Climate Actions

Dyrehaugen Web Notebook

2023-12-22

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1

Climate Change

The issue of Climate Change is treated across several web notebooks:

- Climate System (github) (geek) (loc)
- Climate Models (github) (geek) (loc)
- Climate Impacts (github) (geek) (loc)
- Climate Actions (github) (geek) (loc)

You are now visiting the **Climate Action** Web Notebook.

> **Climate is someone else's Weather**

> **Climate Crisis and Economic Development are one and the same problem**

> **The neoliberal solution to climate change is to hope that somehow it will become profitable to save the planet. This will not work.**

Part I

Actions

2

Action Strategy

2.1 Mitigation Strategies

Xu Abstract

The historic Paris Agreement calls for limiting global temperature rise to "well below 2 °C." Because of uncertainties in emission scenarios, climate, and carbon cycle feedback, we interpret the Paris Agreement in terms of three climate risk categories and bring in considerations of low-probability (5%) high-impact (LPHI) warming in addition to the central (50% probability) value. The current risk category of dangerous warming is extended to more categories, which are defined by us here as follows: >1.5 °C as dangerous; >3 °C as catastrophic; and >5 °C as unknown, implying beyond catastrophic, including existential threats. With unchecked emissions, the central warming can reach the dangerous level within three decades, with the LPHI warming becoming catastrophic by 2050. We outline **a three-lever strategy** to limit the central warming below the dangerous level and the LPHI below the catastrophic level, both in the near term (<2050) and in the long term (2100): the carbon neutral (CN) lever to achieve zero net emissions of CO2, the super pollutant (SP) lever to mitigate short-lived climate pollutants, and the carbon extraction and sequestration (CES) lever to thin the atmospheric CO2 blanket. Pulling on both CN and SP levers and bending the emissions curve by 2020 can keep the central warming below dangerous levels. To limit the LPHI warming below dangerous levels, the CES lever must be pulled as well to extract as much as 1 trillion tons of CO2 before 2100 to both limit the preindustrial to 2100 cumulative net CO2 emissions to 2.2 trillion tons and bend the warming curve to a cooling trend.

Xu Memo

The overall objectives of this perspective piece are threefold:

i) Assess the low-probability (5%) high-impact (LPHI) warming outcomes in the absence of a climate mitigation policy after accounting for major uncertainties in: (a) future emission trajectories; (b) physical climate feedback involving water vapor, clouds, and snow/ice albedo; (c) carbon cycle feedback involving biogeochemistry; and (d) aerosol radiative forcing. We ensure that the extreme outcomes projected in this study are consistent with published model parameters.

ii) Identify the constraints imposed by WB2C and the criteria for meeting WB2C, and thus sharpen the definition of WB2C.

iii) Explore the mitigation pathways that are still available to meet the WB2C goal.

Xu Summary

Basically, for a safe climate, all three levers (CN, SP, and CES) must be deployed as soon as possible. The CN and SP levers must be deployed by 2030 and 2020, respectively; the cumulative CO2 emissions from preindustrial must be limited to 2.2 trillion tons of CO2 (or 0.6 trillion tons of carbon); and the CES lever should extract and sequester as much as 1 trillion tons of CO2 (CES1t), depending on when the CN lever is deployed. If the CN lever is deployed as early as 2020, the required CES is much less than 1 trillion tons. We propose that mitigation goals be set in terms of climate risk category instead of a temperature threshold. In this paper, we offer three broad risk categories, but it is likely that a more granular set of categories is required. The temperature threshold has served policy very well; however, given the imminence of dangerous warming within decades, the focus must broaden to include extreme climate changes. Precipitation, flooding, fire, and drought will all become serious sources of concern. The temperature will still occupy our attention because of the heat stress phenomenon and the likelihood of approximately half of the population exposed to deadly heat by 2050. We conclude with a commentary on the feasibility of the mitigation options considered thus far. Over 24 technological measures to reduce SLCPs have been detailed previously. These measures include providing clean cook stoves to the poorest three billion of the world's total population and installing particulate filters in all diesel vehicles to reduce global BC emissions by nearly 80% and also reduce air pollution-related mortalities by 2 million; routine maintenance of gas pipes and banning gas flaring to reduce methane leaks; recovering methane from landfills, water sewage treatment plants, and farm manure; replacing HFCs with other available refrigerants that have negligible greenhouse effects; and installing catalytic converters in vehicles to reduce emissions of ozone precursors. CN levers require switching from fossil fuels to renewables such as wind, solar, geothermal and nuclear sources, among others. Also, CO2 emissions from industrial processes should be eliminated. This requires electrification of all end uses and production of electricity from renewables. Since many renewables (solar and wind) are intermittent, storage is a crucial issue. Batteries, hydrogen production by renewables, and pumped hydropower are all possible options for storage. While about 50% of reductions are possible with scaling up of existing technologies, innovations are required for achieving carbon neutrality in a cost-effective manner (40). Achievement of carbon neutrality also requires societal transformation, governance, and market mechanisms such as cap and trade and carbon pricing (40). The encouraging sign is that 52 cities, 65 businesses, and numerous universities have already embarked on the CN pathway. Some of these living laboratories, like California and Stockholm, have shown that the gross domestic product (GDP) can be decoupled from carbon emissions. Their carbon emission per GDP has decreased by 20% while bending the carbon emissions curve. The technology development and innovations from these living laboratories should be scaled to the world to greatly accelerate efforts to achieve CN within decades. Of the three levers recommended here, the third lever dealing with CES is the most challenging and formidable due to lack of scalable technologies. However, many technologies are being explored, including capturing CO_2 in bioenergy power plants (42), biochar production by pyrolysis and storage in soils (43), restoration of soil organic pools (44), chemical weathering of rocks, mineral sequestration, reforestation, and urban forestry, among others. The availability of land and conflict with food production is another important constraint in some of the CES solutions. Major breakthroughs are needed urgently, and in the meantime, the best option is to start on the CN goal by 2020 and mitigate the SPs as soon as possible, since cost-effective technologies are already present to immediately start bending the emission curves.

Xu (2017) Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes

2.2 Adaptation Strategies

2.3 (Joint Strategies?)

Battistoni

Paradoxically, it is because climate change is a permanent state of affairs that the politics of it have tended to focus outsized attention on *events*, whether climate disasters or Cop summits, which offer discrete moments of action and attention in the face of an otherwise *amorphous problem.*

If everyone expects that this “climate chaos” will lead us to turn on each other – every person or nation or “race” for itself – then that is what we will get.

The need for “an ecosystem of tactics – electoral campaigns, community and union organizing, public demonstrations, and, yes, property destruction”. In Gramsci’s terms, the moment requires both wars of manoeuvre and wars of position: we need to dig in on some fronts, and disrupt and destabilise on some others.

Our efforts must help manage not only the “energy transition” but a fundamental reconstruction of productive and reproductive systems (at least those upon which the wealthiest parts of the world rely), and of the collective commitment to global wellbeing. It is impossible to imagine that there is only one answer to these challenges.

Battistoni (2021) Was Donald Trump's 'war on coal' real, or just the market at work? To make sense of a destabilising planet we must look to the ideas of Antonio Gramsci.

Abstract Fazey

The most critical question for climate research is no longer about the problem, but about how to facilitate the transformative changes necessary to avoid catastrophic climate-induced change. Addressing this question, however, will require massive upscaling of research that can rapidly enhance learning about transformations. Ten essentials for guiding action-oriented transformation and energy research are therefore presented, framed in relation to second-order science. They include:

(1) Focus on transformations to low-carbon, resilient living; (2)Focus on solution processes;
(2) Focus on 'how to' practical knowledge;
(3) Approach research as occurring from within the system being intervened;
(4) Work with normative aspects;
(5) Seek to transcend current thinking;
(6) Take a multi-faceted approach to understand and shape change;
(7) Acknowledge the value of alternative roles of researchers;
(8) Encourage second-order experimentation; and
(9) Be reflexive.

Joint application of the essentials would create highly adaptive, reflexive, collaborative and impact-oriented research able to enhance capacity to respond to the climate challenge. At present, however, the practice of such approaches is limited and constrained by dominance of other approaches. For wider transformations to low carbon living and energy systems to occur, transformations will therefore also be needed in the way in which knowledge is produced and used.

Fazey: Ten Essentials for Action (pdf)

2.4 Authoritarian or Democratic Action

Mittiga Abstract

Is authoritarian power ever legitimate? The contemporary political theory literature—which largely conceptualizes legitimacy in terms of democracy or basic rights—would seem to suggest not. I argue, however, that there exists another, overlooked aspect of legitimacy concerning a government's ability to ensure safety and security. While, under normal conditions, maintaining democracy and rights is typically compatible with guaranteeing safety, in emergency situations, conflicts between these two aspects of legitimacy can and often do arise. A salient example of this is the COVID-19 pandemic, during which severe limitations on free movement and association have become legitimate techniques of government. Climate change poses an even graver threat to public safety. Consequently, I argue, legitimacy may require a similarly authoritarian approach. While unsettling, this suggests the political importance of climate action. For if we wish to avoid legitimating authoritarian power, we must act to prevent crises from arising that can only be resolved by such means.

Mittiga (2021) Political Legitimacy, Authoritarianism, and Climate Change (paywall)

Mittiga Homepage

Drumm Comment

Dont act shocked by this if you arent willing to admit that you believe that genocide is okay as long as it's done by democracy. That probably really is what you believe!

Drumm (twitter thread)

Wuttke Comment

Wuttke (twitter thread)

Povitkina Abstract

Previous research has shown that democracies exhibit stronger commitments to mitigate climate change and, generally, emit less carbon dioxide than non-democratic regimes. However, there remains much unexplained variation in how democratic regimes perform in this regard. Here it is argued that the benefits of democracy for climate change mitigation are limited in the presence of widespread corruption that reduces the capacity of democratic governments to reach climate targets and reduce CO_2 emissions. Using a sample of 144 countries over 1970–2011, the previously established relationship between the amount of countries' CO_2 emissions and their level of democracy is revisited. It is empirically tested whether this relationship is instead moderated by the levels of corruption. The results indicate that more democracy is only associated with lower CO_2 emissions in low-corruption contexts. If corruption is high, democracies do not seem to do better than authoritarian regimes.

Povikina (2018) The limits of democracy in tackling climate change (pdf)

2.5 STS - Societal Transformation Scenario

Kuhnhenn: Beyond IPCC

To stop climate change, we have to limit global warming to 1.5°C. But can we still achieve this target? And if so, what pathways can society take in transiting towards a climate-just economy? One important yardstick emerging from it was the need for global emissions to reach net-zero by 2050, the Intergovernmental Panel on Climate Change (IPCC) says in his «Special Report on Global Warming to 1.5°C». One important problem with this and other scenarios is that virtually all rely on continued global economic growth.

The Heinrich-Böll-Stiftung and the Konzeptwerk Neue Ökonomie realised the importance of broadening the discussion's perspective and considering societal pathways that are currently not included in either the IPCC reports or the public debate. Together with researchers from engineering and the natural and social sciences, Heinrich Böll Foundation and Konzeptwerk Neue Ökonomie developed a «Societal Transformation Scenario» for this publication – a global climate mitigation scenario that explores the climate effects of limiting global production and consumptions and of envisioning a broader societal transformation to accompany these transformations to reach a good life for all.

The Societal Transformation Scenario (STS) is a climate mitigation scenario that distinguishes itself from the scenarios cited by the IPCC in that it assumes a socio-ecological transformation, leading to a better life while reducing consumption and production in the Global North.

The scenarios so far covered by the IPCC usually portray a world that sees no radical societal change, and has global GDP to rising until 2100 in all regions. Since economic growth is a major driver of greenhouse gas (GHG) emissions, these scenarios often rely on high-risk Carbon Dioxide Removal technologies and on a dangerous "overshoot" of the 1.5°C limit.

IPCC scenarios are very much shaped by what is currently often assumed to be economically and socially feasible, without considering new lines of societal change and progress.

The consequence of adhering to the growth paradigm is that mitigation scenarios have to rely on high- risk technologies such as geoengineering, CCS and nuclear energy to reach mitigation goals. In many cases, such scenarios even assume the temperature will «overshoot» the 1.5°C goal at least temporarily – with unknown consequence for humans and eco- systems and at the risk of hitting irreversible tipping points.

Being convinced that a sufficient decoupling of economic growth from GHG emissions is unlikely to happen in the future (see Section 1), we focus on reducing consumption and production in countries of the Global North as a way to reduce emissions.

A substantial reduction in consumption cannot result from a sum of individuals changing their behaviour; it has to be achieved by reshaping key infrastructures of socie- ties and by regulative frameworks, economic principles and incentive structures guiding behaviour within society. For different sectors (mobility, housing, food), we provide a first rough collection of instruments for achieving just those aims.

The STS instead envisages is a comprehensive socio-ecological transformation that involves radical redistribution of wealth and labour and a change of welfare systems, economic principles and lifestyles.

The STS excludes any mitigation options that lead to disproportionate environmental degradation and destruction, including nuclear energy 31 and so-called «negative emissions» technologies.

The STS is not primarily about producing and consuming less; it is about organising society differently.

The assumes a society that finds ways and instruments to prosper without an ever-increasing level of consumption and production, to prosper beyond growth, with redistribution of wealth and work as a fundamental building block.

The transformation is not envisaged as the result of some master plan that is implemented top-down; it is developed bottom-up.

Kuhnhenn (2020) Societal Transformation Strategy (pdf)

STS-FAQ

GlobalCalculator

Global Calculator Tool

2.6 Societal Impact (Lack of)

How to reshape research agendas for sustainability

Abstract Lahsen:

After decades of inadequate responses to scientists' warnings about global environmental threats, leading analysts of the science-policy interface are seeking an important shift of research focus. This switch is from continued modeling and diagnoses of biogeochemical conditions in favor of enhanced efforts to understand the many socio-political obstacles to achieving just transformations towards sustainability, and how to overcome them. We discuss why this shift continues to prove elusive. We argue that rarely analyzed mutually reinforcing power structures, interests, needs, and norms within the institutions of global environmental change science obstruct rethinking and reform. The blockage created by these countervailing forces are shielded from scrutiny and change through retreats behind shields of neutrality and objectivity, stoked and legitimated by fears of losing scientific authority. These responses are maladaptive, however, since transparency and reflexivity are essential for rethinking and reform, even in contexts marked by anti-environmentalism. We therefore urge greater openness, self-critique, and power-sharing across research communities, to create spaces and support for conversations, diverse knowledges, and decisions conducive to sustainability transformations.

Memo Lahsen:

Lock-in on biogeochemical climate science

…witnessed internal conversations about not 'overselling' policy-relevant science by mak- ing overly strong claims about its conclusiveness, reflecting attempts to reconcile continued science funding with policy relevance. Decades later, dia- gnoses of biogeochemical realities and uncertainty reduction remain the dominant center of global change research.

A study of the allocation of climate research funding by 333 funding sources in 37 countries found that 770% more funding went to natural science compared to social science, and that only 0.12% of funding went to social science focused on climate mitigation — that is, to prevention of climate change, as opposed to generally less transformative resilience and adaptation efforts.

Early career scientists, pushed for greater inclusion of social questions, including devel- opment and inequality challenges, and questioned decades-old prioritization of atmospheric and Earth system modeling and observation systems.

Starved of decisive funds and power, Future Earth was born weak, however, a shadow of what was intended.

The Belmont Forum has since joined forces with Future Earth in some endeavors, including a sub- program on transformations to sustainability. How- ever, it continues to direct its massive budget primar- ily towards diagnosing biogeochemical conditions and earth system modeling.

The shield of value neutrality allows incum- bent interests against institutional restructuring to present the lack of support of Future Earth as a defense of quality science.

The persistent underfunding contrasts the importance of these branches of research for understanding and foster- ing cultural orientations—including 'changes in the hearts and minds of the people' — conducive to transformations towards greater environmental sustainability and socio- economic solidarity and equity.

Lahsen (2021) Sustainability Transformation Obstruction (pdf)

Anderson

The main socioeconomic problem with CDR is that only a tiny fraction of the population is aware of carbon removal, which limits meaningful engagement and just deployment. This lack of awareness is set within the wider problem that many in society do not realize the scope of transformation needed for decarbonization, in terms of deploying clean energy at a massive scale, building electrification, redesigning transport, retrofitting factories, reforming agricultural practices and more. Without that knowledge base, publics are not well-equipped to debate the nuances of CDR approaches within the wider climate response. So if you ask someone whether they want a CDR facility near them, the answer is probably no because it is an unfamiliar industrial project. This is similar to challenges with battery manufacturing plants, transmission lines or other industrial underpinnings of this transition. If you ask people whether they think there should be CDR facilities to compensate for emissions from aviation, or alternatively whether they think there should be limitations on flying, or whether we should use biomass-derived aviation fuels (even if they bring land use and food price impacts) or whether we should carry on as we are despite climate change, who knows what the answer would be. But we are very far from a society-wide deliberation on these trade-offs because the basic contours of the challenge are not fully appreciated.

Anderson (2023) Controversies of carbon dioxide removal

2.7 Deep Adaptation

Bendell Abstarct

Abstract The purpose of this conceptual paper is to provide readers with an opportunity to reassess their work and life in the face of what I believe to be an inevitable near-term societal collapse due to climate change. The approach of the paper is to analyse recent studies on climate change and its implications for our ecosystems, economies and societies, as provided by academic journals and publications direct from research institutes. That synthesis leads to my conclusion there will be a near-term collapse in society with serious ramifications for the lives of readers. The paper does not prove the inevitability of such collapse, which would involve further discussion of social, economic, political and cultural factors, but it proves that such a topic is of urgent importance. The paper reviews some of the reasons why collapse-denial may exist, in particular, in the professions of sustainability research and practice, therefore leading to these arguments having been absent from these fields until now. The paper offers a new meta-framing of the implications for research, organisational practice, personal development and public policy, called the Deep Adaptation Agenda. Its key aspects of resilience, relinquishment, restoration and reconciliation are explained. This agenda does not seek to build on existing scholarship on "climate adaptation" as it is premised on the view that societal collapse is now likely, inevitable or already unfolding. The author believes this is one of the first papers in the sustainability management field to conclude that climate-induced near-term societal collapse should now be a central concern for everyone, and therefore to invite scholars to explore the implications.

Bendell (2018) Deep Adaption: A Map for Navigating Climate Tradegy (pdf)

3

Academic Failure

Steinberger

On climate change, the scientific community (by and large) has been criminally negligent when it comes to observing — and especially learning from — its own track record.

The physical science of climate change has been a resounding, phenomenal, triumphant success.

Science, as a whole body of institutions, people and knowledge, has failed on climate change. Spectacularly failed to curb or even slow down increases in greenhouse gas emissions.

Trying to exist outside history

The scientific endeavor, since at least Enlightenment & Newton, tries to see its contributions as existing outside history and culture. If something is scientifically true, it should be true before it was "discovered" and for all eternity after. This is a lovely idea in theory, but with devastating consequences. Because no matter the eternal truth of a scientific finding: its interpretation and translation into understanding and action relies upon the cultural and historical context surrounding its discovery.

The historical context of the late 20th century should have been taken much, much, much more seriously by scientific institutions and communities, because it included an ominous domination of neoclassical economic thinking in politics and culture, and a circumscribed, idealized role for scientists in public pronouncements and public life.

Partly as a result of descending from the Enlightenment, partly as a result of the structure of scientific institutions (universities, academies, national research centers), partly because this model worked relatively well for a long time without needing to be challenged, many scientific disciplines took on the idealized position of remote, neutral observers, staying well apart from the object of observation, emerging from their ivory towers to bestow impartial pronouncements on the busy world around.

Climate impacts will tear through social systems and disrupt them. Technological transitions will either happen (or not) depending on experimentation and adoption within social systems. An insistence on science as purely apolitical and technocratic thus leaves a blind spot the size of humanity in how climate impacts will affect us, and how we might respond and act proactively.

A final problem with the aspirations to being purely technocratic and apolitical advisors to power is that we have been generally averse to take our scientific findings directly to the people.

Julia Steinberger (2017) Postmortem

4

Capitalism and Climate Change

4.1 Orthogonal?

Milanovic

The third critique that Alyssa Battistoni makes is in my opinion the easiest to answer. She criticizes the absence of discussion of climate change in "Capitalism, Alone", calling such absence "irresponsible". This is because development of capitalism is hitting the planetary limits and might lead to substantial catastrophes through the change in climate and loss of livelihood for many people, especially in Africa. I find this critique relatively easy to answer because it is based on a misunderstanding or even sloppy thinking. What is responsible for climate change is economic growth, not capitalism as such. Economic growth in turn comes from our desire, in poor and rich countries alike, among poor and rich people alike, to lead better lives and to have more goods and services. It is the production and consumption of these goods and services that is responsible for climate change. So if one wants to stop the climate change one needs to reduce the production of goods and services that are CO2 emission-intensive. But doing so through a combination of taxes and subsidies does in no way change capitalism.

No partisan of climate change, however radical, whether it be Alexandria Ocasio-Cortez, Bernie Sanders, or Greta Thunberg has suggested that large oil companies be nationalized, or that many of the companies responsible for emissions be run by worker councils; they have not suggested that profits of "bad" companies be confiscated. All such movements would indeed spell the end of capitalism in at least some sectors. Yet such ideas are never mentioned. No partisan of struggle against climate change is ever advocating policies that would effectively stop capitalism even in one small part of the economy. What they are advocating is a specific combination of taxes and subsidies, discouragement of consumption, carbon permits, and moral suasion (or moral shaming) which would result in the reduction of emissions.

But whether electricity or oil companies or meat producers or a person using air conditioning are working within one set of incentives, where the products that are responsible for climate change are cheap or expensive, they are still working within the capitalist framework. The company is still privately owned, the objective of the company is still maximization of profit, the objective of individuals is still maximization of wealth. It is just taking place under a different structure of prices. Differently structured prices may, one hopes, curb climate change but they have really nothing to do with eliminating capitalism. Since my book is about capitalism, I have very little to say about proposals which have nothing to say about capitalism as a mode of production. Despite much “noise”, capitalism, as accurately defined, and climate change, even in the words of their most vocal opponents, are really orthogonal. Whatever policies are adopted regarding climate change—even if they are of the most radical kind currently on offer—will have very little impact on capitalism as an economic system. Such policies can reduce profit rates of some companies or some branches of production but they will simply redistribute profits within the capitalist sector, not end capitalism as a system. To be blunt: capitalism and greed would be pursued under different relative prices.

Milanovic

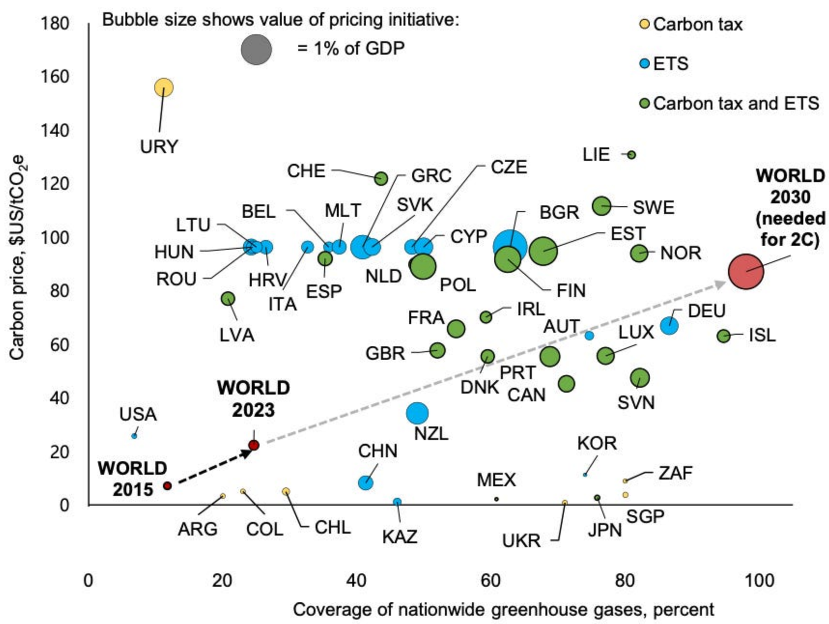
5

Carbon Pricing

Tooze

Carbon pricing continues to be adopted by countries, having doubled in emissions coverage since 2015 .... To date, 73 carbon taxes and emissions trading systems (ETSs) are in operation in 47 countries, covering 25 percent of global GHGs, up from 12 per cent in 2015. National coverage of emissions varies, from below 30 percent in some cases to more than 70 percent in others (for example, Canada, Germany, Korea, and Sweden). Carbon prices vary from below $5 to over $100 per ton (mostly in European countries). The average (emissions weighted) price of covered emissions has grown from $7 in 2015 to about $22 in 2023.

Figure 10. Explicit Carbon Pricing Schemes at the National, Sub-National, and Regional Level, 2023



Sources: National sources; World Bank 2023; and IMF staff.
Note: labels use International Organization for Standardization (ISO) codes.

Pricing systems have an expansive logic. Given the significant carbon prices, the EU has no option but to adopt a Carbon Border Adjustment Mechanism (CBAM), to avoid its industries being undercut by unpriced imports. Despite intense pressure from the Biden administration, Brussels has not fallen in line with America's non-WTO-conforming quick fixes. The WTO-conformity of Europe's own system remains to be tested.

The critical decision lies with China. If Beijing reinforces its system of carbon pricing, then carbon pricing will be a common policy of the two blocs that are at this point most credibly committed to long-range decarbonization - the EU and China.

The best hope is that the large polluters accelerate their level of effort out of self-interest. At least if you believe the economic models, the balance of cost and benefit is hugely stacked in favor of action.

The question is not whether decarbonization is desirable or even whether it is technically feasible. The steps we need to take by 2030 clearly are within our reach. The central question is whether a coalition can be built to breakthrough the inertia of the existing system and powerful vested interests and not only to add new power but to aggressively run down polluting fossil fuel sectors. Those decisions have to be made within the small group of polluters responsible for the majority of global emissions (G7 plus China plus India). A coalition for a new energy model is emerging but that is not the same as a model for decarbonization which is a far more daunting political proposition.

Tooze (2023) Chartbook Carbon Notes 9 Slouching towards a 2 Degree-Plus World

6

Climate Treaties

Monbiot

Inaction and self-interest are built into climate summits. Instead, we need a voting system that can't be subverted by fossil fuel producers

Throughout these Conference of the Parties (Cop) summits, fossil fuel lobbyists have swarmed the corridors and meeting rooms. It's like allowing weapons manufacturers to dominate a peace conference.

It's not surprising that the two decisive measures these negotiations should have delivered at the outset – agreements to leave fossil fuels in the ground and to end most livestock farming – have never featured in the final outcome of any Cop summit. Nor should we be astonished that these agreements favour non-solutions such as carbon capture and storage, whose sole purpose is to provide an excuse for inaction.

Perhaps it's unsurprising that, of 27 summits completed so far, 25 have been abject failures, while two (1997's Kyoto protocol and the Paris agreement, in 2015) have been half-successes. If any other process had a 3.7% success rate, it would be abandoned in favour of something better.

The first and most obvious reform is to shut out the lobbyists.

The only global negotiations that are organised like the climate summits are other environmental summits, such as the UN biodiversity conferences. When states want something to happen – trade agreements, for example – they use different methods.

Since this horrible farce began 31 years ago, plenty of people have proposed reforms. The proposals fall into three categories. One is to improve the way consensus decisions are made. Well-meaning as these are, they're futile: you can tweak the process, but it will remain dysfunctional.

Another approach is to replace consensus decision-making with voting, an option that remains, in draft form, in the UN rules. The obvious objection is that a majority would impose decisions on other nations. But this reflects a narrow conception of what voting could do. There are plenty of ways of ensuring everyone can be heard, without relying on crude binary choices. One of the most promising is the Borda count, a decision-making method first proposed in 1435.

The modified Borda count developed by the de Borda Institute looks especially useful. First, the delegates agree on what the principal issues are. These are then turned into a list of options, on which everyone is asked to agree (the options could range from the immediate phase-out of fossil fuels to planetary Armageddon). The options are listed on a ballot paper, and each delegate is asked to rank them in order of preference. A scoring system awards points for every ranking. The more options a delegate ranks, the more points each one is worth to them. This enables complex decisions to be made without excluding anyone.

The third approach, which could run alongside the second, is to bypass the Cop process by developing new binding treaties. The professor of environmental politics Anthony Burke suggests an approach modelled on the 2017 treaty on the prohibition of nuclear weapons, the 1997 anti-personnel mine ban convention and the 2008 convention on cluster munitions. In these cases, states and citizens' groups frustrated with a lack of progress began building treaties without the participation of the powerful nations – the US in particular – that sought to resist them. They developed enough momentum not only to push the treaties through the UN general assembly, but also to establish new diplomatic norms that made defiance of the treaties much harder to justify, even for nations that refuse to ratify them.

Burke proposes treaties on deforestation and the elimination of coal, and a stronger version of the fossil fuel non-proliferation treaty that others have developed. He suggests that if they don't immediately gain the support of the general assembly, they can begin as regional treaties, establishing, for example, deforestation-free zones. He argues that these treaties should be folded into an overarching greenhouse convention, supported by an International Climate Agency, modelled on the International Atomic Energy Agency.

Monbiot (2023) Cop28 is a farce rigged to fail, but there are other ways we can try to save the planet

7

Climate Finance

7.1 Green Investing

Fancy

The market is the market

"The evidence on climate risk is compelling investors to reassess core assumptions about modern finance," the BlackRock chairman, Larry Fink, wrote in his highly influential annual letter to CEOs in 2020. "In the near future – and sooner than most anticipate – there will be a significant reallocation of capital."

But the climate crisis can never be solved by today's free markets - because the system is built to extract profits. Investors have a fiduciary duty to maximise returns to their clients and as long as there is money to be made in activities that contribute to global warming, no amount of rhetoric about the need for sustainable investing will change that. It's cheaper and easier to market yourself as green rather than do the long tail work of actually improving your sustainability profile. That's expensive and if there is no penalty from the government, in the form of a carbon tax or anything else, then this market failure is going to persist.

Moving money to green investments doesn't mean polluters will no longer find backers. The argument is similar to that of divestment, another strategy that doesn't work. If you sell your stock in a company that has a high emissions footprint, it doesn't matter. The company still exists, the only difference is that you don't own them. The company is going to keep on going the way they were and there are 20 hedge funds who will buy that stock overnight. The market is the market.

The public don't realizes we are not talking about stopping climate change. We are literally talking about selling assets so we don't get caught up in the damage when it hits.

BAU

Under the current system the costs are simply too high and the benefits of conducting business as usual are too great.

Government led

The overarching point is that real change has to be led by government, not Wall Street.

Fancy (2021) Green investing 'is definitely not going to work'

7.2 Sustainable Finance

> Basel rules limiting the ability of banks to provide long-term, non-recourse finance to clean energy projects. Solvency rules that prevented investors from funding infrastructure and public transport. Liquidity rules that made it impossible for pension funds and life insurers to back newer technologies. Definitions of fiduciary duties that stopped pension fund trustees from taking into account ESG considerations. Accounting regulations that failed to require disclosure of climate risks. Public investment funds forced by regulators to use ratings agencies that ignored climate change.

World Economic Forum published a version of the white paper at Davos in January 2013, kicking off a heated debate among delegates and at subsequent events.

In January 2014, The United Nations Environment Programme picked up the baton, launching an Inquiry into the Design of a Sustainable Financial System, which resulted in October 2015 in a major report entitled The Financial System We Need. Then, December 2015 saw the formation of the Task Force on Climate-related Financial Disclosures (TCFD), chaired by Mike Bloomberg (founder and majority owner of Bloomberg LP) at the request of the Financial Stability Board and its (then) chair Mark Carney (governor of the Bank of England at the time). TCFD has done much to raise awareness of climate change and the need for more climate-related disclosures in financial circles.

It is now hard to argue that the financial system is institutionally fossilist. Indeed, there is a lively debate going on about whether central banks should be promoting climate action – being 'institutionally anti-fossilist' – or not.

A veritable smorgasbord of organizations has sprung up in recent years, promoting sustainable finance from various angles. All of them, however, depend on methodologies that are at best not transparent, and at worst downright misleading.

No amount of investment in clean energy and transportation will get the world to net zero if the capital markets continue to invest at the same time in fossil fuel-based infrastructure. Investors must also stop funding fossil assets, and they may even have to walk away from assets before the end of their productive lives. How can the capital markets contribute to, rather than impede, such decisions?

It is not up to the financial system to protect the environment: that's the job of regulators in energy, transport, industry and so on. As soon as clean solutions made economic sense, the money would flow – but not before, because of their risks.

Central banks should stick to managing risks within the financial system posed by societal choices, not trying to manipulate the choices made by society.

Greenhouse Gas Protocol

The methodologies of the Greenhouse Gas Protocol. Originally developed 20 years ago by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), this is the rule-book defining Scope 1, Scope 2 and Scope 3 emissions.

A quick reminder: Scope 1 are emissions from your own burning of fossil fuels or emissions of other greenhouse gases; Scope 2 are emissions embodied in purchased energy services – electricity, steam, heating and cooling; and Scope 3 are emissions elsewhere in your value chain, either upstream or downstream.

Accounting for Scope 1 and Scope 2 is relatively straightforward. A utility's Scope 1 is a power user's Scope 2, so if you own shares in both, there is a double-count, but it is fairly easily removed. Scope 3, however, is a whole different ball game.

Scope 3

Take the example of a sustainability consultant taking a flight as part of a client engagement. The resulting emissions would count as Scope 1 for the airline, and Scope 3 for both the provider of jet fuel and the consultant's employer. They should also, however, be counted as Scope 3 by her client. And by the company which extracted the crude oil from which the jet fuel was produced. And by the owner of the refinery where it was refined. And the 'fixed base operator' who delivered the fuel to the plane. The same emissions should also be counted as Scope 3 by the owners of the departure and arrival airports, the leasing company that owns the plane, and the insurers of the oil production platform, the refinery, the airport and the aircraft – as well as the provider of the consultant's travel insurance. Then there are the companies providing the air traffic control system, components and subassemblies of the aircraft, aircraft maintenance, airport security and catering services.

A big asset owner or asset manager might conceivably hold shares in every one of these companies. Not only that, but in addition to equity, they might own some of each company's debt too, perhaps several issues of different maturities. And what about derivatives? If you buy a call option on a company's stock, are you responsible for some of its emissions? A credit default swap? If you borrow stock and sell it short? If you warehouse debt as collateral for a collateralized debt obligation?

How is any investor meant to keep up with this, not on an annual or quarterly basis, but as it changes by the millisecond?

f the goal is to get executives and investors to think about the carbon intensity of the value chain to which their organizations or portfolio companies belong, and to push them to work with other value chain players to reduce emissions, this approach is great. It is clearly working, and its promoters are to be lauded.

If, however, you want to find out how many tons of carbon dioxide companies in your investment portfolio are actually emitting, or if you want to differentiate between two possible funds on the basis of their impacts on the climate, or if you want to regulate your capital markets to ensure compatibility with the Paris Agreements – then Scope 3 is simply a mess.

EU Taxonomy

The European Union, meanwhile, is plumping for a completely different approach: the EU Taxonomy for Sustainable Activities, an attempt to define a master list to make it easy to see which companies are sustainable and, by extension, which investors are backing sustainable economic activity. As so often in sustainable finance, practice and theory diverge fast.

For the average EU business, the Taxonomy will entail a level of disclosure far beyond anything found in financial statements. Taken literally, it would reveal profitability by line item, investment plans for individual plants and future project launches. The more likely outcome is that an army of accountants and consultants will ensure that data are estimated and aggregated in such a way as to meet legal requirements while revealing little of value to competitors – or investors.

Disclosure will be little more than educated guesswork – and expensive guesswork, particularly for smaller players.

From January 2022, the EU expects asset managers to use the Taxonomy to disclose the sustainability of their investments and funds.

What is needed is a way of allocating responsibility to specific players in an economic activity, which will generally be the *first player in the supply chain* who could have avoided causing them, but did not do so.

That is my one-line summary of the conclusions reached by the Expert Group on Climate Obligations for Corporations, a collection of 68 eminent jurists and human rights experts who have produced the Principles on Climate Obligations for Corporations (pdf). In its 372 pages they attempt to establish – in the absence of explicit law or precedent – where companies' and investors' legal obligations with respect to climate change are likely to lie.

Differentiate between emissions that are avoidable and those that are excessive, and take into account which player actually has control over the decisions that drive emissions.

Demand Focus

holding everyone responsible for emissions means holding no one responsible, and blaming fossil fuel producers – however egregious their past misconduct – effectively means placing the onus for climate action on those with most to lose from accelerating it. Instead of demonizing the supply of fossil fuels, we need to focus primarily on choking off demand. By demanding action on climate while maintaining demand for the products that cause it, society is sending mixed signals.

Each ton of carbon extracted anywhere in the world should automatically be tracked through the point where it is burned to the product or service for which it is used.

Distributed Ledger

Distributed ledger technology could have been designed with a job like this in mind, as the OECD acknowledges in this white paper (pdf), particularly in the era of satellite technology, sensor networks, big data and machine learning. Knowing exactly what is emitted and who is responsible will be a game-changer.

The long-term shift of climate risk from fuzzy and voluntary ESG reports to quantified and regulated financial statements will mark a huge inflection point in the history of climate action.

Focusing responsibility for Scope 3 emissions on those who make the decisions that cause them, and ensuring that risks are quantified and included in financial reports, will do a huge amount to drive capital into decarbonizing the global economy.

None of the currently available carbon accounting methodologies focuses corporations unequivocally on the two goals: reducing controllable emissions and developing high-quality offsets capturing carbon and sequestering it permanently.

The world will never get to net zero if avoided emissions count.

Where developing world countries require incentives to avoid deforestation or leave fossil fuels in the ground, these must be provided by governments, not private players.

If we can accelerate these four trends – transparently allocating emissions to the organizations causing them; integrating climate risk into financial reporting; extending carbon pricing; and focusing on net zero – we can build a sustainable financial system. A future in which the health of the capital markets is not in opposition to the health of the planet.

Liebreich

7.3 Financial Stability

FED Note

Climate change-related financial risks pose both micro- and macroprudential concerns, but analysis and research is at an early stage. This Note describes an approach to understanding how risks arising from climate change may affect financial stability, and connects this discussion to the financial stability monitoring framework described in the Federal Reserve's Financial Stability Reports. That framework distinguishes between shocks to the financial system and economy, which are difficult to predict, and vulnerabilities, which are underlying features of an economic or financial system that can amplify the negative effects of shocks. We describe how climate-related risks may emerge both as shocks and as vulnerabilities that could amplify the effects of climate-change related shocks or other shocks.

This analysis offers a way to assess the financial stability impact of risks resulting from climate change as information on the nature, extent, and timing of those risks improves. Our approach to describing climate-related financial stability risks is complementary to, though both simpler and broader than, the existing international typology described in Carney (2015).

We offer three main conclusions. First, the Federal Reserve's financial stability monitoring framework is flexible enough to broadly incorporate many key elements of climate-related risks. Second, although we believe that climate change increases financial stability risks, more research and analysis is needed to incorporate these risks fully into financial stability monitoring, including substantial improvements in data and models. Third, domestic and international transparency efforts around climate-related financial exposures may help clarify the nature and scope of financial stability risks related to climate change.

In principle, quantifying climate-related risks should be similar to quantifying other financial stability risks. In practice, however, climate-related risks face several challenges to measurement beyond those associated with conventional financial system vulnerabilities and potential shocks, and which will require investment to address. These climate-related features impair not only estimation and modeling at the level of the overall economy, but also the analysis of region-, sector-, asset-, institution-, and investor-level exposures. Investment in data procurement, and careful analysis of climate-related data to describe specific economic and financial risks, is critical to addressing these challenges and producing high-quality research on climate-related outcomes.

A fundamental challenge relates to merging and cleaning climate-related data for use in economic models.24 Availability of sufficiently granular spatiotemporal and climate-related financial data is limited, including information on exposure to physical hazards or the emission levels of activities associated with particular investments or financial institutions. Investors or researchers hoping to assess the financial impacts of climate-related risks must often use proxies involving spatiotemporal weather data.

Models that seek to link climate directly to economic output involve a separate set of challenges. Climate models typically simulate the interaction of a wide range of variables over many decades. In addition, the effects of climate change on economic activity may involve heterogeneous local or regional effects. These factors introduce uncertainty into even short- and medium-term projections, making aggregate climate models an imprecise source of information for near-term economic estimates and risk assessment.

Deeper analysis of the specific channels by which climate-related risks create hidden vulnerabilities in the financial sector will be an especially important topic for exploration.

FED Note on Climate Risk and Financial Stability

To take action, central banks must decide on some strategic issues Central banks can formulate a clear strategic view on their tolerance of climate-related risks and decide how forward- looking they wish their frameworks to be.

Central banks need to form a clear opinion surrounding the appropriateness of various climate-related metrics in order to adjust their operational frameworks. At the current juncture, in the absence of reliable and commonly agreed ways of putting a price tag on climate-related risks, central banks wishing to act may have no choice but to consider using non-financial climate-related metrics as a pragmatic starting point. Central banks should develop policies to monitor and manage issues surrounding data quality and availability. The limited availability and accuracy of relevant data is currently constraining virtually all climate-related risk metrics.

NGFS Adapting Central Bank Operations to a hotter World (pdf)

7.3.1 Methods and Data

Battison

Climate change has been recently recognised as a new source of risk for the financial system. Over the last years, several central banks and financial supervisors have recommended that investors and financial institutions need to assess their exposure to climate-related financial risks. Central banks and financial supervisors have also started designing climate stress tests that can assess how vulnerable the financial system is to climate change. Nevertheless, the financial community falls short of methodologies that allow the successful analysis of the risks that climate change poses to the financial system.

Indeed, the characteristics of climate risks (i.e., deep uncertainty, non-linearity and endogeneity) challenge traditional approaches to macroeconomic and financial risk analysis.

Embedding climate change in macroeconomic and financial analysis using innovative perspectives is fundamental for a comprehensive understanding of risks and opportunities in the era of the climate crisis.

This Special Issue is devoted to the relation between climate risks and financial stability and represents the first comprehensive attempt to fill methodological gaps in this area and to shed light on the financial implications of climate change. It includes original contributions that use a range of methodologies such as network modelling, dynamic evolutionary macroeconomic modelling and financial econometrics to analyse climate-related financial risks and the implications of financial policies and instruments aiming at the low-carbon transition. The research insights of these contributions can inform the decisions of central banks and financial supervisors about the integration of climate change considerations into their policies and financial risk assessment.

Battison (2021) Climate Risk and Financial Stability (Paywall)

8

IPCC

8.1 Risk Assesments

Hunziker

The Intergovernmental Panel on Climate Change (IPCC), in many respects, is a *Delphic institution* whose reports are a function of political discretion as it provides justification for nation/state policies that are seldom fulfilled, e.g., only a handful of the 193 signatory nations to Paris '15 have met commitments. This scandalous outright failure at a dicey time for the climate system only serves to hasten loss of stability and integrity of the planet's most important ecosystems.

That provocative depiction is examined in a recent Nick Breeze ClimateGenn podcast interview: Existential Risk Management with David Spratt, research director of the Breakthrough National Centre for Climate Restoration in Melbourne. Dr. Spratt is highly regarded for solid research, which is evidenced throughout his refreshingly straightforward interview.

Spratt's interview tackles: (1) failings of the IPCC, (2) tipping points, and (3) a nearly out of control global warming challenge that's not realistically understood, even as wobbly ecosystems start to falter.

The truth is the IPCC has been politicized to such an extent that its reports unintentionally confuse public opinion whilst misdirecting public policy issues for mitigation. At the center of the issue the IPCC does not expose the full extent of existential risk, which happens to be such an unthinkable event so hard to accept that nobody believes it will ever really truly happen, more on this later.

Regarding the IPCC's approach to risk, first it is important to emphasize the fact that big risks must be the key to successful climate change analysis. By definition, big risks are at the top end of a range of possibilities. But, the

IPCC does not see risks that way. Their view is more generalized and this has become normalized over the past 20 years, e.g., we have a 50% chance of not exceeding 2°C with our current carbon budget. According to Spratt: That is catastrophically wrong. That type of risk assessment has been normalized now for 20 years in policy-making, and "it is horribly wrong."

When risks are existential, and they clearly are in this particular instance, everybody knows if it gets to the range of 3C to 4C pre-industrial (and 60% of scientists say we're already headed for 3C plus) "we'll destroy human civilization."

Therefore, when risks are existential, you can't look at an on-average analysis, rather, you must look at the worst possible outcome as your primary calculation. It's the only way to approach an existential risk.

In that regard and interestingly enough the foreword of the IPCC report of a few years ago actually said: "Critical instances calculating probabilities don't matter. What matters is the high-end possibility."

But nowadays a figure such as "50% probability introduces a fundamental problem with the assessment process. More realistically, the proper way to look at existential risks is by stating x-amount of additional carbon has a 50% chance of reaching 2C but also has a 10% chance of 4C or in other words, a 50% chance of staying below 2C is also a 10% chance of reaching 4C. *Would you take an elevator ride with a 10% chance of the cable breaking at the 75th floor?*

When it comes to existential risks, the expectation should be: "Why should we accept risks with the climate system that we would not accept with our own lives?" They are really one in the same.

Thus, the core of existential risk management must focus on the high-end, not middling ranges of probability. The focus must be, and this is an absolute: "What is the worst that can happen, and what do we have to do to prevent it?"

That assumption is not part of the latest IPCC report. When it comes to non-linear responses of cascades, the IPCC says: "There is no evidence of such non-linear responses at the global scaling climate projections for the next century. But, according to Spratt: "This is just wrong."

After all, "everybody knows, for example, that emissions from permafrost are non-trivial at the moment. We know that warming in the last decade has been higher than in previous decades and the system is about to warm at an accelerating rate as major systems are already changing state. And the IPCC says there is no evidence of moving into non-linear climate change. This is absurd!" (Spratt)

Ipso facto, because of a badly misjudged bias, IPCC models can't deal with non-linear processes. As a result, they're missing the big picture by a country mile. And, mitigation policies, for what that's worth, are inadequate.

All of which leads to inadvertent problems for policy makers because people judge the IPCC report as pure science. "It is not. The IPCC is a political body. Diplomats of 190 governments run the IPCC. They appoint the lead authors for reports. The IPCC is the intersection of policy and politics." (Spratt)

As things now stand current mitigation stems from the IPCC's embedded idea that there can be "incremental non-destructive change as a solution… This will not work." (Spratt)

There is no way that a system with 'hands-off' government, other than a few token regulations, and 'the free market deciding the outcome' is going to work. Those in the elite, whether it's in business or in politics, simply, I think, do not understand the problem as it really exists.

There's a profound ignorance because of the IPCC telling a story that incrementalism is a successful approach when it's clearly not.

A collateral problem is a large segment of the professional climate advocacy NGO community has been "swallowed by the whale," meaning they buy into the lame Conference of the Parties "COP" meetings and swallow the corporate-origin net zero nonsense by 2050, over and over again, umm, but it's too little too late, horribly misdirected. Whereas, according to several scientists, 2030 is the deadly deadline, not incremental movement to 2050.

The crux of the matter is that the most prominent existential risk in human history does not conform to scientific models. It's almost always ahead of the scientific models.

Hunziker (2023) The Truth About IPCC Reports

8.2 Warming Pipeline

Hansen

Global Warming in the Pipeline will be published in Oxford Open Climate Change of Oxford University Press next week. The paper describes an alternative perspective on global climate change – alternative to that of the Intergovernmental Panel on Climate Change (IPCC), which provides scientific advice on climate change to the United Nations.

Our paper may be read as being critical of IPCC. But we have no criticism of individual scientists, who include world-leading researchers volunteering their time to produce IPCC reports. Rather we are questioning whether the IPCC procedure and product yield the advice that the public, especially young people, need to understand and protect their home planet.

Discussion of our paper will likely focus on differences between our conclusions and those of IPCC. I hope, however, that it may lead to consideration of some basic underlying matters.

- IPCC climate analysis leans heavily on GCMs (global climate models), too heavily in my opinion. We prefer a comparable weight on (1) information from Earth's paleoclimate history, (2) GCMs, and (3) observations of ongoing climate processes and climate change.
- Guidance for global energy and climate policies is also hindered by over-reliance on models. As a result, science has not informed policymakers well about the prospects for ongoing climate change, as evidenced by claims that targets for limiting global warming can still be achieved via realistic phasedown of emissions. This fiction is maintained via the combination of unrealistic assumptions in Integrated Assessment Models and low-sensitivity climate models.

Hansen (2023) To Understand and Protect the Home Planet

9

Legal Action

youth4climate The Case

9.1 Ecocide: Crime?

Ecocide is not yet illegal. International lawyers are working to codify it as a fifth crime but their campaign faces a long and uncertain road, riddled with thorny issues.

Pope Francis

Pope Francis, shepherd of 1.2 billion Catholics, has been among the most outspoken, calling out the wrongdoing with the full force of his office. He has advocated for the prosecution of corporations for ecocide, defining it as the damage or destruction of natural resources, flora and fauna or ecosystems. He has also suggested enumerating it as a sin in the Catechism of the Catholic Church, a reference text for teaching the doctrine of the faith.

President Emmanuel Macron of France, too, has been sharply vociferous. He has called the burning of the Amazon's rainforests an ecocide and blamed Brazilian President Jair Bolsonaro for reckless mismanagement of a planetary resource.

Indigenous leaders have gone further. They have formally requested the International Criminal Court to investigate Bolsonaro for crimes against humanity.

To prosecute and imprison political leaders and corporate executives for ecocidal actions, like Bolsonaro's, would require a parsing of legal boundaries and a recalibration of criminal accountability.

The moral power of advocates is increasing with the advance of environmental destruction. They already have much admissible evidence to make a case for placing limits on behaviors that make planetary matters worse.

Half a century after the problem was clearly identified, no one and no entity can yet be held responsible for climate change, the largest ecocide of all.

Sasson

Kutznet

The International Criminal Court, which was formally established in 2002 under a treaty called the Rome Statute to prosecute genocide, crimes against humanity, crimes of aggression and war crimes when its member countries, which currently number 123, fail to do so themselves.

Early drafts of the Rome Statute included the crime of environmental destruction, but it was removed after opposition from the United States, United Kingdom and the Netherlands, relegated instead to a wartime offense that has never been enforced.

As a result, international criminal law includes few guardrails to prevent peacetime environmental destruction.

"We currently cannot hold big corporations or big governments accountable for ecocide. So, what do you do? We name and shame, that's all we've got."

An ecocide crime would require International Criminal Court members to enact their own national ecocide laws, and failure to enforce those laws would enable the international court to step in.

Making ecocide a crime could help in weak states, where corporate polluters are sometimes more powerful than national governments.

While political leaders and warlords have been the usual targets of the court, an ecocide crime could place business executives on notice, too.

China, the United States, India and Russia—four of the world's top polluters—are not members of the International Criminal Court, but if a corporation based in one of those countries were to operate within a member state, as many of them do, their executives could fall under the court's jurisdiction.

The push to criminalize ecocide remained on the periphery until December 2019, when Vanuatu and the Maldives, two island nations threatened by rising seas and climate change-driven extreme weather, recommended that the court consider amending its statute to "criminalize acts that amount to ecocide."

After Vanuatu asked the International Criminal Court to consider criminalizing ecocide, Mehta's Stop Ecocide Foundation independently convened a panel of international legal experts, including Mackintosh of UCLA, to draft a clear definition of ecocide. They plan to publish their definition in June, at which point they hope at least one of the court's member nations will formally propose making ecocide the fifth international crime against peace.

Mehta has said the definition would likely require *"willful disregard"* for environmental destruction related to practices like widespread logging, drilling, mining and deep-sea trawling.

But climate change poses a greater challenge: Not only is it difficult to connect polluters to specific harms, he said, but there's also nothing illegal about extracting or burning fossil fuels.

"The situation we're dealing with is that the carbon system, which has fueled our economies since the Industrial Revolution, has not only been lawful, but it's been encouraged,"

Another point that the drafters will have to grapple with is whether the crime of ecocide should require prosecutors to prove that humans have been harmed. Mackintosh said that while this "human harm" threshold could prove appealing politically—the court's existing crimes all largely involve harm to humans—focusing ecocide only on the environment could make it easier for prosecutors to prove, especially when it comes to harms related to climate change, which are often incremental and indirect.

If a nation agrees to introduce the ecocide proposal to the International Criminal Court for consideration, that is when even harder work will begin. Ratification is a multi-step process that ultimately requires support from either two-thirds or seven-eighths of the court's members, depending on the type of amendment introduced.

While no country has committed to formally proposing that the court adopt ecocide, the campaign is gaining traction, fueled by the youth-led climate movement and radical new groups like Extinction Rebellion.

In December, Belgian Foreign Minister Sophie Wilmès asked International Criminal Court member states to examine the possibility of adopting ecocide as a crime. A member of Belgium's Parliament has also proposed a bill to criminalize ecocide. And French lawmakers are working on legislation to make ecocide an offense punishable by fines and prison, though Stop Ecocide criticized the bill as "weak."

At least 10 countries have national ecocide laws already, including Vietnam, which enacted the law in 1990.

Separately, French lawyers in January filed a request with the International Criminal Court on behalf of Amazonian indigenous groups asking that the court investigate Brazil's Bolsonaro for crimes against humanity.

Mehta's campaign is also part of a wider effort by activists who have been looking to the courts to force more aggressive action on climate change.

As of July 1, 2020, at least 1,550 climate change cases have been filed in 38 countries, according to a U.N. report.

Kusnetz

9.2 German Constitutional Court

In an order published today, the First Senate of the Federal Constitutional Court held that the provisions of the Federal Climate Change Act of 12 December 2019 (Bundes-Klimaschutzgesetz – KSG) governing national climate targets and the annual emission amounts allowed until 2030 are incompatible with fundamental rights insofar as they lack sufficient specifications for further emission reductions from 2031 onwards. In all other respects, the constitutional complaints were rejected.

BVerfG

The judgment of 29 April 2021 quashing parts of the Climate Protection Act (CPA) has made history. Not only because the First Senate of the BVerfG put an end to deferring the reduction of greenhouse gasses to the future, or at least to the next government. But because this turn to the future came in the form of a turn to international law and institutions. It is precisely by relying on international law that the court overcomes the counter-majoritarian difficulty commonly tantalizing climate litigation and human rights law generally. The most astonishing fact is, however, that the court entirely avoids the tragic choice between supposedly undemocratic international commitments and the democratic legislature. I argue that it does so by approaching constitutional law in a decidedly postcolonial perspective.

[Goldman - Verfassingablog 30 april 2021](https://verfassungsblog.de/judges-for-future/

9.3 EU Import Ban

Guardian

Beef, palm oil, cocoa and other products linked to deforestation will be banned from entering the European Union under landmark legal proposals that attempt to help prevent the felling of the world's great forests.

"What we propose is a pioneering initiative," Virginijus Sinkevičius, the EU environment commissioner, said. "EU action alone will not solve the problem. We also need major markets like the US and China to clean up their supply chain and we need producers to step up protection of the forests, but we stand ready to help."

The EU's proposals left out fragile ecosystems such as Brazil's Cerrado savannah and peatlands in south-east Asia, both rich stores of carbon, plant and animal life.

Between 1990 and 2008, EU consumption led to 10% of global deforestation, according to a commission estimate.

Gurdian (2021) EU aims to curb deforestation with beef and coffee import ban

10

Lobbying

Lobbying might be viewd as an ‘anti-action’ action

The oil industry knew at least 50 years ago that air pollution from burning fossil fuels posed serious risks to human health, only to spend decades aggressively lobbying against clean air regulations.

The industry was long aware that it created large amounts of air pollution, that pollutants could lodge deep in the lungs and be “real villains in health effects”, and even that its own workers may be experiencing birth defects among their children.

These concerns did little to stop oil and gas companies, and their proxies, spreading doubt about the growing body of science linking the burning of fossil fuels to an array of health problems that kill millions of people around the world each year. Echoing the fossil-fuel industry’s history of undermining of climate science, oil and gas interests released a torrent of material aimed at raising uncertainty over the harm caused by air pollution and used this to deter US lawmakers from placing further limits on pollutants.

Guardian

11

Net Zero

The predecessor to 'Net Zero' was and still is called 'offsetting'.

11.1 Net Zero Trap

Burn Now - Pay Later

The threats of climate change are the direct result of there being too much carbon dioxide in the atmosphere. So it follows that we must stop emitting more and even remove some of it. This idea is central to the world's current plan to avoid catastrophe. In fact, there are many suggestions as to how to actually do this, from mass tree planting, to high tech direct air capture devices that suck out carbon dioxide from the air.

The current consensus is that if we deploy these and other so-called "carbon dioxide removal" techniques at the same time as reducing our burning of fossil fuels, we can more rapidly halt global warming. Hopefully around the middle of this century we will achieve "net zero". This is the point at which any residual emissions of greenhouse gases are balanced by technologies removing them from the atmosphere.

This is a great idea, in principle. Unfortunately, in practice it helps perpetuate a belief in technological salvation and diminishes the sense of urgency surrounding the need to curb emissions now.

We have arrived at the painful realisation that the idea of net zero has licensed a recklessly cavalier "burn now, pay later" approach which has seen carbon emissions continue to soar. It has also hastened the destruction of the natural world by increasing deforestation today, and greatly increases the risk of further devastation in the future.

11.2 Net Negative

Overshoot

Given the dawning realisation of how difficult Paris would be in the light of ever rising emissions and limited potential of BECCS, a new buzzword emerged in policy circles: the "overshoot scenario". Temperatures would be allowed to go beyond 1.5°C in the near term, but then be brought down with a range of carbon dioxide removal by the end of the century. This means that net zero actually means carbon negative. Within a few decades, we will need to transform our civilisation from one that currently pumps out 40 billion tons of carbon dioxide into the atmosphere each year, to one that produces a net removal of tens of billions.

11.3 Direct Air Capture

Direct air capture, now being touted by some as the most promising technology out there, has taken hold. It is generally more benign to ecosystems because it requires significantly less land to operate than BECCS, including the land needed to power them using wind or solar panels.

Unfortunately, it is widely believed that direct air capture, because of its exorbitant costs and energy demand, if it ever becomes feasible to be deployed at scale, will not be able to compete with BECCS with its voracious appetite for prime agricultural land.

Dyke

11.4 Net Zero Targeting

Navigating the nuances of net-zero targets analyses the momentum of targets for net-zero emissions across companies, cities and regions worldwide. We seek to unravel the net-zero targets to better enable the identification of truly ambitious actors and enhance support towards them. We offer recommendations for increasing target transparency with the aim of achieving greater accountability and ambition.

NewClimate Institute (2020) Net-Zero Targets Report (pdf)

11.5 Action Tracker

climateactiontracker

11.5.1 Net Negative

India

India does not have a target for when it will cut emissions and has been under diplomatic pressure ahead of the COP26 summit in Glasgow in November.

Instead it aims to reduce emissions intensity — or the amount of pollution relative to GDP — by 33 per cent by 2030, relative to 2005 levels. Emissions intensity targets do not guarantee reductions in absolute emissions.

India is expected to be among the world's biggest contributors to emissions growth in coming years because of its increasing energy needs, although its total emissions today are less than half of the US level.

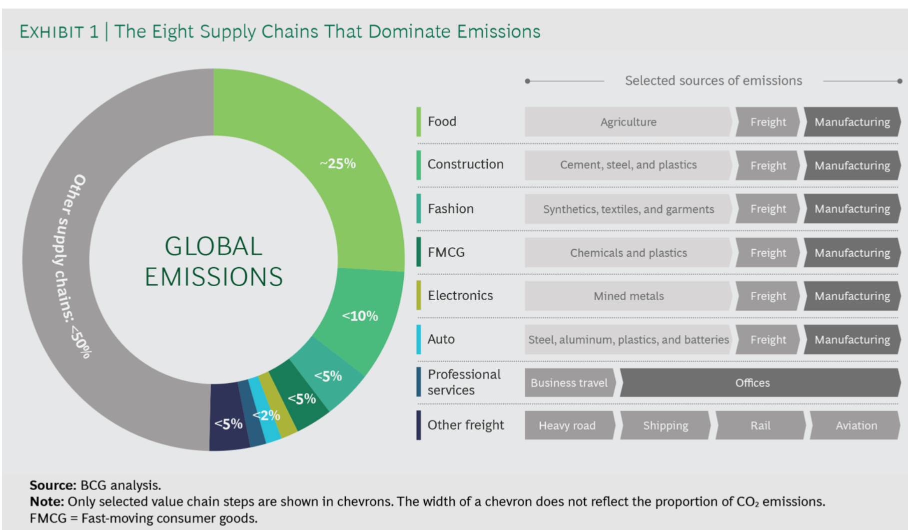
Energy Minister Singh said: "I believe that it's important for all the developed countries to talk about, not net zero, but about removing more carbon from the atmosphere than they are adding — net negative is what they need to talk about."

ft

11.6 Scope3 Value Chain Emissions

> Addressing scope 3 emissions is fundamental for companies to realize credible climate change commitments and is mandatory for all members of Race to Zero. It lets customer-facing sectors use their influence to speed and support rapid decarbonization throughout the economy.

In most supply chains, the costs of getting to net zero (the state in which as much carbon is absorbed as is released into the atmosphere) are surprisingly low.



Eight global supply chains account for more than 50% of annual greenhouse gas emissions. Only a small proportion of these emissions are produced during final manufacturing. Most are embedded in the supply chain—in base materials, agriculture, and the freight transport needed to move goods around the world.

For producers of many of these materials, as well as for freight transport players, ambitious decarbonization is extremely challenging. Many emission reduction measures are comparatively expensive. Supply chain partners often operate in markets that are commoditized, with slim margins and limited opportunities for differentiation. Across a whole value chain, however, emissions may be addressed more affordably. In most supply chains, there is the potential for substantially more efficiency and for much greater reuse of materials. In addition, a large share of emissions comes from traditional power, which can be replaced relatively cheaply with renewables.

As a result of this—and the fact that emission-intensive base materials account for only a small share of end consumer prices—decarbonization is much less expensive for companies at the end of any given value chain. In fact, in all the value chains we have analyzed, full decarbonization would lead to an increase of no more than 4% in end consumer prices.

So why is supply chain decarbonization not already commonplace? The answer is that it is challenging.

For one thing, most companies do not understand the extent or the nature of the problem. While a manufacturer can calculate the greenhouse gas emissions from its own operations with a relatively high degree of confidence, getting a view on scope 3 emissions is complex. The challenges are especially daunting for companies with tens of thousands of individual products and significant turnover in the supplier base. Some even struggle to understand who their suppliers are in the first place. It does not help that data-sharing on product emission footprints is still in its infancy.

BCG

11.7 The Science Based Targets initiative (SBTi)

Beslik

Transition is win-win for us, who cares about the rest!

The Science Based Targets initiative (SBTi) will become a standalone UK company that will examine and validate corporate net zero emission targets, a service for which it charges fees. The profits will go to a separate non-profit umbrella body that will continue to set the standards for those targets, with the full structure to be put into place by year end.

Originally a partnership of a handful of non-profit organisations, including an

UN initiative, CDP, the World Resources Institute and WWF, the body grew rapidly after it launched ahead of the 2015 Paris accord.

But it was forced to review its own governance practices following a formal complaint last year about potential conflicts of interest, based on concerns that it was setting the criteria for net zero targets while also charging companies to validate their targets.

The new chair of the SBTi board of trustees will be Francesco Starace, former chief executive of Enel, the Italian state-controlled utility company, who was on the board of the UN Global Compact corporate initiative.

SBTi has become one of the most influential advisers on climate change to companies and investors and the gold standard for corporate net zero plans. It has validated the plans of about 3,400 companies and institutions since it was established.

Although the group said it validated 87 per cent more companies in 2022 than the previous year, Starace said the company will "need to hire more people" and make better use of technology to meet rising demand.

The number of companies publishing targets this year had more than doubled from the previous year, and it aims to sign off plans for 10,000 companies by 2025. At the same time, it will face the challenge of companies weakening or restating their previously verified pledges. Oil and gas companies are among those that have shifted their targets, for example, including Shell and BP.

`But the SBTi does not check the accuracy of the emissions data reported by companies and does not`

And, Mr Starace probably does not know this or maybe he does but then again, and so what? ExxonMobil executives privately sought to undermine climate science even after the oil and gas giant publicly acknowledged the link between fossil fuel emissions and climate change, according to previously unreported documents revealed by the Wall Street Journal.

The new revelations are based on previously unreported documents subpoenaed by New York's attorney general as part of an investigation into the company announced in 2015. They add to a slew of documents that record a decades-long misinformation campaign waged by Exxon, which are cited in a growing number of state and municipal lawsuits against big oil.

Many of the newly released documents date back to the 2006-16 tenure of former chief executive Rex Tillerson, who oversaw a major shift in the company's climate messaging. In 2006, Exxon publicly accepted that the climate crisis posed risks, and it went on to support the Paris agreement. Yet behind closed doors, the company behaved differently, the documents show.

The documents also show Exxon's displeasure with scientific warnings from top authorities. After the Intergovernmental Panel on Climate Change, the United Nations' top climate body, sounded the alarm about the urgent need to curb greenhouse-gas emissions in 2011, Tillerson told a leading Exxon researcher that the IPCC's warning was "not credible", and said he was "dissatisfied" with the media's coverage of the warning about the worst-case climate scenarios.

Tillerson also wanted to engage with the scientists "to influence [the group], in addition to gathering info", the Exxon researcher told colleagues in a 2012 email about the findings. Years later, Tillerson expressed doubt about the United Nations' Paris accord months before it was signed. The international agreement aims to keep global heating "well below" 2C over pre-industrial temperatures.

After a climate science presentation to Exxon's board of directors in April 2015, Tillerson called the 2C goal "something magical", according to a summary of the meeting. "Who is to say 2.5 is not good enough?" he said, noting that meeting such targets would be "very expensive". More here.

And we know most of this, and we know what it means, and, and, and, and, and. Nothing.

Beslik (2023) And .. so what?

12

Outreach

Fossil fuel emissions from human activity are driving up Earth's temperature—yet something else is at work. The warming has set in motion nature's own feedback loops which are raising temperatures even higher. The urgent question is: Are we approaching a point of no return, leading to an uninhabitable Earth, or do we have the vision and will to slow, halt, and reverse them?

Feedbackloops 5 Videos

13

Climate Politics

People need to drive less. But this message is lost in the excitement over electric vehicles.

Hansen

Phasedown of emissions cannot restore Earth's energy balance within less than several decades, which is too slow to prevent grievous escalation of climate impacts and probably too slow to avoid locking in loss of the West Antarctic ice sheet and sea level rise of several meters.

Hansen (2023) PipelinePaper230705 (pdf)

13.1 Asset Revaluation - Existential Politics

Colgan Abstract

Whereas scholars have typically modeled climate change as a global col- lective action challenge, we offer a dynamic theory of climate politics based on the present and future revaluation of assets. Climate politics can be understood as a contest between owners of assets that accelerate climate change, such as fossil fuel plants, and owners of assets vulnerable to climate change, such as coastal property. To date, obstruction by "climate-forcing" asset holders has been a large barrier to effect- ive climate policy. But as climate change and decarbonization policies proceed, holders of both climate-forcing and "climate-vulnerable" assets stand to lose some or even all of their assets' value over time, and with them, the basis of their political power. This dynamic contest between opposing interests is likely to intensify in many sites of polit- ical contestation, from the subnational to transnational levels. As it does so, climate politics will become increasingly existential, potentially reshaping political alignments within and across countries. Such shifts may further undermine the Liberal International Order (LIO); as countries develop pro-climate policies at different speeds and magni- tudes, they will have incentives to diverge from existing arrangements over trade and economic integration.

Colgan memo

For the last three decades, international relations (IR) theory has presented the politics of climate change as a collective action problem, relying on models of strategic interaction to explain the presence or absence of international cooperation. We suggest a different approach. We offer a dynamic theory of climate change politics based on the present and future revaluation of assets. We use “assets” as a broad category that includes all inputs to production and sources of material wealth: capital, labor, and natural endowments. We argue that climate change, along with decarbonization policies to mitigate it, will trigger a profound and uneven process of economic revaluation of these assets. That revaluation will ultimately render certain assets valueless, creating a stark distributional struggle, which we term “existential politics.” Our aim is to develop a parsimonious political-economic model of the role of asset revaluation on climate politics. It serves as a materialist conceptual scaffolding upon which scholars can add ideational variables to explain climate politics.

The traditional thinking over- emphasizes free riding by viewing climate change as a static collective action problem among states. It underemphasizes distributional struggles, particularly those in domestic politics.

The politics of asset revaluation are central to understanding the interests and contestation around climate change.

CFA (Climate Forcing Assets) - CVA (Climate Vulnerable Assets)

We distinguish between two ideal-typical groups: holders of climate-forcing assets (CFAs) (for example, oil fields, beef farms) and holders of climate-vulnerable assets (CVAs) (for example, coastal property, fisheries). As climate change proceeds, and steps to address it unfold, they alter the value of these assets, and thus, over time, alter the balance of political power between their holders.

LIO Liberal International Order

Our theory of asset revaluation highlights a particular threat to the Liberal International Order (LIO) not commonly explored in the IR literature. The variation in climate and industrial policies across nations will affect the costs of exports and imports, incentivizing nations to place new restrictions on trade or other economic linkages. This threat is distinct from those commonly associated with climate change, such as increased risk of conflict, mass migration, or economic crises

We view current plans to introduce carbon border adjustment mechanisms, which would apply tariffs to certain goods from countries that do not have pro-climate pol- icies, as an early indicator of the tensions that we expect to grow between climate pol- itics and the LIO.

Our argument also challenges the implicit normative assumption underpinning much of this special issue: that the LIO as it has existed should be preserved.

The focus on climate multilateralism from the 1992 Rio Summit to the 2015 Paris Agreement has emphasized the collective action problem of mitigation. According to this view, free riding is the key political challenge. This account overlooks critical features of the problem. Many states are defying the static logic of collective action, and instead are choosing to enact pro-climate policies such as carbon pricing or regulations that restrict emissions.

The key driver of climate politics is domestic politics: politicians are responding to the demands of their constituents, many of whom want emissions reductions regardless of what other countries are doing.

We focus on how policy choices iteratively affect the size of economic interests that underpin domestic politics.

Climate change is a distributional problem unprecedented in scale, not only among states, but also within them.

Conventional bargaining models are useful in understanding the role of such obstruc- tionists, but the solutions they suggest have limited application to climate. Bargaining theory offers little insight on the conditions under which actors' preferences change, and how that affects political outcomes.

Unlike international trade, for example, reciprocity is not a key feature of a potential climate bargain because climate benefits accrue globally, not dyadically.

The *infeasibility of intergenerational distribution*: conventional bargaining theory has been less successful when applied to climate change.

The empirical results reflect these difficulties: whereas inter- national trade negotiators have overcome various bargaining problems, climate change negotiators have not had similar success.

Existential Politics

Existential politics often means that there is a contest over whose way of life gets to survive. Should we have Miami Beach and the Marshall Islands, or should we have coal miners, ExxonMobil, and Chevron?

This extreme form of distributional politics exists in other areas of international political economy (for example, a trade agree- ment or technological change can wipe out an uncompetitive industry), but we suggest that the scale of climate change will make existential politics the increasingly dominant lens through which to understand climate politics.

As distributional conflicts expand and intensify, climate politics will become existential. Different interests will not only fight over who gets what but also over whose way of life survives.

A greater number of actors will be directly, and sometimes gravely, affected by climate change. In turn, the gravity of these effects shifts the policy discussion from extract- ing concessions—an issue of distribution—to ensuring survival. The politics of mitigation thus seems primed to become increasingly existential.

Colgan (2020) Asset Revaluation and the Existential Politics of Climate Change (pdf)

13.2 Climate Clubs

Falkner Abstract

The idea of a stringent climate club, once the reserve of academic debates, is quickly gaining ground in international policy circles. This reflects dissatisfaction with the multilateral UNFCCC process, but also hope that a minilateral club could increase climate policy ambition, reinvigorate the Paris Agreement process, and make future emissions pledges stick. With the Biden Presidency renewing the US commitment toward climate action and the European Green Deal proposal for carbon border tariffs, some are advocating the creation of a transatlantic climate club. What could a club approach hope to achieve, and what do we know about its political feasibility and desirability? In this article, we seek conceptual clarification by establishing a typology of different club models; we inject a greater sense of political realism into current debates on the feasibility of these models; and we consider their legitimacy in the context of international climate cooperation.

Key policy insights

- Knowledge gaps and confusion regarding the nature of climate clubs hold back debates about what intergovernmental clubs can contribute to international climate policy.
- Club design matters: existing club models vary in terms of the proposed size, purpose, operational principles, legal strength, and relationship to the UNFCCC.
- Clubs focused on normative commitments face low barriers to establishment. They lack legal strength but can help raise policy ambition.
- Clubs aimed at negotiating targets and measures can increase bargaining efficiency, but struggle to deal with equity and distributional conflicts.
- Clubs seeking to change incentives via club benefits and sanctions face the highest hurdles to implementation. Their promise to tackle free-riding remains untested and difficult to achieve.
- Climate clubs face an international legitimacy deficit. Any club proposal needs to consider how to add to, and not distract from, the multilateral climate regime.

Falkner Memo

We propose three ideal types of climate clubs (for similar categorizations: (a) normative clubs, consisting of countries that make a normative commitment to certain climate policy objectives; (b) bargaining clubs, which facilitate more effective negotiation of climate mitigation targets, measures and rules among significant powers; and (c) transformational clubs, with legally binding membership rules, tangible club benefits and sanctioning mechanisms that seek to change the incentive structure of a select group of members.

Clubs can be small or large in size. Due to more or less demanding entry rules, they would tend to start out as small minilateral forums, but can grow into larger multilateral bodies, as is the case with the GATT/WTO trade regime. In the climate field, where the United Nations Framework Convention on Climate Change (UNFCCC) serves as the central multilateral regime with near-universal membership, most clubs are smaller and often minilateral in nature. Unlike ad-hoc coalitions in multilateral negotiations or one-off gatherings of state representatives, clubs are permanent creations, whether formally or informally constituted, that are built around a common purpose and with rules governing membership.

A *normative club* brings together countries that share a normative commitment to achieving certain objectives. The key membership criterion is adherence to the shared climate policy ambition.

The main purpose of a *bargaining club* is to facilitate more efficient negotiations of common objectives, targets and policies, especially among powerful or significant players in a given issue area. The key membership criterion is significant international status, power and relevant capabilities. Rather than rally like-minded actors behind an ambitious normative commitment, a bargaining club seeks to promote compromise-seeking among relevant players, including those with diverging normative ambition. The minilateral form is the main reason for their greater bargaining efficiency. Bargaining clubs can serve as an alternative to multilateral forums when they achieve deeper levels of cooperation.

Transformational clubs are the most demanding type of climate clubs. They comprise countries that share a common purpose but also seek to change members' incentive structure. In doing so, they seek to overcome the free-riding problem and enhance compliance with ambitious climate targets. This works in two principal ways: by creating club benefits that are available only to members (e.g. preferential trading, access to technology and finance), and by sanctioning members that are non-compliant.

Falkner (2021) Climate clubs: politically feasible and desirable? (pdf)

13.3 Climate Debt

Sasha

The global North is responsible for 92% of emissions in excess of the planetary boundary, while the global South bears the brunt of the destruction. The climate breakdown is a process of atmospheric colonisation.

To date, there has been no robust attempt to quantify national responsibility for the ecological, social, and economic damages caused by excess global CO2 emissions.

The predominant approaches to conceptualising national responsibility for emissions focus on current annual territorial emissions, or in some cases cumulative territorial emissions, in a manner that does not account simultaneously for both the scale of national emissions and population size of countries.

The literature on climate debt addresses this limitation by recognising the principle of equal per capita access to atmospheric commons, yet existing methods in the literature do not allow quantification of national responsibility for emissions in excess of a given safe global carbon budget.

Furthermore, no existing methods have attempted to quantify responsibility for emissions in consumption-based terms, in a manner that accounts for international trade.

ESG on Sunday 2021 Week 41

13.4 Distributive Conflicts vs Commons Free-riders

Aklin Abstract

Climate change policy is generally modeled as a global collective action problem struc- tured by free-riding concerns. Drawing on quantitative data, archival work, and elite inter- views, we review empirical support for this model and find that the evidence for its claims is weak relative to the theory's pervasive influence. We find, first, that the strongest collec- tive action claims appear empirically unsubstantiated in many important climate politics cases. Second, collective action claims—whether in their strongest or in more nuanced versions—appear observationally equivalent to alternative theories focused on distributive conflict within countries. We argue that extant patterns of climate policy making can be explained without invoking free-riding. Governments implement climate policies regard- less of what other countries do, and they do so whether a climate treaty dealing with free- riding has been in place or not. Without an empirically grounded model for global climate policy making, institutional and political responses to climate change may ineffectively target the wrong policy-making dilemma. We urge scholars to redouble their efforts to analyze the empirical linkages between domestic and international factors shaping climate policy making in an effort to empirically ground theories of global climate politics. Such analysis is, in turn, the topic of this issue's special section.

Aklin Memo

Over the past decades, many social scientists have come to view environmental problems as, first and foremost, commons management issues.

Collective action characterizations of commons management issues highlight two distinct logics. First, players must expect an outcome under the "business-as- usual" that is suboptimal compared to some other possible outcome. What makes competing outcomes "better" is not always specified. Second, players face individual disincentives to move from the suboptimal to the optimal outcome. Investing in public goods production is individually costly, but the benefits of action are contin- gent on the number and scale of group contributions. Furthermore, no actor can unilaterally produce the public good alone. Thus, every player has an incentive to free-ride and let others shoulder the costs of public goods provision. But the public good will not be provided if every player behaves this way.

Decades of international negotiations have sought to address free-riding because there was widespread belief that this was holding back climate policy. Treaties such as the Kyoto Protocol and the Paris Agreement sought to create transparent and verifiable commitments, presumably in order to increase compliance. Our findings join critical voices arguing that this was the wrong solution to a misunderstood prob- lem.

Solutions such as climate clubs, while offering several benefits, may still not solve the climate problem if the logic of climate politics has been misdiagnosed. To the extent that distributive conflicts are the main constraint on effective policies, international agreements may be more successful if they instead focus on empowering key pro-climate interest groups and neutralizing veto players, such as fossil fuel interests.

Collective action theory does not provide the only theoretical framework to make sense of political conflict over climate policy. A distinct meta-theoretical approach begins by recognizing the fundamentally redistributive nature of climate policy making. Climate policy involves a dramatic renegotiation of the institutions that structure economic and social activity within each economy. Consequently, climate policies create new economic winners and losers. Sharp divisions in the material interests of political and economic stakeholders subsequently trigger distributive conflict over climate policy making. Conflicts over material benefits are further reinforced by ideological struggles among politicians, voters, and interest groups.

An emerging literature on distributive climate conflict highlights two families of explanations. One literature describes climate policy outcomes as a function of special interest control; a second (possibly complementary) literature emphasizes the importance of a sectoral and ideological balance of power. Together, these accounts highlight an alternative meta-theoretical account that can motivate expla- nations for climate policy action and inaction without invoking the importance of free-riding concerns.

Aklin (2020) Prisoners of the Wrong Dilemma: Why Distributive Conflict, Not

Collective Action, Characterizes the Politics of Climate Change (pdf)

14

Technology

14.1 CCS

Most existing CCS projects in the world are enhanced oil recovery projects. That means that the captured carbon is used to produce more oil, not to reduce emissions.

The push for offshore CCS reflects the same attitude that has left the oceans in crisis today: treating them as a limitless resource to exploit and a bottomless receptacle for humanity's waste.

Offshore CCS represents the next frontier of ocean abuse by the fossil fuel industry.

Whether on land or under the sea, CCS is not a solution to the climate crisis. Experience shows it is costly and ineffective, and only prolongs dependence on fossil fuels.

Carbon Storage in Theory Once CO is captured, operators can inject it underground or under the seabed into a variety of different geologic formations, including saline aquifers, oil and gas reservoirs, coal seams, basalt formations, and organic shale formations.3 While storage in each of these formations is theoretically possible, there are geologic variables at each injection site that make it difficult to predict the behavior of the CO underground.4 In principle, each of these formations can hold the CO underground at a temperature and pressure that keeps the CO in a supercritical state, meaning that it has properties of both a liquid and a gas. Depending on the site's geology, the CO may dissolve into some of the brine underground or trigger a chemical reaction that slowly turns the carbon into a solid mineral, over thousands of years, but most injected CO is physically held underground by a seal known as a caprock.5 De-

> scriptions of how CO storage may work must be interpreted in light of the limited experience with CO sequestration to date, the site-specific nature of geologic variations and leakage pathways, and the difficulty of tracking these developments over geological rather than human timescales.

Tooze on IEA Report

One scenario that the fossil fuel industry should not comfort itself with, according to the IEA (pdf), is the idea that gigantic carbon capture will permit a continuation or even expansion of the current industry.

> If oil and natural gas consumption were to evolve as projected under today's policy settings, this would require an inconceivable 32 billion tonnes of carbon captured for utilisation or storage by 2050, including 23 billion tonnes via direct air capture to limit the temperature rise to 1.5 °C. The necessary carbon capture technologies would require 26 000 terawatt hours of electricity generation to operate in 2050, which is more than global electricity demand in 2022. And it would require over USD 3.5 trillion in annual investments all the way from today through to mid-century, which is an amount equal to the entire industry's annual average revenue in recent years.

Given the industry's heavy reliance on carbon capture fantasies, this is a strong and important statement from the IEA.

Tooze (2023) Carbon Notes 7 - The IEA's message to the oil and gas industry: wake up!

CIEL

Deep Trouble

Facing growing scrutiny over their contributions to climate change, polluting industries are increasingly looking for ways to cover up their continued emissions rather than phase out the fossil fuels driving them. One way companies claim the world can continue producing and using oil, gas, and coal without harming the climate is through carbon capture and storage (CCS), which purports to enable polluters to trap their carbon dioxide (CO_2) emissions and bury them underground or under the seabed.

Despite the fanfare around CCS, it is a costly and risky endeavor and nearly all the world's past CCS projects have experienced unexpected problems or failed outright. The technology's poor track record hasn't stopped the fossil fuel industry from championing new projects, and over the last few years, companies and governments have put forward a rash of new proposals that aim to store industrial emissions offshore under the seabed.

A new wave of proposed projects aims to pool CO_2 waste from various fossil fuel and industrial activities for injection in offshore storage "hubs" in oceans around the world. This untested technique, which involves a step change in the scale and complexity of offshore CCS, poses uncalculated risks. Some of the envisioned hubs are associated with the buildout of new fossil fuel projects, and most would store waste from industries that must be scaled down or phased out if the world is to avoid catastrophic climate change.

Deep Trouble: The Risks of Offshore Carbon Capture and Storage explains the threat presented by a massive buildout of offshore CCS infrastructure and uncovers the government financing and fossil fuel interests enabling and advancing this new wave of projects. The report concludes that governments must halt the expansion of offshore CCS by ending subsidies and support for these projects, while interpreting existing laws and strengthening emerging regulations to protect the oceans from absorbing even more of humanity's waste and safeguard communities, the environment, and the global climate.

**Ciel memo*

Until now, global experience with offshore CCS has been based on just two projects in Norway, both of which encountered unpredicted problems despite their relatively simple designs and small scales. Far from a proof of concept, those projects prove the complexity of offshore CCS and raise serious con- cerns about proposals to ramp it up in size and scope.

Injecting CO under the seabed presents uncalcu- lated risks and untested monitoring challenges. Whether onshore or offshore, injecting CO under the Earth's surface has the potential to contaminate groundwater, cause earthquakes, and displace deposits of brine, which can be toxic. These risks have never been confronted at scale, and the magnitude of offshore injection contemplated by proponents would create unprecedented challenges in managing reservoir pressure and monitoring CO plumes in the depths of the ocean.

Proposed CO storage hubs are concentrated in areas most prone to leaks. The single biggest risk of CO leakage comes from the interaction of injected CO with legacy oil and gas wells.

Offshore CCS projects are costly and largely dependent on public subsidies. CCS is inherently expensive, and the costs for its deployment are only heightened offshore. These high costs are driving industry demands for public subsidies, which effec- tively pay polluters to bury some of their pollution rather than require them to stop generating it in the first place.

Regardless of how the captured carbon is used, any CCS project requires significant energy inputs and a web of different facilities to function, and all of this infra- structure poses risks to the public. CO processing facilities, for example, release large amounts of air pollutants like sulfur dioxide, while carbon capture equipment is known to greatly increase the amount of ammonia that a facility spews into the air. Running carbon capture equipment is also enormously energy-intensive, increasing the overall emissions of the facility where the capture equipment is installed.14 This is known as an "energy penalty."

At high concentrations, CO is a toxic gas and an asphyxiant capable of causing "rapid 'circulatory insufficiency,' coma and death." (When a CO pipeline ruptured in Mississippi in 2020, dozens of people nearby were knocked unconscious and at least forty-five wound up in the hospital).

Tthe total projected capture amount of 450 million metric tons (tonnes) remains relatively insignificant from a climate change perspective, amounting to approximately 1.5 percent of current annual global CO emissions from energy and industry.

The very idea that offshore CO storage is feasible at all is based almost entirely on two small projects, both in Norway. These storage ventures both encountered problems in their early phases and prove that CO storage is a challenging and unpre- dictable task.26 Moreover, uncertainties remain regarding the permanence of storage, processes for long-term monitoring, and liability for leaks. Many of these risks have yet to be fully assessed, let alone comprehensively regulated.

Sleipner and Snøhvit

he world's first offshore CCS project, called Sleipner, began operating in 1996. The Norwegian petroleum company Statoil (now Equinor) started capturing CO from its Sleipner gas field and inject- ing it into saline reservoirs beneath the North Sea in order to avoid paying the 1991 Norwegian CO tax.32 In 2008, Statoil launched a second CCS project that began capturing CO from its offshore operations at the Snøhvit gas field and reinjecting it beneath the seabed.

In both projects, geologists failed to accurately predict how the injected CO would behave under- ground. At Sleipner, the CO migrated upward from its intended storage point into a different layer of the subsurface. The Snøhvit project turned out to have significantly less storage capacity than expected, forc- ing Equinor to sink an unplanned USD225 million or so into identifying the problem and developing a new storage site. A 2023 report on Sleipner and Snøhvit from the Institute for Energy Economics and Financial Analysis (IEEFA) points to the projects' problems as evidence that storing CO underground is "not an exact science," and that CCS, even after "extensive repeated study, using the most modern methods, is not foolproof."

Despite the significant challenges with these two relatively simple projects, industry leaders still often refer to Sleipner and Snøhvit as success stories that substantiate the safety and feasibility of much larger, more complex offshore CCS projects, such as the hubs being proposed worldwide. The projects have emboldened Equinor and the Norwegian govern- ment to promote Norway as a primary destination for CO waste from other countries.

Until now, these two projects have received little scrutiny in Norwegian political debate or in the broader environmental movement — perhaps due in part to the dearth of independent research into CCS free of funding or participation by the oil and gas industry, including at Norwegian higher education institutions.

Both the Norwegian projects are relatively small in scale: They each have a maximum injection rate of less than 1 million tonnes per year. This amounts to less than one thirtieth of Norway's annual emissions, and pales in comparison to the much larger ambitions of major proposed projects.

CCS Hubs

The pervasive concept of offshore "CCS hubs" introduces additional complexities beyond what stand-alone facilities like Sleipner and Snøhvit were designed for. Both Sleipner and Snøhvit involve CO captured from a single source, while many new CCS proposals envision storing CO from multiple sources in one location. Because different indus- trial processes produce CO streams with different chemical makeups, hub operators would need to ensure that the substances they accept from different industries would not damage their infrastructure or elevate risks. Impurities like water, hydrogen sulfide, sulfur oxides, or carbon monoxide can all be present in industrial CO streams at varying levels.40 These impurities can cause pipeline corrosion41 and compound the dangers workers would face from a blowout: Even with pure CO , a blowout could be deadly due to the risk of asphyxiation, but impurities could make a rupture toxic as well.

Denmark

Denmark's embrace of CCS is at odds with its commitment to phase out fossil fuels. As a found- ing member of the Beyond Oil and Gas Alliance (BOGA) launched in 2021 at the 26th Conference of the Parties to the United Nations Framework Con- vention on Climate Change (UNFCCC COP26),55 Denmark promised to sunset oil and gas production domestically by 2050. And yet, the offshore CCS projects Denmark is promoting only prolong reliance on oil and gas.

Longship

In 2020, the Norwegian government announced plans to launch a large-scale CCS demonstration project in an effort to create a new market for CO disposal as a service across the European continent. The project, known as Longship, would be an open- source network of CCS infrastructure that includes carbon capture at industrial facilities throughout the continent, paired with transport and storage in a sub-seabed site located off the western coast of Norway. The Norwegian government will fund two- thirds of the project, an estimated USD1.57 billion (NOK 16.8 billion), while the remaining costs will be shared among the project's partners. The transport and storage component of the project, is known as Northern Lights.

Northen Lights

In Norway, developments are underway for a new offshore CCS project — led by Equinor in partnership with Shell and Total — called Northern Lights. The Norwegian government is providing 80 percent of the funding for the first phase.48 The project would seek to inject 1.5 million tonnes per year of CO in its first phase and up to 5 million in its second. This second phase would increase the amount of CO injected under the seabed by a large margin, but even so, it remains a drop in the proverbial bucket: The carbon injected would amount to less than one tenth of 1 percent of Europe's annual CO emissions from fossil fuels in 2021.

Northern Lights project involves transporting CO captured from European industrial facilities by ship to an onshore receiving terminal and then moving it back offshore via pipeline for injection into a storage reservoir beneath the North Sea. The subsea storage site is located about 2,600 meters (1.6 miles) beneath the seabed. Phase 1 of the project aims to capture and store 1.5 million tonnes of CO per year and be operational by 2024.

The Longship project was initially planned to start with carbon capture at two Norwegian facilities, the Heidelberg Materials cement plant in Brevik and the Hafslund Oslo Celsio waste-to-energy plant. Con- struction is underway at Heidelberg Materials, but the Hasflund Oslo Celsio plant suspended the installation of carbon capture equipment in April 2023 after the project exceeded its budget.

Longship is seeking additional emitters within and outside of Norway to sign onto the project, exem- plifying how the "carbon management" economy depends on steady pollution streams. In late August 2022, the project announced an agreement with the Norwegian fertilizer firm Yara to transport and store CO captured from Yara's Sluiskil ammonia plant in the Netherlands.

Although Northern Lights is pitched as a major proj- ect, its potential contribution to climate mitigation is quite limited. The project aims to scale up beyond the starting goal of storing 1.5 million tonnes of CO per year, adding 3.5 million tonnes of capacity to reach 5 million tonnes depending on market demand.

This represents a potential five-fold increase in the offshore injection rate compared to Norway's flagship Sleipner project, and with it, increased complexities. But the scale of emissions must be kept in perspective: Norway's emissions alone amounted to about 49 million tonnes carbon dioxide equivalent (CO e) in 2021. The CO volumes that this project aims to bury — drawn from the entire continent — are minor in comparison.

RISKS

> The risks of offshore CO injection must be considered in the context of the myriad pressures facing global oceans and seas, including those from increasing temperatures, acidification, nitrogen and other chemical pollution, and the proliferation of microplastics.

While carbon capture equipment may reduce the CO emitted from a facility, it perpetuates, and can even increase, the release of other air pollutants that harm public health and the environment, undermining human rights.

The CCS process itself presents hazards to the climate and environment. Whether onshore or offshore, injecting CO under the Earth's surface has the potential to contaminate groundwater, cause earth- quakes, and displace deposits of toxic brine.

Brines can be detrimental to surrounding sea life because they can have salt concentrations far in excess of seawater and can contain contaminants such as heavy metals.

Preventing or mitigating hazards associated with CCS is even more technically challenging and expensive at great depths under the sea, where the dynamics of CO may be harder to ascertain than on land and the resulting problems harder to resolve.

It isn't only the offshore storage of CO that presents possible hazards. Each stage of the CCS process — capture, transport, injection, and storage — has the potential to harm communities and the environ- ment, jeopardizing the right to a clean, healthy, and sustainable environment and other human rights.

Operation of carbon capture equipment could increase emis- sions of harmful fine particulate matter (PM2.5) and nitrogen oxide, and significantly increase toxic ammonia emissions.

Existing oil and gas pipelines, designed to withstand much less pressure, cannot readily be repurposed for moving large amounts of CO .

A large vessel capable of storing CO does not yet exist, much less a fleet of them.

Unlike gas or oil pipelines, the risk from a CO pipeline rupture is not combustion, but **asphyxiation**. CO is heavily pressurized and denser than air, so if a pipeline bursts, large volumes can be released extremely quickly and stay close to the ground, threatening people in a wide radius from the release.

The US has the largest pipeline network in the world and only has about 8,000 kilometers (km) (about 5,000 miles) of active CO pipelines, compared with 425,605 km (about 265,000 miles) of oil and gas pipelines.

Although experience operating CO pipelines is lim- ited, extensive experience with oil and gas pipelines makes one thing clear: **Pipelines leak**. Over an eight-year period in the US, there were more than 2,000 recorded incidents with gas pipelines alone. These incidents resulted in more than 100 deaths and nearly 600 injuries.

Presence of water, contaminants, or impurities such as hydrogen sulfide in the CO stream increases the risks of pipe corrosion.

Shipping CO increases emissions in one of the most difficult-to-decarbonize trans- port sectors. Generating fossil fuel emissions to transport fossil fuel emissions is counterproductive at best. Refrigerating the CO cargo — which must be kept under high pressure and low temperature to be transported in liquid form — and powering the ship requires burning more fossil fuels. Research by oil and gas industry analyst Rystad, considering potential CO shipping routes, found that some vessels traveling long distances could produce emissions equivalent to as much as 5 percent of the CO being transported.

CO leaks would affect the marine environment as well. Its interactions with the sea would be complex: hydrates and ice might form, and temperature differences would induce strong currents. Some of the gas would dissolve in the sea, but some would be released to the atmosphere.

The injection of high-pressure CO under the seabed is a complicated process that creates significant risks and uncertainties beyond just leakage. The aquifers into which CO could be injected are not simply empty pockets underground, but porous rock formations that can be filled with brine, water, sand, or other materials. CCS operators propose injecting CO into the "pore space" that these other substances occupy. Injecting the CO into this space displaces whatever was there before, elevating the pressure underground and often pressurizing areas well beyond the boundaries of the injection site. Too much pressure can cause the **caprock**, the impervious rock layer that seals the brine and CO underground, to crack, causing a leak. Operators must also limit pressure build up in order to avoid triggering earth- quakes, a known risk with any subsurface injection.

Brine can leak from pipelines and needs to be properly managed and disposed of to avoid contaminating the environment. As acknowledged in an EU-funded report involving Statoil (now Equinor), the high salinity of brine can be toxic to benthic (deep sea) organisms like coral and sea anemones.

If brine is allowed to percolate to the surface of the seabed, such brines could cause a ten-fold increase in local salinity in surface sediments and seabed depressions, thus representing a potentially severe source of osmotic shock to benthic organisms.

New studies demonstrate the risks of assuming that the ocean has a vast storage capacity. Researchers warn that the dynamics within each individual geologic formation are unpredictable, and that macro estimates of geologic storage capacity are likely flawed.

Building out industrial-scale CCS may not be as feasible as current regional inventories suggest and pressure management techniques may not function as planned.

Legacy deposits of oil in offshore wells can react with injected CO to form bitumen, a viscous hydrocarbon substance, creating blockages and reducing the ability to inject more CO .

If CCS is widely deployed onshore and offshore, even a 0.1 percent leakage rate could cause up to 25 gigatonnes of additional CO emissions in the 21st century, posing a major risk to the climate.

Despite the fact that legacy oil and gas wells pose the single greatest risk of CO leakage at offshore storage sites, the areas being heavily targeted for offshore

CCS development are precisely those zones where old wells abound: sites of long-standing oil and gas drilling.

There is little reason to believe that injecting CO into areas where countless existing leaks from oil and gas wells go undetected or unreported would guarantee "permanent" storage.

In the event of a storage well failure or other extreme release of CO offshore, the problem may be very difficult, if not impossible, to correct.

CO might cause wells to fail due to its incompatibility with certain commonly used materials.

If there is a leaking CO well or a blowout, the mitiga- tion measures used for oil and gas well accidents, like a physical barrier, won't work to contain CO . The only option may be to stop injection altogether.

Significant uncertainties about the long-term performance of a CO storage site should be resolved prior to injection of large volumes of CO ; if uncertainties cannot be resolved, injection should be stopped.

If injection is halted, the CO that would have been captured to supply the injection site will end up simply vented into the atmosphere, assuming the underlying emitting activity is not also paused. This would undermine any climate rationale for operating a carbon capture system in the first place.

CIEL (2023) Deep Trouble -The Risks of Offshore Carbon Capture and Storage (pdf)

14.1.1 CCS Costs

Beslik

Oxford University conducted a massive study of the phenomena known as rights law, the cost-reduction curves for technologies, and we've seen in our lives some stunning examples: the mobile phones, the flat screen TVs, not to mention computer chips.

And so they studied all of them, and some go down in cost very rapidly, some a bit slowly. They have a very small category labelled non-improving technologies. That's the category that carbon capture and sequestration is in. For 50 years, there has been zero reduction in cost for carbon capture and sequestration. ZERO.

Beslik (2023) Oil-Cave Jabs and the Dramatic Dance of Petrostates at COP28

14.1.2 EOR - Enhaced Oil Recovery

CIEL

The vast majority of the CO captured at existing carbon capture and storage (CCS) projects around the world is used in oil fields, where it is injected into depleted wells to force more oil to the surface, a process known as enhanced oil recovery (EOR)

CIEL (2023) Deep Trouble -The Risks of Offshore Carbon Capture and Storage (pdf)

14.2 CDR - Carbon Dioxide Removal

Carbon dioxide removal (CDR) encompasses various deliberate human approaches that can remove CO2 from the atmosphere and store it in oceanic, terrestrial or geological reservoirs over climate-relevant timescales of decades to millennia. These approaches include schemes such as reforestation, afforestation, iron fertilisation, ocean alkalinity enhancement, enhanced rock weathering, bioenergy with carbon capture and storage (BECCS) and direct air capture and storage (DACCS). CDR is distinct from methods aimed at preventing new emissions at point sources, such as carbon capture and storage (CCS) at fossil power plants or cement works, as these prevention methods are classed as emission reduction strategies.

CDR focuses on removing CO2 that is already in the atmosphere or in the upper ocean, and permanently storing it for centuries or longer.

Office of Fossil Energy and Carbon Management (2023) Carbon Negative Shot

14.2.1 GMO - enhanced photosynthesis

Corbyn

Carbon-guzzling trees and crops, genetically altered to boost photosynthesis and store carbon in the roots, could absorb millions of tonnes of CO2 from the atmosphere

There are projects under way around the world to genetically engineer plants – namely crops – for traits such as bigger yields, disease resistance or drought or heat tolerance. But efforts to engineer them to do better at drawing CO2 out of the atmosphere to fight the climate crisis directly are newer.

Living Carbon, founded in 2019 and which has received $36m in venture capital funding to date, is in the vanguard of establishing the technology in trees. Meanwhile, a handful of others, including two world-leading California-based scientific institutions, are tackling how it might be done in agricultural crops. Both the Salk Institute for Biological Studies in San Diego and the Innovative Genomics Institute (IGI) in Berkeley, a joint venture between the University of California, Berkeley and UC, San Francisco, have received large amounts of philanthropic funding.

The possible impact of this approach on global CO2 emissions is difficult to quantify – it depends on how significant the gains could be, and how widely it's deployed. But its proponents are bullish that if scaled up it could make a significant contribution and buy the world some time.

It is by increasing the efficiency of photosynthesis – the process by which plants use light, water and CO2 to make sugars that fuel plant growth (with oxygen as the byproduct) – that Living Carbon's trees are able to capture more CO2 than they naturally would.

In a scientific paper published this April, the company reports that in a four-month-long greenhouse trial its modified poplars increased in biomass by 35-53% over its controls, equivalent to removing 17-27% more CO2 from the air.

It has been found, for example, that trees now growing in warmer conditions because of climate change grow faster because they suck up more CO2 anyway – though the trade-off is that they might die sooner.

Corbyn (2023) Could superpowered plants be the heroes of the climate crisis?

14.2.2 Carbon Casting (Graphyte)

Osaka

Now, a start-up says it has discovered a deceptively simple way to take CO2 from the atmosphere and store it for thousands of years. It involves making bricks out of smushed pieces of plants. And it could be a game changer for the growing industry working to pull carbon from the air.

Graphyte, a new company incubated by Bill Gates's investment group Breakthrough Energy Ventures, announced Monday that it has created a method for turning bits of wood chips and rice hulls into low-cost, dehydrated chunks of plant matter. Those blocks of carbon-laden plant matter — which look a bit like shoe-box sized Lego blocks — can then be buried deep underground for hundreds of years.

The approach, the company claims, could store CO2 for around $100 a ton, a number long considered a milestone for affordably removing carbon dioxide from the air.

Graphyte's approach uses the power of plants and trees to photosynthesize and pull carbon dioxide from the air. While trees and plants are excellent at carbon capture, they don't store that carbon for very long — when a plant burns or decays, its stored carbon comes spilling back out into the air and soil.

Graphyte plans to avoid that decomposition by taking plant waste from timber harvesters and farmers and drying it thoroughly, removing all the microbes that could cause it to decompose and release greenhouse gases. Then, in a process that they call "carbon casting," it will compress the waste and wrap it into Lego-like bricks, for easier storage about 10 feet underground. The company says that with the right monitoring systems, the blocks can stay there for a thousand years.

Graphyte is planning to build its first project in Pine Bluff, Ark., and the company hopes to sequester its first carbon for a customer in 2024.

Osaka (2023) The Lego-like way to get CO2 out of the atmosphere

14.2.3 DAC -Direct Air Capture

> If direct air removal costs $500 per tonne, removing just US emissions would cost ~$3 trillion annually (that's ~4x US military spending). It would also require twice the total power generation capacity of the US today (and it has to be carbon-free). Ho toot

House

Separating carbon dioxide from air, while technically straightforward, is outrageously expensive.

House (2023) Direct air capture: An expensive, dangerous distraction from real climate solutions

Room

DACCS - a costly distraction

DACCS systems generally use enormous fans to push large volumes of air over either a liquid solvent or solid sorbent that absorbs CO2. Then a large amount of energy is needed to release the CO2 and regenerate the sorbents. The overall efficiency of this process is very low (5% to 10%) and the price very high because CO2 in the air is so diluted—it's 300 times more diffuse than the CO2 in a coal plant's flue gas, and the entire Houston Astrodome contains only about 1 ton of CO2.

Per ton of CO2 captured and stored, current DACCS costs range from several hundreds of dollars to $1000 or more. A 2018 "techno-economic assessment" of DAC concluded, "CO2 separation from air is unable to economically compete with CCS."

At more than 50 times the cost per metric ton of most natural climate solutions, long-term solutions [like DACCS] today are both limited in availability and practically cost prohibitive. These prices for carbon removal assume DACCS is powered entirely by carbon-free power such as solar and wind. Powering DACCS system by natural gas, increases costs for the negative emissions by 250%.

DAC is an expensive and inefficient way to use vast amounts of renewables (or nuclear power). That carbon-free power could have been used to directly replace the CO2 emissions from fossil fuel plants and cars cheaply and efficiently.

Only when the region's electricity system is nearly completely decarbonized, do the opportunity costs of dedicating a low- carbon electricity source to DAC disappear.

DACC is unfortunately an energetically and financially costly distraction in effective mitigation of climate changes at a meaningful scale.

The affordability, scalability, and wisdom of running DACCS on carbon–free power are likely to remain problematic for decades. Yet, tree planting also has limited scalability, and scaling up BECCS increases CO2 in the air for several decades.

Since CDR will very likely be a bit player for decades, "net zero" is a dangerous myth.

The idea we can overshoot a temperature target by mid-century and then turn global emissions massively negative to quickly cool back down is magical thinking.

(Reference contains usefull introduction to DACCS in the appendix):

Romm (2023) Why direct air carbon capture and storage (DACCS) is not scalable and 'net zero' is a dangerous myth (pdf)

Gallucci

The startup Heirloom says it's capturing CO2 from the sky and locking away the planet-warming gas, making it the first and only commercial U.S. plant to do so. On Thursday, the startup Heirloom unveiled its "direct air capture" facility in Tracy, California, which the company says has so far clocked nearly 1,000 hours of operations. Heirloom's technology uses limestone to absorb CO2 from the atmosphere. Through a novel process, the captured carbon is then injected into concrete, where it ostensibly stays trapped forever.

To be sure, Heirloom's plant is hardly capable of reversing the damage caused by decades of rampant fossil fuel consumption. The open-air warehouse, located some 70 miles east of San Francisco, can absorb a maximum of 1,000 metric tons of CO2 per year — less than 0.1 percent of the annual emissions from a single gas-fired power plant.

In 2017, the Swiss company Climeworks opened the world's first DAC facility near Zurich, which used large fans to suck air into containers and filter out CO2 molecules. Although that facility stopped operating last year, Climeworks now runs a 4,000-metric-ton plant in Iceland.

Heirloom's own process begins with an industrial kiln, which the company says is powered by renewable electricity from a local provider. Inside the kiln, limestone is heated to 1,650 degrees Fahrenheit, which breaks down the mineral into its constituent parts of calcium oxide and CO2. The same reaction occurs in cement-making, which is why cement is one of the world's top-emitting industries.

But instead of releasing CO2 like cement kilns do, Heirloom's kiln pumps the gas into a storage tank. The remaining calcium oxide is then spread onto hundreds of flat silver trays that are stacked vertically on 40-foot-tall racks, resembling a bakery of comically large proportions. The racks are exposed to open air for several days, during which time the white powder soaks up CO2 from the air like a sponge. Once saturated, the material heads back into the kiln, and the process starts again.

According to Heirloom, the captured CO2 gas could eventually be permanently stored "safely underground." For now, however, the company is working with the startup CarbonCure to turn the CO2 into a dry-ice-like material and mix it with concrete, where the CO2 mineralizes and gets trapped.

By some estimates, DAC currently costs around $600 to $1,000 per metric ton of CO2.

Direct air capture allows polluting industries to live on, when we should be focusing on a just transition to renewables.

Gallucci (2023) America's first commercial direct air capture plant just got going

14.2.4 ERW - Enhanced Rock Weathering

Ho

Enhanced rock weathering (#ERW) seems like a promising way to remove CO from the atmosphere. However, this paper says that to remove 1 billion tonne of CO per year requires land area larger than the entire United States.

Ho (2023) Mastodon

Linke Abstract

The ability of engineered enhanced rock weathering to impact atmospheric CO2 has been challenging to demonstrate due to the many processes occurring in soils and the short time span of current projects. Here we report the carbon balance in an Icelandic Histic/Gleyic Andosol that has received large quantities of basaltic dust over 3,300 years, providing opportunity to quantify the rates and long-term consequences of enhanced rock weathering. The added basaltic dust has dissolved continuously since its deposition. The alkalinity of the soil waters is more than 10-times higher than in equivalent basalt-dust-free soils. After accounting for oxidation and degassing when the soil waters are exposed to the atmosphere, the annual CO2 drawdown due to alkalinity generation is 0.17 tC ha-1 yr-1. This study validates the ability of fine grained mafic mineral addition to soils to attenuate increasing atmospheric CO2 by alkalinity export. Induced changes in soil organic carbon storage, however, likely dominate the net CO2 drawdown of enhanced weathering efforts.

Linke Conclusions

The results of this study confirm the ability of the addition of fine-grained basaltic rock to soils to enhance CO_2 drawdown directly from the atmosphere due to alkalinity production. In total it is estimated that 17 ± 3.6 g C m− 2 yr− 1 is currently drawn down and added to rivers by alkalinity production from our South Iceland field site. The enhanced alkalinity production of our soils was produced by the addition of approximately 1.7–2.6 t m− 2 of basaltic dust to this soil over 3,300 years. Upscaling of this process to address even a small fraction of the mass of anthropogenic CO_2 emissions to the atmosphere, however, may be challenging for two reasons: 1) this enhanced weathering process is slow and would require more land than what is available for a sizeable drawdown of anthropogenic CO_2 through alkalinity production and 2) the here to date unquantified effect of adding basalt powder to soils on soil organic matter. So, although this study serves as a proof of concept of the potential of enhanced weathering efforts to contribute to attenuating atmospheric CO_2 concentrations, the degree to which this approach will prove successful at a larger scale remains unclear.

Linke (2023) Direct evidence of CO_2 drawdown through enhanced weathering in soils

14.2.5 Marine CDR

Doney

A variety of ways to capture and store CO_2 from the ocean have been suggested. For example, marine CDR may include altering the chemical composition of sea water so that the ocean absorbs more CO_2 from the atmosphere; using electrochemical techniques to remove dissolved CO_2 from seawater and then storing that CO_2 underground; or adding nutrients such as iron to areas of the ocean to encourage the growth of microscopic plankton that can sink to the seafloor and be stored for centuries or longer.

Doney (2023) Marine Carbon Dioxide Removal: Potential Ways to Harness the Ocean to Mitigate Climate Change

14.2.6 Blue Carbon

Johannesen

Blue carbon will not solve climate change. The effect is too small; existing sediment carbon stock is a liability; and there is a timescale mismatch between ancient fossil fuel emissions and uptake by vegetation. Clearer communication would support informed decision-making.

The protection or expansion of blue carbon ecosystems can only make a very limited contribution to solving the problem of excess atmospheric CO_2. In this Comment, we address three issues that relate to this point: (1) the magnitude of the effect, (2) the security of the existing sediment carbon stock, and (3) the mismatch in timescales. Despite these limitations, blue carbon ecosystems are important ecologically and can play a role in short-term carbon sequestration.

The global rate of blue carbon burial in seagrass meadow sediment has been greatly overestimated as a result of systematic methodological problems. Briefly, most global estimates neglect the effects of sediment mixing (wave mixing or bioturbation), which overestimates sedimentation rates; neglect remineralization of organic carbon in surface sediment, which overestimates carbon burial rates; include terrigenous organic carbon, much of which would have been buried even in the absence of the seagrass meadow; and extrapolate from a few sites with tropical species that have extensive, carbon-rich root mattes to the whole global extent of seagrass habitat

Also, many estimates of organic carbon accretion do not consider the effect of CaCO3 formation, which releases carbon to the atmosphere and negates a variable fraction of the drawdown associated with organic carbon burial5 or the release of CH4 or N2O from seagrass meadows and salt marshes.

Even the most optimistic estimates suggest that full restoration of mangrove, salt marsh and seagrass ecosystems would only provide an ongoing sink equivalent to 3% of current global anthropogenic emissions. Full restoration is unlikely, and the 3% estimate relies on carbon burial rates that are almost certainly too high.

Existing sediment carbon stock is a liability, not an asset

Blue carbon stock refers to the inventory of organic carbon stored over a defined depth (often 1 m) in the sediment of vegetated coastal ecosystems. Most blue carbon papers quantify sediment carbon stock, rather than ongoing burial rates.

The existing stock is buried in sediment but no longer draws down any more carbon dioxide from the atmosphere. In fact, existing sediment carbon stock represents a potential liability, i.e., an insecure reservoir of carbon that could be released into the atmosphere in the future. This is an important factor that has been largely overlooked in the public discussion of offsetting schemes.

When a seagrass meadow dies or a forest burns, some of the stored carbon is re-released into the atmosphere8. Existing stocks are increasingly threatened as a result of climate change, both by sea-level rise and by episodic marine heatwaves. The magnitude of the re-release of carbon as a result of these processes is unknown, but integrated over a long enough time, it could easily become as large as or larger than ongoing burial. Accretion is gradual and incremental, while release is episodic and highly variable.

Timescale mismatch

Even if we exclude the possibility of avoided emissions offsets, a fundamental problem with the idea of blue carbon offsets for fossil fuel emissions is the orders of magnitude difference in timescales. The modern carbon cycle acts on timescales of days to about a century, or up to a few thousand years in the case of equilibration with the deep ocean Carbon exchanges readily among the atmosphere, surface ocean, vegetation and surface sediment: the expansion of a seagrass meadow moves some carbon from the atmosphere into vegetation and surface sediment; a forest fire releases carbon from the trees back into the atmosphere. These processes only represent exchange among the compartments of the active, modern carbon system, and not a true removal from the system.

By contrast, fossil fuels have been isolated from the active carbon cycle for hundreds of millions of years. Burning fossil fuels adds ancient carbon into the modern carbon cycle, increasing the total amount to be distributed among the atmosphere, vegetation, etc. The timescale for the removal of the excess carbon dioxide by natural processes is tens of thousands to hundreds of thousands of years for silicate rock weathering and hundreds of millions of years for the reformation of fossil fuels. Moving carbon from one short-term reservoir to another does not remove it from the actively cycling modern system.

Important role of blue carbon ecosystems

Blue carbon ecosystems do serve important functions. They provide critical habitat for juvenile fish and other marine species; they protect shorelines from erosion; they provide food security for coastal communities; and they protect existing stocks of organic carbon.

Johannesen (2023) Why blue carbon cannot truly offset fossil fuel emissions

14.2.7 Ocean Geoengineering

Mehta

- Carbon dioxide makes seawater more acidic while warmer seas bleach corals and absorb less CO2
- Nascent technologies aim to remove CO2 by tapping into the ocean's natural carbon cycles
- Ocean alkalinity enhancement decreases acidity encouraging absorption of more CO2
- Estimates suggest the technology could reach 2 gigatons of removals across the world's coastlines
- Other systems use membranes to filter CO2 from seawater and convert it for capture and storage

Carbon dioxide makes seawater more acidic, so it's harder for sea creatures to grow shells, while the heat bleaches corals and destroys breeding grounds for fish and marine mammals. Warmer waters also absorb less CO2.

Finding ways to increase the carbon sink at the depths of the ocean, where it can be stored for millennia, and to extract carbon dioxide from surface water offer opportunities to remove CO2 at scale.

Summary

- Carbon dioxide makes seawater more acidic while warmer seas bleach corals and absorb less CO2
- Nascent technologies aim to remove CO2 by tapping into the ocean's natural carbon cycles
- Ocean alkalinity enhancement decreases acidity encouraging absorption of more CO2 Estimates suggest the technology could reach 2 gigatons of removals across the world's coastlines
- Other systems use membranes to filter CO2 from seawater and convert it for capture and storage

Much of our planet is covered by oceans, which protect us from the worst ravages of global heating. Water and air are constantly exchanging carbon dioxide, and the seas around us have absorbed about a third of the CO2 we've pumped into the air, as well as the bulk of the warming it has caused. This has come at a huge cost to marine ecosystems. Carbon dioxide makes seawater more acidic, so it's harder for sea creatures to grow shells, while the heat bleaches corals and destroys breeding grounds for fish and marine mammals. Warmer waters also absorb less CO2. Over a year. 02:00 02:28

Now a clutch of startups are trying to open up new avenues to remove even more carbon dioxide from our atmosphere by tapping into the ocean's natural carbon cycles.

Proponents say finding ways to increase the carbon sink at the depths of the ocean, where it can be stored for millennia, and to extract carbon dioxide from surface water offer opportunities to remove CO2 at the scale required to meet the goals of the Paris Agreement. While the chemistry and modelling may stack up, these are nascent technologies. How can we be sure they'll work in practice and won't ultimately cause even more damage to the delicate ecosystems on which we rely?

Some startups want to speed up the natural process by which biomass from land reaches the depths of the ocean. Israel-based Rewind plans to transport forest and agriculture residues to the bottom of the Black Sea. This is an ideal environment, the company says, because it lacks oxygen, so the residues will decompose only very slowly.

U.S. startup Running Tide is designing "carbon buoys", combinations of biomass and alkaline minerals which could help reduce the acidity of ocean surface waters or provide a growth medium for macroalgae. Later these would be sunk to take carbon to the bottom of the ocean.

Another pathway is to speed up the natural weathering of rock that washes carbonate and bicarbonate minerals into the sea through adding alkaline minerals.

So called ocean alkalinity enhancement decreases acidity, so encouraging the absorption of more CO2 from the atmosphere.

David Keller, a scientist at the GEOMAR Helmholtz Centre for Ocean Research in Germany, is coordinating a pan-European project to assess the feasibility of using the ocean to stabilise the climate. Experiments where an alkaline mineral is added to closed tanks floating out at sea suggest it's safe to do field trials of ocean alkalinity enhancement. There are upper limits because too much alkalinity can cause the release of CO2.

By volume, the ocean holds 150 times more CO2 than the atmosphere, requiring less water to be processed for the same impact. But water is heavier so takes more energy to move. Co-locating Captura's systems with desalination plants or harnessing ocean currents could cut energy needs. Energy consumption will be about 20-25% of DAC systems today.

Technology developed at UCLA is being exploited by spin-out, Equatic, to both produce clean hydrogen and capture CO2 from air and seawater. In its process, electrolysis of seawater produces hydrogen and creates an alkaline and acid stream of water. In the alkaline stream, the dissolved carbon dioxide forms solid calcium carbonate which can be stored, used to make cement or put back into the sea, where it's already prevalent. Bubbling air through this (now CO2 depleted) seawater captures more CO2, which gets locked up for thousands of years as a bicarbonate. On the other side of the equation, the addition of olivine (one of the most common minerals on the planet) neutralises the acidic seawater. In turn it too should take up more CO2 from the atmosphere, when returned to the sea.

Ebb Carbon's solution would take the water flowing out of a desalination plant or cooling water from a power plant and put it through a series of membranes to remove acidity, in the form of hydrochloric acid. The less acidic water that goes back into the sea will draw down atmospheric CO2, to be converted to bicarbonate ions and held in that form for thousands of years. There's enough existing desalination and power-plant infrastructure to reach the two gigaton scale soon.

For now, the challenge is accurately measuring and verifying how much CO2 is being locked away, and that's where Ebb's emphasis is. "There's a lot of rigour, a lot of science behind the detailed measurements and modelling that enable us to say, with a high degree of certainty, how much CO2 is pulled out of the air," says Tarbell. That monitoring, reporting and verification is going to be critical to provide faith in the removals companies hope to claim. Nor is it cheap, suggests GEOMAR's Keller. There are no standard approaches to do this.

As the entrepreneurs press on with modelling and experiments, they argue there's no choice but to recruit the ocean's natural systems if we're to limit further warming. Our carbon emissions are already destroying the marine biodiversity upon which we depend, so we have to try everything to prevent things getting far worse.

Mehta (2023) Should we be geo-engineering the oceans?

14.2.8 CDR Controversies

Anderson

> Who is responsible for cleaning up CO2 from the atmosphere?

Various methods of carbon dioxide removal (CDR) are being pursued in response to the climate crisis, but they are mostly not proven at scale. Climate experts are divided over whether CDR is a necessary requirement or a dangerous distraction from limiting emissions. In this Viewpoint, six experts offer their views on the CDR debate.

CDR started appearing in mainstream emission scenarios in the late 2000s and has become a dominant element of most mitigation scenarios consistent with the Paris Agreement's temperature goals. Initially, CDR was dependent on the assumed success of CCS applied to bioenergy (termed BECCS). Although there was much promise for CCS in the 2000s, including an IPCC Special Report in 2005, the technology has not yet lived up to its hope, despite lofty policy ambitions5. CCS and most CDR methods are a complex set of technologies that have proved difficult to deploy at scale in real-world contexts. The repeated failure of CCS and CDR to deliver as promised has led many to question their feasibility, particularly at scale.

CDR terminology can be confusing as it combines two very different methods: restoring natural carbon sinks, such as forests, soils or oceans, and investing in unproven technologies, like BECCS, DACCS or enhanced weathering.

CDR has long been identified as a potential 'dangerous distraction' owing to its widespread deployment in emission scenarios but not in reality.

Given that the entire mitigation agenda is predicated on CDR working at scale, and if CDR does not work at the scale intended, then the world will go more rapidly into carbon debt and be locked into a higher-temperature pathway. A more risk-averse approach that uses only a modest scale of CDR would require greater near-term emission reductions that avoid going into carbon debt.

Enormous volumes of CDR are built into implausible mitigation scenarios for the second half of the century, generating a false sense of optimism that we can still meet ambitious temperature goals, even though global emissions are still not declining.

CDR in scenarios are effectively masking insufficient political action.

The main (IAM) modelling groups might work quite objectively, but they do so within deeply subjective political boundaries. Their low carbon futures are locked into tech-dominated versions of the present with no changes to core political elements or values of society in relation to fairness, or distribution of resources or power.

Tight political criteria, combined with very small carbon budgets, force all mitigation scenarios assessed by the IPCC to include increasingly extreme levels of CDR.

Restoration of natural carbon sinks should certainly not be used to justify any additional industrial or fossil fuel emissions. Speculative and largely unavailable CDR technologies are very different because they would require setting up entirely new industrial infrastructures at a large scale.

There is already about 2 billion tonnes of CDR occurring on land.

Big polluters and fossil fuel companies are promoting technological CDR as a cover-up for expanding their business.

The IPCC's Working Group III report highlights the dangers of overreliance of governments on these unproven technologies. Unfortunately, these warnings are downplayed in the heavily negotiated IPCC Summary for Policymakers. They are buried under an array of models and pathways that rely on precisely such technologies, that project continued use of fossil fuels for decades and that overwhelmingly assume that the world will go beyond 1.5 °C for decades or longer — with surprisingly little attention paid to the human and environmental consequences such assumptions entail.

The major IAM modelling groups have inadvertently done the bidding of both Big Oil and those deeply wedded to the obscene asymmetry in responsibility for emissions. Since the early 2000s, these models have increasingly normalized many hundreds of billions of tonnes of CDR as a means of maintaining the political status quo and seriously delaying the need to phase out fossil fuels.

0.3 trillion tonnes of CO2 since the Paris Agreement in 2015.

An alliance has arisen between failed (and failing) political leadership and complicit IAM modelling of the community's escalating dependence on CDR to reconcile the irreconcilable of delivering on the Paris Agreement 1.5 °C to 2 °C commitments without rocking the political boat.

As the climate is heating up, extreme weather events are becoming more frequent and we are approaching various tipping points; we risk losing the sink capacity of various ecosystems.

Industrial-scale 'carbon farming' to produce carbon credits is a false and dangerous promise.

It is not possible to say which CDR methods are most promising because, so far, all have failed to deploy at any meaningful scale.

It is possible to postulate theoretical pros and cons of each CDR method, but without sufficient deployment, they remain theoretical. Even afforestation and reforestation have limits, not only in terms of land competition but also in resilience to a changing climate and verifying how much carbon dioxide is removed over extended periods.

BECCS has little to no worthwhile potential, for multiple reasons. DACCS and some carefully applied nature-based solutions could have a useful role in GHG mitigation but should in no way be assumed to compensate for any fossil fuel emissions.

Important to keep a strong focus on CDR methods with characteristic timescales of storage beyond 100 years, like biochar, enhanced mineral weathering or DACCS.

CDR methods range widely regarding their climate mitigation potential, technology readiness level (TRL) and expected price range. Conventional CDR methods like afforestation, reforestation, soil carbon sequestration and peatland restoration have the highest TRL levels but do not offer long-term durability for CO2 storage. DACCS, BECCS and biochar are much more novel methods that offer strong mitigation potential and high durability and are not too far behind in terms of TRL.

The main problem is that international policymakers are implicitly relying on remarkably high volumes of CDR to help fix trajectories that already indicate a 1.5 °C overshoot, without necessarily knowing much about CDR or taking responsibility for the expected overshoot

Incorporating CDR in global scenarios is not slowing down emission reduction efforts, but it is hiding the impact of increasing global emissions and sparing climate policymakers the embarrassment of admitting that always staying under 1.5 °C is no longer achievable. But with the advent of national net-zero emission targets, the level of political scrutiny becomes higher, and it is easier to keep expectations about future national CDR levels in check.

Once governments start splitting their net-zero emission targets into emission reductions and carbon removal components, we can expect healthy national debates on the assumed trajectories, not only regarding CDR but also regarding the types and volumes of residual emissions.

Scaling up CDR could delay reducing emissions. Policymakers can address this risk by establishing separate climate targets for emission reductions and CDR.

We should cut emissions from our energy system assuming CDR will not work at scale.

Scaling these novel CDR technologies will require dedicated innovation policies.

Durability of different CDR methods are ranging from a few decades to thousands of years.It is crucial to guarantee that any residual emissions of fossil carbon are balanced by storage on the same millennial timescale

Setting up biochar production is relatively fast, hence, the reason biochar carbon removal has become the leading novel CDR method to deliver tonnes of carbon removed today. Building DACCS and BECCS plants is a longer and more complex undertaking that takes several years. Therefore, very different policy mixes and sequences must emerge to scale the vast ecosystem of CDR methods.

For direct air capture, low-carbon energy and cost are the main limitations. For biomass with carbon removal and storage, biomass and land are limitations. Other techniques face limitations in terms of land or in terms of robust schemes for monitoring and verification. The most relevant limitations will probably be social rather than technological.

There is the naive assumption that a few pilot schemes with chequered technical histories can unproblematically be rolled out at a planetary scale.

Global rates of CCS deployment are far below those in modelled pathways.

Anderson (2023) Controversies of carbon dioxide removal

14.2.9 BECCS

Anderson

Biomass carbon removal and storage involves using biomass (such as algae, municipal waste, agricultural or forest residues) to remove CO2 from the atmosphere and store it underground or in products. It looks promising in many areas but is very context-dependent. There are a number of methods that deserve more research, including ocean alkalinity enhancement, enhanced rock weathering and agrigenomic ideas such as engineering plants for enhanced carbon sequestration or microbe-based carbon capture soil amendments. It is early to assess the scalability of all these approaches, and much of the scalability depends on culture and policy. The IPCC assesses that moderate-to-large future mitigation potentials are estimated for direct air carbon capture and sequestration, enhanced weathering and ocean-based CDR methods, with medium evidence and medium agreement.

As an engineer with a background in design and construction in the petrochemical industry, I feel a streak of professional shame when, in 2023, the pinnacle of engineering prowess is burning plants and burying the carbon (termed BECCS).

There are many reasons for this shame, but key amongst these is the very low energy density of plants. Add this to the inefficiencies in thermal electricity generation and nation-sized areas of land needed to be put aside to deliver the volumes of BECCS assumed in the IAM models. Yet, with very few exceptions, it is such an unsustainable and yesteryear approach to current problems that the IAM modelling groups evoke on a huge planetary scale. So, for me, and on so many levels, BECCS is a blunder of monumental proportions and illustrates just how low we are prepared to stoop to get the carbon molecules to add up in models.

Anderson (2023) Controversies of carbon dioxide removal

14.2.10 DACCS

Anderson

DACCS typically relies on renewable energy to flow air over a catalyst, where the CO2 is captured before being stripped from the catalyst and subsequently stored. Despite its engineering appeal, it is still a fledgling technology and with very little scope to deliver real carbon reductions within the tight 1.5 °C–2 °C timelines. Moreover, as it stands today, in almost all nations, electricity, the key power source for DACCS, is under 20% of 'final energy consumption', and only a relatively small fraction of that is from low carbon generation. A triage approach to how we use what low-carbon energy supply we have would very likely see DACCS a long way down the priority order.

Anderson (2023) Controversies of carbon dioxide removal

14.2.11 Planting Trees

Anderson

The carbon budgets provided by the IPCC already rely on a massive shift away from deforestation and a programme of forestry management, reforestation and some afforestation. So caution needs to be applied to ensure these options are not double counted.

Trees are not a secure carbon sink, as situations such as fire, land use practices, fuel shortages or pest movements can release the carbon back into the atmosphere. Finally, whilst there is immediate popular appeal to planting trees as a store of carbon, in practice, trees need to be considered as part of a rich ecosystem, including their impact on soil carbon cycling.

Anderson (2023) Controversies of carbon dioxide removal

14.3 Cement

Lobet

> "Our dream is to decarbonize cement, and we want to do it as fast as possible"

The chemical reaction at the heart of today's cement-manufacturing process is a major reason why the production of this essential building material accounts for an estimated 7 percent of global carbon dioxide emissions from energy and industrial sources.

But a small group of tech entrepreneurs says they've found a better way. Cody Finke, co-founder and CEO of Brimstone Energy, is one of them.

Today, producers use limestone, a common rock, as the basis of cement. They mine it, grind it and then heat it up to temperatures roughly a quarter as hot as the surface of the sun. This drives carbon dioxide out of the rock and into the atmosphere.

Limestone is a form of calcium carbonate, a chemical compound with the formula $CaCO3$, made up of three main elements: calcium, carbon and oxygen. Extracting the calcium and oxygen needed for cement leaves behind the single carbon atom and two oxygen atoms — $CO2$. Fifty to 65 percent of the $CO2$ emissions from cement production result from the fact that the source rock is limestone, not from heating cement kilns to high temperatures.

Brimstone's alternative recipe swaps out this limestone for calcium silicate rocks, which are also very common. The silicates contain the same calcium oxide, commonly known as lime. But "there is…no $CO2$ in the rock,"

Using an alternative source rock also allows Brimstone to lower the kiln temperatures — another way the company can reduce $CO2$ emissions. Typical cement production requires temperatures of approximately 900 degrees Celsius for one key part of the process and 1,450 degrees Celsius for the other. Brimstone's process, in contrast, requires temperatures above 500ºC for only 20 percent of its heat energy.

Because of these lower temperature requirements, Brimstone can use electric kilns for most of its process instead of kilns fired by coal, petroleum coke or natural gas. For now, the company still expects to burn a fossil fuel for the hottest 20 percent of its process or use hydrogen if it's available. It's possible to electrify the entire process, Finke said; it's just uneconomical to do so today.

Lobet (2021) Changing up the recipe to make low-carbon cement

St. John

"There are a lot of novel technologies out there that work, and work fine. But they're not scalable, they're not commercially viable — and usually it's because the feedstock is not available in full volume, or not available where it's needed."
"There are a lot of novel technologies out there that work, and work fine. But they're not scalable, they're not commercially viable — and usually it's because the feedstock is not available in full volume, or not available where it's needed."

Cement and concrete production are responsible for 8 percent of human-caused carbon dioxide emissions worldwide, and novel SCMs like Terra's offer one path to reducing that massive carbon footprint. SCMs lower emissions from concrete production because they reduce reliance on Portland cement — by far the most common type of cement made today and also the driver of concrete's carbon impact. The production of Portland cement requires super-high temperatures that are achieved by burning fossil fuels, and the carbon-rich limestone used in its production also leaks $CO2$ into the air.

Major cement and concrete companies such as Cemex and Holcim already use millions of tons of SCMs today, mostly fly ash from coal plants and slag from steel mills, both to reduce their concrete's carbon footprint and to strengthen the material. But the same climate imperatives that are pushing the cement industry to cut its carbon emissions are also driving the closure of coal plants and steel blast furnaces, making these components less ubiquitous and more expensive to get.

Terra CO2's SCM, by contrast, is made from a variety of silicate rocks, including granite, basalt, alluvial sand and gravel, glacial flood gravel and clay-sand mixtures. Silica rock for the most part doesn't have any embodied CO2." That's in contrast to limestone, the primary ingredient of Portland cement, which "by weight is about 50 percent embodied CO2" — carbon that's released into the atmosphere when it's processed into clinker, the precursor to Portland cement.

Terra CO2 puts these rocks into a reactor that heats them to their melting point, yielding glassy powders that can replace 25 to 40 percent of the Portland cement needed for different mixes of concrete. The company estimates that every ton of cement replaced by Terra's SCM results in 70 percent lower carbon-dioxide emissions compared to pure Portland cement.

CarbonCure, a Canadian startup that injects carbon dioxide captured from other emitting sources into concrete, which both strengthens the concrete and stores the carbon, preventing it from entering the atmosphere. This practice can reduce the carbon footprint of concrete by roughly 5 to 15 percent, and it is relatively simple to integrate into how concrete is produced today.

Low-carbon SCMs tend to be the next step for cement-makers trying to cut their carbon emissions.

Fly ash is already supply-distressed now. By the end of the decade, it's going to go away. And blast furnace slag is going away as well.

Cement makers such as Heidelberg Materials and Hoffman Green Cement Technologies are pursuing one SCM option known as calcined clays. This material is widely available in Asia and Africa, but not as much in North America and Europe, making it less suitable for those markets.

Other approaches that promise a completely zero-carbon replacement for Portland cement are in a more experimental phase and would require retooling the cement industry to bring to scale. Some examples include startups such as Sublime Systems and Chement, which are developing electrochemical processes to replace the high-heat methods used to make cement. More esoteric concepts include using living organisms to "grow" cement.

St. John (2023) Terra CO2 says its Texas factory will cut carbon and cost from cement

St. John

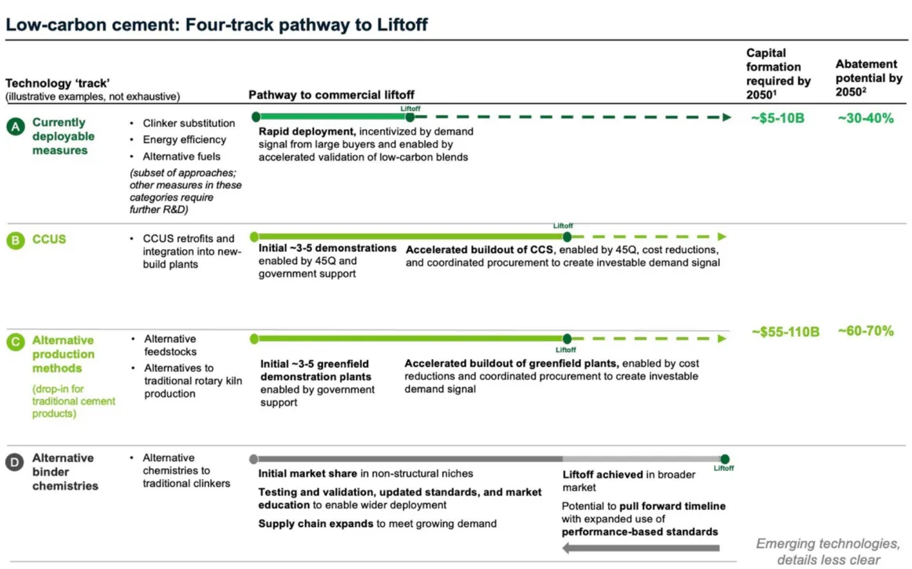
Holcim has managed to chip away at its emissions in recent years: Its 2022 annual report cited a 21 percent reduction in carbon emissions per unit of net sales from direct production and electricity consumption compared to the year before. The company has made progress largely because of a shift to lower-carbon cement and concrete products that reduce its use of clinker, the precursor material for cement, and by far the most emissions-intensive part of the industry. Crucially, costs have actually dropped along with emissions.

But not every solution to cement's climate problem will present companies with such a clear-cut economic calculus. And while the U.S. Department of Energy estimates that more than a third of the industry's emissions can be jettisoned using established technologies and processes like clinker substitution, the remainder of the solutions have yet to come into full focus.

Most uncertain of all is the pathway to eliminating what are called "process emissions," which account for the majority of cement's climate problem.

Process emissions are an unavoidable part of cement-making's status quo. The core input of ordinary Portland cement — the product that makes up the vast majority of cement made today — is limestone, a mineral that's about half calcium and half carbon and oxygen by chemical composition. When that limestone is converted to calcium oxide, the immediate precursor to clinker, the CO2 trapped inside the mineral is released into the atmosphere.

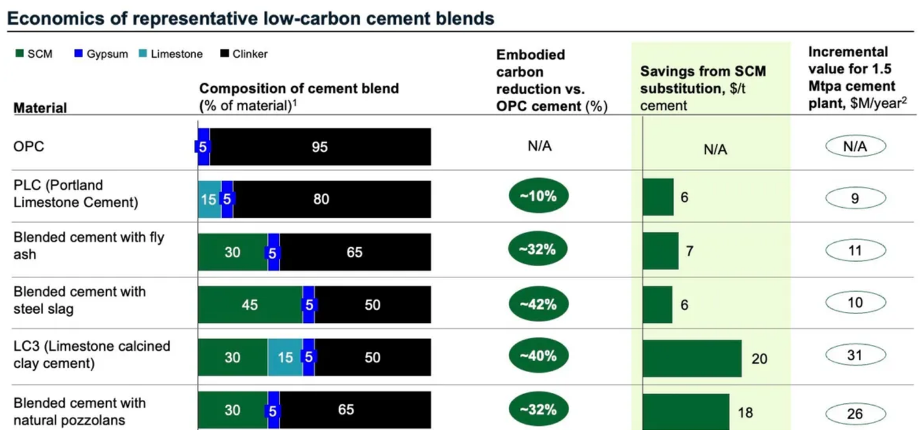
Eliminating these emissions means either finding novel, emissions-free ways to create ordinary Portland cement or a safe structural equivalent, or figuring out how to economically use carbon capture, utilization and sequestration (CCUS) technology to keep the CO2 generated from the manufacturing process from entering the atmosphere. Though plenty of startups, companies and researchers are hard at work on both methods, neither has, at this point, proven to be workable at the necessary scale.



The science and economics of cement substitution

The math is fairly simple on clinker substitution: The greater the amount of clinker that's substituted with another material, the lower the carbon footprint per ton of cement that results.

By far the most widely adopted substitute is "Portland limestone cement," which replaces up to 15 percent of clinker with ground-up limestone. Because that ground-up limestone hasn't been processed in a way that releases its embedded carbon dioxide, this variety of cement yields an average 8 percent reduction in emissions-intensity compared to ordinary Portland cement.



A long list of supplementary cementing materials that can displace clinker and make up 30 to 45 percent of a cement mix. By far the most commonly used today are fly ash from coal plants and slag from steel mills.

The key to deploying clinker substitution at scale and keeping the economics positive are moving toward what we call next-generation substitutes. One promising "next-gen" substitute is calcined clays, a form of naturally occurring minerals.

Other next-gen supplementary cementing materials (SCMs) involve commonly available calcium silicate rock such as basalt, gabbro and other minerals. Because these rocks contain no carbon, they can be processed without releasing CO2.

New cements, new processes — a steeper path to progress

Reducing clinker use and working lower-carbon SCMs into cement mixes can have a major impact now — but outright replacing or revamping the production of ordinary Portland cement is what the industry needs to eventually reckon with.

There are dozens of startups and university and government research projects working to come up with alternatives to ordinary Portland cement. Some are even engaged in pilot-scale demonstrations. But none have yet been embraced by the cement industry as a viable option for revamping a single integrated cement manufacturing plant.

The challenge is that the chemistry of cement and concrete — the mix of cement and rocks, gravel and other materials that harden into forms and slabs — is incredibly complex.

While Portland cement is well understood, “there are still fundamental debates among scientists” on the nature of the chemical reactions that yield better or worse forms of concrete from different types of cement for use in different applications.

Meanwhile, the industry has become more fragmented in recent years, moving from large centralized cement manufacturing to a more diverse lineup of smaller ready-mix and precast concrete operations that serve a multitude of end users. Each party in this chain relies on being able to secure consistent supplies and types of products for different needs, with an array of different standards that are difficult to alter to allow for new products to get to market.

The original patent for ordinary Portland cement was issued in 1824, giving the world nearly 200 years to understand its fundamental material properties.

Fortera’s alternative cement is based on technology first developed back in the 2000s to mimic the process that leads to growth in coral reefs, but it’s just one of many contenders. Others include geopolymer chemistries like Cemex’s Vertua low-carbon concrete, magnesium oxides derived from magnesium silicate chemistries developed more than a decade ago by now-defunct U.K.-based startup Novacem, and the belite-ye’elimite-ferrite clinker being developed by Holcim.

Some methods for reinventing cement aim to forgo the high-temperature kilns altogether in favor of electrochemical processes. Sublime Systems and Chement are developing ways to use electrolyzers, like those used to make hydrogen from electricity and water, to dissolve and then extract the precursor compounds that make up cement.

There’s only a relatively small fraction of the cement market that can be replaced by alternative cements — “maybe at most 25 percent of the cement market,” according to Cody Finke, CEO of Brimstone, whose company is making a product that’s structurally and chemically identical to Portland cement. “We want to decarbonize the whole cement industry.”

It’s a worthwhile approach, but one that also remains far from guaranteed. Brimstone, the only startup to win industry approval that its alternative process results in ordinary Portland cement.

St. John (2023) To decarbonize cement, the industry needs a full transformation

Gallucci (2023) 6 innovative startups that are kicking CO2 out of cement and concrete

14.4 Afforesting

Stevens

Afforesting grassy systems for carbon gain using flammable plantation trees could shift the fire regime from lower intensity grass-fuelled fires to high-intensity crown fires. Future changes in climate will worsen this. We highlight the fire risk of trees planted for carbon and costs of fire protection using African examples.

Tree planting projects in previously open ecosystems using non-native flammable species such as pines and eucalypts should not be allowed to begin, or continue, unless the projections for future plantation management, and especially fire protection, have been planned and suitable funding models developed. Without adequate funding, and the skills and technology to protect plantations far into the future, investment in tree planting has a high probability of going up in smoke while adding more carbon to the atmosphere as the trees burn.

Well-planned and executed commercial and state forestry programmes can contribute significantly to national economies. But afforestation of grassy ecosystems with highly flammable non-native plantation trees has long-term costs far exceeding initial planting costs. These costs and consequences of tree planting as 'Natural Climate Solutions' to global change need careful scrutiny by those committing their land to major land transformation. Targeting deforested and denuded formerly forest areas offers considerable scope for carbon sequestration and restoration with native species in parts of Africa and South America [14]. However to reduce the risk of inappropriate NBS, it also demands revision of the historical misclassification of African grassy ecosystems which has resulted in large-scale inappropriate 'forest' restoration.

Stevens (2023) A trillion trees: carbon capture or fuelling fires?

14.5 Geoengineering

Harvey

Climate Overshoot Commision Report

The Climate Overshoot Commission, a group of senior former diplomats, policy experts and scientists including Laurence Tubiana, the former French diplomat who was one of the main architects of the Paris agreement, focused on solar radiation management because that is one of the most controversial and dangerous ideas.

While regrowing trees is usually regarded as safe, putting mirrors in space to reflect sunlight or seeding clouds to reflect more rays into space could have huge impacts that would be hard to control, and would be impossible to confine within country borders. As well as the risks inherent to changing the climate in one place, there could be a "termination shock" – the concern that if emissions continued to pour into the atmosphere while geo engineering was used, stopping use of the technology would cause severe disruption to the climate as the underlying heating effect took hold again.

Harvey (2023) Experts call for global moratorium on efforts to geoengineer climate

14.6 Wildfire technology

> If wildfires were a country, they'd be ranked No. 4, behind China, the U.S. and India in terms of carbon emissions.

Wesoff

The growing urgency of this issue has given rise to a category of startups called "firetech," a technology ecosystem that aims to confront the threat of wildfires and restore the health of the world's forests.

For much of the twentieth century, U.S. fire-management strategy focused on total suppression rather than nature-aligned regenerative management. As a result, the country is home to a backlog of denser, fuel-heavy forests that are dangerously prone to catastrophic wildfires, especially in this warmer, drier era. Beneficial fire in the form of strategic controlled burns can reduce the amount of fuel sources available to a fire while preventing the growth of invasive species, which are often less fire-tolerant.

Prescribed burns not only decrease wildfire risk and bestow ecological benefits — they are also more cost-effective than other types of fuel management, such as manually or mechanically removing leaf litter and downed woody material.

Although prescribed burns have been used for thousands of years, a new crop of startups claim they are improving on the techniques used to plan, carry out and control managed fires.

Nebraska-based Drone Amplified aims to replace the human-piloted helicopters that are now used for aerial ignition by using drones to drop golf-ball-sized incendiary spheres to set off prescribed burns. The drones are also equipped with surveillance equipment to monitor the fires as they run their course or to detect naturally occurring and other types of fires.

Vegetation-management startups are attacking the problem of tree-thinning and fuel removal with innovations in sensors, software and carbon sequestration.

Delos develops wildfire risk models for insurers and underwriters, and ClimUp provides actionable risk and mitigation data — providing insights at the structure level for almost any property. Finally, Kettle is modeling fire risk to optimize its role as an underwriter for insurers.

Wesoff (2023) A new wave of startups is tackling a huge emissions source: wildfires

14.7 Floating farms of solar fuel leaves

McKie

Automated floating factories that manufacture green versions of petrol or diesel could soon be in operation thanks to pioneering work at the University of Cambridge. The revolutionary system would produce a net-zero fuel that would burn without creating fossil-derived emissions of carbon dioxide, say researchers.

The Cambridge project is based on a floating artificial leaf which has been developed at the university and which can turn sunlight, water and carbon dioxide into synthetic fuel. The group believe these thin, flexible devices could one day be exploited on a industrial scale.

Carpets of artificial leaves that would float on lakes and river estuaries, and use sunlight to convert water and carbon dioxide into the components of petrol and other fuels. "The crucial point is that we are not decarbonising the economy through techniques like these," Reisner said. "Carbon is still a key component. What we are doing is to 'defossilise' the economy. We will no longer be burning ancient sources of carbon – coal, oil and gas – and adding greenhouse gases to the atmosphere, a process that is doing so much damage at present."

The artificial leaf created at Cambridge takes its inspiration from plants, which use photosynthesis to create food. An early prototype consisted of chemical light absorbers and catalysts that turned carbon dioxide and water into a mixture of carbon monoxide and hydrogen. This combination is known industrially as syngas and it is an intermediary in the production of many chemicals and fuels.

Floated on water, the artificial leaf produces hydrogen and carbon monoxide.

McKie (2023) Floating factories of artificial leaves could make green fuel for jets and ships

14.8 Deep-sea mining

Chung

As the world's hunger for metals and minerals to go green increasingly clashes with the realities of the mining process, the deep sea has become the latest focal point. Ultimately, manufacturers aim to create a circular "closed-loop" system, where old electronics are recycled and their metals are used to build new products.

But reaching that goal is expected to take decades. Debate about whether sensitive ecosystems on land should be dug up have empowered deep-sea mining advocates. Some companies competing with The Metals Co believe that the robotic vacuum is the problem, and are offering potential solutions.

The startup Impossible Metals has developed a robotic device with a large claw that collects nodules as the claw glides along the seafloor. Using artificial intelligence, the robot's claw is able to distinguish between nodules and aquatic life, the company says.

"From day one, we are focused on preserving the ecosystem," said Jason Gillham, the CEO of Impossible Metals. However, while the Impossible Metals robot is battery-powered, its energy comes from a diesel generator on a ship at the ocean's surface, fueling charges that the company's methods are not fully green.

A Japanese company plans to start mining next year in territorial waters controlled by Tokyo. Chinese officials have acknowledged they lag behind other nations in the deep-sea race, but are vowing to vigorously compete in this "new frontier for international competition." China is already exploring a massive part of the Pacific seabed west of Hawaii - an area that dwarfs the CCZ. Norway, already a prolific offshore oil producer, is on track to be the first country to allow deep-sea mining if its parliament approves, as expected, plans to mine hydrothermal vents.

For now, the ISA's members are hotly debating the best standards for deep-sea mining.

"Nothing we do will have zero impact," said Joe Carr, a mining engineer with the metals consultancy Axora. "We're going to need mining for the green energy transition."

Chung (2023) The promise and risks of deep-sea mining (scroll-graphics)

Tooze

Norway has secured a parliamentary majority for its plans to open up for deep-sea mining despite opposition from environmentalists and the fishing industry, who warn that the move risks further damage to fragile oceans. The country's minority centre-left government on Tuesday said it had won the support of the two main opposition centre-right parties for deep-sea mining exploration but that there would be tough environmental criteria to proceed with any extraction. "The renewable green industries run on minerals. This is an important contribution internationally," said Bård Ludvig Thorheim, an MP from the main opposition Conservatives. But the decision by Norway, western Europe's largest petroleum producer, drew fierce criticism from environmentalists as the Nordic country aims to become the first in the world to conduct deep-sea mining on a commercial scale.

Oslo's plans could also generate geopolitical tensions. The area it proposes to open up to exploration, in the Barents Sea and Greenland Sea, is close to Svalbard, the Norwegian archipelago in the Arctic. Norway believes it has exclusive mining rights off the Arctic islands, a position disputed by Russia, the EU and UK.

Tooze (2023) Not so green Norway

14.9 Biochar

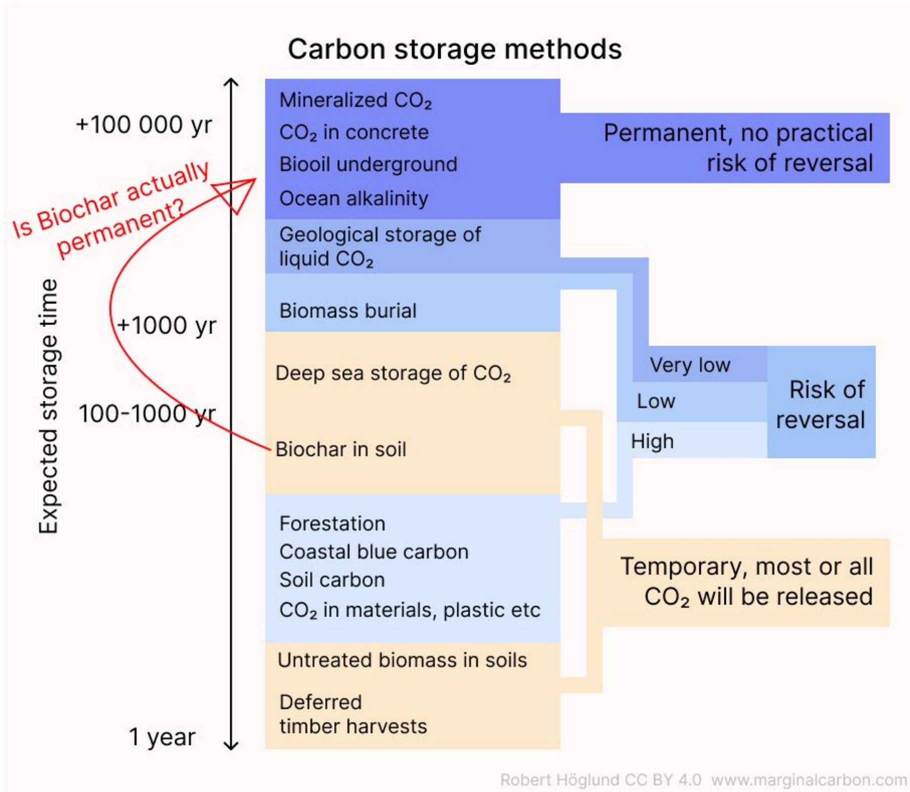
Höglund

Looks like I may need to redraw this graph. A new peer-reviewed paper points to biochar being permanent carbon storage with just a small part decomposing.

Previous meta-studies have estimated that around 20% of the carbon in biochar is lost after 100 years and half after 500 years. It is challenging to prove empirically since the decay you see in the first years may be just the volatile parts being lost, it does not necessarily say anything about the fate of the bulk of the char. The new paper uses a novel method to test the stability and proposes a new test to determine permanence, "Random reflectance" (Ro). It finds that most biochar is actually "inertinite", stable for millions of years.

The transformation of biomass to inertinite is one of the two main natural pathways exerted by Earth to permanently store organic carbon, mineralization being the other.

The paradigm shift has started, but I would be curious to hear what other biochar researchers have to say.



Höglund (2023) X post

Sanei Abstract

The natural removal of carbon dioxide and its permanent storage by the Earth system occurs through (i) inorganic carbon and (ii) organic carbon pathways. The former involves the "mineralization" of carbon and formation of carbonate minerals, whereas the latter employs the "maceralization" or natural carbonization of biomass into the "inertinite maceral". The production of biochar is a carbon dioxide removal (CDR) method that imitates the geological organic carbon pathway, using controlled pyrolysis to rapidly carbonize and transform biomass into inertinite maceral for permanent storage. Therefore, the main challenge in assessing biochar's permanence is to ensure complete transformation has been achieved.

Inertinite is the most stable maceral in the Earth's crust and is hence considered an ultimate benchmark of organic carbon permanence in the environment. Therefore, this study aims to measure the degree of biochar's carbonization with respect to the well-established compositional and microscopic characteristics of the inertinite. The random reflectance (Ro) of 2% is proposed as the "inertinite benchmark" (IBRo2%) and applied to quantify the permanent pool of carbon in a biochar using the Ro frequency distribution histogram. The result shows that 76% of the studied commercial biochar samples have their entire Ro distribution range well above IBRo2% and are considered pure inertinite biochar. The oxidation kinetic reaction model for a typical inertinite biochar indicates a time frame of approximately 100 million years for the degradation and loss of half of the carbon in the biochar. This estimate assumes exposure to a highly oxidizing environment with a constant surface temperature of 30°C, highlighting the inherent "permanent" nature of the material. In a less hostile environment, the expected permanence of inertinite is generally anticipated to be even longer.

In addition to the inertinite that constitutes the largest fraction of the typical commercial biochar, an incompletely carbonized biochar may contain up to three other organic pools in descending order of stability. The relative concentration of these pools in a biochar can be quantified by a combination of geochemical pyrolysis and random reflectance methods. Furthermore, the Ro can be used to calculate the carbonization temperature (CT oC) of a biochar, which is the maximum temperature to which biochar fragments have been exposed during pyrolysis. This indicator provides important information about the efficiency of the carbonization process and subsequently the biochar's stability, with respect to production temperature (PT oC), heating residence time, and thermal diffusivity.

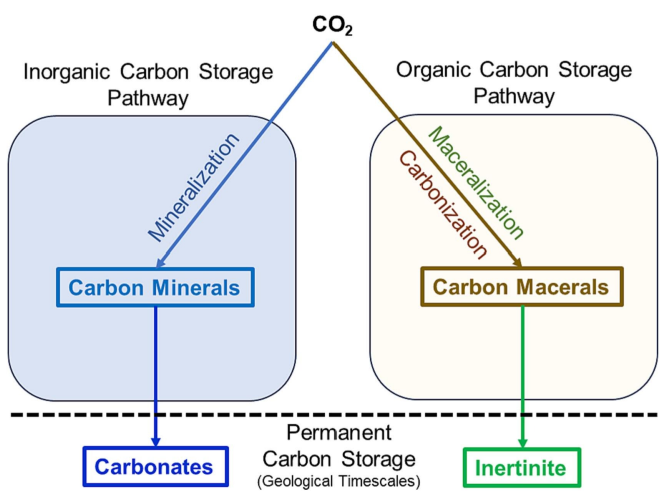


Figure: A simplified schematic representing permanent carbon storage through natural inorganic and organic carbon pathways. In the inorganic pathway, CO2 is mineralized into carbonate minerals, enabling the permanent storage of carbon. Simultaneously, the organic pathway involves the carbonization (maceralization) of biomass into inertinite maceral for permanent carbon storage.

The accelerated carbon mineralization via industrial processes is a widely accepted CDR method. This acceptance is largely rooted in the notion that mineral carbon is seen as a "permanent" storage of inorganic carbon. However, a notable discrepancy arises when considering CO2 removal through the organic carbon pathway. While inertinite maceral is generally believed to be the most stable form of organic carbon in the sedimentary systems, the same benchmark of permanence accepted for mineral carbon does not exist for organic carbon stored in the inertinite macerals. Biochar uses pyrolysis and subsequent rapid carbonization of biomass to enrich carbon in a stable form for storage in soil. Production of biochar imitates the natural organic carbon pathway by accelerating the biogeochemical processes responsible for transferring a fraction of organic carbon from the biosphere into the geosphere.

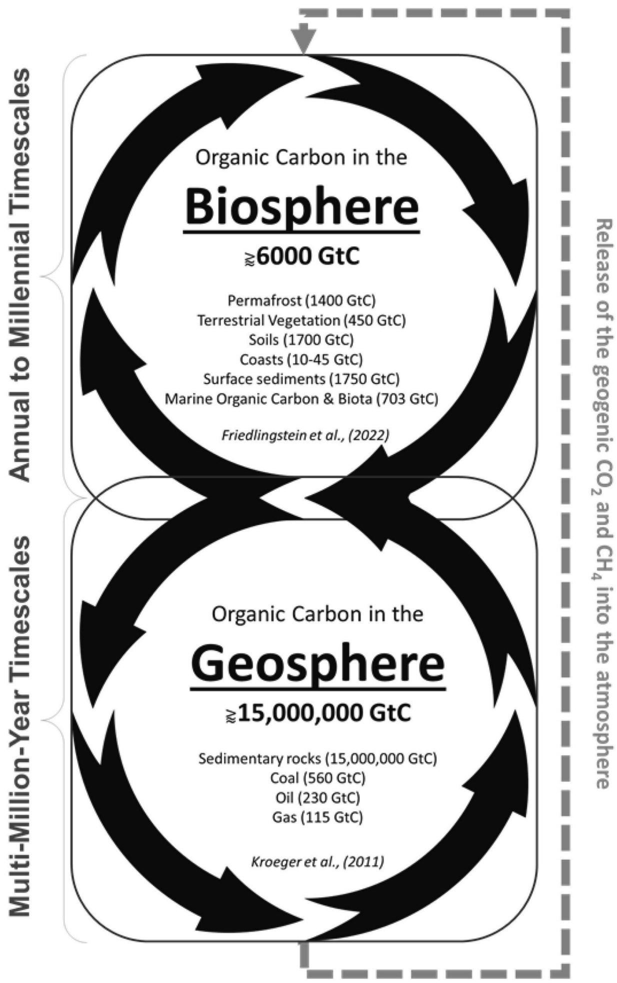


Figure: A schematic illustrates the organic carbon cycle within the biosphere and geosphere. A portion of preserved organic matter is transported into the geosphere/lithosphere through the uppermost diagenetic layer of the Earth's surface (2 km). Within the geosphere, this organic matter undergoes a multi-million-year cycle.

For more than a decade, the issue of the biochar's permanence has been explored within the realm of bioscience, using methods typically dedicated to studying organic carbon turnover in the biosphere. However, with the exception of the microscopic structure inherited from its biological precursor, there is nothing compositionally biological about biochar. The high pyrolysis temperature alters biological molecules into a highly refractory, carbon polymer that is on par with the most stable form of organic carbon maceral, referred to as "inertinite." As the name suggests, inertinite is commonly believed to be chemically inert and abundantly preserved in carbonaceous rocks of any age and depositional environment (from anoxic to highly oxic). Inertinite is the most stable form of organic maceral in the Earth's crust, and any further alteration of it may only occur beyond sedimentary conditions involving high temperature metamorphism.

Transformation of biomass into inertinite maceral through the process of carbonization or "maceralization" is one of the two main natural pathways exerted by Earth to permanently store organic carbon. "Carbon mineralization" is the other geological process, which involves the inorganic carbon pathway.

Inertinite macerals can be formed either through slow and gradual carbonization (organic carbon maturation), which results from the continuous bacterial and thermal alteration of organic matter during the sedimentary burial process and over geological timescales. Alternatively, rapid carbonization of biomass in oxygen-depleted natural wildfires could expedite the maceralization process. Production of biochar imitates the latter process, using controlled heating pyrolysis of biomass to rapidly carbonize and transform the organic matter into the inertinite maceral. The degree to which the carbonization process has achieved the complete transformation of biomass into the inertinite maceral is an important outcome that defines the biochar's permanence.

Sanei (2023) Assessing biochar's permanence: An inertinite benchmark

Graham

The process of turning wood, twigs or leaves into biochar, through a procedure called pyrolysis, could turn about half of that matter's original carbon content into a stable form that could stay in the ground for centuries. A study published in March in the Journal of Environmental Quality also found that using biochar, which helps keep nutrients like nitrogen in the ground, could cut planet-warming nitrous oxide emissions from agriculture by almost one-fifth.

Fig: The biochar retort, an airtight tank

As soon as you start converting forests or fields into rows of crops with the aim of producing biochar, you get into a lot more complicated questions. At that point, if you factor in the greenhouse gas emissions caused by the changes in land use (say, logging), then biochar may worsen climate change, not solve it.

While there's significant demand for biochar on the carbon market, industry proponents are trying to generate more interest among farmers and other businesses, such as concrete companies that are adding the soot to asphalt to make their product less carbon-intensive or governments that could pour it into abandoned oil and gas wells.

Biochar doesn't exactly fit into the standard American farming curriculum. It's neither a fertilizer nor a pesticide, and it doesn't supercharge crop production.

Not all biochar is equal. How it's made and how it's applied to soil can affect how it works.

Graham (2023) Biochar is a proven form of carbon removal. Can it scale up?

Hammond Abstract

Life cycle assessment (LCA) of slow pyrolysis biochar systems (PBS) in the UK for small, medium and large scale process chains and ten feedstocks was performed, assessing carbon abatement and electricity production. Pyrolysis biochar systems appear to offer greater carbon abatement than other bioenergy systems. Carbon abatement of 0.7–1.3 t CO2 equivalent per oven dry tonne of feedstock processed was found. In terms of delivered energy, medium to large scale PBS abates 1.4–1.9 t CO2e/MWh, which compares to average carbon emissions of 0.05–0.30 t CO2e/MWh for other bioenergy systems. The largest contribution to PBS carbon abatement is from the feedstock carbon stabilised in biochar (40–50%), followed by the less certain indirect effects of biochar in the soil (25–40%)—mainly due to increase in soil organic carbon levels. Change in soil organic carbon levels was found to be a key sensitivity. Electricity production off-setting emissions from fossil fuels accounted for 10–25% of carbon abatement. The LCA suggests that provided 43% of the carbon in the biochar remains stable, PBS will out-perform direct combustion of biomass at 33% efficiency in terms of carbon abatement, even if there is no beneficial effect upon soil organic carbon levels from biochar application.

Biochar systems offer greater carbon abatement than combustion or gasification. Carbon abatement of 0.7−1.4t CO2e/dry tonne of feedstock processed was found. Change in soil organic carbon stocks induced by biochar is the key sensitivity. Biochar systems produce less electricity then combustion or gasification.

Hammond (2011) Prospective life cycle carbon abatement for pyrolysis biochar systems in the UK

15

OAE -Ocean Alkalinity Enhancement

15.1 Tranform Faults

Reusch

Ocean alkalinity enhancement (OAE), in which the addition of ions like Mg^{2+} and Ca^{2+} (sourced from materials such as olivine or lime) to the ocean drives more dissolution of atmospheric CO_2 to form bicarbonate (HCO_3^-), holds considerable promise, because the ocean's capacity for storing bicarbonate is ample on the relevant time frame.

Indeed, OAE approaches—often involving materials dispersed at the ocean surface—are being studied, though they, too, face questions about their large-scale feasibility.

Are there other marine settings where OAE could be pursued on a broad scale and with durable results?

Transform Faults Offer a Transformative Approach

Earth's mantle, constituting more than 80% of the planet's volume, is a vast reservoir of ultramafic (low-silica) rock. In concept, a small fraction of this rock—minimally about 600 cubic kilometers if completely converted to carbonate—could neutralize the entire slug of Industrial Age fossil carbon in the atmosphere.

Oceanic transform faults and their fracture zone extensions present tectonic settings where such reactive mantle rocks, which are typically buried under kilometers of crust, are exposed at Earth's surface. The discovery of transform faults—which connect the divergent plate boundaries located at mid-ocean spreading centers—was key to unleashing the plate tectonic revolution in the 1960s. And today, the co-occurrence of the right rocks and high-relief bathymetry presents an optimal combination of chemical and gravitational disequilibria, suggesting a potential for large-scale CDR found nowhere else on Earth (Figure 1).

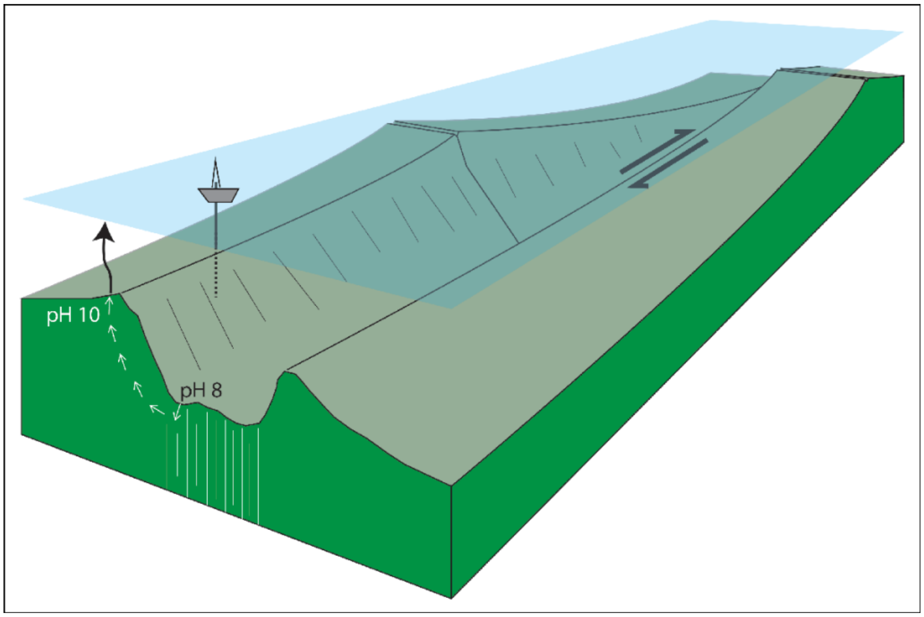


Figure: Oceanic transform faults and their fracture zone extensions (vertical white lines) may be settings where a natural carbon dioxide removal (CDR) process could be enhanced. In these settings, seawater (pH ~ 8) infiltrates fractured rock below the seafloor, where it can react with rock (e.g., peridotite), releasing thermal and mechanical energy and creating alkaline hydrothermal fluids (pH ~ 10) that buoyantly rise (small white arrows) and precipitate mineral carbonate when they mix with seawater back at the seafloor. The drilling ship shown on the ocean surface suggests how this process might be enhanced by creating additional fractures around the fault to drive more hydrothermal circulation. The resulting hydrothermal fluids might be piped (black vertical arrow) to the surface ocean mixed layer where they counter ocean acidification and remove carbon dioxide from the atmosphere. The approximate width, length, and height of this block diagram are 100, 400, and 10 kilometers, respectively, with 5:1 vertical exaggeration.

Especially at magma-poor slow spreading (<4 centimeters per year) plate boundaries, transform fault settings feature relatively fast reacting magnesium silicate minerals in abundance. The scale of transform fault valleys dwarfs that of terrestrial erosional features such as the Grand Canyon. Submarine valley walls are prone to mass wasting, which exposes fresh surfaces of reactive silicate minerals. Locally, the motion of almost-horizontal detachment faults results in portions of crust sliding off the underlying mantle, allowing further exposure of ultramafic rock on the seafloor.

Active fracturing, needed for water-rock reactions to yield alkaline solutions, is widespread. Slow velocities of seismic waves observed along oceanic transform faults imply that water penetrates to depths of more than 30 kilometers. Because of differential cooling in the seafloor rock in these settings, the fracture zone extensions of transform plate boundaries also continue to experience differential vertical movement and fresh fracturing. In addition, active faults exposing reactive mantle rock are locally present along ridge crests and along trench walls.

Drilling and hydrofracturing at sites of active mass wasting would create fresh reactive mineral surfaces and promote serpentinization, further cracking, and the production of greater volumes of alkaline, high-pH hydrothermal fluids. Then the fluids could be either pumped or directed to rise buoyantly through insulated pipelines to raise the alkalinity of the surface ocean mixed layer. By comparison with the existing fossil fuel infrastructure that crisscrosses the continents and seafloor, piping these fluids to the surface should be eminently doable. As for surface infrastructure, mothballed fleets of aircraft carriers—presumably powered by nonfossil sources of energy such as nuclear or wind—might serve as drilling platforms. Earth's transform fault scarps cover on the order of 100,000 square kilometers, an area likely more than sufficient for this approach to CDR.

Even if the fundamental technology and scale of exposed mantle material are available, however, there are practical scientific questions to address. For example, additional research would be needed to understand the relative importance of negative and positive feedbacks in low-temperature hydrothermal settings. Negative feedbacks might include "clogging," where the precipitation of secondary minerals inhibits permeability and the production of alkaline fluids. Positive feedbacks that keep these systems going, meanwhile, are evidenced by both the long lives of vents and the pervasiveness of fractured and altered rock.

There are also potential kinetic issues to contend with—although the chemistry favors increased consumption of CO2 in the ocean, the pace of the reactions may be too slow to matter on human timelines. Several options have been explored to accelerate rates of CO2-consuming reactions. The rate of olivine carbonation increases a millionfold above typical rates at the optimal reaction temperature of 185°C (365°F) and high partial pressures of CO2. Electrochemical strategies to accelerate the process have also been explored.

Methane

Methane, a potent greenhouse gas, is a ubiquitous product of serpentinization. What role do carbon-free minerals play in the formation of carbon-rich methane?

In serpentinization reactions, mantle olivine, a solid solution of typically 90% forsterite (Mg2SiO4) and 10% fayalite (Fe2SiO4), releases reduced iron (Fe2+), which is the culprit. Water oxidizes the reduced iron, forming molecular hydrogen (H2) in the process (i.e., 3Fe2SiO4 + 2H2O $\rightarrow$ 2Fe3O4 + 3SiO2 + 2H2).

This hydrogen then converts any oxidized carbon (e.g., CO2) present to methane (i.e., 4H2 + CO2 $\rightarrow$ CH4 + 2H2O). It clearly would be undesirable to create or enlarge methane sources and have the gas end up in the atmosphere.

Both hydrogen and methane gases are energy sources—the former a clean energy source. Harvesting the gases could help to meet continuing demand for conventional energy and growing demand for clean energy while also helping to finance drilling and CDR infrastructure. In an alternate, economically focused framing, the main goal for expanding hydrothermal vent systems as described could even be to produce and market income-generating sources of hydrogen gas, with CDR as a beneficial by-product.

Whether an artificial infrastructure would focus the gases produced without excessive leakage is an open question.

Proximity to sites of high heat flow is to be avoided.

Drilling above fault scarps could also conceivably trigger mass wasting events and tsunamis.

Activities associated with the proposed CDR approach could also disrupt seafloor and ocean surface habitats.

Is this a potentially planet-saving idea worth exploring, or an intriguing but distracting one?

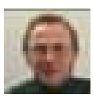
Reusch (2023) A Transformative Carbon Sink in the Ocean?

Part II

Appendices

Appendix A

About



Dyre Haugen and *Dyrehaugen* are Webians for *Jon Martin* - self-owned Globian, Webian, Norwegian and Canarian with a background from industrial research policy, urban planning and economic development consulting on global, regional and urban scales. I am deeply concerned about the (insane) way humanity (i.e. capitalism) interfere with nature. In an effort to gain insights in how and why this happens stuff is collected from around the web and put together in a linked set of web-sites. The sites are operated as personal notebooks. However, these days things can be easily published to the benefit of others concerned with the same issues. But be aware - this is not polished for presentation or peer-reviewed for exactness. I offer you just to have a look at my 'work-desk' as it appears in the moment. Any comment or suggestion can be mailed to dyrehaugen@pm.me Currently migrating from twitter (@dyrehaugen) to Mastodon (@dyrehaugen@mastodon.online) Thanks for visiting!

Appendix B

History

In Norwegian Allerede på 1950-tallet oppdaget en gruppe amerikanske forskere tegn på at menneskelig aktivitet kunne gjøre jorda varmere.

Prinsippene bak global oppvarming hadde da vært kjent siden slutten av 1800-tallet.

Det skulle likevel ta lang tid før temaet fikk stor oppmerksomhet her i landet.

I 1959 dukket for første gang ordet «drivhuseffekt» opp i en norsk avis. Men vi skal langt inn på 1980-tallet før den norske offentligheten fikk et forhold til det som senere blir omtalt som klimaendringer eller global oppvarming.

Klimaforskerne varslet ikke (Lars Sandved Dalen i Forskning.no)

Replikk til Dalen

Appendix C

Links

Current Dyrehaugen Sites:

- Capitalism (github) (geek) (loc)
- Climate System (github) (geek) (loc)
- Climate Models (github) (geek) (loc)
- Climate Impacts (github) (geek) (loc)
- Climate Actions (github) (geek) (loc)
- Economics (github) (geek) (loc)
- Economics of Countries (github) (geek) (loc)
- Finance (github) (geek) (loc)
- Energy (github) (geek) (loc)
- Environment (github) (geek) (loc)
- History (github) (geek) (loc)
- Marxian Economics (github) (geek) (loc)
- Statistics (github) (geek) (loc)
- Synthesis (github) (geek) (loc)
- Urbanization (github) (geek) (loc)
- Varia (other themes)(github) (geek) (loc)
- Wisdom (github) (geek) (loc)

Blogs:

- Opinions - Blog in English (github) (geek) (loc)

- Ytringer - Blog in Norwegian (github) (geek) (loc)

Discontinued:

- Climate Change (Up to Sept. 2023) (github) (geek) (loc)
- Collection (Jekyll) (up to 2018) (github) (geek) (loc)
- Collection (Hugo) (2019-2020) (github) (geek) (loc)

Not listed:

- (q:) dhe dhn jrw56
- (z:) rcsa rpad rstart

Appendix D

NEWS

D.1 230908 Antarctica Polar Amplification

Antarctica is likely warming at almost twice the rate of the rest of the world and faster than climate change models are predicting, with potentially far-reaching implications for global sea level rise.

Scientists analysed 78 Antarctic ice cores to recreate temperatures going back 1,000 years and found the warming across the continent was outside what could be expected from natural swings.

In West Antarctica, a region considered particularly vulnerable to warming with an ice sheet that could push up global sea levels by several metres if it collapsed, the study found warming at twice the rate suggested by climate models.

Climate scientists have long expected that polar regions would warm faster than the rest of the planet – a phenomenon known as polar amplification – and this has been seen in the Arctic.

Antarctica was warming at a rate of between 0.22C and 0.32C per decade, compared to 0.18C per decade predicted by climate models.

Part of the warming in Antarctica is likely being masked by a change in a pattern of winds – also thought to be linked to global heating and the loss of ozone over the continent – that has tended to reduce temperatures.

Guardian (2023) Antarctica warming much faster than models predicted in ‘deeply concerning’ sign for sea levels

D.2 230116 No US Green Monetary Policy - but EU?

Jay Powell has said the Federal Reserve will not become a “climate policymaker”, as he mounted a full-throated defence of the US central bank’s independence from political influence.

In a speech delivered on Tuesday, the Fed chair said the central bank must steer clear of issues outside its congressionally mandated purview and instead maintain a narrow focus on keeping consumer prices stable, fostering a healthy labour market and ensuring the safety of the country’s banking system.

“It is essential that we stick to our statutory goals and authorities, and that we resist the temptation to broaden our scope to address other important social issues of the day,” he said at a conference hosted by Sweden’s central bank. “Without explicit congressional legislation, it would be inappropriate for us to use our monetary policy or supervisory tools to promote a greener economy or to achieve other climate-based goals.” He added: “We are not, and will not be, a ‘climate policymaker’.”

At the same event, Isabel Schnabel, a member of the six-person executive board of the European Central Bank, advocated greater action to address climate change.

The German economist pledged to “ensure that all of the ECB’s policies are aligned with the objectives of the Paris Agreement to limit global warming to well below 2C”. The ECB’s position is clear. It worries that high interest rates to control inflation will undermine the green transition by raising the cost of investing in wind, solar, hydrogen and other clean energies necessary for moving to a net zero carbon world.

But ECB and Fed are aligned on two important issues:

First, that the primary role of green intervention lies not with independent central banks but with governments. Powell said that “in a well-functioning democracy, important public policy decisions should be made, in almost all cases, by the elected branches of government”. Schnabel concurred, saying, “governments must remain in the lead in accelerating the green transition”.

Second, they agree central banks have a role when supervising the banking system in ensuring commercial banks understand and manage financial risks from global warming. These include weather-related risks to infrastructure that banks have financed or fossil fuel assets that might become near-worthless in future.

ESG on a Sunday

D.3 211104 Global CO2 emissions have been flat for a decade, new data reveals

Global carbon dioxide (CO2) emissions from fossil fuels and cement have rebounded by 4.9% this year, new estimates suggest, following a Covid-related dip of 5.4% in 2020.

The Global Carbon Project (GCP) projects that fossil emissions in 2021 will reach 36.4bn tonnes of CO2 (GtCO2), only 0.8% below their pre-pandemic high of 36.7GtCO2 in 2019.

The researchers say they "were expecting some sort of rebound in 2021" as the global economy bounced back from Covid-19, but that it was "bigger than expected".

While fossil emissions are expected to return to near-record levels, the study also reassesses historical emissions from land-use change, revealing that global CO2 output overall may have been effectively flat over the past decade.

The 2021 GCP almost halves the estimate of net emissions from land-use change over the past two years – and by an average of 25% over the past decade.

These changes come from an update to underlying land-use datasets that lower estimates of cropland expansion, particularly in tropical regions. Emissions from land-use change in the new GCP dataset have been decreasing by around 4% per year over the past decade, compared to an increase of 1.8% per year in the prior version.

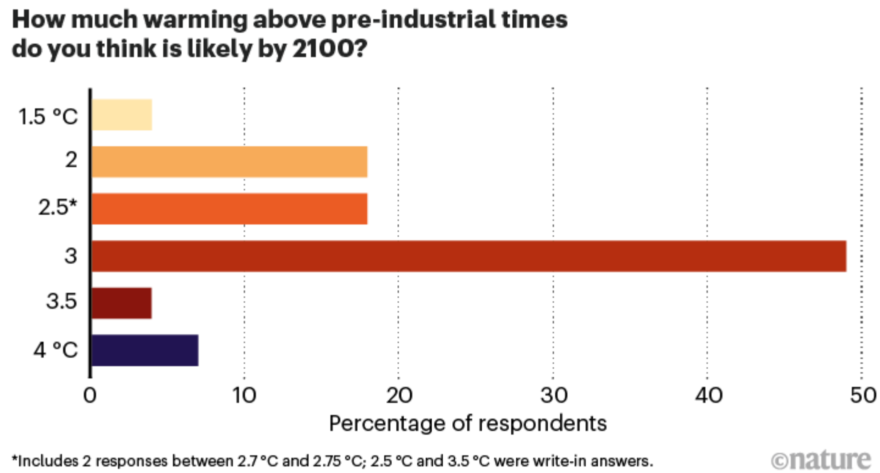
However, the GCP authors caution that uncertainties in land-use change emissions remain large and "this trend remains to be confirmed".

CarbonBrief

D.4 211104 Top climate scientists are sceptical that nations will rein in global warming

Nature conducted an anonymous survey of the 233 living IPCC authors last month and received responses from 92 scientists — about 40% of the group. Their answers suggest strong scepticism that governments will markedly slow the pace of global warming, despite political promises made by international leaders as part of the 2015 Paris climate agreement.

Six in ten of the respondents said that they expect the world to warm by at least 3 °C by the end of the century, compared with what conditions were like before the Industrial Revolution. That is far beyond the Paris agreement's goal to limit warming to 1.5–2 °C.



Most of the survey's respondents — 88% — said they think global warming constitutes a 'crisis', and nearly as many said they expect to see catastrophic impacts of climate change in their lifetimes.

Nature

D.5 210921 Microsoft CO2-removal

In January this year, Microsoft made a major announcement: it had paid for the removal of 1.3 million tonnes of carbon dioxide from the atmosphere. Among its purchases were projects to expand forests in Peru, Nicaragua and the United States, as well as initiatives to regenerate soil across US farms. Microsoft will pay the Swiss firm Climeworks to operate a machine in Iceland that pulls CO2 from the air and injects it into the ground, where it mineralizes and turns to stone. The amount of CO2 to be removed is equivalent to about 11% of the annual emissions from Microsoft's value chain; of this, the company will count less than half as being certified to officially compensate for its emissions. It is the largest corporate procurement of carbon removal so far.

Microsoft did this as part of its 2020 commitment to slash its greenhouse-gas emissions to 'net zero' — as one of more than 120 nations and 1,500 companies to set such goals1. By 2030, the company will reduce its emissions by half or more, and will have 100% of its electricity consumption matched by zero-carbon energy purchases. It will electrify its vehicle fleet, stop using diesel for backup energy and reduce emissions across its value chain. Emissions that are harder to abate, including historical emissions, will be compensated for by withdrawing carbon from the atmosphere. The firm is levying an internal carbon tax across all types of greenhouse-gas emission. It has set up a US$1-billion fund to invest in carbon reduction and removal technologies, and partnerships to provide social and environmental benefits. The aim is that, by 2030, the company will be carbon negative. By 2050, it will have removed all of its emissions since it was founded in 1975.

Here we summarize the lessons learnt from Microsoft's carbon-removal efforts, along with those from another early corporate procurement — the $9-million purchases of carbon removal in 2020 and 2021 by the US–Irish financial-infrastructure company Stripe. Although these are just two companies' efforts, they are the first significant open solicitations focused exclusively on carbon removal. We write as a team composed of Microsoft staff working on the company's carbon-negative programme and research scientists who analyse carbon reduction and removal strategies.

We highlight three 'bugs' in the current system: inconsistent definitions of net zero, poor measurement and accounting of carbon, and an immature market in CO2 removal and offsets. These challenges need to be overcome if the world is to reach net zero by mid-century.

Nature

D.6 210909 ORCA turned on - Iceland

The world's largest plant designed to suck carbon dioxide out of the air and turn it into rock has started running, the companies behind the project said on Wednesday.

The plant, named Orca after the Icelandic word "orka" meaning "energy", consists of four units, each made up of two metal boxes that look like shipping containers.

Constructed by Switzerland's Climeworks and Iceland's Carbfix, when operating at capacity the plant will draw 4,000 tonnes of carbon dioxide out of the air every year, according to the companies. The climate crisis requires a new culture and politics, not just new tech Peter Sutoris Read more

According to the US Environmental Protection Agency, that equates to the emissions from about 870 cars. The plant cost between US$10 and 15m to build, Bloomberg reported.

To collect the carbon dioxide, the plant uses fans to draw air into a collector, which has a filter material inside.

Once the filter material is filled with CO2, the collector is closed and the temperature is raised to release the CO2 from the material, after which the highly concentrated gas can be collected.

The CO2 is then mixed with the water before being injected at a depth of 1,000 metres into the nearby basalt rock where it is mineralised.

Guardian

D.7 210715 Arctic Sea Ice at Record Low

ARCTIC SEA ICE AT RECORD LOW for this time of year. This is an enormous source of amplifying feedback. Losing the remaining Arctic sea ice and its reflection of solar energy back to space would be equivalent to another one trillion tons of CO2.

Peter Carter (twitter)

D.8 210526 Dutch Court against Shell

This is a real ruling: it includes Scope 3 emissions.

Rechtspraak

De rechtbank Den Haag beveelt Royal Dutch Shell (RDS) om via het concernbeleid van de Shell-groep de CO2-uitstoot eind 2030 terug te brengen tot netto 45% ten opzichte van het niveau van 2019.

Rechtsspraak (Dutch) English Translation

D.9 210509 NDCs need 80% increase to 2°C

On current trends, the probability of staying below 2 °C of warming is only 5%

Liu (2021) Nature (pdf)

D.10 210508 Young Legal Action

The young people taking their countries to court over climate inaction

Children and young adults around the world are demanding action from governments on global heating and the ecological crisis,

Guardian

D.11 210424 Earth's Axis tilted by Melting Glaciers

Since the 1990s, the loss of hundreds of billions of tonnes of ice a year into the oceans resulting from the climate crisis has caused the poles to move in new directions.

The direction of polar drift shifted from southward to eastward in 1995 and that the average speed of drift from 1995 to 2020 was 17 times faster than from 1981 to 1995.

Since 1980, the position of the poles has moved about 4 metres in distance.

The accelerated decline [in water stored on land] resulting from glacial ice melting is the main driver of the rapid polar drift after the 1990s.

Guardian

D.12 210410 CO2 and Methane surged in 2020

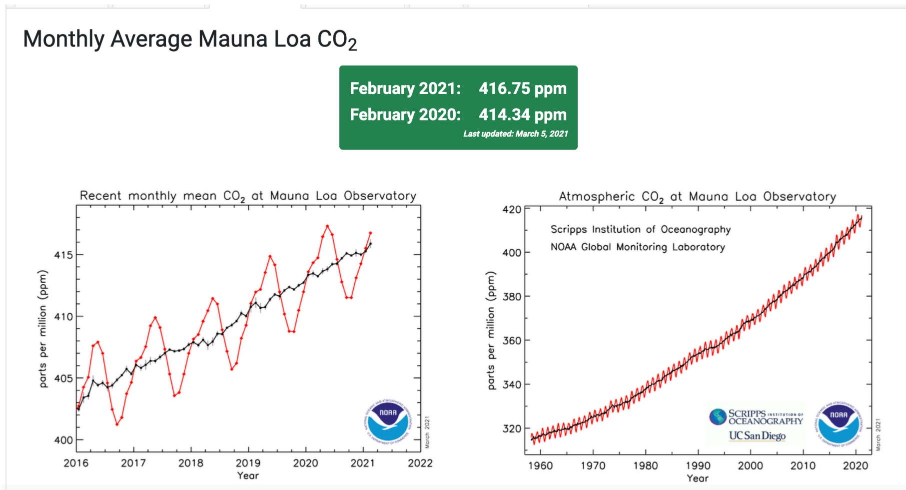
Levels of the two most important anthropogenic greenhouse gases, carbon dioxide and methane, continued their unrelenting rise in 2020 despite the economic slowdown caused by the coronavirus pandemic response.

CO2

The global surface average for carbon dioxide (CO2), calculated from measurements collected at NOAA's remote sampling locations, was 412.5 parts per million (ppm) in 2020, rising by 2.6 ppm during the year. The global rate of increase was the fifth-highest in NOAA's 63-year record, following 1987, 1998, 2015 and 2016. The annual mean at NOAA's Mauna Loa Observatory in Hawaii was 414.4 ppm during 2020.

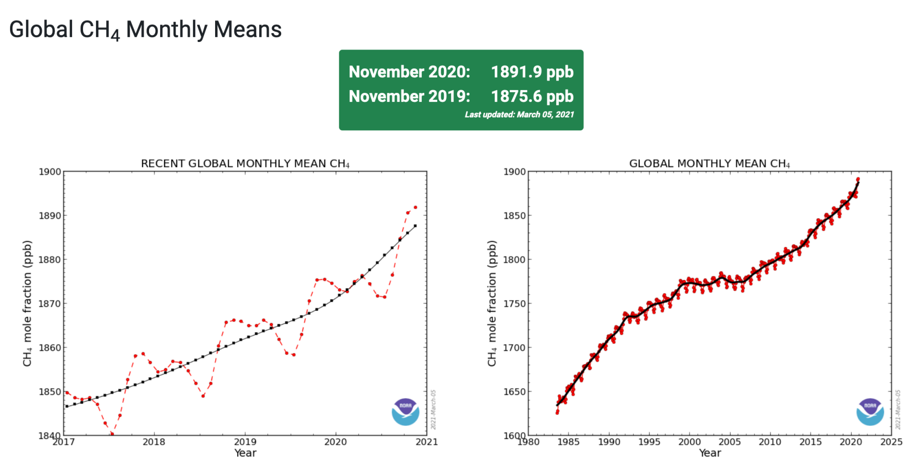
The economic recession was estimated to have reduced carbon emissions by about 7 percent during 2020. Without the economic slowdown, the 2020 increase would have been the highest on record, according to Pieter Tans, senior scientist at NOAA's Global Monitoring Laboratory. Since 2000, the global CO2 average has grown by 43.5 ppm, an increase of 12 percent.

The atmospheric burden of CO2 is now comparable to where it was during the Mid-Pliocene Warm Period around 3.6 million years ago, when concentrations of carbon dioxide ranged from about 380 to 450 parts per million. During that time sea level was about 78 feet higher than today, the average temperature was 7 degrees Fahrenheit higher than in pre-industrial times, and studies indicate large forests occupied areas of the Arctic that are now tundra.



Methane

Analysis of samples from 2020 also showed a significant jump in the atmospheric burden of methane, which is far less abundant but 28 times more potent than CO2 at trapping heat over a 100-year time frame. NOAA's preliminary analysis showed the annual increase in atmospheric methane for 2020 was 14.7 parts per billion (ppb), which is the largest annual increase recorded since systematic measurements began in 1983. The global average burden of methane for December 2020, the last month for which data has been analyzed, was 1892.3 ppb. That would represent an increase of about 119 ppb, or 6 percent, since 2000.



NOAA

D.13 210404 Gas Sustainability

**Scientifically Sustainable*

The European Commission is attempting to finish its sustainable finance taxonomy, a landmark regulation that from next year will define what can be labelled as a sustainable investment in the EU.

A leaked proposal for the rules, shared with EU states last week, would label as sustainable some gas plants that generate power and also provide heating or cooling. That came after the Commission's original proposal – which denied natural gas-fuelled power plants a green label, following the recommendation of the bloc's expert advisers – faced resistance from some EU countries.

Nine members of the expert group advising the European Union on its sustainable finance rules have threatened to step down if Brussels pushes ahead with plans that they say would discredit its efforts to fight climate change.

EU countries disagree on what role natural gas should play in meeting climate goals. Gas emits roughly half the CO2 of coal when burned in power plants, but gas infrastructure is associated with leaks of methane, a potent greenhouse gas.

"The concept of what is scientifically sustainable, that's really not for politicians to decide," said Andreas Hoepner, a professor at University College Dublin who signed the letter.

Reuters

D.14 210220 US SCC Update in Progress

In its 2013 revision of the SCC, the Obama IWG arrived at a central value of around US$50 per tonne of CO2 emitted in 2020 (all values expressed in today's dollars). It also established a range for the SCC ($15–75) and presented an estimate at the 95th percentile ($150). The time is ripe for this update,

That IWG did a careful job, but devastating storms and wildfires are now more common, and costs are mounting. Advances in attribution science mean that researchers can now link many more extreme weather events directly to climate change, and new econometric techniques help to quantify the dollar impacts. The monetary losses exceed the predictions of early models. The same goes for sea-level rise and many other types of damage.

Plenty of scientific and economic judgements need to be made. These include how to deal with endemic uncertainties, including sudden and irreversible 'tipping points', such as ice-sheet collapses. Ethical questions must be considered, including the consequences for vulnerable communities and future generations.

Revising the SCC will take extensive research. A 2017 study by the US National Academies of Sciences, Engineering, and Medicine proposed building a new climate-economy model based on modules — separate components that handle climate change, socio-economic projections, damages, valuation and discounting

Other nations use widely different SCC values or overall approaches2. Germany's 2020 guidance presented two values: €195 (US$235) and €680 ($820). Some countries instead establish a goal for emissions reductions (such as the United Kingdom's 68% reduction by 2030 compared to 1990 levels) and then focus on minimizing the costs of achieving it, estimated at $20–100 per tonne of CO2. This is called a target-consistent approach.

Wagner (Nature)

D.15 210215 Focus on Steel, Meat and Cement

Bill Gates has written about Climate Change.

His assessment is that there is not the time, money or political will to reconfigure the energy sector in 10 years, and encouraging an impossible goal dooms the world to short-term measures that prove insufficient.

Crucially, people need to radically change how they produce the worst climate offenders: steel, meat and cement. Making steel and cement accounts for roughly 10% of all global emissions, and beef alone 4%.

Bill Gates

D.16 210127 10 New Insights in Climate Science 2020

Someof which are:

Earth's temperature response to doubling the levels of carbon dioxide in the atmosphere is now better understood. While previous IPCC assessments have used an estimated range of 1.5–4.5°C, recent research now suggests a narrower range of 2.3–4.5°C.

Emissions of greenhouse gases from permafrost will be larger than earlier projections because of abrupt thaw processes, which are not yet included in global climate models.

Global plant biomass uptake of carbon due to CO 2 fertilization may be limited in the future by nitrogen and phosphorus.

Rights-based litigation is emerging as a tool to address climate change.

Moving forward, the latest research calls for innovative, imaginative, and transformative approaches to building sustainable and resilient human societies. For instance, by strengthening global cooperative frameworks and building new governance arrangements that can include bottom-up community initiatives. In the short term, we have a one-off opportunity to get on the right path by directing post-pandemic recovery spending to green investments. If the focus is instead on economic growth, with sustainability as an afterthought, it would jeopardize our ability to deliver on the Paris Agreement. Alarmingly, governments do not yet seem to be seizing the opportunity to shift towards low-carbon, healthier, and more resilient societies.

futureearth (pdf)

D.17 210130 Adaptation Summit

Climate change adaptation seems to be a fairly new concept to many leaders. It were sometimes mix-ups with mitigation during the high-level talks. Mitigation and adaptation are both important and sometimes they overlap, so mix-ups are understandable. Climate adaptation involves many communities and disciplines (e.g. weather forecasting, climate services, regional climate modelling, “distillation“, disaster risk reduction).

Financing is clearly needed for climate change adaptation. To ensure progress and avoid lofty visions without results on the ground, there may also be a need for tangible results and to show examples and demonstrations. One specific type discussed at the summit was “Early warning systems” which play an important role.

But early warning systems, the way I understand them, don’t provide information about climate risks on longer timescales. Weather and climate – short and long timescales – are of course connected but nevertheless different

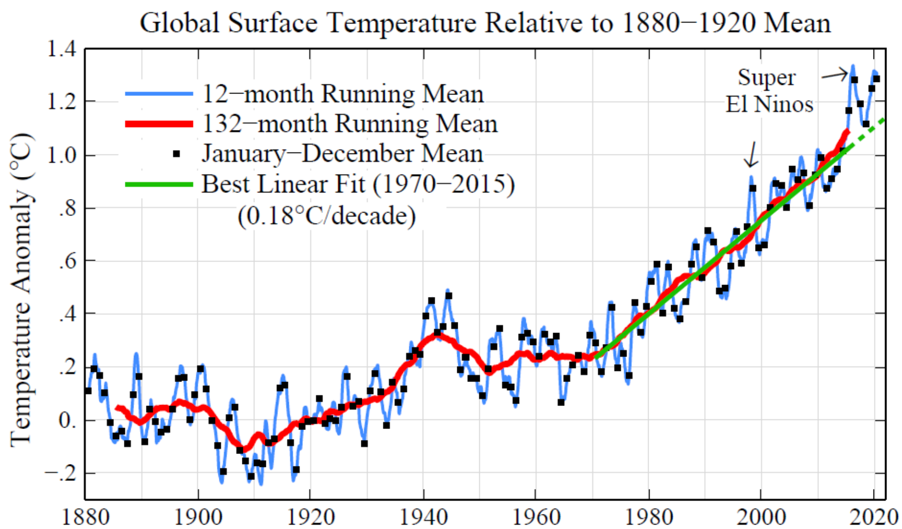
Rasmus (2021) Adaptation Summit

D.18 210118 Warming all anthropogenic

Parties to the Paris Agreement agreed to holding global average temperature increases “well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels”. Monitoring the contributions of human-induced climate forcings to warming so far is key to understanding progress towards these goals. Here we use climate model simulations from the Detection and Attribution Model Intercomparison Project, as well as regularized optimal fingerprinting, to show that *anthropogenic forcings caused 0.9 to 1.3 °C of warming in global mean near-surface air temperature in 2010–2019 relative to 1850–1900, compared with an observed warming of 1.1 °C.* Greenhouse gases and aerosols contributed changes of 1.2 to 1.9 °C and −0.7 to −0.1 °C, respectively, and *natural forcings contributed negligibly.* These results demonstrate the substantial human influence on climate so far and the urgency of action needed to meet the Paris Agreement goals.

Nature (paywall)

D.19 21014 Globale Temperature 1880-2020



The rate of global warming has accelerated in the past several years. The 2020 global temperature was +1.3°C (~2.3°F) warmer than in the 1880-1920 base period; global temperature in that base period is a reasonable estimate of 'pre-industrial' temperature. The six warmest years in the GISS record all occur in the past six years, and the 10 warmest years are all in the 21st century. Growth rates of the greenhouse gases driving global warming are increasing, not declining.

[GISSTEMP 2020 Update] (https://mailchi.mp/caa/global-temperature-in-2020?e=96d59a909f)

D.20 210104 Not so long lag?

> Until recently, Mann explained in The Guardian, scientists believed the climate system—a catch-all term for the interaction among the Earth's atmosphere, oceans, and other parts of the biosphere—carried a long lag effect. This lag effect was mainly a function of carbon dioxide remaining in the atmosphere and trapping heat for many decades after being emitted. So, even if humanity halted all CO2 emissions overnight, average global temperatures would continue to rise for 25 to 30 years, while also driving more intense heat waves, droughts, and other climate impacts. Halting emissions

> will take at least twenty years, under the best of circumstances, and so humanity was likely locked in to at least 50 more years of rising temperatures and impacts.
>
> Research over the past ten years, however, has revised this vision of the climate system. Scientists used to “treat carbon dioxide in the atmosphere as if it was a simple control knob that you turn up” and temperatures climb accordingly, “but in the real world we now know that’s not what happens,” Mann said. Instead, if humans “stop emitting carbon right now … the oceans start to take up carbon more rapidly.” The actual lag effect between halting CO2 emissions and halting temperature rise, then, is not 25 to 30 years but, per Mann, “more like three to five years.” (October 2020)

Guardian article

Covering Climate Now article

D.21 210102 Climate Finance Shadow Report 2020

Oxfam has released this report with subtitle *Asessing progress towards the $100 billion commitment* Progress is NOT in line with need or pledges.

> Climate change could undo decades of progress in development and dramatically increase global inequalities. There is an urgent need for climate finance to help countries cope and adapt. Over a decade ago, developed countries committed to mobilize $100bn per year by 2020 to support developing countries to adapt and reduce their emissions. The goal is a critical part of the Paris Agreement. As 2020 draws to a close, Oxfam’s Climate Finance Shadow Report 2020 offers an assessment of progress towards the $100bn goal.
>
> Based on 2017–18 reported numbers, developed countries are likely to claim they are on track to meet the $100bn goal. And on their own terms, they may be. But how the goal is met is as important as whether it is met. The dubious veracity of reported numbers, the extent to which climate finance is increasing developing country indebtedness, and the enduring gap in support for adaptation, LDCs and SIDS, are grave concerns. Meeting the $100bn goal on these terms would be cause for concern, not celebration.

Oxfam Report (pdf)

Appendix E

Sitelog

Latest Additions

December 9, 2023 climate-treaties
climate treaties design
December 10, 2023 technology
no reduction in ccs costs for 50 years
December 11, 2023 carbon-pricing\ carbon pricing progress - and its continuing inadequacy
December 12, 2023 biochar\ sanei study on biochar permanence
December 12, 2023 technology\ biochar moved to seperate file
December 15, 2023 technology\ December 15, 2023 technology\ dac is unrealisticaaly expensive
December 17, 2023 technology\ typos
December 17, 2023 oae\ reusch on oae - ocean alkalinity enhancement
December 21, 2023 technology\ December 21, 2023 technology\ norway open for deep sea mining