Are carbon offsets unscalable, unjust, and unfixable—and a threat to the Paris Climate Agreement?

A White Paper from the Penn Center for Science, Sustainability, and the Media

Joseph Romm, Ph.D.

EXECUTIVE SUMMARY

"If the world were graded on the historic reliability of carbon offsets, the result would be a solid F." That was the conclusion of a 2019 analysis by ProPublica of global carbon offsets of the past two decades, the scientific literature, technical reports, and new satellite imagery. Numerous investigative reports, scientific studies, and leading experts support that conclusion.

What is new is that—absent major changes—"there is a risk that … the voluntary carbon market undermines the objectives of the Paris Climate Agreement instead of supporting the required transformational change," as one review article explained.

What is also new is the rapidly rising reputational—and legal—risks offsets pose to companies. As recently as November 2021, McKinsey said "net zero" was now "a core principle for business." By February 2023, a leading publisher for media and marketing companies wrote, **"Carbon offsets present an emerging risk to advertisers,"** and **"firms relying on offsetting to hit net zero targets risk greenwashing—and the law might be coming for them."** In September 2022, a law firm with over 1000 lawyers in 12 countries issued a client memo titled, "Carbon Offsets: A Coming Wave of Litigation?" In May 2023, the CEO of United Airlines said of offsets, "the majority of them are fraud," and Delta was sued in federal court over its claim to be "the world's first carbon-neutral airline."

Carbon offsets are "reductions of greenhouse gas emissions from an activity in one place to compensate for emissions elsewhere," as the U.S. Government Accountability Office (GAO) put it. In a typical transaction, a developed country or company—instead of reducing its own heat-trapping CO_2 emissions—pays a developing country to reduce its emissions by an equivalent amount instead. If the buyer purchases enough offsets to cover all its emissions, then it calls itself "carbon neutral" or "net zero." Typical projects are deploying clean energy, planting new trees, and paying people not to cut down trees**. But research on offsets shows "the large majority are not real or are over-credited or both,"** said Dr. Barbara Haya, Director of The Berkeley Carbon Trading Project, in 2023.

These problems pervade every major offset program. Consider the UN's Clean Development Mechanism (CDM)—the world's biggest program, launched in 2006. Over 50% of CDM offsets came from China, nearly 70% from China and India. **Studies have found the vast majority of those credits were not genuine—either the projects would have happened anyway (without the offset money) or they were credited for far more reductions than actually occurred or both**. Also since 2006, China built so many coal plants its yearly CO_2 emissions *increased* by nearly as much as the U.S. emits today. India's emissions doubled. So not only was there little actual clean development, but those offsets were sold to developed countries, letting them generate as much as 6 billion tons of CO_2 more than they would have otherwise. **Too often, offsets cause pollution and discourage genuine CO_2 reductions.**

This paper explores whether the carbon offset market is fixable, just, and scalable. **One finding: There is a growing consensus that companies should not be using any offsets they buy from developing countries to make claims about emissions reductions or net zero.** The Science Based Targets initiative (SBTi), which works with thousands of companies, said in 2021, **"Net-zero targets are mostly greenwash" that focus on "offsets instead of reducing emissions.**"

This growing consensus is very visible in the price history since June 2022 of Nature-Based Global Emissions Offsets (NGEOs), such as forest conservation or restoration projects:

We will look at the dramatic but poorly understood changes in the offset market that the world adopted since Paris. These changes will create a new UN-run market of "authorized" offsets that, experts say, will disincentivize developing countries from participating *and* from making strong CO_2

reduction pledges. The details are not finalized, but if the current changes stick, **authorized offsets would allow developed countries to make achieving their Paris climate commitments *easier* by paying developing countries to make achieving their commitments *harder*.** In 2023, Dr. Haya said of this burden shifting, “I don’t think it’s fair, and I don’t think it’s what we should be doing.”

This burden shifting is also not popular with most developing countries. So, we are unlikely to see it happen at scale—at least until those offsets are much costlier than today, perhaps by a factor of 10 or more. **In 2023, the World Bank modeled authorized offsets and found they may well exceed $100 a ton. A high price is especially likely because there are far fewer “negative emissions”—tons of carbon dioxide removal (CDR)—available than are widely expected**.

“Carbon dioxide removal is not a current climate solution,” argues a 2023 *Nature* article. If we don’t “drastically reduce emissions first,” CDR “will be next to useless.” **Bioenergy with carbon capture and storage (BECCS) is unlikely to generate significant negative emissions by 2050 and scaling it up may well increase global warming for decades**. **At a June 2023 Direct Air Capture Summit hosted by industry leader Climeworks, the company’s co-founder and co-CEO Jan Wurzbacher “told the crowd his company could see its prices remain as high as $300 by 2050.”**

So, achieving net zero for most countries in the coming decades will involve fewer purchases of carbon removal and more pursuit of domestic emissions reductions, which will likely become more expensive over time. So, **selling off your easiest emission reductions cheaply now may be a counterproductive policy for any country**.

We’ll examine whether the UN should be running a major new offset effort similar to the CDM for nations party to the Paris Agreement—given its inability to fix the CDM’s key problems after two decades of trying. **We will explore the issues raised by a May 2023 deal where Microsoft is buying and claiming the same carbon offsets from a BECCS project in Denmark that the Danish government is officially buying and counting in its national CO_2 inventory**. We will also look at the many climate justice issues offsets raise. Ultimately, we’ll see why **the fact that the entire world must get emissions as close to zero as possible undercuts the rationale for carbon offsets**. The solution is to replace offsets with programs whereby the richer countries and corporations focus on 1) meeting their climate targets by reducing their own emissions and 2) helping the poorer countries reduce their emissions without offset projects.

INTRODUCTION

Offsets took off in the 2000s when the UN launched the Clean Development Mechanism. The CDM was created to help developed countries meet their greenhouse gas (GHG) reduction targets under the 1997 Kyoto Protocol, an international climate treaty, while helping developing countries grow more sustainably. As the UN explains, “The CDM allowed countries with emission-reduction targets to partly meet their commitments by buying Certified Emission Reductions (CERs), one tonne of CO2 equivalent each, from projects that reduced or avoided emissions in developing countries.”[1]

These CERs allowed developed countries to officially offset an equivalent amount of their pledged reductions. If Germany had to reduce emissions by 100 million tons, for example, they could fund a renewable energy facility in China that was projected to save (or avoid) 10 MT, and then they would only have to reduce their own CO_2 emissions by 90 MT to meet their goal.

A 2016 analysis of CDM projects for the European Commission’s Directorate-General for Climate Action found that **“85% of the covered projects … have a low likelihood of ensuring environmental integrity (i.e. ensuring that emission reductions are additional and not over-estimated). Only 2% of the projects … have a high likelihood.”[2]** A great many offsets were awarded to clean energy projects, such as wind and hydropower, that would have happened anyway (so they were not “additional” as discussed below). By the mid-2010s, the CDM “pipeline” had more than 2000 dams in various stages of approval. Some two-thirds were in China. **Yet, these dams “are being built at a rapid rate by countries such as China, India and Brazil independent of any subsidy for supposed mitigation benefits,”** noted a 2015 study.[3] They would have been built anyway—without the CDM. “In addition, tropical dams emit greenhouse gases despite CDM regulations allowing zero emissions to be claimed by many dams.”

Recent studies have estimated the CDM may well have led to a substantial *increase* in CO_2 emissions—6 billion tons, in the case of one 2021 study.[4] Why? The reductions in the developing countries would have happened anyway and were far smaller in reality than they were credited for—10 CERs were issued but, in reality, it should’ve been 2 or perhaps 0. Yet the extra carbon pollution that the developed countries were allowed to emit by purchasing CDM offsets was real. **One 2018 study explained the mechanism “does not reduce global emissions” by its very design**.[5]

The CDM’s Certified Emission Reductions were part of a “compliance market,” since they allowed a developed country to comply with a mandatory emissions reduction target. At the same time as the CDM, the *voluntary* offset market was also developing. It let companies (and others) help meet a voluntary emissions reduction target by paying someone (typically in a developing country) to reduce their emissions by an equivalent amount in their place. If a company purchased enough of these unofficial offsets to cover all its emissions, then it could call itself "carbon neutral" or "net zero." The first carbon offset was in 1988, but the overall voluntary market had only about $300 million in c*umulative* sales pre-2005.[6] When the CDM launched in the mid-2000s, the voluntary market also took off and from 2005 to 2020 averaged about $350 million in *annual* sales, with many ups and downs.

Then in 2021, the market exploded to $2 billion.

Why? In the 2015 Paris Agreement, the world's leading countries—developed and developing—unanimously agreed to reduce greenhouse gas emissions to a level that would avoid dangerous climate impacts. This meant, according to the Agreement, "holding the increase in the global average temperature to well below 2°C [3.6°F] above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C [2.7°F]."

After Paris, momentum grew for 1.5°C as the target. The parties to the Agreement asked the world's top climate scientists of the Intergovernmental Panel on Climate Change (IPCC) to do a special report on 1.5°C warming, which was released in 2018. The IPCC found climate impacts beyond 1.5°C were much more serious than realized.[7] Thus, limiting warming to 1.5°C was imperative—but meeting the 1.5°C limit required reducing global CO_2 emissions 45% by 2030 compared to 2010 levels and to "net zero" around mid-century. Net zero for the world means that whatever emissions can't be mitigated must be offset by carbon removals (such as tree-planting or technologies that directly capture CO_2 from the air). The report further stated, "**Limiting global mean temperature increase at any level requires global CO_2 emissions to become net zero at some point in the future**."[8]

Leading up to the Glasgow, Scotland climate summit (COP26) in the fall of 2021, more and more countries (and companies) began making net-zero pledges. President Xi Jinping announced in September 2020 that China would aim to "achieve carbon neutrality before 2060." At the summit, India said it would aim for net zero by 2070. By the end of Glasgow, more than 70 countries—including most of the top emitters—had made the net-zero pledge.[9]

At the same time, many companies made similar pledges. Over 450 banks, pension funds, and other firms that together manage $130 trillion pledged at Glasgow to use their money to reach net-zero by 2050.[10] During the summit, McKinsey published a piece, "COP26 made net zero a core principle for business. Here's how leaders can act."[11] It argued that now, "net-zero commitments are the norm."

So, business pledges for net zero soared over the course of 2021. Coupled with a growth in speculation by investors believing they could make a profit by buying offsets before the gold rush, the unregulated sale of voluntary offsets soared in 2021 to $2 billion, quadruple 2020 spending. One market research firm projected in December 2022 that offset purchases could hit $17 billion by 2027.[12] In 2023, Boston Consulting Group and Shell Group projected purchases could hit $10 to $40 billion by 2030.[13]

Yet there is a tremendous disconnect between all this activity and what the scientific literature and investigative reports on offsets have been saying for the past two decades as well as what many major practitioners—and the world as a whole—have started doing in the last few years.

THE PROBLEMS WITH OFFSETS AND NET ZERO

In September 2022, the Gold Standard—a top certifier of carbon credits—changed its "claims guidelines" to ensure its certified projects were communicated "accurately."[14] **All credits would now be called an "impact claim" or "contribution claim"—whereby the buyer can say it is contributing to a domestic carbon target "without stating or implying" they've offset their own emissions. Moreover, the buyer cannot credibly make offsetting claims unless credits meet key criteria (which few if any can), including that they "are highly likely to be additional" and that "organisations should prioritise the avoidance and reduction of emissions, in line with science"—with a strong preference the offsets are not double claimed with the selling country's Paris Agreement commitments.[15]** At the same time, other certifiers are still calling what they sell "offsets," and many companies are still buying them and asserting they are offsetting their own emissions.

The market for "authorized" offsets in the emerging compliance market for countries to meet their climate commitments under the Paris Agreement is moving in a similar direction as the Gold Standard—following the dramatic changes in offset rules the world adopted at the last two global climate conferences. Because the underlying realities of offsets are so opaque and confusing, the full implication of these changes are not well understood, so they will be discussed at length below. But the key point for now is that—once the rules are finalized—**for an offset to become "authorized" by the UN, the selling country will have to effectively agree to make their official climate commitment harder to achieve**. If the seller does not agree to that, then the offset will likely be reclassified to something very similar to the "contribution claim" the Gold Standard has shifted to. And that means the buyer can't use it to meet their official Paris commitments.

Returning to the voluntary market, the Science Based Targets initiative (SBTi) launched a new "Net-Zero Standard" in 2021, which it revised in April 2023. SBTi is the leader in setting and verifying credible voluntary targets. It works with thousands of companies, of which more than 2600 have science-based targets and over 1700 have pledged to meet its specific requirements for a genuine "net zero" commitment.

SBTi noted in October 2021 that nearly 70% of the global economy had committed to net-zero by 2050 but that **"Net-zero targets are mostly greenwash" that focus on "offsets instead of reducing emissions.**"[16] SBTi explained that **now, to be net zero, the vast majority of companies working with SBTi must directly cut their emissions 90-95% before 2050.** Virtually none of the offsets available on the voluntary market play a part here: "When a company reaches its net-zero target, only a very limited amount of residual emissions can be neutralised with high quality carbon removals, this will be no more than 5-10%."

In its April 2023 *Corporate Net-Zero Standard, Version 1.1*, SBTi underscored the point that "**The use of carbon credits must not be counted as emission reductions toward the progress of companies' near-term or long-term science-based targets**."[17] SBTi does, however, allow companies to use something similar to an offset—a Renewable Energy Credit (REC)—to meet any of its targets for offsetting emissions from its electricity purchases. Yet as we will see in the next section, RECs don't represent real emissions reductions, and corporations should not be allowed to use them as such.

In terms of neutralizing residual emissions, SBTi explains, "**Companies shall remove carbon from the atmosphere and permanently store it to counterbalance the impact of any unabated emissions that remain *once* companies have achieved their long-term science-based target**."[18] The permanent storage requirement eliminates the most popular nature-based offsets used today, such as tree planting, as we'll see. Finally, SBTi explains it will take quite some time before most company can say they are net zero: "**A company cannot claim to have reached net-zero until the long-term science-based target for all scopes is achieved, and the company has neutralized residual emissions**."

The world's leading climate experts embraced a similar view for countries—"focusing on direct emission reductions within their own territory; minimal reliance on offsets"—in their 2900-page IPCC report summarizing the state of climate change mitigation knowledge in 2022.[19]

In November 2022 during the big climate conference in Egypt (COP27), the UN's High-Level Expert Group on the Net Zero Emissions Commitments of Non-State Entities" released, "Integrity Matters: Net Zero Commitments by Businesses, Financial Institutions, Cities and Regions."[20] The

Group had "over 40 regional and thematic consultations" that included over 500 organizations worldwide. One of its "main recommendations" is **"Non-state actors must prioritise urgent and deep reduction of emissions across their value chain. High integrity carbon credits in voluntary markets should be used for beyond value chain mitigation but cannot be counted toward a non-state actor's interim emissions reductions required by its net zero pathway."**

The Expert Group explains that to "be considered and recognised as net zero," a non-state actor (such as a company) must meet two conditions. First, its targets and pathway to net zero should be "consistent with limiting warming to 1.5°C" using a methodology verified by an independent third party like SBTi. Second, "it has achieved its long-term net zero target with any residual emissions neutralised by permanent greenhouse gas removals" as verified by "a credible, independent third party." **In short, companies should not be using any offsets they buy in the voluntary market to make any claims about emissions reductions or net zero for the foreseeable future.**

So at the same time that many experts were predicting the market for offsets would keep rising sharply, many companies and others were concluding that offsets were not a viable solution to the climate crisis, and that most net zero claims were, as SBTi says, "greenwash"—an attempt to look environmentally responsible without actually doing so. Offset expert Dr. Mark Trexler, who worked on the first offset (in 1988), said in 2023, "**I don't think corporate net-zero leads to decarbonization."**[21] Similarly, Dr. Barbara Haya, Director of the University of California's Berkeley Carbon Trading Project, said in 2023, **"the offset market is broken, and too far gone to fix."**[22]

Let's start by looking at the challenges facing the offset market to understand why the world's nations made big changes and whether they could make offsets a viable climate solution.

THE ADDITIONALITY AND OVER-CREDITING PROBLEMS

Bloomberg published a 3-part investigation in 2022, "Inside the Billion-Dollar Market for Junk Carbon Offsets."[23] They examined "more than 215,000 transactions last year" focusing on renewable-energy projects. **Renewables have become so low cost those projects almost certainly would have happened without offset revenues. But genuine offsets must be "additional"—which means the carbon reductions associated with a given project would not have occurred without the revenues from the offset sale.** Offsets that are not additional should not be used as a license to pollute by the buyer. Yet, the report notes many big corporations are using offsets to claim they are "carbon neutral."

Years earlier, the 2016 analysis of the CDM for the European Commission had come to the same conclusion. After examining hundreds of CDM projects, the report concluded, "**Most energy-related project types (wind, hydro, waste heat recovery, fossil fuel switch and efficient lighting) are unlikely to be additional, irrespective of whether they involve the increase of renewable energy, energy efficiency improvements or fossil fuel switch**."[24] And renewables are much cheaper now.

In 2019, the two largest offset certifiers, Verra and Gold Standard, stopped issuing offsets from grid-connected renewable projects anywhere but the poorest countries. But the voluntary carbon market is unregulated—essentially anyone can participate. "It's like the Wild West, where anything goes," said Stefan Reichelstein, professor emeritus of accounting at Stanford Business School in 2022.[25] So, in 2019, in advance of the World Cup, the Qatari government launched its own offset certifier. The Doha-based Global Carbon Council (GCC) now "signs off on the kinds of projects that fail to meet minimum standards anywhere else in the world," including renewables, as *Bloomberg* explained in November 2022.[26] To become carbon neutral, "World Cup organizers have been the sole purchasers of credits verified by GCC." **The carbon market is gameable.**

But gaming the system—such as dubious claims of carbon neutrality—is coming with increasing reputational risk. Responding to complaints, the commission regulating advertising in Switzerland ruled in June 2023 that FIFA, which is based in the country, misled fans with its claims of a "carbon-neutral Qatar World Cup," the *Guardian* reported.[27] While FIFA "repeatedly hints that it will fully offset the emissions to be definitively calculated at a later date, it is unable to provide proof that the estimated emissions have been offset," the Commission said in a press release.[28] "In addition, it is unclear whether [FIFA's] offsetting measures comply with Swiss standards, eg the complete and sustainable removal of CO_2 from the atmosphere." Finally, the Commission "has advised FIFA to refrain from making unsubstantiated claims in the future," including carbon neutrality claims for the 2022 World Cup.

Just as most renewable energy offsets are non-additional, so too is a nearly identical product, a Renewable Energy Credit (REC)—a certificate representing the environmental value of one megawatt-hour of renewable power. In buying a REC, you are paying a renewable project owner (or broker) a little bit of money so you can claim the entire environmental benefit of the electricity produced. Corporations and others often buy RECs to claim a smaller carbon footprint from their electricity purchases, just like an offset. But as Dr. Mark Trexler explains in his 2022 online offsets course: There is "no evidence, unfortunately, the renewable energy certificate market is resulting in any more renewable energy being generated. There is no evidence of additionality."[29] Trexler calls RECS, "just an accounting shell game."

The projects would've happened anyway, as many studies have found, a point also made in the 2022 *Nature* article, "**Renewable energy certificates threaten the integrity of corporate science-based targets**."[30] This study looked at "the climate change disclosures of 115 companies" with science-based targets. It found two-thirds of the claimed emissions reductions from these companies' electricity usage (so-called Scope 2 emissions) came from RECs and so were "unlikely to be real reductions." In October 2022, *Bloomberg Green* found a similar reliance on RECS in what they called "the broadest investigation yet into how companies are using this accounting technique to dramatically exaggerate their emissions reductions."[31] They analyzed nearly 6,000 climate reports filed by companies in 2021.

Back in 2007, a *Nature* article explained, "There is no correct technique for determining additionality because it involves the evaluation of counterfactual circumstances. No test for additionality can provide certainty about what would have happened otherwise."[32] In 2008, the GAO similarly said of the CDM: "it is impossible to know with certainty whether any given project is additional."[33]

Consider the common case where the offset is paying a landowner or country not to cut down trees. The counterfactual is no payment. But how do you know the landowner was going to let some lumber company cut down their trees? Investigations have revealed many cases where the land was already set aside as a preserve. What if only half the trees were to be cut down? What if the trees were destined to be used not for making wood products, which store carbon a long time, but for burning to generate heat, releasing a huge amount of CO_2? What if the company simply cuts down the same number of trees somewhere else? And what if the preserved forest is later burned down in a wildfire?

How do you do a credible life-cycle analysis if you don't even know what will happen to the trees? You can't. And that is true of most offsets—particularly the so-called "avoided emissions" offsets, where you aren't actually funding a direct reduction in emissions but, rather, you're theoretically trying to avoid future emissions, as in the case above of paying someone not to cut down trees.

Back in 2007, the *Guardian* called this "a crisis of legitimacy in the voluntary market, as offsetters lay claim to certainties that are beyond their reach."[34] **Their "major investigation" showed "how greenhouse gas credits do little or nothing to combat global warming**." They quoted Dan Welch, a journalist who scrutinized offsets: "Offsets are an imaginary commodity created by deducting what you hope happens from what you guess would have happened."

A 2022 *New Scientist* article explained that "**California's carbon offsetting may actually be increasing emissions**."[35] A 2019 study by Dr. Haya had found most credits offered by California for forest preservation "likely do not represent true emissions reductions due to the protocol's use of lenient leakage accounting methods."[36] Leakage occurs when your effort to reduce emissions in one place leads to increased emissions in another—for instance, reducing timber harvesting in one place causes an increase in timber harvesting in another place to meet the demand for wood. Research indicates the actual leakage rate is four times higher than what California's protocol assumes. This coupled with California's lenient leakage accounting methods is why the state is greatly over-crediting forest preservation tons.[37]

Significant over-crediting is commonplace in the voluntary carbon market (VCM). As one carbon management firm wrote in 2022, "**Studies have found very high rates of over-crediting by all major offset programs** that have developed offset protocols with credits available on the VCM, including the UN's Clean Development Mechanism, California's offset program, and a range of project types developed by the voluntary market registries, including soil carbon, improved cookstoves, and improved forest management."[38] Dr. Barbara Haya said in 2023, "**everyone has not just failed, but deeply failed**."[39]

The over-crediting can be considerable, as in the case of replacing inefficient, dirty cookstoves (used by nearly 3 billion people globally) with more efficient ones. The 2023 study, "Cooking the books: Pervasive over-crediting from cookstoves offset methodologies," noted cookstoves represent more than 10% of projects on the VCM.[40] The authors analyzed the climate benefit of 36 cookstove projects, concluding, "We estimate that our project sample, on average, is over-credited by 6.3 times." That is, "**the average project generated roughly 6 times more credits than our estimated climate benefits**." Extrapolating their methodology to all cookstove offsets, **their analysis found that of the 53 million VCM-issued credits, only some 8.7 million (~16%) "likely should have been issued**."

All of these studies and exposes may be starting to discredit key carbon offsets used by companies to become carbon neutral or net zero, thereby weakening demand. **The amount of "avoided deforestation" credits supplied to the market "shrank by a third from 2021 to 2022," explained a 2023 BloombergNEF analysis. Why the drop? "Some companies were accused of greenwashing after buying such offsets."**[41] And in the first half of 2023, the price of a great many carbon offsets declined sharply.[42] On May 26, 2023, *Quantum Commodity Intelligence* reported, nature-based offsets hit "**a new all-time low**" of $1/tCO2e.[43] In June 2023, *CarbonCredits.com* did an "in-depth analysis" of the collapse in prices of Nature-Based Global Emissions Offsets (NGEOs), which are "generated by projects that reduce, remove, or prevent carbon emissions through nature-based solutions," such as forest conservation or restoration projects (see chart).[44]

The analysis noted that "while **the prices of all voluntary market carbon offsets … have taken a beating**, the decline in NGEO prices stands out due to the premium they were trading at over the other offsets last year." Nature-based offsets "trade at a premium due to the additional co-benefits they bring, like biodiversity protection." They have been the most popular offsets, comprising 45% of all offsets in 2022. But this 90% drop in prices in just 12 months suggests that their myriad problems are making them much less attractive to corporate offset buyers and others.

THE DOUBLE COUNTING PROBLEM

Double counting is, along with additionality, leakage, and over-crediting, one of the biggest problems offsets face—although it's much more confusing. But you can't understand the game-changing implications of the "authorized" offsets created by the Paris Agreement—or how voluntary offsets threaten that Agreement—without understanding the issue.

Double counting occurs when a project cuts emissions by, say, 10 million tons of CO_2 (10 MT), and the buyer of the offsets takes credit for the emissions reduction (by claiming its "net" emissions have dropped by 10 MT)—but the country selling the offset *also* takes credit for reducing its own total emissions (by 10 MT).[45] Thus one project that (may have) reduced global emissions by 10 MT gets counted as if it reduced global emissions by 20 MT. That's why, for an offset to be genuine, if a developing country uses a project to reduce its own officially-recognized emissions—as it invariably does—then that same project shouldn't be used to offset the buyer's emissions too.

One reason the double-counting problem took so long to address is that it's very counterintuitive. And that's because we are used to thinking in terms of buying and selling actual commodities, whereas offsets are a hypothetical reduction of a commodity—essentially a negative commodity, a theoretical cut in CO_2 emissions. Genuine commodities operate very differently, since buying a positive number of real items is completely different than buying a negative number of hypothetical ones.

If I have 10 oranges and you have 10 oranges, then when I sell you those 10 oranges, you have 20 oranges, and I have zero oranges. You the buyer would never let me sell you 10 fake plastic oranges—let alone sell you 2 fake oranges and claim that I was selling you 10 real ones, which is basically how the carbon offset market operates. **With real commodities, it's *caveat emptor*—the buyer is motivated to ensure the quantity and quality, even if the seller is not.**

But imagine you could sell negative oranges or the reduction in the number of oranges. If I eat my 10 oranges (taking me to zero) and then sell you 10 orange offsets, which you use to claim you also have zero oranges, then to the world we are each claiming we have zero oranges. But the total number of oranges between us is not zero—it is in fact clearly 10. We just double counted the reductions.

Now imagine the world is trying to reduce the number of oranges and that I, the seller, am a country, and you, the buyer, are a company that doesn't really care if you reduce your quantity of oranges—you only want to convince the public you have. The country is happy to sell you 10 fake plastic orange offsets—which is to say they don't actually have to consume their own oranges. Now whereas the buyer would normally ensure the quantity and quality of a real commodity, in this case the company doesn't really care whether they are getting genuine orange reductions. They just want to be able to publicly claim as many orange reductions as they can at the lowest possible price.

Now back to something the world is actually trying to eliminate—CO_2 emissions. The selling country also is not incentivized to care if the emissions reductions are real. And it genuinely benefits the country if they are overcounted—since the seller gets paid (per ton) as if they are real and counted correctly. But you, as the greenwashing company paying for the project, don't care either because you get to count all the non-genuine emissions reductions—at minimal cost. **In fact, you generally don't**

want to buy high-quality tons because those tons would each cost more (being higher quality), and the project's total tons would generally be lower (after correctly accounting for leakage, over-crediting, and the like). This problem in the offset market is not new. Indeed, two decades ago, a 2001 study on forestry carbon projects explained, "**In the case of carbon offsets, both the host country and the project developer have an incentive to exaggerate their accomplishments**."[46]

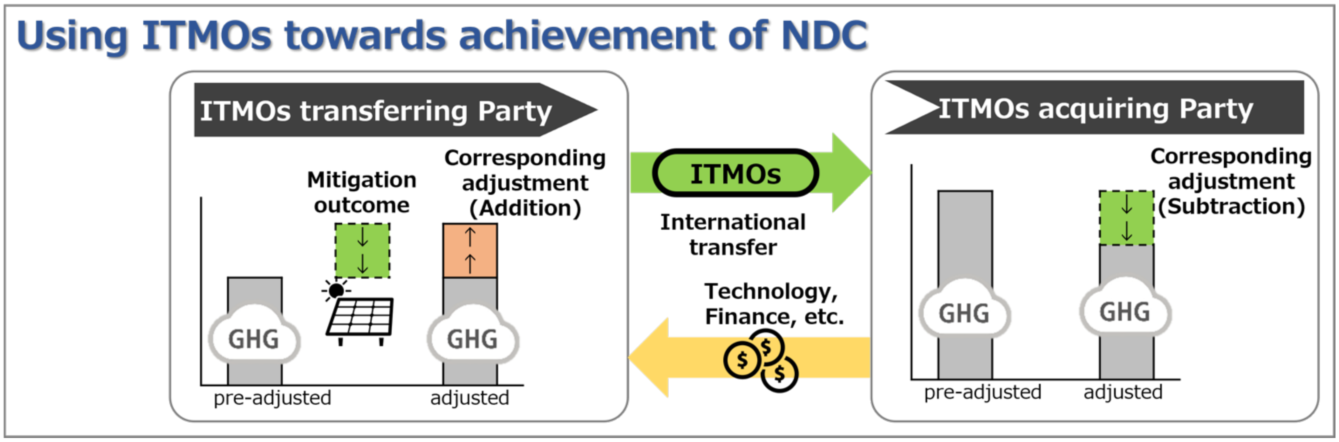
HOW THE DOUBLE COUNTING SOLUTION CHANGES EVERYTHING

Fixing the double-counting problem was at the heart of the changes the world made at the big climate conferences in late 2021 (COP26 in Scotland) and 2022 (COP27 in Egypt).

For years the world could not agree on a new offset system because Brazil (and others) refused to fix the problem. At COP26, Brazil agreed to a fix—but with a twist, as we'll see. The fix is a type of double-entry bookkeeping called "corresponding adjustments." *SPGlobal* explained in 2021, **"the host country will have to issue a guarantee that it won't use the transferred credits against its own NDCs," Nationally Determined Contributions, the emissions reduction commitments it made under the Paris Agreement**.[47] These emissions reduction credits transferred from one country to another are called Internationally Transferred Mitigation Outcomes (ITMOs). To be an offset officially "authorized" under the Paris Agreement, its emissions reductions "can only be claimed once: either by the credit-generating country, or by the second country buying that credit from the international market."

As the journal *Science* explained, in practice this means "**The country selling emission reductions makes an addition to its emission level, and the country acquiring the emission reductions makes a subtraction**."[48] To be clear, at the start of the transaction, the seller has *already counted* the offset reductions (say 10 million tons of CO_2), thereby reducing its total emissions 10 MT. Then, after the sale, it must add back those 10 MT. **The seller must keep its official emissions total flat as if it never reduced its emissions in the first place.**

Japan's Ministry of the Environment has a good illustration (below).[49] Here, the seller transfers ITMOs (mitigation outcomes) of GHG (greenhouse gas) reductions in return for technology and finance and the like from the acquiring party to help it achieve its NDC, its Paris commitment.



On the right, the acquiring party starts with its current, real-world (pre-adjusted) emissions total (tall gray bar). Then it buys the ITMOs (in green) and subtracts them from its pre-adjusted total. That leaves it with an adjusted level (shorter gray bar on far right) that now represents its official emissions.

On the left, the transferring party had, with the help of the buyer, built some solar panels thereby reducing or avoiding emissions (in theory). So, its actual emissions level is reduced by the same amount of ITMOs to the pre-adjusted level (short gray bar on far left). But after selling those ITMOs, the seller must—to avoid double counting—correspondingly adjust its emissions level back to what it was before doing the project (the gray plus orange bar). **So, the buyer gets to pretend the reductions occurred in its country, while the seller must pretend their own emission reductions never occurred at all.**

This is confusing stuff. The Boston Consulting Group and Shell Group "conducted a worldwide survey of over 200 environmental and sustainability executives across sectors and interviewed over 20 executives in depth" for a January 2023 report on the carbon market. They found "**Companies have limited clarity on the impact of Article 6 and corresponding adjustments**."[50] Article 6 is the part of the Paris Agreement dealing with the carbon credit and offset markets.

Does all this matter in the real world? Yes. "Transferred mitigation outcomes contribute to the NDC targets of the party that purchases the ITMO," as a UN Development Program explainer put it.[51] The seller "has to 'un-count' these mitigation outcomes from the emission reductions that contribute to its NDC targets." **Translation: The buyer just made achieving their Paris climate commitment easier, while the seller just made achieving theirs harder**—a key point we will return to.

The reason this is counterintuitive and confusing is that again we're used to buying (and selling) a quantity of real things, so we are used to tracking transactions by *adding* the quantity we bought to what we owned while *subtracting* the quantity from what the seller owned. We don't buy hypothetical negative things like a carbon offset where you do the opposite—you, the buyer, *subtract* the quantity from your books, while the seller must *add back* the quantity to their books as if it never happened.

In the orange example, the double counting is avoided if I tell the world I am selling my reductions ("my mitigation outcome") to you—and so you get to subtract it from your total oranges, whereas I must add it back to my official orange total. That is, you can now say you have zero oranges (even though you actually have 10) because, from the perspective of official global accounting, I still have those 10 oranges (even though I don't because I ate them).

Back in the carbon world, if Brazil sells an authorized offset of 10 MT to the U.S., then the U.S. gets to reduce its total emissions by 10 MT, while Brazil must tell the world it is officially keeping its emissions flat (because it cut its emissions 10 MT but then had to add back an adjustment of 10 MT). **In other words, the richer country gets to pretend that the reductions occurred in their country, while the poorer country must pretend their own emissions reduction never occurred at all.**

The implications of all this are poorly understood—but huge. *Note: The world has not finalized offset rules yet and could even change the ones they've already agreed to, so any discussion of the implications is speculative. What follows should be seen as a scenario, though probably the most likely scenario if the changes made at COP26 and COP27 are maintained.*

Also, because of the confusing and counterintuitive nature of the corresponding adjustment, the A.I. ChatGPT was asked to come up with an analogy to help explain it. That analogy is in the Appendix.

THE IMPLICATIONS OF THE DOUBLE COUNTING SOLUTION

The first implication is how this is going to look to the world—it is unfair. **If the developing countries let the developed ones skim off their easiest emissions reductions as lower-cost authorized offsets today, then those emission reductions never officially happened. So, to achieve their own emissions targets, they would have to make up those reductions another way in the future—most likely by buying expensive authorized offsets that other developing nations will also be bidding for. That is to say, the richer countries are paying to *weaken* their original climate targets while shifting the burden to the poorer countries who must *strengthen* their original targets. That is not climate justice.**

Dr. Barbara Haya said in 2023, "I think corresponding adjustments reveal what's wrong with the current system, but I don't think it's fair and I don't think it's what we should be doing."[52]

Chirag Gajjar, former head of subnational climate action at the global think tank World Resources Institute, India, was interviewed in 2022 on this subject: "**The developed countries will get away buying the cheap credits. They will continue to maintain the emissions they have. Whereas, the burden of emission reduction will be on vulnerable countries of the developing world, he added**."[53] In March 2023, Gajjar said he stands by those comments and added, "a lot of people [from developing countries] shared similar concerns" after Glasgow (COP26).[54]

"The demand for corresponding adjustments is outright patronizing and fails to recognize the real needs of developing countries," wrote Sandeep Roy Choudhury, Co-Chair of the International Carbon Reduction and Offset Alliance in June 2021.[55] **"Corresponding adjustments cement existing power structures and frustrate emerging calls for climate justice." He notes, "The result is as it always has been: The developed world sets the rules, and the rest of the world is forced to accept the bent logic supporting them."**

A second implication: Developing countries may choose not to sell authorized offsets, in part because it would make the cost of abating their own emissions higher. As Pedro Moura Costa explains in a September 2022 article in *Environmental Finance*, "because of the effect of corresponding adjustments on the marginal abatement costs to the host countries, many countries may refrain to engage in emissions trading."[56] Costa is Executive Director of BVRio, a Brazil-based nonprofit with a trading platform for environmental credits.[57]

As far back as 2014, an analysis by Stockholm Environment Institute commissioned by the Swiss Federal Office for the Environment concluded that in the real world any transaction of this kind is likely to be unpopular: "Agreeing domestically on mitigation pledges is often a long and difficult political process, and any adjustments to agreed pledges in order to compensate for double counting may be politically controversial. **In our assessment, it is thus politically unlikely that countries would adjust their pledges to correct for double counting**."[58]

The nonprofit *Ecosystems Marketplace*, in a November 2021 explainer on Glasgow (COP 26), noted, "**Many developing countries, however, say they don't want to transfer emission reductions abroad."[59]** The article also said, "In the lead-up to the signing of the Paris Agreement in 2015, **many developing countries were surprised to learn they'd have to transfer their emission reductions abroad if selling ITMOs, and few have done so."**

A great many developing countries will probably just keep those emissions reductions for themselves, rather than selling them off. And that's the twist: Brazil insisted developing countries must have a choice as to whether they keep the emissions reductions or give them to the buyer as an authorized offset. But again, why would a poorer country give up its own emissions reductions—effectively increasing its original CO_2 emissions reduction pledge? This seems politically unlikely—especially at current offset prices.

So, the third implication is that if any such transactions do occur, these authorized offsets will not be low cost. In fact, they will probably be quite expensive, as explained in a detailed 2023 World Bank analysis, "Corresponding Adjustment and Pricing of Mitigation Outcomes" (see below).[60]

In 2023, a great many voluntary carbon offsets are under $3 a ton of CO_2, and the weighted average is below $5.[61] By comparison, the CO_2 price that must be paid in perhaps the most credible regulated market—the EU's European Trading System—was $80 to $100 a ton in June 2023. That is the price Germany would pay to buy a permit (or allowance) equal to a ton of CO_2 emissions from France. It is essentially the marginal cost of reducing one ton of CO_2 emissions in the EU today.

Offsets being inexpensive is not inherent to their nature. "As a general rule, the lower the price, the lower and more dubious the quality," noted Michael Sheldrick, cofounder and policy chief at Global Citizen, in *Forbes* in November 2022.[62] In explaining "how worthless a lot of" offsets are, Stefan Reichelstein, Stanford Business professor emeritus of accounting, said in 2022, "Believe me, you can't really eliminate a ton of carbon for $3."[63] **Offsets are very low cost now because the large majority, as Dr. Haya and others have said, are not real or are significantly overcounted—or both.** That's why many actors in the voluntary market have started to move away from calling them offsets or using them to claim their own emissions cuts, as we've seen.

Indeed, at COP27 in Egypt in 2022, the world adopted "a new kind of carbon credit in the centralised carbon market for companies and governments under Article 6.4," of the Paris Agreement, as *Carbon Market Watch* explained.[64] It's called a "mitigation contribution emission reduction" (MCER), and it's similar to what the Gold Standard now calls an "impact claim" or "contribution claim." That is, "**Companies purchasing these contribution credits must not claim the emission reductions they represent to offset their own pollution because the underlying mitigation will continue to count towards the climate target of the country where the climate project(s) are based.**"

Once these rules are finalized, we could have multiple tradeable products. One is an "authorized" offset that does avoid double counting and can be used to reduce the buyer's total official emissions—whereas the MCER and voluntary credit do not and cannot. It's unclear why voluntary credits would cost much more than they do now once they become officially unauthorized. They might even be cheaper once it's clearer to all they don't represent a sale of real and credible emission reductions anymore. The reputational risks to buyers of greenwashing offsets are already rising (see next section). The MCER might be higher cost since it could be perceived as higher quality than the voluntary credit—even if it is not. Also, it's not clear why the world needs another category of unauthorized offset—such as the Bezos Earth Fund, Rockefeller Foundation, and U.S. State Department proposed in 2022.

There may well be a bifurcated market as many have pointed out. The price disparity between the authorized offset and the MCER (and voluntary offset) should be significant because, if it weren't, everyone would simply buy the authorized offset.

Beyond being formally recognized by the U.N. and world, authorized offsets will have another advantage over typical offsets—higher quality and more accurately counted tons. **In the vast majority of offset programs both the buyer and the seller are incentivized to downplay issues of quality and overestimate CO_2 reductions,** as we've seen**.** In the authorized market, the buyer still has little reason to care about quality. They still want maximum tons at a minimum cost. But now the seller is highly motivated not to overcount the tons or sell tons that aren't additional or might leak. Every ton they sell is a ton that they don't get to count toward meeting their own climate goals and that they will probably have to make up at some point in the future when tons are much more expensive. So, they wouldn't want to overestimate emissions reductions or sell reductions that would have happened anyway.

HOW THE VOLUNTARY MARKET THREATENS THE PARIS AGREEMENT

There is one more reason why offsets with corresponding adjustments will be in higher demand: Many corporate and other buyers in the voluntary carbon market (VCM) will be very interested in them. Indeed, for years a number of researchers and VCM participants have expressed concern that voluntary offsets without a corresponding adjustment could actually threaten the credibility of the VCM and undermine the Paris Agreement.

A 2021 synthesis article and literature review, "Caught in between: credibility and feasibility of the voluntary carbon market post-2020," has an extensive discussion of this issue.[65] The authors conclude that the VCM "has not yet found a way to align itself with the new legal architecture of the Paris Agreement in a credible and legitimate way." The article explains:

> "Mitigation activities implemented within the capped environment contribute (at least in theory) automatically towards the achievement of the host Party's NDC. The mitigation outcomes generated by a mitigation activity would be claimed against the national target. **If the same mitigation outcomes are also claimed on the demand side by the investor (another country**

> **or a private sector actor) of the mitigation activity, there would be double claiming, which is considered one form of double counting in the academic literature**."

These concerns about double claiming and its potential impact on the credibility of the voluntary market were raised by the same authors in a 2016 report just a year after the Paris Agreement was signed.[66]

As we've seen, at COP 26 in Glasgow the world agreed to put in place the "corresponding adjustment" to solve the double counting problem in the Paris compliance market for countries. Left unanswered, though, is how the VCM would solve the double claiming problem. Some involved in the VCM want to treat this as a non-problem, maintain the status quo, and allow companies to buy offsets without the corresponding adjustment—which they would use to claim they had lowered their net emissions even as the host country claimed those reductions in its official emissions inventory effectively using them to achieve its NDC. Others argue a corresponding adjustment is needed.

The authors point out the "risk" that a failure to resolve this debate consistently could create "a race to the bottom in which the voluntary carbon market undermines the objectives of the Paris Agreement instead of supporting the required transformational change." After analyzing articles and reports on the debate and on various solutions proposed, the authors conclude, "**Finally, we deem that *NDC crediting with corresponding adjustments* is the only solution that strengthens and protects the legitimacy of using carbon credits for offsetting in the context of carbon neutrality targets while ensuring a high degree of environmental integrity**."

A 2022 analysis from the University of Edinburgh Business School also examines the debate in detail and concludes, "We find that the arguments against corresponding adjustments do not address the fundamental requirement that voluntary offsets must achieve a lower level of emissions than would have happened anyway." The authors also address the issue of whether this problem should be called "double counting" or something else. They argue that what it is called is a semantic issue, but the problem itself "is whether an offset project reduces emissions below what would have happened anyway."[67]

How could double claimed offsets undermine the Paris agreement as well as the legitimacy of voluntary offsets and the VCM? *Carbon Market Watch* examines that question in a December 2022 article, "**Was COP27 the beginning of the end for corporate offsetting?**"[68] They note that this double counting/claiming "is problematic, including on the voluntary market, since it can displace or delay climate action. **A country may no longer implement emissions reductions they would have normally carried out, if they can still count them after they've been sold to someone else (who also counts**

them)." That is, countries will be in no hurry to spend their own money to reduce emissions to meet their NDCs if they can just wait long enough until some company pays them to make that reduction.

"**When double counting displaces climate action, it undermines the core promise that a carbon credit must always unlock additional mitigation**," writes *Carbon Market Watch*. "**This means that any offset claims based on double-counted credits are unreliable and inappropriate. Not all claims will be false, but the promise that they are right is no longer strong enough**."

Finally, for VCM buyers who don't want to pay for a corresponding adjustment, *Carbon Market Watch* endorses the solution that came out of COP27, the "mitigation contribution" discussed earlier. This new designation the world agreed to in Egypt "sends a strong reminder to companies and wider voluntary carbon market actors that an alternative to offsetting is not only possible but even better."

The Gold Standard takes a similar approach—and, as we've seen, has already been urging buyers to treat their credits as impact claims or contribution claims, which cannot be used to offset the buyers' emissions. Their 2020 report on the "Post-2020 Voluntary Carbon Market," explains that **"without Corresponding Adjustments, it is difficult to be certain there is no double claiming" because it is "challenging to be sure that the impact of a carbon credit has not inadvertently displaced an equivalent impact for which the host country has stated targets."**[69] A December 2021 post titled, "Why does Gold Standard believe that Corresponding Adjustments are needed for offsetting claims in the future?" states that if such displacement were to occur then**, "the underlying premise of the offset claim—that the atmosphere is no worse off—is no longer assured, as the underlying emission impact has replaced rather than added to abatement that would otherwise have happened**."[70]

A 2020 report for the German Environment Agency, "Future role for voluntary carbon markets in the Paris era," raises very similar concerns:

> A critical focus is whether and how 'double counting' of emission reductions—using the same emission reduction for voluntary offsetting and to achieve a country's target under the Paris Agreement—is avoided. **We show that, where there is a risk that the same emission reduction outcome could be claimed more than once, the impact of voluntary engagement in carbon markets could be negligible, or even lead to an overall negative climate impact**.[71]

The "only solution" to all of these risks, according to the 2021 synthesis article, is for any offset that helps a developing country achieve its NDC to include a corresponding adjustment**.** "If, however, the main actors in the voluntary carbon market do not unite behind an approach based on corresponding adjustments, they risk losing ground altogether." If that happens, the authors conclude, **"the voluntary carbon market may become obsolete or worse, a threat to effective climate change mitigation**."

MICROSOFT, THE DANISH GOVERNMENT, AND DOUBLE CLAIMING

A May 2023 deal involving Microsoft, the Danish government, and Ørsted Bioenergy & Thermal Power exemplifies the challenges that even the best corporations face when they do offset deals. Microsoft has "committed to one of the country's most ambitious corporate carbon-cutting programs," as *National Geographic* noted in 2022.[72] On May 15, 2023, *Bloomberg* published an article headlined, "Microsoft Inks Deal to Pay for CO_2 Stored Below the Sea."[73] It begins, "Microsoft Corp. is buying credits for CO_2 captured at two Danish power plants and then stored beneath the North Sea." The article then explains, "The tech giant's deal with Orsted A/S helped the utility in its bid to secure backing from the Danish government to trap CO_2 from the biomass-fired power stations."

But then the article states: "Orsted will be paid by the Danish government for every metric ton of CO2 that it stores, with a target to trap 430,000 tons a year. Additionally, Microsoft agreed to buy credits for 2.76 million tons of carbon removal over a period of 11 years." So, if everything works as planned, Microsoft will be buying 250,000 tons of carbon removal a year out of the 430,000 tons trapped. And yet the Danish government is itself going to pay for every metric ton stored.

This story seemed to suggest that the Danish government was buying the 430,000 tons of removal a year, but Microsoft was also buying more than half of *the exact same tons*. (The issue of whether such bioenergy with carbon capture and storage—BECCS—offsets are sustainable and scalable will be addressed in a forthcoming report.)

The Danish Energy Agency (DEA), which is part of their Ministry of Climate, Energy and Utilities, put out a press release on the project the same day.[74] The release quotes DEA Deputy Director Mogens Hagelskær: "Ørsted has offered capture and storage of 430,000 tonnes of CO_2 annually from 2026 and guaranteed a start-up of CCS in 2025. This brings Denmark closer to the climate goals, and it even goes a little further than the political agreement requires." The release explains the money came from a special subsidy fund: "The CCUS subsidy scheme (carbon capture, usage, and storage) with a total of DKK 16 billion was adopted with the Climate Agreement on energy and industry etc. from 2020." The release also notes, "The aid will be paid out per tonne of CO_2 reduced."

In other words, using a special fund designed to subsidize CCUS, the Danish government will be paying money for each of the 430,000 tonnes captured every year and claiming all those tons for itself to achieve its climate goals. **The Danish Energy Agency release makes no mention of Microsoft**.

The Ørsted press release from May 15 quotes Ole Thomsen, Senior Vice President and Head of Ørsted's Bioenergy business, saying "our CCS project will contribute significantly to realising the politically decided Danish climate targets for 2025 and 2030."[75]

Since this seemed like a clear-cut case of Microsoft claiming most of the same tons the Danish government was claiming, I wrote emails to the tech giant, to Ørsted's Thomsen, and to DEA Deputy Director Hagelskær. I asked the DEA if they were paying for all 430,000 annual tonnes and claiming them all—and if so, wasn't this double claiming given that Microsoft was claiming 250,000 of those annual tons at the same time. Henrik Sulsbrück, Head of Division of the DEA's CCS Center responded, "On behalf of Mogens Hagelskær." He argued that Denmark's national greenhouse gas (GHG) registry is completely different from "the trade of voluntary CO_2 credits, in which the Danish government is not involved." The body of his argument is worth quoting at length:

> Hence, in the case of Ørsted deal, the reductions obtained by the CCS project will be accounted for in the Danish national GHG inventory, which has been the main purpose of the subsidy scheme.
>
> Neither the Danish Energy Agency nor the Danish State is involved in the deal between Microsoft and Ørsted.
>
> However, the claiming of the credits under the voluntary scheme will not affect the site-specific emissions from neither the seller nor the buyer of the certificates, as the specific emissions from the buying party are reported as emissions in the national GHG inventories.
>
> As the national GHG inventories and the voluntary CO_2 credit market are two separate accounting systems, we do not consider that the agreement entered by Ørsted and Microsoft lead to double claiming.

This is a position held by many, but as discussed in the previous section, whether you call it double claiming or not, if this type of approach to offsets were widely adopted it would undermine both the integrity of the voluntary market and the Paris Agreement. Also, it seems problematic on its face. **How can Microsoft acquire the same tons in the VCM that the Danish government has already legally acquired and plans to account for in its official national GHG inventory?**

I asked Auden Schendler, Senior VP for Sustainability at Aspen Skiing Company for his thoughts on this deal. Schendler, an expert on offsets who has published articles on them in *the New York Times*[76] and elsewhere, replied: "**This is complicated, yes, but it's also incredibly simple. Only one entity can claim carbon reduction. The second claimant is just practicing PR**. Microsoft's contribution may well be helpful, in that they inject money into a system that cuts emissions**.** But that can't result in a carbon reduction claim if Denmark is officially claiming the reductions."

Ørsted confirmed in its response that the project "will capture and store approx. 430,000 tonnes of biogenic CO2 every year," and that the Danish government has a 20-year contract to acquire those, while Microsoft "has agreed to buy credits for 2.76 million tons of carbon removal over a period of 11 years." Ørsted explains:

> Due to the funding pledged by the Danish state to help make this project a reality, the Danish state will include these removals in its national carbon accounting and in the Nationally Determined Contribution (NDC) of the European Union. Due to the funding pledged by Microsoft to help make this project a reality, Microsoft also plans to include these carbon removals in its own private-sector carbon accounting in support of its commitment to be carbon negative by 2030.
>
> Both public-sector and private-sector funding was required to realize the project, and the parallel national and private-sector, non-conflicting claims to the carbon outcome are in line with the goals of the Paris Agreement and are an important component of rapidly scaling the carbon removal industry. National and corporate greenhouse gas inventories are two separate inventory systems – just as fossil emissions count in both systems today.

It is true that there are two separate inventory systems for tracking fossil fuel emissions. But that doesn't change the fact that Orsted is selling Microsoft the exact same tons in the voluntary market system that it has already sold to the Danish government in the official national accounting system that will track the country's progress on its Paris climate targets. As Schendler says, in this scenario the Microsoft claim is just public relations.

Since Microsoft had not yet replied, I re-sent the original note but added that the Danish government did confirm that they were claiming all 430,000 tons a year for their national GHG registry, which meant the tech giant was claiming 250,000 tons a year that the Danish government was already claiming. A few days later, I sent them a draft of the previous section, which examines why many experts believe that if such deals became standard practice, it would undermine both the VCM and Paris. I pointed out that if Microsoft wanted to maintain their investment in support of the deal, then all they had to do was call it a contribution claim or an impact claim as the Gold Standard is doing, or call it a mitigation contribution, as the nations of the world agreed to do for the Paris compliance market in Egypt (COP27)—but that would mean not using this deal to offset any of the company's emissions.

Microsoft did not respond to requests for comment.

Significantly, this type of deal—where the host country officially claims the CO2 reductions (as part of its Paris commitments) but so does a corporation (in the voluntary market)—is not expressly disallowed under the Paris Agreement, at least not yet. And essentially anything is allowed on the unregulated voluntary market as previously noted. Because of the threat double claiming poses to the Paris Agreement discussed in the previous section—and because it's not clear that the VCM can or will try to enforce any self-regulation—it will be up to the nations of the world to fix this problem, ideally at COP28 in Dubai in December 2023 or as soon as possible after that.

In the meantime, do leading companies really want to risk the reputational damage that could come from engaging in such a problematic offset deal and from being seen as embracing, endorsing, and advancing a transaction that could potentially undermine the Paris Climate Agreement? Instead, most companies whose goal is to help the world achieve the Paris goal of averting catastrophic climate change are likely to prefer offsets with corresponding adjustments.

RISING CORPORATE REPUTATIONAL—AND LEGAL—RISKS

Once the compliance offset market for Paris is in place, purchasing a voluntary offset without a corresponding adjustment may increase the reputational risks companies are already taking using the VCM. And reputational risks from buying offsets have already started rising sharply.

"Carbon offsets present an emerging risk to advertisers," explained a February 2023 article in *The Drum*, a global publisher for media and marketing companies.[77] **"Bad practice and questionable science in the voluntary carbon markets mean firms relying on offsetting to hit net zero targets risk greenwashing–and the law might be coming for them."** We've already seen the Swiss regulatory agency rebuke FIFA for claiming the 2022 World Cup was "carbon-neutral." We've seen major investigative reports call into question the integrity of large numbers of offsets purchased by companies like Disney and Shell.

In June 2022, the Dutch Advertising Code Committee "ruled for the fourth time this year that an ad campaign by Shell Plc about its efforts to reduce carbon-dioxide emissions is misleading and must be pulled from circulation," as *Bloomberg* reported that month.[78] In September 2022, the global law firm Quinn Emanuel issued a 9-page memo to its clients titled, "**Carbon Offsets: A Coming Wave of Litigation?**"[79] The firm, which has over 1000 lawyers operating in 12 countries, cited a variety of different offset-related lawsuits. It explained, "**The VCM's lack of oversight, combined with the**

difficulty in accurately measuring the impact of carbon offsets, makes it ripe for litigation." This is particularly the case because "Regulators, investors, and NGOs are increasingly scrutinizing the quality of offsets used by companies to meet 'net zero' goals."

In October 2022, *FoodNavigator*, an online news source for the food industry, posed the headline question, "**Will 'carbon neutral' claims land brands in legal hot water?**"[80] The story concerned a proposed class action lawsuit filed against Danone Waters of America in the Southern District of New York that asserted Evian bottled water "is not 'carbon neutral' based on how a reasonable consumer would understand the term." Evian, which uses offsets, had been independently certified as carbon neutral in 2020 by the Carbon Trust.

David Kwasniewski, a partner at a U.S. litigation and corporate law firm, told *FoodNavigator*, **"Even with a third-party certifier that is truly independent and objective, that is not going to be sufficient to prevent some plaintiffs' lawyers from making an argument that consumers believe neutrality means something other than what that third party body says," he stated. "So I think right now, these things are very risky and will be challenging to defend."** He noted that lawsuits alleging greenwashing are growing in number. Perkins Coie, with 1200 lawyers in the US and Asia, reports that lawsuits challenging a company's sustainability or environmental practices have risen sharply. There were 3 in 2017, while the two-year period of 2021 to 2022 saw 61.[81]

In a 2022 *Bloomberg* piece, "This Timber Company Sold Millions of Dollars of Useless Carbon Offsets," Robert Mendelsohn, professor of forest policy and economics at Yale, said, **"There's a distinct possibility that a great deal of existing carbon offsets are effectively fake."[82]** In May 2023, United Airlines CEO Scott Kirby told Politico that one reason he is against carbon offsets is, "the majority of them are fraud."[83]

The same month, Delta was sued in federal court over its claim to be "the world's first carbon-neutral airline," which plaintiffs say is "false and misleading." The *Guardian* notes, "The class-action lawsuit says Delta's carbon neutrality claim is demonstrably false as it heavily relies on junk offsets that do nothing to counteract the climate crisis."[84] The lawsuit alleges that "offsets purchased by and relied upon by Defendant" are "replete" with "non-additional effects on worldwide carbon levels due to the vendors crediting offsets for projects that would have occurred with or without offset market investment" and "non-immediate speculative emissions reductions that will at best occur over decades, despite crediting purchasers with the sum of those projected offsets" and "impermanent projects subject to disease, natural disasters, and human intervention."[85] The lawsuit sites scientific studies, government regulators, and investigative journalism reports to defend its claims.

A spokesperson for Delta said: "This lawsuit is without legal merit. Delta is a vigorous advocate for more sustainable aviation, adopting industry-leading climate goals as we work towards achieving net-zero carbon emissions by 2050. Delta committed to carbon neutrality in March 2020, and since 31 March 2022, has fully transitioned its focus away from carbon offsets toward decarbonisation of our operations, focusing our efforts on investing in sustainable aviation fuel, renewing our fleet for more fuel-efficient aircraft and implementing operational efficiencies."[86]

Although Delta says that since March 31, 2022 it "has fully transitioned its focus away from carbon offsets," Delta's own *2022 ESG Report*, published April 2023, does not appear to support such a statement.[87] For instance, Delta pledged to invest $1 billion by 2030 to become the world's first carbon neutral airline. The *2022 ESG Report* explains that Delta purchased $116 million of carbon offsets in 2022, adding "We expect much of the remaining investment to support our goal to spend $1 billion through the end of 2030 toward airline decarbonization focusing on solutions other than offsets." Why did Delta choose the word "much" here, which isn't even as strong as "most"? In any case, "all" is the word that would be consistent with the claim that Delta has "fully transitioned" away from offsets.

The report's section on offsets states, "Offsets will play a role in compliance with the global CORSIA scheme and ultimately achieving net-zero by 2050." CORSIA is the International Carbon Offsetting and Reduction Scheme for International Aviation agreement. CORSIA has been widely criticized by the European Commission[88] and others for having "major flaws in the scheme," as well as "questionable quality of offsets" and "having issues with double counting."[89] As for their value, *Quantum Commodity Intelligence* reported on May 16, 2023, "The spot Corsia-Eligible Offset (CEO) price fell below the $1/tCO2e mark for the first time since January 2021."[90]

If the risk to companies from buying traditional offsets and using phrases like "carbon neutral" continues to rise, then the price of voluntary offsets without the adjustment will most likely continue its recent decline while the price of an offset with one will likely be quite high when it becomes available.

JUST HOW EXPENSIVE COULD AUTHORIZED OFFSETS BE?

So, what might higher quality authorized offsets cost in the coming years? The $80 to $100 price of one of the highest quality official tons today is a plausible guess. Authorized tons *should* reflect the future price of the more expensive credits or offsets or permits developing countries will otherwise have to buy if they sell off their easier emissions reductions now as inexpensive offsets.

The problem, as Pedro Moura Costa explained in his 2022 *Environmental Finance* article, is that outside "investors usually look for low-cost mitigation options," when they fund projects for the purpose of reducing developing country emissions that are then sold off to a developed country as an official offset.[91] That leaves a host country with higher-cost options for reducing its own emissions. "The result is that the overall cost of meeting NDCs will increase at the national economy level."

As the 2023 World Bank report explained, **this extra burden means host countries will need to charge significant "Corresponding Adjustment fees well above US$25/t$CO_2$e *in addition* to the cost of the emission reduction credits."**[92] Also, the credits themselves will cost more than typical offsets because, as noted, they should be much higher quality and include fewer over-credited tons (although the UN has not yet demonstrated it can create such an improved program, as discussed below). The combined price of the fee and the unit cost of these credits could be substantial.

The Bank report suggests that this combined price would be the minimum or floor price the host country could consider for the actual price of the Internationally Transferred Mitigation Outcomes (ITMOs)—and that the fee would be the marginal cost to the host country of achieving its 2030 NDC pledge.[93]

Why is it the floor price? "The actual price will in practice be determined based on negotiation between the seller and buyer countries in relation to many factors including the quality of the credits, underlying category of the project (e.g., sector, technology) and so on," explains the Bank report. **The negotiated price "will also be determined by the buyer's willingness to pay which, in turn, will be influenced by the marginal costs of the buyer's NDC. This means that the price of ITMO will be determined at some level between these two."**

The report contains a list of the marginal costs for achieving the 2030 NDCs of various developed countries (buyers) and developing country regions (hosts) derived from a dynamic model used to explore climate policies. Most of the host regions have marginal costs ranging from $31 and $78 per ton of CO_2, but some are much lower. As expected, **the marginal cost for major developed countries of achieving their 2030 NDCs is considerably higher, $129 per ton for the EU and $155 for the United States**.

Significantly, we are in a world that must get emissions down to near zero—a world with far fewer "negative emissions" (tons of carbon removal) available than are widely expected, as discussed below. This means the price of authorized offsets that are truly additional, unleaky, not over-credited, and so on should be closer to the high marginal cost of the buyer's NDC than the lower marginal cost in the host country. If it weren't, then the developed country buyers would increase their demand for authorized offsets from the developing country sellers and bid up their price until it was—or the big developing countries would form a cartel to achieve the same thing.[94]

Already, developing countries are adopting new regulations for the carbon credit market, in part so that they can get a piece of the coming demand for higher priced offsets. For instance, in May 2023, *Bloomberg* reported that "**Zimbabwe's government said it will take control of the production of carbon credits in the country, stipulating that it will be entitled to half of the revenue from the securities**."[95] Foreign investors will be limited to 30% of the revenues, while local investors will get at least 20%. The information minister said that all previous agreements signed with international agencies and groups are now "null and void." The legal consulting firm HFW has labeled this kind of "legislative upheaval" in host countries over carbon markets a "Nationalisation Risk."[96] If such new legislation becomes commonplace in host countries, that should further drive up the price of all offsets.

So, the cost of an authorized offset could well be considerably above $100 per ton. How high could it go? Consider what happens if the authorized offset market moves toward a focus on "high quality carbon removals"? That's what SBTi and others propose for the voluntary carbon market. In one of its three 2023 scenarios of a possible future market—a world where only carbon removal offsets count—BloombergNEF projects the offset price hitting $200 a ton in the early 2030s, as expensive direct air carbon capture and storage systems (DACCS) drive the price.[97]

Finally, the World Bank's analysis reveals a potentially perverse outcome from authorized offsets. Authorized offsets increase the cost to a seller of meeting its NDC. So why would developing countries sellers want to increase that burden even more by adopting an ambitious NDC to start with?[98] **As Pedro Moura Costa explained in March 2022,** "**in essence, host countries are disincentivised to adopt ambitious NDCs**."[99] And so this yet another threat that offsets pose to the Paris agreement.

IF THE GOAL IS ZERO EMISSIONS, WHAT ARE OFFSETS FOR?

In today's world, much of the original rationale for offsets no longer holds. Confusion has arisen in part because emissions trading and offsets developed in a world where companies or countries did not have to go to zero.

Corporate emissions trading was popularized in the U.S. acid rain program where sulfur dioxide (SO2) was traded under a cap that was phased in—with the final 2010 cap set at "a level of about one-half of the emissions from the power sector in 1980," the EPA explains.[100] To oversimplify, imagine every company had to reduce emissions 50%. The idea was that one company might find it much cheaper to cut its emissions 60% than it would cost another to cut its emissions beyond 40%. In this world, it is economically efficient—it reduces the total amount of money spent to comply with the program—to allow the first company to sell its excess reductions to the second one. That's a key reason economists and businesses liked trading. **But if every company had to reduce its own emissions to zero, trading would have far less purpose and perhaps none at all—after all, each company needs credit for all of its reductions to get to zero. Selling them would be self-defeating.**

Similarly, when the first big official offset program was created, the Clean Development Mechanism, it was for a climate treaty (the Kyoto Protocol) where the richer countries had to cut their emissions under a modest cap. In a world where all countries had to cut their emissions by amounts not close to 100%, offsets could theoretically bring efficiency and lower costs if they were additional and permanent and so on. In the case of CDM, however, the poorer countries did not have an emissions cap, which meant that the CDM as a whole was not likely to accomplish much. **As the Environmental Defense Fund explained in a 2018 report, "Under the current CDM design," it is "a mechanism that … does not reduce global emissions."**[101]

When the world realized in the mid-to-late 2010s that it had to take total emissions as close to zero as possible by around mid-century, suddenly offsets also didn't have as much purpose. Why wasn't that obvious at the time? Most of the offsets were artificially cheap since the large majority were significantly overcounted or not real or both. So, **it *seemed* like there was a bonanza of inexpensive offset tons that richer countries could buy from poorer ones to save themselves the effort and cost of reducing their own emissions. But there wasn't. Genuine, additional offsets that were not double counted were always going to be much pricier.** And that means on the path to global net zero, selling off your easiest emission reductions cheaply now is a counterproductive policy.

That's especially true because it is unlikely there will be an abundance of affordable negative emissions—genuine, inexpensive carbon removal tons—to purchase in the future.

THE PROBLEMS WITH CARBON REMOVAL TECHNOLOGIES

As emissions kept rising over the past two decades, many climate modelers realized just how challenging getting close to zero would be for the world. So, they added in some negative emissions strategies that were not close to being commercial and scalable. Now instead of getting to zero, we only had to get to "net zero."

Many modelers added vast gigatons of negative emissions from carbon removal by bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS). Carbon capture and storage (CCS) by itself does not remove carbon from the atmosphere but only reduces the amount that gets into it in the first place. But over the past decade, reality set in (as discussed in forthcoming reports on the challenges facing BECCS and DACCS, briefly summarized below).

First, it became clear that simply adding a CCS system—which recovers CO_2 from industrial facilities and buries it underground—to a coal or gas power plant was challenging. In its 2022 assessment of climate mitigation strategies, the UN Intergovernmental Panel on Climate Change (IPCC) concluded that "Implementation of CCS currently faces technological, economic, institutional, ecological-environmental and socio-cultural barriers."[102] This conclusion was signed off on by all the nations of the world. The U.S. will be spending billions of dollars on CCS under the 2021 Bipartisan Infrastructure Law and 2022 Inflation Reduction Act (IRA) to help fossil fuel companies and others address these challenges.

Second, BECCS—using biomass to remove CO_2 from the air and adding a CCS system to a bioenergy plant to capture and bury the CO_2—is more challenging and problematic than fossil fuel CCS. **A growing number of scientists and peer-reviewed articles cast doubt on whether BECCS could truly scale.** And indeed, the IPCC scaled back its use of BECCS in its 2022 report, noting "**BECCS is not projected to be widely implemented for several decades.**"

Many studies also make the case BECCS would not actually generate significant negative emissions by 2050 if ever—particularly compared to the increasingly low-carbon power plants it will be competing against. Most lifecycle analyses (LCAs) of bioenergy emissions do this calculation incorrectly. They compare the biopower plant's emissions to that of a coal plant, rather than, say, the average new plant being built.[103] Also, most LCAs leave out key variables, including a full accounting of the greenhouse gas emissions related to land-use impacts of BECCS. **The true cost per ton of CO_2 removed by BECCS will likely be hundreds of dollars per ton.**

But while scaling up BECCS has little if any benefit, it has a huge opportunity cost—the tremendous amount of water and land needed for bioenergy could have been used for something better. In particular, our world is running short on unused land—land that will be needed to feed everyone in 2050, to provide the wood products they want, and to plant the vast number of trees that are currently in the emissions reduction plans of every major country and company, as discussed below. For the foreseeable future, **studies find that rather than putting CCS systems on existing (or new) biomass plants, putting them on existing (or new) fossil fuel plants would achieve far more reductions for far less money.**[104] It would also preserve large amounts of land and water for better uses.

Third, DACCS, which pulls CO_2 directly out of the air and then buries it, is more challenging than BECCS. Because CO_2 in the air is so diluted—420 parts per million—capturing it is expensive and energy intensive. The overall efficiency of this process is low, in the range of 5% to 10% according to the National Academy of Sciences.[105] To actually reduce emissions, DACCS must run on large amounts of carbon-free power (such as renewables). Studies have found that until a region's electricity system is virtually decarbonized, dedicating carbon-free power to DACCS is a costly way to reduce emissions. The opportunity cost of not using those renewables to first reduce CO_2 emissions instead is large.

Per ton of CO_2 captured and stored, current DACCS costs range from several hundreds of dollars to $1000 or more. ***Bloomberg* reports that at a June 2023 Direct Air Capture Summit hosted by industry leader Climeworks, the company's co-founder and co-CEO Jan Wurzbacher "told the crowd his company could see its prices remain as high as $300 by 2050."**[106]

The models in the 2022 IPCC mitigation report contain little DACCS by 2050.

Finally, consider the scale required for BECCS and DACCS to sequester just 3 billion tons (Gt) of CO_2 a year *combined*—only 6% of total global greenhouse gas emissions. That would require capturing, transporting, and storing a volume of compressed CO_2 greater than the more than 90 million barrels of oil a day extracted by the global oil industry, which took a century to develop. As one expert put it, "**Needless to say, such a technical feat could not be accomplished within a single generation**."[107] Achieving it by 2050 would be exceedingly difficult and yet still leave us 47 billion tons of CO_2 equivalent emissions a year to deal with. **Again, for the foreseeable future, the best use of CCS technology (including infrastructure like pipelines) is for fossil fuel plants.**

"A United Nations panel is casting doubt on the promise of using machines to remove vast amounts of carbon dioxide from the air and sea in order to fight climate change," reported *Climate Wire* in May 2023.[108] "**Engineering-based removal activities are technologically and economically**

unproven, especially at scale, and pose unknown environmental and social risks," wrote the panel supervising the set-up of the carbon trading and offset system under Article 6.4 of the Paris Agreement.[109] The 96-page Information note also states, "**These activities do not contribute to sustainable development, are not suitable for implementation in the developing countries and do not contribute to reducing the global mitigation costs, and therefore do not serve any of the objectives of the Article 6.4 mechanism**." A letter organized by the Carbon Business Council, a trade association, signed by over a hundred executives and experts in carbon removal, took strong exception to the panel's background document.[110] This issue will be taken up in December at the COP28 climate conference in Dubai.

Negative emissions technologies remain controversial, and the ones most often found in major climate models—BECCS and DACCS—are unlikely to be major contributors to solving the climate crisis for decades and won't be providing the offset market a scalable amount of affordable and sustainable offsets anytime soon.

THE PROBLEMS WITH NATURE-BASED CARBON REMOVAL

The major nature-based carbon removal solutions most often found in climate models and NDCs are planting trees, paying people not to cut down trees, and boosting CO_2 in soils. Avoided deforestation is the most popular offset today, despite being the most heavily critiqued. This "offset" is not actually a reduction in emissions but rather a hypothetical avoidance of future emissions. As discussed earlier, it is not possible to know how many if any of the trees were going to be cut down by the timber company. So, it is not possible to demonstrate with any confidence that any of these carbon offsets were additional, that they would not have happened anyway.

Also, since the original demand for the wood products hasn't changed, there is the leakage problem that the timber company can and generally will simply go someplace else and cut down trees. The leakage rate can be high as we've seen, which means this offset is being greatly over-credited in the marketplace—if a reduction of 10 million tons of CO_2 is claimed, the actual net reduction is far less.

A nine-month investigation by the *Guardian*, *SourceMaterial*, and *Die Zeit* published in early 2023 found **"more than 90% of rainforest carbon offsets by [the] biggest certifier are worthless."[111]** Most of these deforestation avoidance offsets—used by big companies like Shell, Disney, and Gucci—are "phantom credits" and may even "worsen global heating." The certifier, Verra, has "strongly disputed the studies' conclusions about its rainforest projects."

The journalists analyzed almost 100 million carbon credits.[112] They also had "dozens of interviews and on-the-ground reporting with scientists, industry insiders, and Indigenous communities." They made use of three new studies analyzing projects to avoid rainforest deforestation using different methods and did their own further analysis. "The implications of this analysis are huge," Dr. Barbara Haya told the *Guardian*. **"Companies are using credits to make claims of reducing emissions when most of these credits don't represent emissions reductions at all." She added, "But these problems are not just limited to this credit type. These problems exist with nearly every kind of credit."**

Stopping deforestation in developing countries is a crucial climate solution—it just shouldn't be turned into a license to emit heat-trapping CO_2 by developed countries. *That* CO_2 is going to be 100% real, whereas the actual emissions reduction in any specific offset project is, as we've seen, unknowable, but invariably much less than whatever the buyer and seller have agreed upon.

That license to emit CO_2 has another problem—the risk of environmental injustice for the buyer. In California's carbon trading program, the benefits of offsets have often led to more inequitable harm because they are a reprieve for so many local facilities that would otherwise be the source of emissions cuts. And while those facilities' emissions of CO_2 do not directly endanger the local residents, the toxic air pollution accompanying that CO_2 does directly harm human health. A 2018 study found "facilities regulated under California's cap-and-trade program are disproportionately located in disadvantaged neighborhoods."[113] A follow-up 2022 study found that while the majority of "Disadvantaged Communities" (DACs) saw reduced toxic pollutants from cap-and-trade facilities, "these improvements were less than those in the non-DACs, with many of the contrasts being statistically significant." Also, many facilities and neighborhoods saw a rise in greenhouse gas emissions and co-pollutants, and those "tended to have higher proportions of people of color, people living below 200 percent of the federal poverty level," and other socially vulnerable people.[114]

The great majority of nature-based solutions projects do not appear to represent high-quality carbon removal offsets. Consider Microsoft, which has pledged that by 2050 it will have removed carbon from the atmosphere equal to all its cumulative emissions since it was founded. In a 2021 article in *Nature*, Microsoft staff and outside scientists analyzed the proposals received from a 2020 solicitation for carbon removal projects—one of the first solicitations of its kind from a major company.[115] Proposals representing over 95% of total CO_2 volume were "nature-based storage." Yet while Microsoft **"received 189 proposals offering 154 megatonnes of CO_2 ($MtCO_2$) over the coming years," only "a mere 2 $MtCO_2$ met Microsoft's criteria for high-quality CO_2 removal."** Those criteria include requirements to demonstrate additionality, perform a comprehensive lifecycle analysis, explain how long the carbon will be stored, address the concerns of environmental justice and local communities, and "conclusively demonstrate leakage avoidance, or robustly and conservatively account for the carbon impacts of leakage caused by the project."[116] If such criteria were enforced in the voluntary carbon market, it's likely a similarly large fraction of projects would be rejected.[117]

One general problem for all nature-based offsets—especially ones involving trees—is that "very few nature-based offsets today can promise anything like true permanence because of the fact that they are reversible at any time," as Dr. Mark Trexler explains in his 2022 online offsets course.[118] Wildfires, extreme drought, deluges, disease and pests—all of which keep getting worse because of climate change—can, for instance, wipe out part of an existing forest or a plantation of new trees. When that happens, the trees stop absorbing CO_2 and start emitting it—very quickly in the case of wildfires. This has already begun in California forests being preserved as offsets.

A 2022 study led by ecologist William Anderegg looked at "Future climate risks from stress, insects and fire across US forests."[119] A major finding is, "**Our results reveal that US forests are very likely to experience increasing risks from climate change that undermine their C [carbon] sequestration potential**, an important factor that should be considered in climate change mitigation policy." In an explanatory article, Anderegg described "The big picture" impact: "**As the planet warms, wildfire risk increases substantially over the current century, especially in the Western U.S. In a scenario with medium emissions, wildfire risk is projected to increase by a factor of four. Drought and insect risks increase by about 50% to 80%**."[120] He added, "climate policymakers and offset developers need to be very careful about how they count on forest offsets to deliver benefits."

The issue of permanence (or "durability") is particularly salient for offsetting carbon pollution because when humans put CO2 into the air, it stays there warming the planet for centuries. That's why, as a 2021 Congressional Research Service report on agriculture and forestry offsets noted, "**Many carbon standards require 100-year permanence**."[121]

Nature-based solutions projects rarely promise such durability. As the 2021 *Nature* article noted, "Nature-based storage projects sequestering carbon for less than 100 years accounted for most proposals that Microsoft received (in total, more than 95% of CO_2 volume)."[122] Many sequestered carbon for less than 50 years. One approach to address this problem in places like California has been an insurance program known as a buffer pool. "Landowners pay into the pool when they sell credits," explained a 2022 *New Scientist* article.[123] "When there are unintentional reversals—when wildfire burns down trees that were supposed to be storing carbon, for example—the state can withdraw credits from the buffer pool." But warming-worsened wildfires in California have become so prevalent, the article explains, "that in the last 10 years, fires have depleted a jaw-dropping 95 per cent of the buffer that was intended to manage the next century's wildfire risks."[124]

In a 2021 report by Microsoft on lessons learned from its program that funded carbon removal, the company said, "we think that a full, healthy market will require stronger protections" than just buffer pools.[125] **"Today, there's simply not a lot of really secure forest carbon projects," the company's carbon program director Elizabeth Willmott told *National Geographic* in 2022. "We see a problem with that across the U.S. and across the world."[126]**

THE PROBLEMS WITH TREE-PLANTING OFFSETS

Planting trees may have the biggest long-term potential of any nature-based strategy, and it is more straightforward to quantify and verify as an offset than most other nature-based solutions, such as boosting CO_2 in soils. Yet tree-planting has real challenges as an offset—whether it is reforestation (replanting an area with trees) or afforestation (planting trees where there had previously been none).

First, the CO_2 reductions are not immediate. They could take decades to achieve their full offset potential. Meanwhile in too many cases the offset is used by the buyer to continue pouring CO_2 into the air right now—the period most important to slowing warming. *Technology Review* noted in 2020 that one popular travel booking app offers to plant trees to offset emissions from air travel but that, "it'll generally take about 25 years to offset the share of emissions from each flight."[127]

One longer-term study looked at carbon sequestration in degraded land "following 18 years of active tropical forest restoration."[128] The first 10 years of "above ground biomass" accumulation were extremely slow. Even after "18 years of regeneration, biomass is only 12% of that seen in old-growth forests." For restoration to hit 90%, projections suggest it would take more than another half century, and possibly a century in total. **Significantly this was "active forest restoration" with fire protection. "Restoration consisted of protection from fire (creation and maintenance of 10 m fire breaks; staffed fire towers for monitoring) and planting areas with native seedlings."**

The real world sees far less (if any) protection and far less focus on storing carbon as opposed to planting trees with commercial prospects. An analysis of 74 groups planting trees in the tropics referenced nearly 700 species, but "by far the most widely mentioned species were familiar tree crops, like cacao, coffee and mango — good for economic development, less so for storing carbon or supporting biodiversity," the *New York Times* reported in 2022.[129] A 2019 study of 24 national plans to help reforest vast areas of degraded and deforested land found "nearly half the land involved was slated to be turned into plantations of fast-growing commercial trees." Also, "The carbon these monocultures store is mostly released in a decade or so, when the trees are harvested, the researchers wrote."

In a 2022 article on Australia's widely-criticized[130] offset program, the *UK Guardian* reported, "Projects meant to regenerate Australia's outback forests to store carbon dioxide have been awarded millions of carbon credits—worth hundreds of millions of dollars—despite total tree and shrub cover in those areas having declined, a new analysis has found."[131] In other cases, "projects are being credited for increases in tree and shrub cover that would have happened anyway because they are mainly a product of rainfall (i.e. increased plant water availability) rather than the project activities."[132]

The 2020 *Technology Review* article noted that studies have found **"We have a terrible track record on carrying out reforestation efforts to date."**[133] For instance, the 2020 study "How feasible are global forest restoration commitments?" looked at 62 global reforestation pledges and found most countries are not good at keeping them—partly because many make unrealistic promises.[134] The study found "one-quarter of countries made commitments larger than either their current forest or agricultural areas." Noting that previous studies had found "restored forests may be ephemeral," the study reported "a quarter of countries experienced more recent forest loss and agricultural conversion (2000–2015) than their restoration commitment for the next 15 years (2015–2030)."

Second, and relatedly, what gets planted is much more vulnerable and much less permanent than regular trees in a forest because, as the *New York Times* noted in 2020, people aren't generally planting trees, which "are famously tough."[135] **They are, rather, planting seeds or seedlings, which "are not tough at all."** Seedlings can be killed by everything trees can—drought, fire, and flood—plus "they are eaten, shaded out, stepped on. Often they die of simple neglect." Again, not much monitoring is going on. One study found that "less than a fifth of the 174 tree-planting organizations they examined mentioned any monitoring of their trees after planting, and only eight companies mentioned the survival rates of their trees."

There are numerous examples in the scientific literature and media of tree-planting efforts gone awry. A 2022 study of tropical and sub-tropical forest restoration at 176 sites in Asia, for instance, found a first-year mortality rate of nearly 20% rising to nearly 50% by year 5 and beyond.[136] *Vice* describes several cases in a 2022 investigation—such as 6000 trees that were planted in Norfolk, England to be a new carbon sink.[137] Almost all of them died. Experts said the trees were planted too shallowly, at the wrong time of year, and in the wrong location (in already carbon–rich grasslands). "Simply planting trees isn't the answer," said Dr Charlie Gardner, a local conservation scientist. "**If we want these trees to have a real impact, they've got to still be alive in 100 years and that means it's a 100-year commitment, not a 1-day commitment."** Yet another reason those offsets can't be so low cost.

A third challenge is that planting or replanting trees "in boreal zones will have a warming effect that exceeds the cooling effect of reducing GHGs," as the National Academy of Sciences explained in a 2019 report on negative emissions strategies.[138] Above the snow line "an increase in forest cover reduces surface reflectivity causing more surface warming." This "albedo" effect limits the benefit to the climate of planting trees in northern regions.

Fourth, tree-planting also suffers from leakage. As Dr. Mark Trexler explained in his online course, "How do you know when you plant trees that other landowners aren't *not* planting trees because they're anticipating that there will be a glut of trees in 30 or 40 years—and therefore your planting trees today causes them not to plant their trees today?"[139]

A related concern is that if we're going to be planting a lot of trees, we'll be displacing a lot of people or a lot of land that people were using (or planning to use) for other purposes like grazing or growing crops. "Suppose forests are established in one place to sequester carbon but lead to forest clearing elsewhere," posits a 2009 policy brief on leakage in forestry offset programs by Duke University.[140] "The induced leakage is immediate and large, while the direct sequestration benefits take time to accrue. This shifting of impacts over time has implications for the climate benefits of the project (nearer-term mitigation is generally more valuable than farther-term), which complicates leakage estimation." This may perhaps not be a big problem if you're planting a few thousand trees—but people and governments are talking today about planting tens of billions of trees and perhaps as many as a trillion. Figuring out where to put those trees may be the biggest challenge of all.

So, fifth, demand for land will rise sharply with climate action, even as the world faces "looming global land scarcity," as one study put it.[141] **A 2017 study noted, "The vast majority of models estimate expansion of agricultural land by 2050, including several by more than half a billion hectare**s."[142] The entirety of net U.S. cropland is about 166 million hectares.[143]

The Land Gap Report—a 2022 analysis by 20 international researchers—added up "the area of land required to meet projected biological carbon removal in national climate pledges and commitments."[144] They found "almost 1.2 billion hectares of land—close to the extent of current global cropland—are required to meet them." More than half this area involves reforestation and "requires a land-use change to achieve the projected carbon removal, with the potential to displace food production." Are nations already counting on an unrealistic amount of tree planting in their climate pledges? What about companies? A 2021 Oxfam study concluded net-zero claims from just BP, Total Energies, Eni, and Shell would require some 70 million hectares of land by 2050 for tree planting.[145]

In its 2019 *Climate Change and Land* report, the IPCC noted that, "**Large-scale afforestation could cause increases in food prices of 80% by 2050**, and more general mitigation measures in the AFOLU [Agriculture, Forestry, and Other Land Use] sector can translate into a rise in undernourishment of 80–300 million people."[146] **Just how scalable is land-use change for carbon removal?**

This brings us to a final challenge. *The Land Gap Report* noted, "**The vast majority of lands and forests targeted by national and international pledges on climate change mitigation and forest restoration are neither unclaimed nor unused**. **They constitute the customary lands and territories of indigenous peoples and local communities." And so**, **"without a social justice lens, any attempt to fulfil the many land-based climate pledges is likely to perpetuate injustices**."

How many large-scale carbon-removal offset plans are inherently unjust?

THE TWO-DECADE FAILURE OF CDM

Much of the discussion here has been predicated on the idea that the new UN-authorized offsets will actually be genuine, additional, durable, verifiable, accurately quantifiable, and not leaky. On the positive side, as discussed earlier, unlike regular offsets, the developing country sellers of the authorized offsets will be highly motivated to make sure that the tons are additional and not over-credited, since every authorized ton they sell is a ton that needs to be added to their Paris climate commitment.

On the negative side, the U.N. has failed in the last two decades to prove it can create or run a credible official regulated offset market—the Clean Development Mechanism. The flaws in the CDM have been detailed again and again in the literature and media, yet the UN has failed to fix them. It bears repeating that a 2016 analysis of hundreds of CDM projects for the European Commission found **"85% of the covered projects … have a low likelihood of ensuring environmental integrity (i.e. ensuring that emission reductions are additional and not over-estimated). Only 2% of the projects … have a high likelihood of ensuring environmental integrity."** The analysis found "most energy-related project types … are unlikely to be additional," in part because "the revenue from the CDM for these project types is small compared to the investment costs and other cost or revenue streams."

Significantly, the study found **"Compared to earlier assessments of the environmental integrity of the CDM, our analysis suggests that the CDM's performance as a whole has anything but improved." Why? "The main reason is a shift in the project portfolio towards projects with more questionable additionality." How can you run an effective offset program without a very strong focus on ensuring additionality?**

Yet just two years later, in December 2018, the UN published, *Achievements of the Clean Development Mechanism, Harnessing Incentive for Climate Action (2001-2018)*. The report asserts that "the CDM exceeded everyone's expectations." It briefly mentions major problems only to state they "have been looked at critically and addressed by the CDM's Executive Board wherever possible." In particular, "Criticism over the environmental integrity and additionality of projects ... have resulted in the CDM Board strengthening the mechanism's methodologies and procedures."[147]

These statements are at odds with many earlier scientific studies and media investigations—and many to follow. A 2020 study in the journal *Climatic Change* on CDM projects in Cambodia wrote, "Our findings support the observation that the CDM finances ecologically and socially harmful projects in the name of GHG reductions."[148] They concluded, "**We highlight the apparent lack of improvements in critical areas of the CDM despite years of criticisms and suggest that there are framing and structural issues that will make reforming the CDM difficult."**

A 2021 report noted, "Most CDM credits have been issued from projects which would probably have happened anyway, and **in some cases the mechanism even set an incentive for companies to increase their production of pollutants in order to generate credits for their destruction.**"[149] In other words, like most offset programs, the CDM was gameable. **Also, the CDM has "failed to adopt sufficiently stringent safeguards against harms to the environment or local people, especially indigenous communities."** In Uganda, "a private company blocked access to land vital for the livelihoods of local communities in order to claim credits for planting forests in that area." In India, "a waste incinerator project diverted waste from landfills, where it would get sorted by local informal workers, and burned them in a facility located close to villages." In Chile and Guatemala, "hydroelectricity projects exacerbated land right conflicts, destroyed social cohesion within villages, and damaged ecosystems and biodiversity."

A 2021 study on wind power projects in India found that at least 52% of the projects would have happened anyway and so were not additional.[150] This meant that the developed countries buying these offsets were allowed to emit much more carbon pollution than had actually been avoided. **The authors**

note that if this rate of non-additionality applied to all CDM projects it would mean that developed countries emitted 6 billion tons of CO_2 more than they otherwise were allowed to. And other studies have, as we've seen, found an even higher rate of CDM non-additionality.

Moreover, nearly 70% of all CDM offsets have gone to China and India. Yet during the same time, China built so many coal plants that its CO_2 emissions *increased* by nearly as much as the U.S. emits today. India's emissions doubled. So, in what sense were the clean energy CDM projects—which again, would've happened without CDM money—actually delivering any avoided emissions? What justification could the UN give for letting those offsets be sold to developed countries who then used them as a license to emit more carbon pollution? **In short, the coal plants China and India built increased global emissions—but so did the renewable plants.**

"I don't think the UN is set up to do this," Dr. Barbara Haya said in 2023.[151] "I don't think we'll get quality from the U.N." in their new offset effort. "If the UN-backed carbon market is built largely upon the shaky foundation of earlier offset programs, including its own, it will effectively replicate and magnify the known problems," *Technology Review* wrote after COP 26.[152] "That would threaten to overstate emissions progress, undermine the credibility of Paris agreement achievements, and slow global efforts to address climate change."

CONCLUSION

"**In private, scientists express significant scepticism about the Paris Agreement, BECCS, offsetting, geoengineering and net zero**," wrote three leading climate scientists, including Robert Watson, former chair of the Intergovernmental Panel on Climate Change (IPCC), in a 2021 article.[153] "The path to disastrous climate change is paved with feasibility studies and impact assessments."

Today, every major offset program still has the same exact problems researchers and investigative reports have been identifying for more than two decades. That suggests the core problems are inherent to offsets and intractable—the impossibility of ensuring additionality or of counting them accurately or of solving the double counting problem in a just way. Dr. Haya said in 2023, "everyone has not just failed, but deeply failed."[154] After two decades of researching offsets and working to improve them, she has concluded, "the offset market is too far gone to fix." After COP26 and COP27, the voluntary market does not align with Paris and may instead undermine it.

Thus, the answers to the questions posed in the title are that **carbon offsets are unscalable, unjust, and unfixable—and a threat to the Paris Agreement.** "Net-zero targets are mostly greenwash," as the Science Based Targets initiative (SBTi) says. When asked in May 2023 by Politico "why you're against carbon offsets," United Airlines CEO Scott Kirby answered, "There's two things that are wrong with them. **First, the majority of them are fraud," and "Even if they weren't a fraud, they are not scalable."**[155] A consensus is growing that companies whose goal is addressing climate change should not be buying voluntary offsets today and using them as a license to pollute—because that pollution will be real, but the supposedly offsetting emissions reductions won't be.

The great majority of corporate offsets that have been sold to date were not genuine—they would've happened anyway, or they were greatly overcounted, and usually both. Going forward will be another concern on top of those—that a voluntary offset without a corresponding adjustment will be double claimed, by the developing country seller who uses it to reduce emissions as part of its Paris climate target (NDC) and by the corporate buyer, who uses it to claim to be reducing its own emissions. And the result of the double claiming is that "**the impact of voluntary engagement in carbon markets could be negligible, or even lead to an overall negative climate impact,"** as a 2020 report for the German Environment Agency put it.[156]

When authorized offsets start being sold—and the seller must officially acknowledge that their emissions reductions are being sold to the buyer—that will further underscore the view that non-authorized offsets are not genuine offsets. They should be called "mitigation contributions," as the world has agreed, or "impact claims" or "contribution claims" as the Gold Standard is now doing—and not be used as a license for the buyers to pollute more.

"Carbon dioxide removal is not a current climate solution," argues CDR expert, David T. Ho, an oceanography professor, in an April 2023 *Nature* article.[157] If we don't "drastically reduce emissions first," then CDR "will be next to useless." Ho, who was a reviewer for the $100-million XPRIZE Carbon Removal competition, concludes, **"We must be prepared for CDR to be a failure."**

In a world that must get to near-zero emissions—a world that is also without an overabundance of genuine, verifiable, affordable, and scalable negative emissions—it's likely even an authorized offset program would have relatively small benefits. That's because in such a world, getting close to zero global emissions will require essentially every major country to get close to zero themselves—nobody is going to have a lot of surplus offsets to sell. Whatever they sell today they are likely to have to buy back in the future, probably at a much higher price. So, selling off your easiest emission reductions cheaply now is a counterproductive policy.

Also, authorized offsets would allow developed countries to make achieving their Paris climate commitments *easier* while shifting the burden to the developing countries who must make achieving their commitments *harder*, as discussed. Since this burden sharing does not appear to be popular among developing countries, they may well decide to keep the vast majority of their emissions reductions. So authorized offsets should become expensive—perhaps as expensive as actual large-scale emissions reductions in developed countries. Ultimately, the upside of such a program won't be large but the downside may well be, since it has a significant risk of causing net harm and proving a serious distraction from the urgent task of having every country and company rapidly reduce its own emissions.

Those aiming to avoid catastrophic warming should embrace the basic approach of SBTi and the UN's High-Level Expert Group. Companies (and developed countries, too) should first have to cut their own emissions 90-95% by 2050. Only then can they neutralize the remaining 5-10% of emissions—not with traditional offsets but with "high-quality carbon removals," which are unlikely to be low cost.

In the end, many things that offsets are supposedly funding today, like deploying clean energy and ending deforestation in developing countries, are crucial climate solutions—they just shouldn't be turned into a license for developed countries and companies to keep polluting. The solution is to replace offsets with programs whereby the richer countries and companies focus on 1) meeting their climate targets by reducing their own emissions and 2) helping poorer countries reduce their emissions—without trying to take those emission reductions away from them.

ABOUT THE AUTHOR

Dr. Joseph Romm is Senior Research Fellow at the University of Pennsylvania Center for Science, Sustainability, and the Media. His work focuses on the sustainability and scalability—and the scientific underpinnings—of the major climate solutions, as well as the media coverage of them. Romm spent 5 years in the 1990s working on climate and clean energy solutions at the US Department of Energy. For 3 years, he helped to run the Office of Energy Efficiency and Renewable Energy ultimately serving as Acting Assistant Secretary, where he oversaw a $1 billion budget for R&D, demonstration, and deployment of climate solutions. In 2008, Romm was elected a Fellow of the American Association for the Advancement of Science for "distinguished service toward a sustainable energy future." In 2009, Time magazine named him "Hero of the Environment" and "The Web's most influential climate-change blogger" for his work at Climate Progress. Rolling Stone named him one of "100 people who are changing America." Romm has 10 books in the areas of climate change, clean energy, and communications, including one NY Magazine called "the best single-source primer on the state of climate change." His 2004 book, "The Hype about Hydrogen: Fact and Fiction in the Race to Save the Climate," was named one of the best science and technology books of 2004 by Library Journal. He has written extensively on the problems with carbon offsets for more than 15 years. He holds a PhD in physics from M.I.T.

APPENDIX: CHATGPT'S "AUTHORIZED OFFSET" ANALOGY

Because of the counterintuitive nature of an authorized offset sale and the corresponding adjustment, the A.I. ChatGPT was asked to come up with an analogy to help explain the transaction. Here it is.

QUESTION: Can you provide an analogy that explains how the burden of emission reductions is being shifted from the developed country to the developing country?[158]

CHATGPT: Sure here's an analogy that may help illustrate how the burden of emissions reduction can be shifted from a developed country to a developing country in the context of authorized offset sales:

Imagine two people Alice and Bob who both need to lose weight for health reasons. Alice has a lot of resources at her disposal such as access to a gym a personal trainer and a nutritionist. Bob on the other hand has limited resources and cannot afford these luxuries.

Alice and Bob agree to help each other lose weight by following a joint diet and exercise plan. They set individual weight loss goals based on their starting weights and health needs. However Alice proposes a deal where she can buy "weight loss credits" from Bob for every pound of weight he loses. Alice believes that this will make it easier for her to reach her weight loss goal.

Bob agrees to the deal because he needs the money but he realizes that he is now facing a more difficult weight loss target. He must not only reach his own weight loss goal but also help Alice achieve hers by selling her weight loss credits. Meanwhile Alice can now claim credit for weight loss that she did not actually achieve through her own efforts.

In this analogy Alice represents the developed country with more resources while Bob represents the developing country with fewer resources. The weight loss credits represent authorized offsets and the weight loss goals represent emissions reduction targets under the Paris Agreement. The corresponding adjustments mechanism represents the accountability and transparency measures that prevent double-counting of emissions reductions.

The analogy is not perfect as climate change is a global problem that affects everyone and emissions reduction efforts must be undertaken by all countries regardless of their resources or capabilities. However it may help illustrate how authorized offset sales can impact the distribution of emissions reduction targets and responsibilities between developed and developing countries.

ACKNOWLEDGEMENTS

The contents of this report, including any mistakes, are the responsibility of the author alone. The author would like to thank the following for sharing some of their time and expertise to discuss these opaque issues: Chirag Gajjar, Barbara Haya, Auden Schendler, and Mark Trexler. Special thanks to Barbara Haya, David Ho, Auden Schendler, and Mark Trexler for their comments on early drafts. Thanks go to Tan Copsey and Hunter Cutting for commenting on the executive summary and sharing their expertise on offsets. Zhao Liu's comments, copy editing, and fact checking were invaluable. And finally, the author is very grateful to Michael Mann and Heather Kostick of University of Pennsylvania's Center for Science, Sustainability, and the Media for their tremendous help in bringing this project to fruition.

CITATION: Joseph Romm, *Are carbon offsets unscalable, unjust, and unfixable—and a threat to the Paris Climate Agreement?* A University of Pennsylvania Center for Science, Sustainability, and the Media White Paper, June 2023. https://web.sas.upenn.edu/pcssm

ENDNOTES

[1]UN Framework Convention on Climate Change (UNFCCC) Secretariat, "Achievements of the Clean Development Mechanism, 2001-2018," December 2018.
[2]Dr. Martin Cames *et al*., "How additional is the Clean Development Mechanism?" Institute for Applied Ecology, prepared for EU's Directorate-General for Climate Action of the European Commission, March 2016.
[3]Philip M. Fearnside, "Tropical hydropower in the clean development mechanism: Brazil's Santo Antônio Dam as an example of the need for change," *Climatic Change*, April 2015. See also Barbara Haya and Payal Parekh, "Hydropower in the CDM: Examining Additionality and Criteria for Sustainability," U.C. Berkeley Energy and Resources Group Working Paper, November 25, 2011. This analysis recommended that "large hydropower be excluded from the CDM." It contains references to many studies critical of CDM-backed hydropower. See also, Ian G. Baird and W. Nathan Green, "The Clean Development Mechanism and large dam development: contradictions associated with climate financing in Cambodia," *Climatic Change*, December 2019.
[4]Raphael Calel *et al*., "Do carbon offsets offset carbon?" Grantham Research Institute on Climate Change and the Environment, Centre for Climate Change Economics, London School of Economics, November 2021.
[5]Kristin Qui, *The Future of the Clean Development Mechanism under a New Regime of Higher Climate Ambition*, Environmental Defense Fund (EDF), 2018. See also Barbara Haya, *Carbon Offsetting: An Efficient Way to Reduce Emissions or to Avoid Reducing Emissions? An Investigation and Analysis of Offsetting Design and Practice in India and China,* a peer-reviewed dissertation for a Ph.D. in Energy and Resources, Fall 2010.
[6]Ecosystem Marketplace, "Today's VCM, Explained in Three Figures," August 2022.
[7]UN Intergovernmental Panel on Climate Change, *An IPCC Special Report: Global Warming of 1.5 °C*, 2018.
[8]IPCC, *Global Warming of 1.5 °C*, Chapter Two, 2018.
[9]Clea Schumer, "How National Net-Zero Targets Stack Up After the COP26," World Resources Institute, November 18, 2021.
[10]Lindsay Maizland, "COP26: Here's What Countries Pledged," Council on Foreign Relations, November 15, 2021.
[11]Harry Bowcott *et al*., "COP26 made net zero a core principle for business. Here's how leaders can act," McKinsey & Company, November 12, 2021.
[12]Daedal Research, *Global Voluntary Carbon Market*, December 2022.
[13]Anders Porsborg-Smith *et al*., "The Voluntary Carbon Market Is Thriving," Boston Consulting Group and Shell Group, January 19, 2023.
[14]Gold Standard, "Claims Guidelines," June 2022.
[15]The most straightforward way to avoid double claiming (which is a type of double counting) is to make sure the offset comes with a corresponding adjustment. When asked by email in May 2023 "whether Gold Standard is saying in its 'Claims guidance' that it does not necessarily endorse or support any offsetting claim that comes without a Corresponding Adjustment," Hugh Salway, Senior Director of Market Development and Partnerships at the Gold Standard replied "Yes, this is effectively correct." For more detail and nuance, see Gold Standard, "Claims Guidelines," June 2022.
[16]Tom Dowdall, "Science-Based Net-Zero Targets: 'Less Net, more Zero'," Science Based Targets initiative (SBTi), October 7, 2021.
[17]*SBTi Corporate Net-Zero Standard, Version 1.1*, April 2023.
[18]SBTi's long-term science-based target for net zero also requires very deep reductions in so-called Scope 3 emissions, which are generated by customers using the corporation's products or by the suppliers the corporation uses (including things like shipping and offshore manufacturing).
[19]UN IPCC, *Climate Change 2022: Mitigation of Climate Change,* Working Group III contribution to the Sixth Assessment Report, Chapter 13, 2022.
[20]U.N. High-Level Expert Group on the Net Zero Emissions Commitments of Non-State Entities, *Integrity Matters: Net Zero Commitments by Businesses, Financial Institutions, Cities and Regions*, United Nations, November 2022.
[21]Mark Trexler, personal communications, February 2023.
[22]Barbara Haya, personal communications, February 2023.

---

[23]Akshat Rathi, "Inside the Billion-Dollar Market for Junk Carbon Offsets," Bloomberg, November 21, 2022.
[24]Dr. Martin Cames et al., "How additional is the Clean Development Mechanism?" Institute for Applied Ecology, prepared for EU's Directorate-General for Climate Action of the European Commission, March 2016.
[25]Lee Simmons, "Are Big Companies' Net-Zero Pledges a Well-Intentioned Shell Game?" *Insights by Stanford Business*, April 8, 2022.
[26]Natasha White and Verity Ratcliffe, "How the 2022 World Cup Rebuilt a Market for Dodgy Carbon Credits," *Bloomberg*, November 16, 2022.
[27]Paul MacInnes, "Fifa misled fans over 'carbon-neutral Qatar World Cup', regulator finds," *Guardian*, June 7, 2023.
[28]Allgemeine Themen, "Swiss Commission for Fairness upholds complaints against FIFA," Swiss Commission for Fairness, June 7, 2023.
[29]Mark Trexler, personal communications, February 2023.
[30]Anders Bjørn et al., "Renewable energy certificates threaten the integrity of corporate science-based targets," *Nature Climate Change*, June 2022.
[31]Ben Elgin and Sinduja Rangarajan, "What Really Happens When Emissions Vanish," *Bloomberg*, October 31, 2022.
[32]Michael Wayne Gillenwater *et al*., "Policing the voluntary carbon market," *Nature Climate Change*, October 2007.
[33]United States General Accounting Office, "International Climate Change Programs: Lessons Learned from the European Union's Emissions Trading Scheme and the Kyoto Protocol's Clean Development Mechanism," GAO Report GAO-09-151, November 2008.
[34]Nick Davies, "The inconvenient truth about the carbon offset industry," *The Guardian*, June 16, 2007.
[35]Lois Parshley, "California's carbon offsetting may actually be increasing emissions," *New Scientist*, December 22, 2022.
[36]Barbara Haya, "The California Air Resources Board's US Forest offset protocol underestimates leakage," UC Berkeley Technical Report, May 2019.
[37]Barbara Haya, personal communications, April 2023. Haya explains that California dilutes the leakage deduction by spreading it over 100 years rather than deducting it at the beginning of a project when it is likely to occur.
[38]Carbon Direct, "2022 Commentary on the Voluntary Registry Offsets Database (VROD)," May 2022.
[39]Barbara Haya, personal communications, February 2023.
[40]Annelise Gill-Wiehl, Daniel Kammen, and Barbara Haya, "Cooking the books: Pervasive over-crediting from cookstoves offset methodologies," preprint (not yet peer-reviewed) published on *Research Square*, February 2023.
[41]BloombergNEF, "Carbon Offset Market Could Reach $1 Trillion With Right Rules," January 23, 2023.
[42]CarbonCredits.com, "Live Carbon Prices Today," accessed June 21, 2023.
[43]*Quantum Commodity Intelligence*, "Nature-based prices fall further amid poor demand," May 26, 2023. Nature-based prices have risen from the low some 30% since then as of late June.
[44]Jennifer L, "The Collapse of NGEO Carbon Prices: An In-depth Analysis," *CarbonCredits.com*, June 9, 2023
[45]See Environmental Defense Fund, "How to avoid double counting of emissions reductions," 2018, which notes, "In the absence of rules, a country of origin could reduce emissions to meet its pledged effort and transfer those to a recipient; the recipient could then claim those same reductions to meet its pledged effort. In that case, only one reduction has actually occurred, but it is being claimed twice. Analyses indicate that such double claiming could eliminate the entire climate benefit of all the Nationally Determined Contributions, or NDCs, under the Paris Agreement."
[46]Kenneth R. Richards and Krister P, Andersson, "The leaky sink: Persistent obstacles to a forest carbon sequestration program based on individual projects," *Climate Policy*, January 2001.
[47]Silvia Favasuli , "Paris accord Article 6 approval set to jump-start evolution of voluntary carbon market," *SPGlobal*, November 17, 2021.
[48]Lambert Schneider *et al*., "Double counting and the Paris Agreement rulebook," *Science*, October 11, 2019.
[49]Japan's Joint Crediting Mechanism (JCM) Outreach Project, "Article 6 of the Paris Agreement," Ministry of the Environment, downloaded March, 2023.
[50]Anders Porsborg-Smith *et al*., "The Voluntary Carbon Market Is Thriving," Boston Consulting Group and Shell Group, January 19, 2023.
[51]UN Development Program, "Frequently Asked Questions on Article 6 of the Paris Agreement and Internationally Transferred Mitigation Options (ITMOs)," downloaded March, 2023. See also Silvia Favasuli , "Paris accord Article 6 approval set to jump-start evolution of voluntary carbon market," *SPGlobal*, November 17, 2021, which explains "if Brazil decided to sell the US 100,000 mt of carbon credits generated by a local carbon project for the US to use against its NDCs, Brazil would need to add 100,000 mt of CO2e to its reduction target, while the US would subtract the same volume."
[52]Barbara Haya, personal communications, February 2023.
[53]Bhasker Tripathi, "Article 6: Will Corresponding Adjustments Tool Stop Double Counting?" *CarbonCopy*, January 24, 2022.
[54]Chirag Gajjar, personal communications, March 2023.

[55]Sandeep Roy Choudhury, "Corresponding Adjustments, Equity, and Climate Justice," *Ecosystem Marketplace*, June 10, 2021.
[56]Pedro Moura Costa, "Will Article 6 trading be a flop?" *Environmental Finance*, September 12, 2022.
[57]UNFCCC, "BVRio Environmental Exchange of Rio de Janeiro, Brazil," UN Global Climate Action Awards Activity Database, downloaded March 2023. See also BVRio.org.
[58]Lambert Schneider *et al*., "Addressing the risk of double counting," Stockholm Environment Institute, Working Paper 2014-02, commissioned by the Swiss Federal Office for the Environment (FOEN).
[59]Steve Zwick, "Article 6 and its Glasgow Rulebook: the Basics," *Ecosystem Marketplace*, November 16, 2021.
[60]The World Bank, "Corresponding Adjustment and Pricing of Mitigation Outcomes," World Bank Working Paper, Washington, DC, 2023.
[61]Jean Chemnick, "Who will buy Kerry's carbon credits?" *ClimateWire,* February 2, 2023.
[62]Michael Sheldrick, "Kerry's Carbon Market Proposal Needs More Scrutiny Before It's Hailed A Climate Change Breakthrough," *Forbes*, November 11, 2022.
[63]Lee Simmons, "Are Big Companies' Net-Zero Pledges a Well-Intentioned Shell Game?" *Insights by Stanford Business*, April 8, 2022.
[64]Jonathan Crook, "Was COP27 the beginning of the end for corporate offsetting?" *Carbon Market Watch*, December 7, 2022.
[65]Nicolas Kreibich & Lukas Hermwille, "Caught in between: credibility and feasibility of the voluntary carbon market post-2020," *Climate Policy*, July 2021.
[66]Lukas Hermwille and Nicholas Kreibich, "Identity Crisis? Voluntary Carbon Crediting and the Paris Agreement," JIKO Policy Brief, Wuppertal Institute for Climate, Environment, and Energy, December 2016. The authors write: "We find that the voluntary market must prepare to become part of the Paris architecture if [it] wants to remain credible. Voluntary certification schemes will have to make sure that Parties report on the certificates transferred or set up an international registry that allows to track these transfers. Alternatively, suppliers of the voluntary markets could shift their business models from providing an offset scheme to a labelling scheme in which high-quality mitigation activities are certified including a quantification of the achieved emission reductions, but these could not be used to consolidate the emissions account of whoever purchases the certificates."
[67]Matthew Brander et al., "The Future of the Voluntary Offset Market: The Need for Corresponding Adjustments," *Edinburgh Research Explorer*, University of Edinburgh. The authors explain, "It is worth noting that the problem for the voluntary offset market and the rationale for corresponding adjustments are often expressed in terms of 'double counting', i.e. that two entities (the company purchasing the offset and the host country) are claiming the same emission reduction…. However, framing the problem in this way can be open to misinterpretation, and this appears to be the basis for some of the arguments that challenge the existence of the problem…. **the fundamental issue is whether an offset project reduces emissions below what would have happened anyway, rather than double-counting per se. Double-counting is relevant as it is the mechanism via which projects fail to reduce emissions below what would have happened anyway, i.e., because if countries count the reduction then they will not implement alternative policies, but double-counting is not the problem itself**."
[68]Jonathan Crook, "Was COP27 the beginning of the end for corporate offsetting?" *Carbon Market Watch*, December 7, 2022.
[69]Gold Standard, "Operationalising and Scaling Post-2020 Voluntary Carbon Market," June 2020.
[70]Gold Standard, "Why does Gold Standard believe that Corresponding Adjustments are needed for offsetting claims in the future?" December 2, 2021.
[71]Harry Fearnehough et al., "Future role for voluntary carbon markets in the Paris era," German Environment Agency, 2020.
[72]Craig Welch, "Polluters are using forests as 'carbon offsets.' Climate change has other plans." *National Geographic,* May 5, 2022.
[73]Will Mathis, "Microsoft Inks Deal to Pay for CO_2 Stored Below the Sea," *Bloomberg*, May 15, 2023.
[74]Danish Energy Agency, "The first tender of the CCUS subsidy scheme has been finalized: the Danish Energy Agency awards the contract to Ørsted's full scale CCS project," May 15, 2023.
[75]Ørsted, "Ørsted awarded contract – will capture and store 430,000 tonnes of biogenic CO_2," May 15, 2023.
[76]Auden Schendler, "Worrying About Your Carbon Footprint Is Exactly What Big Oil Wants You to Do," *New York Times*, August 31, 2021.
[77]Ellen Ormesher, "'There is too much impunity': carbon offsets present an emerging risk to advertisers," *The Drum*, February 20, 2023.
[78]Laura Hurst and Diederik Baazil, "Shell Is Called Out Again for Misleading Climate Ads in Holland," *Bloomberg*, June 30, 2022.
[79]Quinn Emanuel Trial Lawyers Firm Memoranda, "Carbon Offsets: A Coming Wave of Litigation?" September 2022.

[80]Elaine Watson, "Will 'carbon neutral' claims land brands in legal hot water? Danone sued over Evian eco claims," *FoodNavigator*, October 18, 2022. See also Elaine Watson, "Lawsuit challenging Evian's 'carbon neutral' claims 'defies science and common sense,' says Danone," *AFN*, May 8, 2023.
[81]Elaine Watson, "Will 'carbon neutral' claims land brands in legal hot water? Danone sued over Evian eco claims," *FoodNavigator*, October 18, 2022.
[82]Ben Elgin, "This Timber Company Sold Millions of Dollars of Useless Carbon Offsets," *Bloomberg*, March 17, 2022.
[83]Allison Prang, "The airline CEO who hates offsets," *Politico*, May 24, 2023.
[84]Patrick Greenfield, "Delta Air Lines faces lawsuit over $1bn carbon neutrality claim," *The Guardian*, May 30, 2023.
[85]Mayanna Berrin vs. Delta Air Lines Inc, Class Action Complaint, filed May 30, 2023, posted on *Courthousenews.com*.
[86]Patrick Greenfield, "Delta Air Lines faces lawsuit over $1bn carbon neutrality claim," *The Guardian*, May 30, 2023.
[87]Delta Air Lines, *2022 ESG Report*, April 2023. The report notes, "progress toward some of our short-, medium- and long-term strategies and initiatives during the first quarter of 2023 is included in this report as well."
[88]ICF Consulting et al., "*Assessment of ICAO's global market-based measure (CORSIA) pursuant to Article 28b and for studying cost pass-through pursuant to Article 3d of the EU ETS Directive*," European Commission, September 2020.
[89]Transport & Environment, "Corsia: worst option for the climate, Briefing on assessment of ICAO's offsetting scheme," March 2021. The quotes in the text are from this paper, which summarizes the 350-page September 2020 European Commission assessment of CORSIA cited above.
[90]*Quantum Commodity Intelligence*, "Corsia-eligible credits fall below symbolic $1/t threshold," May 16, 2023.
[91]Pedro Moura Costa, "Will Article 6 trading be a flop?" *Environmental Finance*, September 12, 2022.
[92]The World Bank, "Corresponding Adjustment and Pricing of Mitigation Outcomes," World Bank Working Paper, Washington, DC, 2023.
[93]The marginal price here is the carbon price of the lowest-cost mitigation activity needed to go beyond the NDC target. By making the corresponding adjustment, the host country is, as we've seen, increasing its NDC-pledged target. Therefore, it will have to do mitigation beyond the original NDC target—and that mitigation cost will be equal to or higher than the marginal cost of achieving the original target.
[94]In a world where the cost of authorized offsets is close to the marginal cost of developing countries meeting their NDC, most companies and countries may well choose to make the vast majority of their own emissions reductions. In this world, the offset market would be much smaller in terms of total tons traded but it could still be a big marketplace if those tons have a very high average price.
[95]Ray Ndlovu and Godfrey Marawanyika, "Zimbabwe to Take over Carbon Credit Trade, Void Past Deals," *Bloomberg*, May 16, 2023.
[96]Peter Zaman, "Nationalisation Risk: Will host countries hedge their bets between Article 6 and the voluntary carbon markets?" *Lexology*, December 5, 2022.
[97]BloombergNEF, "Carbon Offset Market Could Reach $1 Trillion With Right Rules," January 23, 2023.
[98]A developing country with very ambitious climate targets has a higher marginal cost to achieve its NDC than a country with less ambitious targets. So, the ambitious country could make considerably less money from selling authorized tons than the less ambitious country—and may well believe it will find fewer buyers.
[99]Pedro Moura Costa, "Corresponding Adjustments and their Impact on NDCs and Additionality," *Ecosystems Marketplace*, March 9, 2022.
[100]U.S. Environmental Protection Agency, "Acid Rain Program," Last Updated on June 24, 2022.
[101]Kristin Qui, *The Future of the Clean Development Mechanism under a New Regime of Higher Climate Ambition*, Environmental Defense Fund (EDF), 2018. The report states "global emissions need to go down to achieve the PA [Paris Agreement] temperature goals and PA Article 6.4(d) specifically states that the PA Article 6.4 mechanism shall aim to deliver an overall mitigation in global emissions. Under the current CDM design, BAU [business-as-usual] in non-Annex I Parties [developing countries, with no emission caps] is increasing, and a mechanism that simply shifts such BAU increases from non-Annex I to Annex I Parties [primarily developed countries, with caps] does not reduce global emissions**."**
[102]UN IPCC, *Climate Change 2022: Mitigation of Climate Change,* Working Group III contribution to the Sixth Assessment Report, 2022.
[103]Neil Bird, "Using a Life Cycle Assessment Approach to Estimate the Net Greenhouse Gas Emissions of Bioenergy," IEA Bioenergy, January 2011. This issue is discussed at length in my forthcoming BECCS report.
[104]National Academies of Sciences (NAS), *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration*, The National Academies Press, 2015.
[105]National Academy of Sciences*, Negative Emissions Technologies and Reliable Sequestration*, 2019. The efficiency being calculated here is the "exergy efficiency" or the so-called "second-law" [of thermodynamics] efficiency. It is defined as "the ratio of minimum work to real work": Wmin/Wreal. There are two basic types of DACCS systems, ones using a liquid solvent to absorb CO2 from the air and ones using a solid sorbent. The Academy report explains that for liquid solvent DAC

systems, their calculations lead to “an exergy efficiency of 4.1-6.2 percent.” For solid sorbent systems,” the middle-range exergy efficiency estimate is “7.6-11.4 percent.”
[106]Brian Kahn, “Removing Carbon From the Air Enters Its Awkward Teen Years,” *Bloomberg*, June 12, 2023.
[107]Vaclav Smil, “Energy at the Crossroads,” OECD Global Science Forum, May 17-18, 2006. For a similar calculation, see Niall Mac Dowell *et al.*, “The role of CO_2 capture and utilization in mitigating climate change,” *Nature Climate Change*, April 2017.
[108]Corbin Hiar, “U.N. slams carbon removal as unproven and risky,” *Climate Wire*, May 24, 2023.
[109]UN Framework Convention on Climate Change (UNFCCC) Article 6.4 Supervisory Body, “Removal activities under the Article 6.4 mechanism,” Version 4.0, May 17, 2023.
[110]Carbon Business Council, “Meeting the Goals of the Paris Agreement: Letter from 100+ Carbon Removal Experts,” May 24, 2023.”
[111]Patrick Greenfield, “Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows,” *The Guardian*, January 18, 2023.
[112]*SourceMaterial*, “The Carbon Con,” January 18, 2023.
[113]Lara Cushing et al., “Carbon trading, co-pollutants, and environmental equity: Evidence from California’s cap-and-trade program (2011– 2015),” *PLoS Medicine*, July 2018. This study found that, “Since California’s cap-and-trade program began, neighborhoods that experienced increases in annual average GHG and co-pollutant emissions from regulated facilities nearby had higher proportions of people of color and poor, less educated, and linguistically isolated residents, compared to neighborhoods that experienced decreases in GHGs.”
[114]Manuel Pastor et al., “Up in the Air: Revisiting Equity Dimensions of California’s Cap-and-Trade System,” University of Southern California’s Dornsife Equity Research Institute, February 2022. The study notes that California labels certain neighborhoods with a high score from CalEnviroScreen (a statewide environmental hazard and social vulnerability spatial screening tool) as “Disadvantaged Communities.”
[115]Lucas Joppa et al., “Microsoft’s million-tonne CO_2-removal purchase—lessons for net zero,” *Nature*, September 29, 2021.
[116]Microsoft and Carbon Direct, “Criteria for high-quality carbon dioxide removal,” 2022.
[117]See for instance, Compensate, *Reforming the voluntary carbon market*, April 2021. Compensate is a company that evaluates offsets using a stronger set of criteria. Since 2020, “it has evaluated over 100 nature-based, mostly forest conservation and afforestation/reforestation, projects. All evaluated projects are certified by international standards such as Gold Standard [and] Verra.” They are “often in the top tier of projects within their relevant standards in terms of quality and co-benefits.” Only 9% passed the evaluation.
[118]Mark Trexler, “Are Carbon Offsets Helping Tackle Climate Change?” The Climate Web course, 2022.
[119]William Anderegg et al., “Future climate risks from stress, insects and fire across US forests,” *Ecology Letters*, May 11, 2022.
[120]William Anderegg, “Trees aren’t a climate change cure-all—2 new studies on the life and death of trees in a warming world show why,” *The Conversation*, May 12, 2022.
[121]Congressional Research Service, “Agriculture and Forestry Offsets in Carbon Markets: Background and Selected Issues,” November 3, 2021.
[122]Lucas Joppa et al., “Microsoft’s million-tonne CO_2-removal purchase—lessons for net zero,” *Nature*, September 29, 2021.
[123]Lois Parshley, “California's carbon offsetting may actually be increasing emissions,” *New Scientist*, December 22, 2022.
[124]See also Grayson Badgley et al., “California’s forest carbon offsets buffer pool is severely undercapitalized,” *Frontiers in Forest and Global Change*, August 5, 2022.
[125]Microsoft, *Microsoft carbon removal: Lessons from an early corporate purchase*, 2021.
[126]Craig Welch, “Polluters are using forests as ‘carbon offsets.’ Climate change has other plans,” *National Geographic,* May 5, 2022.
[127]James Temple, “’A Trillion Trees’ is a great idea—that could become a dangerous climate distraction,” *Technology Review,* January 28, 2020.
[128]Charlotte E. Wheeler et al., “Carbon sequestration and biodiversity following 18 years of active tropical forest restoration,” *Forest Ecology and Management*, August 2016.
[129]Zach St. George, “Can Planting a Trillion New Trees Save the World?” *New York Times*, July 13, 2022.
[130]For a discussion of the criticisms of Australia’s offset program, see Polly Hemming *et al.*, *State-sponsored Greenwash*, The Australia Institute, October 2022.
[131]Adam Morton, “Forest regeneration that earned multimillion-dollar carbon credits resulted in fewer trees, analysis finds,” *UK Guardian*, November 6, 2022.
[132]Andrew Macintosh *et al.*, “Trends in forest and sparse woody cover inside ERF HIR project areas relative to those in surrounding areas,” The Australian National University, October 30, 2022.

[133]James Temple, "'A Trillion Trees' is a great idea—that could become a dangerous climate distraction," *Technology Review,* January 28, 2020.
[134]Matthew E. Fagan et al., "How feasible are global forest restoration commitments?" *Conservation Letters*, January 16, 2020.
[135]Zach St. George, "Can Planting a Trillion New Trees Save the World?" *New York Times*, July 13, 2022.
[136]Lindsay F. Banin et al., "The road to recovery: a synthesis of outcomes from ecosystem restoration in tropical and sub-tropical Asian forests," *Philosophical Transactions of the Royal Society B*, November 14, 2022.
[137]Sophia Smith Galer, "'Greenwashing': Tree-Planting Schemes are Just Creating Tree Cemeteries," *Vice*, September 1, 2022.
[138]National Academies of Sciences, *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda*, The National Academies Press, 2019.
[139]Mark Trexler, "Are Carbon Offsets Helping Tackle Climate Change?" The Climate Web course, 2022.
[140]Aaron Jenkins et al., "Addressing Leakage in a Greenhouse Gas Mitigation Offsets Program for Forestry and Agriculture," Nicholas Institute for Environmental Policy Solutions, Duke University, March 2009.
[141]Eric F. Lambin et al., "Global land use change, economic globalization, and the looming land scarcity," *Proceedings of the National Academy of Sciences,* February 2011.
[142]Tim Searchinger et al., "Does the world have low-carbon bioenergy potential from the dedicated use of land?" *Energy Policy*, November 2017.
[143]The United States Geological Survey, "Map of Croplands in the United States," downloaded June 2023.
[144]Kate Dooley et al., *The Land Gap Report*, November 2022, Available at: https://www.landgap.org/.
[145]Oxfam International, "'Net zero' carbon targets are dangerous distractions from the priority of cutting emissions says new Oxfam report," August 2021.
[146]P.R. Shukla et al. (eds.), *Summary for Policymakers, Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems,* IPCC, 2019. The IPCC notes that the impact would be minimal if the tree planting were "implemented using best practices in appropriately managed landscape systems that allow for efficient and sustainable resource use and supported by appropriate governance mechanisms."
[147]UN Framework Convention on Climate Change (UNFCCC), *Achievements of the Clean Development Mechanism, Harnessing Incentive for Climate Action (2001-2018)*, August 2018. The full quote: "Criticism over the environmental integrity and additionality of projects (i.e. whether emission reductions are new and would not have occurred in the business-as-usual scenario) and lack of representation in some sectors and regions have resulted in the CDM Board strengthening the mechanism's methodologies and procedures—including its oversight of accredited, independent auditors who ensure that projects meet the mechanism's stringent requirements."
[148]Ian G. Baird and W. Nathan Green, "The Clean Development Mechanism and large dam development: contradictions associated with climate financing in Cambodia," *Climatic Change*, December 2019.
[149]*Carbon Market Watch*, "The Clean Development Mechanism: Local Impacts of a Global System," October 2018.
[150]Raphael Calel *et al*., "Do carbon offsets offset carbon?" Grantham Research Institute on Climate Change and the Environment, Centre for Climate Change Economics, London School of Economics, November 2021.
[151]Barbara Haya, personal communications, February 2023.
[152]James Temple, "How a new global carbon market could exaggerate climate progress," *Technology Review,* November 24, 2021.
[153]James Dyke, Robert Watson, and Wolfgang Knorr, "Climate scientists: concept of net zero is a dangerous trap," *The Conversation*, April 22, 2021.
[154]Barbara Haya, personal communications, February 2023.
[155]Allison Prang, "The airline CEO who hates offsets," *Politico*, May 24, 2023.
[156]Harry Fearnehough et al., "Future role for voluntary carbon markets in the Paris era," German Environment Agency, 2020.
[157]David T. Ho, "Carbon dioxide removal is not a current climate solution— we need to change the narrative," *Nature*, April 4, 2023.
[158]*NOTE: This was not the first question asked of ChatGPT. There were two previous questions to determine the extent of the A.I.'s "understanding" of corresponding adjustments and authorized tons and the like. Also, ChatGPT does not appear to use a lot of commas. Its response to the question is reprinted verbatim here.*