-mitigation-effort/

[14] Ascui and Lovell (2011) As frames collide: making sense of carbon accounting https://www.emerald.com/insight/content/doi/10.1108/09513571111184724/full/html?fullSc=1

[15] Allen et al. 2020. The Oxford Principles for Net Zero Aligned Carbon Offsetting. https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf; Fankhauser, Smith et al. (2021) 'The meaning of net zero and how to get it right'. Nature Climate Change.

[16] Companies can buy carbon credits to 'offset' a ton of carbon dioxide emissions for as little as US$1. The typical range is US$3-5 per tonne. Most of these credits are cheap because they lack additionality and do not actually sequester any carbon from the atmosphere. For example a Chinese windfarm has sold over 2 million tonnes of credits since 2011, which is neither removing carbon from the atmosphere and is not additional, as the windfarm did not need this carbon credit funding to be built. (https://theconversation.com/outdated-carbon-credits-from-old-wind-and-solar-farms-are-threatening-climate-change-efforts-151456).

[17] In theory, temporary removals could help buy time for decarbonization and the development of more durable removals (see eg https://www.frbsf.org/wp-content/uploads/sites/4/groom-vsce-121621-slides.pdf) but reliance on them could also contribute unhelpfully to delay.

stabilise GHG concentrations. The only way of achieving permanence is by turning the captured carbon into a solid or liquid state that cannot escape back into the atmosphere through burning or decomposition. This is one of the reasons behind a growing interest in technology-based carbon removal options which can theoretically capture carbon in stable forms, but for the time being these technologies are expensive and resource-intensive. It remains unclear if they can be scaled in any significant, sustainable and affordable way.

2. Key concerns with the use of carbon offsets in net zero targets

The use of carbon offsets is not a new practice, and important concerns have long been raised, many of which remain unaddressed and indeed are ultimately unsolvable. The inherent ambiguity of the net zero concept and anticipated need for removals paves the way for offsetting to become a central part of climate policy. Current corporate and country pledges are already bearing witness to this. There is a real risk that this will perpetuate and expand existing problems with carbon offsets. At the same time, the net zero conversation also raises a number of new concerns with the use of offsets. Here, we summarize some of the key problems, and why they need to be avoided to achieve rapid, effective and just climate action.

2.1. Avoidance offsets are incompatible with net zero targets

Many net zero pledges are conflating different types of offsets, without considering the widely different implications they have in terms of climate effects. As outlined above, there are fundamental differences in how various offset types relate to global net zero goals, and they cannot be placed in the same basket. Ensuring ambitious climate action demands attention to the key limitations that different offsets face.

Most fundamentally, *avoidance offsets* do not contribute to halting the accumulation of greenhouse gases in the atmosphere. While these offsets currently make up the vast majority of offsets available on international carbon markets, they cannot help achieve net zero goals. As the remaining carbon budget is extremely limited, rapid decarbonization is a non-negotiable part of any net zero strategy.[18]

This is the reason why many voluntary standards and accountability initiatives, such as the 'The Oxford Principles for Net Zero Aligned Carbon Offsetting'[19] and the standard developed by the Science Based Target Initiative (SBTI),[20] now recommend phasing out the use of avoidance offsets. While emissions avoidance projects might provide important sources of funding for ecosystem protection and decarbonization, there is no reason for such funding to be tied to the trading of emission credits.

[18] Strauch, Y., Dordi, T., & Carter, A. (2020). Constraining fossil fuels based on 2 °C carbon budgets: The rapid adoption of a transformative concept in politics and finance. *Climatic Change*, 160(2), 181–201. https://doi.org/10.1007/s10584-020-02695-5
[19] Allen et al. 2020. The Oxford Principles for Net Zero Aligned Carbon Offsetting. https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf
[20] https://sciencebasedtargets.org/blog/science-based-net-zero-targets-less-net-more-zero

2.2. Removal offsets are limited in practical scope

In contrast to avoidance offsets, removal offsets could theoretically help stop the atmospheric accumulation of GHGs. **In practice however, removals are subject not only to biophysical limits and trade-offs (e.g.in terms of land, water, materials and energy),**[21] **but also to social and environmental limits,** particularly as a result of unevenly distributed impacts or side effects. Integrated assessment modelling tends to exaggerate the potential of removals, as the algorithms in many models overlook the uncertainty of future removals, discount the costs of such future interventions, ignore co-benefits of near-term emissions reductions, and seek primarily to optimise financial costs.[22]

Here it is important to distinguish between different removal offsets on the basis of the permanence of the used carbon sink - it is paramount that carbon removal projects are transparent about how permanent their removals are, and how they intend to address potential (physical risks of) leakage.[23]

2.3. Few removal offsets offer permanent carbon removal

Most carbon removal offsets currently rely on enhancing the *capacity of natural ecosystems to remove carbon*. Yet removals in natural ecosystems are necessarily temporary. Carbon is taken up by living organisms and stored in sinks that are subject to future reversals, for example from forest fires, or from commercial or politically driven changes in land use, and they can therefore not be considered permanent in the same way that underground stores of fossil fuels are. As ecosystems are sensitive to climate change, the risk of them turning from sinks to sources depends on climate action today.[24]

Essentially, ecosystem-based removals temporarily store carbon in the biosphere, while unused fossil fuels are permanently sequestered in the geosphere. Ecosystem-based removals are therefore fundamentally non-equivalent to emission reductions from fossil fuels.[25] Substituting the former for the latter introduces significant risks and uncertainties in climate policy. Carbon removal in the land-use sector is part of necessary efforts to help restore and regenerate severely degraded ecosystems, but this is best seen as a way to re-sequester emissions from historical land use change. It cannot also compensate for fossil fuel emissions. Moreover, ecosystems sequester carbon on multi-decadal timescales, and therefore cannot substitute for the urgent emission reductions that need to happen over the next few years.

The only offset type that in principle could compensate for fossil fuel emissions without compromising on the question of permanence, is a removal offset that can guarantee sequestration in the geosphere, or in the deep oceans. Technologies such as direct air capture and

[21] P. Smith, S. J. Davis et al. (2015) Biophysical and economic limits to negative CO2 emissions, *Nature Climate Change* Vol. 6 DOI: 10.1038/nclimate2870

[22] N. Grant, A. Hawkes, S. Mittal and A. Gambhir (2021) The policy implications of an uncertain carbon dioxide removal potential. Joule 5(10) 2593-2605. DOI: https://doi.org/10.1016/j.joule.2021.09.004; D. McLaren (2020) Quantifying the Potential Scale of Mitigation Deterrence from Greenhouse Gas Removal Techniques. *Climatic Change* 162: 2411–2428 DOI: https://doi.org/10.1007/s10584-020-02732-3

[23] Leakage can refer to either the unintended physical release of CO_2 back to the atmosphere, or the various ways in which social processes might displace carbon emissions beyond the boundaries of any particular offsetting project or market. In this text, our use of the term leakage encompasses both meanings.

[24] See e.g. IPCC 2019 *Climate Change and Land: an IPCC special report.*

[25] Matthews et al (2022) https://www.nature.com/articles/s43247-022-00391-z show that such nature based solutions can help reduced peak temperatures in net-zero scenarios, but only as a complement to aggressive emissions reduction.

bioenergy with carbon capture and storage promise to do this, but they face important resource constraints and sustainability trade-offs. Most importantly, they currently only exist on a tiny scale. One estimate places total, permanent removals in 2021 using these kinds of technologies at 20,000 tons of CO_2.[26] By comparison, an average coal-fired power plant produces about 20,000 tons of CO_2 *per day*.[27] This means **there is currently no way for companies or countries to rely on permanent removal offsets on a meaningful scale**, no guarantee that this will be possible in the future, and therefore no way for most companies and countries to achieve net zero in the short term by using removal offsets.

Definitions of 'permanence' or 'durability'[28] in net zero policies and measures should make such uncertainties and risks transparent, and be explicit about the anticipated life of carbon storage and how such durability can be guaranteed.[29]

2.4. Few offsets are truly additional

To ensure that emissions are actually being compensated for, offsetting projects need to show that their activities are 'additional' to what would have happened in the absence of offset funding. This means that the benefits of the project should not have occurred due to some other natural or policy process. In practice, 'additionality' is often impossible to guarantee, and past experience shows that the 'additionality' criterion leaves ample room for companies to come up with questionable claims that allow them to maximize the amount of credits they are eligible for.[30] Consistent concerns with additionality in offsetting markets undermine the claims to climate benefits of these markets. Additionality guarantees are particularly problematic with nature-based mitigation efforts, because of the blurry boundaries between anthropogenic and natural sinks, and the difficulty of accurate measurements when it comes to ecosystem-based sequestration. A recent analysis of the corporate carbon market found 600 million tonnes of carbon credits available to buy that lack this additionality, seven times the current global demand for offset credits.[31]

2.5. Offsetting facilitates false claims of 'residual emissions'

A key argument justifying the use of removal offsets hinges on the need to compensate for so-called 'hard-to-abate', 'unavoidable' or 'residual' emissions. In practice however, there are no clear definitions or standards specifying what emissions fall under this category.[32] Emissions can be described as residual for a wide number of reasons. The inherent ambiguity of the concept

[26] Stein, D., & Merchant, N. (2022). Racing to Net-Zero: A Captivating but Distant Ambition. *Stanford Social Innovation Review*. https://doi.org/10.48558/7W02-8C60
[27] Mapped: The world's coal power plants in 2020 (carbonbrief.org)
[28] These terms are often used interchangeably to describe how long the removed carbon will remain out of the atmosphere.
[29] In their Phase II report, the Taskforce for Scaling Voluntary Carbon Markets (TSVCM) proposes a number of fundamental Core Carbon Principles. One of these principles is called "permanent". However, looking at the details behind this principle, it is clear that "permanent" does not mean that carbon is permanently removed from the atmosphere and stored long term, as the name suggests. In the case of natural carbon solutions, permanence is instead proposed to be achieved through a buffer system. If reversals occur, developers are forced to retire an equivalent number of carbon credits from the buffer system.
[30] See e.g. https://e360.yale.edu/features/perverse_co2_payments_send_flood_of_money_to_china; https://www.technologyreview.com/2021/05/10/1024751/carbon-credits-massachusetts-audubon-california-logging-co2-emissions-increase/
[31] Maslin, M., & Lewis, S. (2021, January 14). Outdated carbon credits from old wind and solar farms are threatening climate change efforts. *The Conversation*. http://theconversation.com/outdated-carbon-credits-from-old-wind-and-solar-farms-are-threatening-climate-change-efforts-151456
[32] Buck, H., Carton, W., Lund, J. and Markusson, N. Why residual emissions matter right now (March 29, 2022). Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4069521

raises the risk that corporations or countries will use the notion of 'unavoidable' emissions loosely in order to justify emissions that would simply be economically or politically inconvenient to eliminate. Ultimately, the question of which emissions are unavoidable is a subjective one, relating to how different groups of people value different human activities. Aviation for example is commonly described as a 'hard-to-abate' sector because there are currently few technological options available for decarbonizing the sector. For a US academic with family spread out over three continents, aviation emissions might therefore seem like a good reason for using scarce removal offsets. From the perspective of a smallholder farmer in sub-Saharan Africa, however, they can equally be seen as a perfectly avoidable luxury.

Because permanent carbon removal opportunities are limited and subject to important trade-offs, the question becomes: what kind of activities or groups of people have a legitimate claim to residual emissions?[33] Compensating residual emissions through offsets – rather than regulation or mandates - leaves this question up the market. It means that those with the most purchasing power can appropriate the largest share of a limited residual emissions budget, to compensate for carbon-intensive activities of their own choosing.

Carbon removal has wide-reaching social, environmental and political implications, and should therefore be incentivized in transparent and democratic ways. This gives strong reasons for avoiding offset markets when it comes to incentivizing and allocating removals. Relying on carbon offsetting to fund carbon removal, particularly in the case of the voluntary carbon market, leaves all discretion about its content and scale to individual companies. This creates the risk of exaggerated carbon removal claims and a market flooded with low-cost removal offsets of low environmental integrity.

2.6. Carbon offsetting reproduces global inequalities

Carbon offsetting allows wealthy nations and individuals to continue emitting and raises important justice concerns. It divides the world into those who can afford to continue to pollute, and those who are paid to deal with that pollution.[34] It contributes, in other words, to reproducing global inequalities, even while potentially contributing to financial flows from rich to poor parts of the world.

At the level of nations, the Paris Agreement clearly states that developing countries should achieve peak emissions later and that concerted efforts to reach net zero at the global level should follow the principle of 'common but differentiated responsibilities and respective capacities'. This implies that pathways to net zero for historic large emitters should be more rapid than the global average (45-50% reductions by 2030), creating space within carbon budgets for poor and vulnerable countries to take a slower pathway including the prospect of achieving net zero later than 2050. Carbon offsetting defies this principle, by promising wealthy countries the possibility of buying credits on the basis of other, typically poorer, nations' removal efforts.

At the level of individuals, offsetting allows corporations to stake claims on the world's limited removal capacity to offset luxury emissions from their customers, e.g. from flying and private car

[33] Carton, W., Hougaard, I-M. and Christiansen, K.L. (2021) https://theconversation.com/we-cant-let-markets-decide-the-future-of-removing-carbon-from-the-atmosphere-171379

[34] The controversial idea that markets in nature can finance conservation, enabling the world's wealthy to pay for environmental sacrifices by the poor, has bedeviled global climate policy since it was introduced in the form of incentives for biodiversity prospecting in the 1994 Convention on Biological Diversity. See McAfee, K. (1999) Selling Nature To Save It?, *Environment and Planning D*; 17:2.

driving. Such market-based allocation effectively denies the world's poorest people carbon removal to counter-balance residual emissions from essential subsistence activities (e.g. from rice growing), reproducing existing inequalities of opportunity.

2.7. Many offsetting projects lead to negative social outcomes

Carbon offsetting is ultimately based in an effort to identify cost-effective alternatives to direct emission reductions. In many cases, this leads to negative social consequences as impacts associated with the carbon offset production are not fully compensated. This is particularly the case for land-based offsets, i.e. based on bioenergy production, avoided deforestation or tree planting projects, that tend to be produced in contexts of poverty where land and labour are cheap.

It is extensively documented that bioenergy production and tree planting programs tend to induce competition with existing land uses, and lead to few to no local benefits. Historically, such efforts have often resulted in the physical displacement of poor people with undocumented land rights. Similarly, forest conservation efforts often result in poor and forest-dependent people losing access to land and/or important forest-based livelihood opportunities.[35] These negative impacts are rarely adequately compensated for by the offset producing entity.

Other forms of carbon removal also risk negative social or environmental side effects, such as from mining for materials for enhanced weathering, or through demand for additional energy for air capture, raising energy costs and affecting the poorest most. Such impacts may not be so severe as to outweigh the carbon benefits of removals, but their effects should not be ignored. Often however, offset projects tend to be very focused on alleged climate mitigation benefits, with social effects treated as an afterthought.

2.8. Offsetting normalizes dynamics of deterrence and delay

Using offsetting as a means to pursue net zero risks fuelling delay in several respects. The ambiguity of net zero targets creates the illusion that offsetting can contribute a much larger share of climate action than is practical, fair or sustainable. It allows different actors to collectively lay claim to actual and notional offsets far beyond the likely practical availability of total removals.[36] This creates - in effect - a collective delusion that net zero can be achieved with less emissions reduction, and more removals.

The use of offsetting risks extending lock-in of high-emissions infrastructures and justifying the continued exploitation of otherwise stranded assets, especially where measures to eliminate emissions from such sources can be labelled as 'recalcitrant' rather than tackled through difficult or expensive regulatory and behavioural change.

Offsetting also risks delay in the development of robust and durable carbon removal. In carbon markets, market mechanisms work to push down costs by favouring the cheapest options. But this

[35] Asiyanbi, A.P. and J.F. Lund (2020) 'Policy persistence: REDD+ between stabilization and contestation'. *Journal of Political Ecology* 27(1): 378–400.; Carton, W., A. Asiyanbi, S. Beck, et al. (2020) 'Negative emissions and the long history of carbon removal'. *Wiley Interdisciplinary Reviews: Climate Change* 11(6): 1–25.
[36] To each individual actor this approach might seem reasonable, and for each actor the attraction of a slower (and less severe) course of emissions reduction is undeniable. Even where emissions reductions offer net social benefit, the actors involved individually tend to face more costs than benefits.

also incentivises the provision of low-quality offsets, with limited guarantees of durability or additionality. Tougher monitoring and verification mechanisms could improve offset quality, but there are inherent uncertainties which make the verification of even the basic amounts captured by many techniques impractical within the financial constraints of carbon markets.

We can be confident that offsetting reduces the incentives for innovation to cut emissions at source, but could it be justified as a means to provide finance to spur innovation in removal techniques? This may be the case if buyers are prepared to pay high prices for emerging options, of which there are some examples (Stripe, for example is paying from $200-2000 per tonne for removals[37]). But such deals are far removed from conventional offset markets and could just as easily be established in their absence, for example by developing non-market mechanisms for supporting climate mitigation under Article 6.8 of the UNFCCC Paris Agreement.[38] Advocates and developers of carbon removal are typically keen to gain access to carbon markets, but that is because there is little alternative finance available at present, and thus no other ways to demonstrate future profitability to potential investors. The establishment of alternative mechanisms such as a carbon contract for difference or a negative emissions tariff could generate revenue flows from carbon removal and stimulate investment.[39]

Although exacerbated by poor standards and weak regulation, such political problems are inherent in the use of offsetting and markets as policy tools - and in part a product of the active lobbying of financial and corporate interests for their use, instead of direct regulatory and investment interventions.

[37] See: https://stripe.com/newsroom/news/spring-21-carbon-removal-purchases
[38] See: https://www.clara.earth/unfccc-negotiations.
[39] See, for example the negative emissions tariff concepts at https://www.yrpri.org/group/10970;; and https://climatestrategies.org/wp-content/uploads/2021/03/Carbon-Contracts_CFMP-Policy-Brief-2020.pdf

3. Recommendations

In a world where neither biodiversity protection, nor carbon removal are being delivered at socially desirable levels, it may be tempting to see offsetting as a means of mobilising additional finance to such ends. This is a dangerous perception. The offsetting process currently guarantees the continued emission of greenhouse gases by the purchaser. Because of the problems of scale, additionality, equivalence, leakage, double counting and low prices noted above, offsets today do not guarantee the removal of an equivalent quantity of CO_2. Moreover, market competition inherent to such systems incentivises the provision of poor-quality, low-cost offsets. These not only risk increasing social or environmental harms, they *deter concerted action on emissions reduction* by suppressing carbon prices and sustaining illusions of easy future fixes for climate change.

Strictly speaking, avoidance offsets have no place in ambitious climate policies. Only durable removal offsets could, theoretically, contribute towards net zero. However, these removal offsets currently only make up a tiny portion of the offset market, and therefore offset markets are not a realistic short-term option for achieving net zero targets. Relying on markets to allocate removals moreover leads to unjust outcomes. Hence, while some level of removals are likely needed to compensate for emissions that cannot be eliminated directly, this is best financed through other means than offset markets.

Robust carbon removals can be incentivised through direct public financing, perhaps involving advance market commitments (as used for COVID vaccines),[40] or through mandates placed on key actors (such as fossil fuel extractors).[41] Rather than buying offsets and claiming neutralisation of emissions, corporate and municipal actors could allocate funds to make investments in removal techniques or biodiversity protection as 'additional contributions' in excess of required emissions reductions.[42] In doing so, it will be important to restrict the use of carbon removals to those situations in which emissions cannot be eliminated directly. In other words, they should be additional to the rapid phase-out of fossil fuels. Investment in low-energy technologies to absorb and permanently sequester carbon in a way that does not rely on extensive land and resource use will be crucial to achieving these types of removals.

Meanwhile, the most prudent and scientifically justifiable approach to the management of the *terrestrial carbon sink* is to maximise the biodiversity and climate change adaptation benefits of existing ecosystems, which tends to co-benefit the carbon sink as well.[43] Direct and targeted (but separate) support for biodiversity protection and restoration of degraded ecosystems is strongly preferable to financing through offsets.[44]

For actors currently using carbon offsets we would concur with the advice given by the Oxford Principles for 'net zero aligned offsetting'[45] to eliminate avoidance offsets, and to move to durable (and broadly sustainable) removals, while significantly accelerating action to minimise residual

[40] Athey et al https://www.politico.com/news/agenda/2021/12/22/carbon-removal-advance-market-commitments-525988; for an initial example in this sector see https://frontierclimate.com/

[41] S. Jenkins, E. Mitchell-Larson et al (2021) Upstream decarbonization through a carbon takeback obligation: An affordable backstop climate policy. *Joule* 5(11) https://doi.org/10.1016/j.joule.2021.10.012

[42] See Jeffery, L., Höhne, N. et al (2020) Options for supporting Carbon Dioxide Removal https://newclimate.org/wp-content/uploads/2020/07/Options-for-supporting-Carbon-Dioxide-Removal_July_2020.pdf

[43] Smith, P., Arneth, A.,et al (2022) How do we best synergise climate mitigation actions to co-benefit biodiversity? *Global Change Biology* (online). doi: 10.1111/gcb.16056; Shin,Y.J., Midgley, G.F., et al (2022) Actions to halt biodiversity loss generally benefit the climate. *Global Change Biology* (online). doi: 10.1111/gcb.16109

[44] Seddon, N., A. Smith, P. Smith, et al. (2021) 'Getting the message right on nature-based solutions to climate change'. Global Change Biology Preprint (September 2020): 1–29.

[45] Allen et al. 2020. The Oxford Principles for Net Zero Aligned Carbon Offsetting. https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf

emissions; and also to avoid making marketing claims such as 'net zero emissions' or 'climate neutral'. But for governments and regulators our advice is to avoid the development or extension of offset markets, and at a minimum, ensure that any trading systems are founded on stringent emissions caps that cannot be weakened through offsetting loopholes.

The priorities for genuine and effective net zero policies are, first and foremost, urgent and comprehensive emissions reductions, followed by measures to ensure the quality and integrity of any removals that might be essential to compensate for unavoidable emissions and/or overshoot; both complemented with legal frameworks to ensure transparency, sustainability and justice in the design and deployment of these measures.[46] Contributing to a global fossil-fuel phase out and cutting underlying energy demands will not only help address climate change, but also reduce global insecurity relating to dependencies on extraction and trade of fossil fuels (as seen in the impact of the war in Ukraine). Whilst net zero targets are essential at the global scale, for reasons of justice and politics they become far less appropriate at smaller scales. For countries, cities and corporates we strongly recommend that net zero objectives should be supplemented with separate, explicit, emissions reduction and carbon removal targets. In the detailed design of net-zero policies, avoidance offsets should be eschewed, the need for removals minimized, and the durability of removals in the face of future high temperature scenarios and associated leakage rates explicitly accounted. Moreover, clear distinctions should be maintained between biogenic and fossil carbon, so that not only are net flows of carbon to the atmosphere halted, but also the balance between carbon stocks in the geosphere and biosphere is restored.

[46] Fankhauser, S., S.M. Smith, M. Allen, et al. (2021) 'The meaning of net zero and how to get it right'. *Nature Climate Change.*

Authors and Contact Information

Dr. Wim Carton, Associate Professor of Political Ecology, Lund University, Center for Sustainability Science (LUCSUS), 0046 46 222 03 94, wim.carton@lucsus.lu.se

Dr. Wolfgang Knorr, Research Scientist, Lund University, Physical Geography and Ecosystem Science, wolfgang.knorr@nateko.lu.se

Dr. Simon Lewis, Professor of Global Change Science, University College London, 0044 7972 165 757, s.l.lewis@ucl.ac.uk

Dr. Jens Friis Lund, Professor of Political Ecology, University of Copenhagen, 0045 2062 7706, jens@ifro.ku.dk

Dr. Kathleen McAfee, Professor of International Relations, San Francisco State University, 001 510 759 0254 kmcafee@sfsu.edu

Dr. Duncan McLaren, Research Fellow, Lancaster University, 0044 7394 306068 d.mclaren@lancaster.ac.uk

Dr. Ina Möller, Research Fellow, Wageningen University and Research, Environmental Policy Group, 0031 6513 21950, ina.moller@wur.nl

Dr. J. P. Sapinski, Assistant Professor of Environmental Studies, Université de Moncton, jean.philippe.sapinski@umoncton.ca

Dr. Doreen Stabinsky, Professor of Global Environmental Politics, College of the Atlantic, 001 207 276 5284, doreenstabinsky@gmail.com

Dr. Pete Smith, Professor of Soils & Global Change, University of Aberdeen, 0044 1224 272702, pete.smith@abdn.ac.uk

Dr. Terese Thoni, Programme Coordinator, Lund University, Centre for Environmental and Climate Science, 0046 46 222 27 519, terese.thoni@cec.lu.se