Once a Fringe Idea, Geoengineering Moves to Center Stage in Policy Arena

Climate geoengineering was once the province only of a few radical scientists gaming worst-case scenarios. Today, it is a dynamic and rapidly emerging suite of potential responses to climate change. Just a decade ago considered as on the outer fringes, deliberate interference in the atmosphere has become a credible option as a consequence of increasing evidence of the catastrophic implications of a warmer world and the failure of the global community to pursue sufficiently aggressive efforts to reduce emissions.

ELI convened a webinar bringing together three experts who collectively believe that it is time to consider at least two forms of geoengineering, solar radiation management and carbon dioxide removal. Shuchi Talati started with an overview of the two major genres and some of the research and implementation considerations. Robert James focused on potential domestic legal governance structures, with an emphasis on solar radiation management. Wil Burns concluded with an overview of the international institutions that might be applicable to governing carbon dioxide removal.

Limiting the global average temperature increase to below 2 degrees, as envisioned in the Paris Agreement, is already unlikely without deploying large-scale technologies that reduce solar insolation or remove greenhouse gases from the atmosphere. However, real-world research, let alone deployment at scale, remains deeply controversial, especially given the lack of international oversight of these relatively low-cost technologies that nonetheless have transboundary implications affecting all of humanity.

Can policymakers addressing climate change today rely upon the technologies of tomorrow? Which methods seem promising and which upon inspection are not? What are the legal frameworks governing research into geoengineering — and what is the best policy to manage global deployment? The edited transcript that follows provides some answers.

Strong Measures Have Become a Necessity

By Shuchi Talati

When considering the word *geoengineering,* the terminology is moving away from using it as an umbrella term for both carbon dioxide removal, or CDR, and solar radiation management (also referred to as solar geoengineering). The two sets of approaches have always been technically different, and are now evolving differently in terms of perception and policy.

CDR takes carbon out of the atmosphere and either uses it or stores it in plants, soils, or geological formations. The captured carbon can be used for fuels, building materials, or for enhanced oil recovery. Enhanced oil recovery is a controversial practice that is already taking place that uses the captured carbon to extract petroleum.

There is an incredible diversity of CDR approaches that are often categorized as nature-based or technological. But within those categories, there are differences in approaches that have varying potentials for permanence, implementation, and cost. Nature-based approaches generally are lower in cost and better understood technologically, but they are also more reversible in terms of how long the carbon can potentially be stored.

For example, afforestation is an important tool with many co-benefits in addition to carbon storage, but the carbon removal would not be permanent due to events like logging or forest fires. It would additionally necessitate massive land-use change to offer large-scale removal. A technology that has been getting more attention is direct air capture, a method that removes carbon from the ambient air and then uses it or stores it underground. But costs are still very high, research is nascent, and the facilities themselves would consume a lot of energy.

The landscape for CDR has changed rapidly over the last two years. It is beginning to form rare coalitions that have some Republican support, and both Occidental and Chevron have recently made investments in some CDR technologies. Environmental NGOs are also paying more attention to carbon removal as a necessary tool. Some NGOs are skeptical about fossil fuel involvement, particularly in enhanced oil recovery, leading many NGOs to focus on nature-based approaches.

An example of this rapid change is in Section 45Q of the U.S. Tax Code: a performance-based tax credit that encourages companies to permanently store or utilize captured carbon, with varying credits per ton. It has been in existence for some time but was revamped in 2018 by a bipartisan coalition in Congress and now includes direct air capture as a method that can receive these credits. This was the first time CDR was included in federal law.

Significantly, the fiscal year 2020 spending package also saw increased funding for CDR technologies at the departments of Energy, Agriculture, and Defense.

All pathways that limit global warming to 1.5 degrees with limited overshoot would need CDR on the order of 100 to 1,000 gigatons of CO_2 over the 21st century. To put that in perspective, 10 gigatons is almost double current U.S. emissions. So while carbon removal is necessary, in all likelihood it might not be sufficient in the timeframe that we need it to be.

Which brings me to solar geoengineering. It is important to reiterate that no one wants to use this technology, rather we are being forced to consider it because we are not aggressively reducing emissions and scaling CDR.

One potential method of deploying solar geoengineering is known as peak shaving. In such a scenario, mitigation can help prevent future climate impacts, and increasing the use of carbon removal can help to slowly reverse that trend after we hit net-zero emissions. Solar geoengineering can be a method of peak shaving to limit harmful climate impacts until carbon removal is at a large enough scale. Solar geoengineering is absolutely not a substitute for mitigation or adaptation but could be used to potentially limit harm.

There are two main solar geoengineering methods that are discussed in literature: stratospheric aerosol injection and marine cloud brightening. SAI would inject aerosols into the stratosphere that would then reflect sunlight to cool the planet. Marine cloud brightening would spray aerosol salts into clouds above the oceans to brighten them and provide regionalized cooling.

According to the IPCC special report on the 1.5 degree goal, SAI is the most researched method, with high agreement that it could limit warming below 1.5 degrees. However, there are still uncertain impacts on global and regional weather patterns. It doesn't address all the impacts of climate change, such as ocean acidification, and it doesn't address rising emissions. And if solar geoengineering is deployed without CDR and then stopped, the world would experience abrupt changes, known as termination shock. There are also major geopolitical and governance concerns.

As solar geoengineering research is in nascent stages, governance over that research is a major issue. Research governance considers the question of should solar geoengineering experiments proceed and, if so, under what conditions. These conditions would likely include measures to provide oversight, transparency, and public engagement. Harvard University has proposed the first SAI small-scale outdoor experiment known as SCoPEx (the Stratospheric Controlled Perturbation Experiment). The university agreed to form an independent advisory committee to provide governance over the experiment, charged with advising on a range of topics including scientific review, environmental and social risks, and stakeholder engagement. The outcome of the committee could potentially serve as a model for future outdoor experiments and can inform future governance processes as well. Another important research governance effort is the forthcoming National Academy of Sciences study on solar geoengineering research priorities and governance. It will provide recommendations on if and how different domains of solar geoengineering research should move forward.

The Union of Concerned Scientists believes that solar geoengineering merits careful study. However, we oppose deployment and large-scale experiments for the foreseeable future due to the substantial risks and uncertainties they pose. We support modeling and observing natural events, and we suggest that small-scale experiments should only go forward with legitimate governance mechanisms and funding sources as well as meaningful stakeholder engagement. The full UCS position on solar geoengineering can be found on our website.

Navigating Legal Challenges to Geoengineering

By Robert James

It is common that a lawyer, considering a subject like geoengineering, will move quickly past whether it will work and focus instead on whether it is legal.

We lawyers do have precedent near to this subject. Before climate modification, there was weather modification. During the Dust Bowl era, there were cases about seeding clouds. Questions arose as to whether it would work, what happened when there was residue from the seeding, and what happened if the rain fell but not where it was intended. Issues also arose with the possibility of hurricane diversion, where the moral question is whether you should intervene to try to save New Orleans but jeopardize Galveston or Mobile instead.

When we talk about geoengineering, whether by solar radiation management or carbon dioxide removal, it seems we are expecting a bit of magic to occur. But when I read those who instead favor drastic emissions reductions, I think getting 190 countries to agree to reduce industrial and transportation sources immediately and for centuries is also engaging in a bit of magical thinking.

For me, whether to use geoengineering is really a debate about whether it can mitigate climate change impacts. To answer that question, we need investigations on efficacy and potential downsides.

Of the challenges to research, I think the first one in the lawyer's view is the set of planning statutes at the federal and state levels. The National Environmental Policy Act applies to federal actions for geoengineering experiments. Some projects may be developed in order to generate emissions credits, and those credits may be applied to projects that themselves will trigger application of NEPA.

A threshold inquiry is whether the federal agency can make an abbreviated environmental assessment or must produce a more complete draft and final environmental impact statement. For the National Science Foundation, there are some general EIS exemptions for research and technical studies. But there is an exclusion for extraordinary circumstances, which can include weather modification. We are mindful of a D.C. Circuit decision where the judges said it is best to review technologies at the R&D stage, before implementation. So there are significant NEPA hurdles even for research projects.

In either type of assessment, policymakers will look at the harms that can occur from deployment of a geoengineering technique. Those harms can include disturbances from the technique itself. They can include the carbon footprint of the vessels or planes used to conduct the experiment. And there is recidivism risk, especially down the road if solar geoengineering is launched and later discontinued.

NEPA requires comparison of the proposed project against alternatives. In the context of research, the key is that we should weigh the consequences of investigation today against the potential large-scale benefits of full deployment tomorrow.

In over half the states, there are NEPA analogues where the states make their own reviews of proposed projects approved by local agencies. In California, for example, the agency is to select the alternative that best mitigates the environmental impact.

In addition to these planning laws, there are laws governing the actual release of materials. In *Climate Engineering and the Law*, Michael Gerrard and Tracy Hester explain how the Clean Air Act could apply to sulfate aerosols deployed in solar radiation management. (Ironically, we have spent the last 50 years limiting the release of these compounds.) Several other statutes govern releases into the atmosphere, oceans, and local waters. In international waters, the London Dumping Convention and a U.S. law were invoked in a geoengineering project by an entity named Planktos challenged by EPA over a decade ago.

Moving from the regulations, I refer to the full array of tort laws in the United States. A trespass involves actual invasion of a property interest, a private nuisance entails interfering with the right of use of private property, and a public nuisance deals with interfering with the public interest. For these and other tort claims, a key point in defending research will be arguing that there are benefits as well as costs. Those benefits are real and should be weighed in deciding whether a given research activity offends one of these causes of action — laws that really were intended for full-scale implementation.

Property and contract law principles will also be relevant to research. From an intellectual property standpoint, if you develop an invention from the investigation, will you make it freely available or license it on nondiscriminatory terms, or will you hold it for commercial exploitation? The answer to that question will color how others view your program.

International conventions may be brought to bear on domestic research. The parties to the Convention for Biological Diversity issued a cautionary note on geoengineering, much like the Union of Concerned Scientists' position, but they made an exception for "small scale research in a controlled setting." Similarly, the London Dumping Convention, on dispersal of materials in the ocean, has an exception for "legitimate scientific research." This is the language of diplomats rather than lawyers. It is not clear how those clauses will be interpreted and by whom. But each affords a reservation for needed research, and an indication that research should be treated differently than implementation.

Observers expect the United Nations bodies to step in. There was an attempt to address solar geoengineering in 2019. That did not transpire due to objections from a handful of countries. It is part of the agenda for the next assessment report, though, and it is expected that solar geoengineering will get its day in court there.

I conclude with a recommendation and an exhortation. My recommendation, as an infrastructure lawyer, is to treat a research project much like other types of infrastructure projects.

You need a strategy for entitlement and development. You must identify the stakeholders, both those who are aligned with you and those who are opposed to you. You should consider why they have those positions and how they might change their views over time, appreciating their concerns and drivers. You should find allies who may be in a better position to advocate points than you are, at least on positions where you have alignment. Transparency is essential: if you are going to say something in one forum, make sure it is consistent with what you are saying elsewhere. In today's world there is no way of compartmentalizing the messages that you deliver. And you should know that diversity and inclusion, in your staffing, your advisors, and your community outreach, are now gating conditions for any project.

My exhortation is that research is research — it is not the same as something else. We should not apply to research the environmental, tort, and property legal rules that apply to full implementation.

Any research project will be too limited to save the planet, but it might nevertheless lead to later success. If you were simply weighing the cost and benefits, the short-term costs might outweigh the short-term benefits and offend some of the regulatory and common-law rules. We cannot let that happen. We need to have research proceed. Then we can tailor the techniques, reject some methods, and let others proceed. That is the only way we can make informed judgments whether we have a technique that will work at the magnitude and for the time periods needed to address climate change.

International Institutions Need to Step Up

By Wil Burns

I will outline the potential international institutions that might govern one of these two categories of geoengineering that we've been discussing, carbon dioxide removal, both in terms of research and, later, the governance issues in deploying these approaches.

There have been two international regimes to date that have sought to regulate geoengineering. The first is the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter, which is usually referred to as the London Dumping Convention, and its associated protocol, and the Convention on Biological Diversity. The impetus for both of these regimes was the small-scale fertilization experiments that were being conducted by private parties and academic institutions that seeded small patches in the ocean with iron to induce phytoplankton production to take up carbon and sequester substantial amounts on the bottom of the ocean.

The parties to the London Dumping Convention passed a resolution in 2008 classifying ocean iron fertilization experiments as an activity other than dumping. However, at the same time it placed serious restrictions on those activities, limiting them to legitimate small-scale scientific research. Ultimately, in 2010 the parties did develop an environmental assessment framework that could conceivably be used for other kinds of geoengineering experiments.

As resolutions, these measures are not legally binding on the parties. However, the 47 parties to the protocol subsequently adopted an amendment establishing legally binding regulation of ocean geoengineering in a number of different ways.

First, the amendment would expand the potential purview of what could be regulated beyond ocean iron fertilization to all "marine geoengineering activities," defined broadly as deliberate intervention of the marine environment to manipulate natural processes. Second, it would require permits issued by the parties to the convention before such activities occur, including a requirement to limit or reduce potential pollution in the marine environment "as far as practicable." Third, permits are limited to legitimate scientific research and there can be no pecuniary gains. Finally, the amendment establishes a risk assessment framework, plus relevant monitoring and reporting to the secretary of the convention and to the other parties.

While this amendment to the protocol would be legally binding and would substantially expand the purview of what could be regulated under the London Dumping Convention, there are some big limitations. It would be restricted to marine-based approaches. Further, this regime has no particular expertise in the context of geoengineering. It has a limited number of parties, only half the number of the convention. Perhaps most importantly the amendment to the protocol will only come into force when two-thirds of the parties have adopted it. To date only five parties have adopted this amendment. So at this point the London Dumping Convention's governance is largely restricted to recommendations with, again, a focus on marine geoengineering activities.

The Convention on Biological Diversity has also scrutinized ocean iron fertilization. The parties passed a resolution in 2008 that called for compiling scientific information on such fertilization, which the regime has been doing on a pretty regular basis. In 2010, the CBD passed a resolution to regulate geoengineering research, again restricting it to "small scale scientific research." Notably, the CBD is not closing expansion of geoengineering activities in the future.

Also notably this is a pretty capacious definition of geoengineering, unlike under the London Dumping Convention, which is restricted to materials placed in the oceans. The CBD measure governs any technologies that deliberately reduce solar insolation, which would encompass solar radiation management approaches, or that increase carbon sequestration on a large scale.

But the CBD also has some serious limitations. First of all, as is true with the London Dumping Convention, these are not legally binding resolutions on the parties. Second, again, this is a regime that doesn't have any particular expertise in this field. Third, and maybe most importantly, the focus of the regime is on the potential impacts of geoengineering activities on biodiversity. So it's not likely to focus on issues such as the impacts that some of these activities might have on human health, or social justice implication, such as impacts of diverting large amounts of land and potentially raising food prices for some of the world's most vulnerable.

Finally, quite frankly this has been a relatively feckless regime. It hasn't done a particularly good job of arresting the decline of biodiversity. And so one would be hard-pressed to be particularly effective in addressing this issue, which is arguably outside of its purview.

The question arises as to what other potentially pertinent regimes and principles might govern carbon dioxide removal approaches at the international level in the future. Probably one of the most logical ones would be the climate regime, right?

If we were to utilize climate geoengineering options in the future, presumably we would be doing it as part of a suite of responses in which we would seek to radically reduce our greenhouse gas emissions, adapting to climatic impacts that are inevitable, and deploying these approaches to presumably buy us time or to help us in so-called overshoot scenarios where temperatures exceed the targets of the Paris Agreement. Since we would be seeking to reduce temperatures by drawing carbon out of the atmosphere, the Paris regime would seem pertinent.

The initial question is whether the parties could include carbon dioxide removal options in their pledges, their so-called Nationally Determined Contributions. Well, if you look at Article 4 of the agreement, it says the parties are to prepare these NDCs and pursue domestic mitigation measures to achieve the objectives of such contributions.

Now, while the term *mitigation* strangely enough is not defined in the Paris Agreement, it is in its parent agreement, the UN Framework Convention on Climate Change. The convention defines mitigation as limiting emissions of greenhouse gases and protecting and enhancing greenhouse gas sinks and reservoirs. So to the extent that carbon dioxide removal options are a way to protect and enhance sinks by taking carbon dioxide from the atmosphere, it would seem that it would be one of the potential forms of mitigation that could be incorporated into parties' NDCs. This is also consistent with Article 5 of the agreement, which expressly calls for the parties to take action and conserve and enhance sinks and reservoirs of greenhouse gases.

Paris could also be invoked to regulate the use of carbon dioxide removal by parties in several ways that might be pertinent. First of all, in the preamble it indicates that when measures are taken to address climate change there is a need to "respect, promote, and consider" obligations in terms of human rights.

Some of the carbon dioxide removal approaches we're talking about could have human rights implications. For example, large-scale use of bioenergy with carbon capture requires huge diversions of agricultural lands for bioenergy feedstocks, which some people argue could massively raise food prices. Some have argued that this could potentially contravene the human right to food.

Bioenergy with carbon capture deployed at large scale also might require as much water as all the water that we currently use for irrigation. As a consequence, it could have implications for the human right to water. To take another example, ocean iron fertilization might undermine fisheries, which could have implications in terms of rights to subsistence and development.

Finally, there are customary international law principles that would be pertinent at least to large-scale deployment of these techniques. This includes the precautionary principle, which arguably could cut either way, either limiting geoengineering deployment or requiring it to offset dangerous climate change, and the no-harm principle where transboundary impacts might occur.