Govern CO_2 removal from the ground up

Scientists and policymakers must acknowledge that carbon dioxide removal can be small in scale and still be relevant for climate policy, that it will primarily emerge 'bottom up', and that different methods have different governance needs.

Rob Bellamy and Oliver Geden

Carbon dioxide removal — the idea to draw down CO_2 directly from the atmosphere — is gaining ground. The Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5 °C has shown that delivering on the ambitions of the Paris Agreement is implausible without carbon dioxide removal (CDR). Indeed, the scenario pathways in the report that limit the warming to 1.5 °C rely heavily on CDR, with a median deployment of 730 $GtCO_2$ removed over the course of the twenty-first century. The latest estimates put annual anthropogenic CO_2 emissions at 42 $GtCO_2$, so the envisaged level of CDR is on the order of almost 20 years of today's emissions[1]. Yet the methods needed to make this happen — such as forestation, soil carbon sequestration, biochar burial, bioenergy with carbon capture and storage (BECCS), enhanced weathering, ocean alkalinization and direct air capture and storage[2] — are far from ready to use.

Progress has been slow, not least because up to now there has been a reluctance among policymakers to openly state that reductions in greenhouse gas emissions alone will not suffice[3]. The reluctance is underpinned by popularly held anxieties about risks and dilemmas that might arise from undertaking deliberate large-scale interventions in the Earth's climate system[4]. Such interventions are collectively referred to as 'geoengineering' and subsume CDR alongside methods for reflecting sunlight away from the Earth — solar radiation management (SRM).

We argue that, contrary to widely held assumptions, methods for CDR do not have to be deployed at large scales to be relevant for climate policy. Nor is it any longer tenable to lump distinct CDR methods together with each other, or with fundamentally different SRM methods. These assumptions and ambiguities stand in the way of the development of meaningful governance and must be rapidly replaced with pragmatism and care.

Gradual build-up

Widely held concerns about the risks and dilemmas of undertaking carbon removal have arisen because of an implicit assumption that CDR would be deployed at the large scales used in global mitigation scenarios to limit climate warming to 1.5 to 2 °C, with only one or two CDR methods, namely BECCS and afforestation. Common criticisms include high requirements for land space, raw materials, energy and water, as well as impacts on biodiversity and pollution[5]. But these concerns are not necessarily specific to carbon removal or any more serious than those posed by the radical scale of 'conventional' climate change mitigation that would now be required to limit global warming to 1.5 to 2 °C in the absence of carbon removal.

Take for instance the alternative deep mitigation pathways that were developed with the explicit aim of not relying too heavily on CDR[6]. In place of what has been called geoengineering we can find ideas that amount to social engineering — more agreeably labelled lifestyle changes — and are equally troubling. Such social engineering scenarios are welcomed in some quarters, such as the non-governmental organization umbrella group Climate Action Network, but could raise enormous social, political and ethical challenges from rapid and unprecedented intrusions into citizens' everyday lives. These include, but are not limited to: the regulation of what people eat (less meat), how much time they spend in the shower (reduced), how many children they have (fewer), and how much they can travel (less).

Mitigation scenarios that limit climate warming to at most 1.5 to 2 °C are usually built on a rapid and vast expansion of low carbon energy supply, including solar, wind, biomass, hydro or nuclear power as well as fossil fuel use with carbon capture and storage. All of these would place huge pressures on (among other things) mineral resource and water availability, and land use and biodiversity[1].

The concerns raised by large-scale mitigation and large-scale CDR are similarly

Biochar, ready for application to soil. Credit: Matthew Bentley / Alamy Stock Photo

significant, even though they are distinct. Despite this, CDR methods such as BECCS are given a comparatively low priority by state and non-state climate policy actors around the world[7].

But just like equivalent mitigation actions, carbon removal will not instantaneously appear at a scale capable of removing, for example, 15 $GtCO_2$ per year (ref. [1]). Contrary to widely held assumptions[8,9], CDR does not have to be deployed at large scales to be relevant for climate policy in the context of the Paris Agreement: nobody would argue that investing political and financial capital in solar photovoltaics or wind energy is only worth the effort if we eventually get to the level of emissions reductions assumed in idealized pathways calculated by integrated assessment models.

Take, for example, how individual companies in countries aiming for net zero greenhouse gas emissions would look at CDR. For them, the priority is conventional mitigation, accompanied by integrating carbon removal into their existing production processes to offset any residual emissions that are hard to eliminate completely[10]. For instance, Stockholm Exergi, the provider of district heating for the capital of Sweden (a country that aims to reach net zero emissions by 2045), is looking to use a combination of biochar and BECCS to generate heat from biogenic waste[11]. On the ground, such challenges are a long way from those that would arise from a globally coordinated removal of up to 15 $GtCO_2$ per year.

In the coming years, more and more examples will emerge in countries, cities and companies that operate under politically credible net zero targets. Furthermore, it is conceivable that early deployment of CDR methods will be catalysed by their non-climate co-benefits, for example the application of enhanced weathering to improve nutrient-poor soils[12].

Such a shift in thinking could also make integrated assessment modelling exercises more realistic: currently used, theoretical global potentials for CDR are probably overestimated. Concrete, national policy designs could help ground-truth the assumptions by clarifying possible conflicting interests and trade-offs.

Unconstructive ambiguity

The idea of removing CO_2 from the atmosphere gained prominence in 2009 when it was subsumed by the broader idea of geoengineering[13]. This move raised the profile of CDR, but it has left a legacy of ambiguity that continues to hamper meaningful governance discussions. CDR was lumped together with SRM and the governance task was framed as one of 'geoengineering governance'. Subsequently, geoengineering governance arrangements were proposed with SRM first and foremost in the minds of those proposing them, with most attention given to the particularly controversial idea of stratospheric aerosol injection — the launch of reflective particles into the lower stratosphere. The focus on stratospheric aerosol injection reflects a broad view among scientists that this method raises more concerns than most. Unfortunately, disproportionate attention towards this particular method has led to geoengineering as a whole being stigmatized[14].

Yet, because stratospheric aerosol injection has transboundary effects and operates in the global commons, it has governance requirements that do not apply to most CDR methods. With the exception of marine-based approaches to carbon removal such as ocean alkalinization or ocean fertilization, CDR methods are mainly bound to the sovereign territory of nation states. Some methods may be part of international supply chains, for example through biomass trading or transport of captured CO_2. But in this regard, CDR is no different from similar conventional mitigation approaches. This diversity alone should rule out singular grand designs for CDR governance[15]. In addition, land-based CDR methods have higher levels of technical readiness[2] as well as political and commercial interest than marine-based ones, and are therefore in more urgent need of targeted governance.

International governance still has a role to play in regulating terrestrial CDR methods, however. For example, consistent and comparable accounting rules for land-based removals need to be established by the United Nations Framework Convention on Climate Change under their existing provisions[9]. Further refining such rules would also be preferable, although not essential, as no rules proscribe land-based removals in principle. The inclusion of land-based CDR in a global market mechanism under the Paris Agreement might also be desirable[16], notwithstanding the notable difficulties in developing such a mechanism under the soon-to-be defunct Kyoto Protocol[17]. In short, certain forms of global governance could be beneficial, but they are not pre-requisites. In reality, there will probably exist a diverse mix of political and regulatory initiatives[18,19].

There are also fundamental differences between still more select subgroupings or even individual carbon removal methods[20]. BECCS and direct air capture and storage, for example, raise unique governance questions around the siting and safety of geological reservoirs for CO_2. Soil carbon sequestration and biochar raise unique governance questions regarding the use and protection of soils. And forestation raises unique governance questions with respect to arboreal biodiversity. Furthermore, attitudes to these different methods — and the means through which they are incentivized — are country specific[21].

Just like conventional mitigation governance, any meaningful governance regime for CDR must recognize such differences. As objects of governance, mitigation regimes recognize individual applications and their specific needs (for example, vehicles and wind energy) as well as overarching categories (for example, emissions and renewable energy). The goals for these objects are enabling and again method specific (for example, more low/zero-emissions vehicles and an increase in wind energy) as well as category wide (for example, lower emissions and an increase in renewable energy). The means through which these goals are achieved are once more category wide (for example, subsidies for renewable energy) and method specific (for example, signalling the end of sales of cars with an internal combustion engine) and applied at both national (for example, carbon taxes) and international (for example, cross-border emissions trading systems) scales.

With its Special Report on Global Warming of 1.5 °C, the IPCC has made some progress in clearly differentiating between CDR and SRM in its communications. However, this technical demarcation has not yet led to considerations as to how individual technologies would have to be governed differently. Indeed, as recently as March 2019, a Swiss-led proposal on geoengineering governance to the UN Environment Assembly failed in part because it lumped everything together[22].

From the ground up

The development of meaningful governance is being threatened by assumptions that CDR must be large in scale and by a conflation with controversial SRM, in particular by stratospheric aerosol injection. If we are to determine whether and if so, when, at what volume and how carbon removal might play a role in climate policy, these afflictions must be urgently resolved. Assumptions about deployment must be replaced with real-world pragmatism, and ambiguities around the object of governance must be replaced

with accuracy. To realize this transition and to facilitate and guide the development of meaningful governance, we offer three recommendations for scientists and policymakers:

1. Treat and govern CDR and conventional mitigation symmetrically; neither must be large scale to be relevant for climate policy or eligible for investment.
2. Recognize and govern CDR on the basis that it will primarily emerge 'bottom up' with companies, cities and countries, and not be comprehensively coordinated 'top down' globally.
3. Govern CDR methods on a case-by-case basis, to reflect the fundamental diversity between different CDR methods and especially with SRM.

We call for governance of CDR from the ground up, with reference to individual methods, as they emerge in specific contexts. ❐

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The hidden politics of climate engineering

Governments disagree even on the current state of climate change engineering governance, as became clear at the 2019 United Nations Environment Assembly negotiations. They must develop mechanisms to provide policy-relevant knowledge, clarify uncertainties and head off potential distributional impacts.

Sikina Jinnah and Simon Nicholson

Emissions abatement alone will most likely be insufficient to keep warming beneath the ambitious 2015 Paris Agreement targets. This gap between aspiration and action opens the door to consideration of carbon dioxide removal (CDR) approaches, such as bioenergy with carbon capture and storage (BECCS) and direct air capture. In addition, solar radiation management (SRM) technologies that address temperature change but not rising atmospheric CO_2 concentrations, such as stratospheric aerosol injection and marine cloud brightening, may have a role to play. Collectively, the array of potential CDR and SRM approaches raise a pressing set of questions related to how one should assess the viability and effectiveness of these options; understand them in relation to one another and other climate change response measures; govern their research; and govern their potential future deployment.

Even as the need to consider CDR and SRM options becomes more pressing, governments (and many non-state actors) have been reticent to discuss them openly. This reticence has been due to concerns about, for example, the so-called moral hazard — the notion that considering CDR or SRM options could dilute critical emissions abatement and adaptation efforts. It could also be that policymakers have been reluctant to signal that traditional forms of climate change mitigation may now prove insufficient[1]. As such, the intergovernmental politics of climate engineering have been rather opaque with very few public statements or policy negotiations surrounding this issue[2].

These hidden politics, particularly with regard to diverging understandings of the governance status quo, became more visible in March 2019 at the fourth United Nations Environment Assembly (UNEA-4) held in Nairobi, Kenya when Switzerland brought forward a proposed resolution on "Geoengineering and its governance"[3] (see Box 1).

State positions and emergent intergovernmental politics concerning CDR and SRM become visible when analysing the various versions of the Swiss-proposed resolution, which in accordance with standard practice at such international meetings, passed through multiple rounds of revision at UNEA-4 in response to demands from opposing states. Centrally, our first glimpse of state positions as illuminated by the March 2019 UNEA negotiations shows that states are operating with very different understandings of the existing CDR and SRM governance landscape. This realization underscores the need to pursue near-term governance responses that initiate the creation of policy-relevant knowledge (rather than policy prescriptions), clarify definitional uncertainties and factual inaccuracies surrounding both CDR and SRM, and head off distributional social impacts, which could, for example, result from unintended changes in regional rainfall or unequal access to decision-making procedures.

The Swiss proposal

The resolution that the Swiss delegation proposed at UNEA-4 (see Box 1) was, at its core, aimed at gathering information and suggesting a preliminary governance framework for CDR and SRM response options. Though modest in its intent, the resolution faced several currents of opposition, including as related to choice of