Centre for International Governance Innovation

SPECIAL REPORT

Climate Engineering under the Paris Agreement

A Legal and Policy Primer

A. Neil Craik and William C.G. Burns

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Neil's current research examines the role of procedural obligations in governance structures addressing transboundary and global commons environmental issues. He has particular interests in the intersection of international and domestic environmental policy, climate and geoengineering governance and environmental impact assessment.

Neil is the author of several books, including *Climate Change Policy in North America: Designing Integration* (University of Toronto Press, 2013), and *The International Law of Environmental Impact Assessment: Process, Substance and Integration* (Cambridge University Press, 2008), in addition to numerous book chapters and journal articles. Since 2011, Neil has served as director of the School of Environment, Enterprise and Development at the University of Waterloo.

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Acronyms and Abbreviations

BECCS	bioenergy with carbon capture and storage
CBD	Convention on Biological Diversity
CDR	carbon dioxide removal
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
COP	Conference of the Parties
EuTRACE	European Transdisciplinary Assessment of Climate Engineering
GHGs	greenhouse gases
GtC	gigatons of carbon
IPCC	Intergovernmental Panel on Climate Change
NAS	National Academy of Sciences
NDCs	nationally determined contributions
NETs	negative emissions technologies
ppm	parts per million
SRM	solar radiation management
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

While the Paris Agreement does not address the issue of climate engineering expressly, the target of limiting global average temperature rise to no more than 2°C (a goal that appears unlikely to be achieved in the absence of significant amounts of carbon removal) raises questions with respect to how the issue of carbon dioxide removal (CDR) and solar radiation management (SRM) technologies may be addressed under the Paris Agreement. This report examines the specific provisions of the Paris Agreement with a view to identifying where legal and policy questions in relation to climate engineering are likely to arise. Inclusion of CDR technologies as part of a state's nationally determined contributions (NDCs) is permissible under article 4 of the Paris Agreement, but will likely trigger concerns respecting technological readiness and equity. SRM technologies would appear to have little entry room within the Paris Agreement, but the process mechanism of the agreement provides opportunities to satisfy SRM research governance demands for transparency and public deliberation.

In light of the increased salience of climate engineering in ongoing negotiations over climate change measures, this report analyzes the individual provisions of the Paris Agreement to assess which elements of the agreement may influence future debates associated with climate engineering options. This report's intention is not to present an argument in favour of or against the incorporation of climate engineering regulation within the UNFCCC framework. Rather, this report seeks to provide an understanding of the intersection of the key legal and governance debates in relation to climate engineering with the central commitments and institutions under the Paris Agreement. By doing so, the report seeks to draw attention to areas of potential future legal and policy debate, as well as possible avenues for improved cooperation and coherence.

Introduction

The Paris Agreement supplies a new architecture for international cooperation on global climate change that relies on bottom-up national mitigation and adaptation plans, combined with more rigorous procedural safeguards to promote accountability and more ambitious targets over time.[1] At the heart of the Paris Agreement is the objective of limiting global average temperatures to "well-below 2°C" and "to pursue efforts to limit the temperature increase to 1.5°C" — a goal that appears unlikely to be achieved without large-scale implementation of carbon removal technologies.[2] Consequently, even though the Paris Agreement does not address climate engineering directly, the 2°C goal that anchors the agreement has necessary implications for climate engineering technologies.

1 D Bodansky, "The Paris Climate Change Agreement: A New Hope?" (2016) AJIL (forthcoming).

2 United Nations Framework Convention on Climate Change (UNFCCC), Adoption of the Paris Agreement, 12 December 2015, Dec CP.21, 21st Sess, UN Doc FCCC/CP/2015/L.9 [Paris Agreement]. The emissions reduction pledges made by the parties to the UNFCCC to date put the globe on track for temperature increases of 2.6–3.7°C by 2100; Joeri Rogelj et al, "Paris Agreement Climate Proposals Need a Boost to Keep Warming Well Below 2°C" (2016) 534 Nature 631 at 634; Climate Action Tracker, "Paris Agreement: Stage Set to Ramp up Climate Action" (12 December 2015), online: <climateactiontracker.org/news/257/Paris-Agreement-stage-set-to-ramp-up-climate-action.html>. This is in addition to even higher temperatures over the course of centuries beyond; Peter U Clark et al, "Consequences of Twenty-First Century Policy for Multi-Millennial Climate and Sea-Level Change" (2016) 6 Nature Climate Change 360 at 361. Of the 204 scenarios in the Intergovernmental Panel on Climate Change's (IPCC's) Fifth Assessment Report that project temperature increases below 2°C by 2100, 184 contemplate large-scale deployment of one form of carbon dioxide removal climate engineering, bioenergy with carbon capture and storage (BECCS); IPCC, Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, "Climate Change 2014: Mitigation of Climate Change" (Geneva: IPCC, 2014) at ch 11, 870; online: <www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter11.pdf> [Fifth Assessment Report]; Olivier Boucher et al, "In the Wake of the Paris Agreement, Scientists Must Embrace New Directions for Climate Change Research" (2016) 113 Proceedings Natl Acad Sci 7287 at 7288.

Climate Engineering Technologies

Climate engineering (sometimes referred to as "climate geoengineering") is an umbrella term for a broad constellation of proposed technologies that are directed toward counteracting the climatic impacts of a build-up of greenhouse gases (GHGs) in the atmosphere. CDR technologies are designed to remove carbon dioxide directly from the atmosphere and store it terrestrially or in the world's oceans. These options include BECCS, ocean iron fertilization, accelerated terrestrial or ocean mineral weathering and direct air capture, as well as land management to enhance natural sinks. SRM technologies seek to reflect incoming solar radiation away from the earth in order to reduce global average temperatures. SRM options include injecting highly reflective aerosols into the stratosphere, seeking to brighten the reflectivity of clouds by seeding them with seawater droplets and genetic modification of crops to increase their reflectivity.[3] Climate engineering, as part of a portfolio of responses to address climate change, has been the subject of serious scientific and policy consideration for the past decade but remains technologically underdeveloped and controversial.[4] Substantial scientific research programs to reduce uncertainties about climate engineering technologies have been recommended by science bodies, but have not materialized at the scale necessary to test potential benefits and risks of such approaches.[5]

While CDR and SRM are often lumped together, each category of technologies raises quite different challenges and concerns. Crucially, CDR and SRM are performing quite different roles within the climate regime.[6] CDR approaches supplement existing mitigation strategies by lowering GHG levels but, unlike emission mitigation measures, decouple reductions from emissions both temporally and spatially. This allows removals to occur later in time and not necessarily in direct connection with specific emission activities.[7] SRM is more of an adaptive strategy that reduces the rate of temperature increases, with potential to lower the severity of impacts or to lengthen the time it would take to reach those impacts, providing more time to decarbonize.[8]

CDR technologies (increasingly referred to as "negative emissions technologies" or "NETs") are projected to have potentially severe land use, water and biodiversity consequences, as well as uncertain ecosystem impacts. The land use impacts have implications for agriculture and food security, which carry with them human rights concerns and trade-offs against other sustainability goals. SRM technologies involve greater scientific uncertainty and also involve significant risks. For example, changes to global average temperatures would not be uniform and could have consequential impacts on precipitation patterns, potentially severely imperilling food production in some regions of the world. Because SRM affects temperature, rather than GHG levels, it conceals warming associated with increasing GHG stocks in the atmosphere, requiring a long-term implementation commitment (greater than 100 to 150 years). Moreover, SRM approaches might not address other environmental concerns associated with carbon dioxide emissions, such as ocean acidification. Unlike CDR, which is projected to be expensive and involve significant lags between implementation and desired impacts on the global climate, SRM options, especially stratospheric aerosol injection, could be relatively

3 For a more detailed discussion of SRM options, see William CG Burns, "Geoengineering the Climate: An Overview of Solar Radiation Management Options" (2012) 46 Tulsa L Rev 283.

4 The literature on geoengineering is vast and growing. Excellent overviews of the scientific and policy debates can be found in the following reports: Royal Society, "Geoengineering the Climate: Science, Governance and Uncertainty" (London: Royal Society, 2009); US National Academy of Sciences (NAS), Committee on Geoengineering Climate: Technical Evaluation and Discussion of Impacts, *Climate Intervention: Reflecting Sunlight to Cool Earth* (Washington, DC: NAS, 2015) [NAS SRM Report]; US NAS, Committee on Geoengineering Climate: Technical Evaluation and Discussion of Impacts, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration* (Washington, DC: NAS, 2015) [NAS CDR Report]; S Schäfer et al, *The European Transdisciplinary Assessment of Climate Engineering (EuTrace): Removing Greenhouse Gases from the Atmosphere and Reflecting Sunlight away from Earth* (2015), online: <www.iass-potsdam.de/sites/default/files/files/rz_150715_eutrace_digital.pdf>.

5 Royal Society, *supra* note 4, Recommendation 1.3; NAS SRM Report, *supra* note 4, Recommendation 4; NAS CDR Report, *supra* note 4, Recommendation 2.

6 K Caldeira, G Bala & L Cao, "The Science of Geoengineering" (2013) 41 Ann Rev Earth Planetary Sci 231.

7 G Lomax et al, "Investing In Negative Emissions" (2015) 5 Nature Climate Change 498.

8 D Keith and D MacMartin, "A Temporary, Moderate and Responsive Scenario for Solar Geoengineering" (2015) 5 Nature Climate Change 201, DOI: <10.1038/nclimate2493>.

inexpensive to deploy and are designed to have immediate impacts on global temperatures.[9]

Virtually every responsible commentator on climate engineering is emphatic that climate engineering technologies are not to be understood as an alternative to mitigation of GHG emissions, but rather must be implemented as part of a portfolio of responses that would provide greater efficiency and flexibility, as well as potentially avoiding some of the more severe impacts associated with large average temperature increases.[10] Nevertheless, there remain concerns that the prospect of implementing climate engineering in the future will reduce the incentives for states to implement mitigation and adaptation measures.[11]

The maturity of technological development is specific to each separate climate engineering technology. Some approaches, such as those relating to improved land management and forestry, are addressed as part of existing mitigation strategies and are well understood, although uncertainties remain about the scale effects. Others, in particular SRM technologies but also many CDR technologies, require further experimentation and development. Some of the uncertainty can be reduced through modelling and laboratory experiments, but field experiments are also required,[12] which have proven to be controversial.[13] In the case of ocean iron fertilization, experiments involving iron deposits have prompted the adoption of rules regulating marine geoengineering under the London Protocol,[14] which remains the only legally binding climate engineering-specific rules adopted by international bodies.[15] Existing customary and treaty law may regulate elements of climate engineering experimentation and deployment, but the development of future rules is likely required.[16]

Finally, it should be noted that the relevance of climate engineering has been acknowledged by the IPCC in the Fifth Assessment Report, where the Synthesis Report contained a brief discussion of the role of CDR technologies (BECCS and afforestation) in many of the mitigation scenarios presented in the report, and the potential future role and limitations of CDR. The Synthesis Report also acknowledged the potential of SRM to offset global temperature rise and some of its effects, while recognizing the substantial levels of uncertainty and governance challenges associated with deployment.[17] Moreover, the IPCC, in its upcoming report (2018) on the implications of exceeding 1.5°C, which was requested by COP in the decision to adopt the Paris Agreement (the Paris Decision),[18] is likely to address the potential implications of climate engineering, including NETs.[19]

9 See E Parsons and L Ernst, "International Governance of Climate Engineering" (2013) 14 Theor Inq L 307 (referring to SRM technologies as "high leverage").

10 For example, both the Royal Society and the NAS stress, in their reports, the criticality of focusing climate responses most heavily on mitigating emissions through reductions and adaptation. See Royal Society, NAS SRM Report & NAS CDR Report, *supra* note 4.

11 The so-called "moral hazard" concern is discussed in C Preston, "Ethics and Geoengineering: Reviewing the Moral Issues Raised by Solar Radiation Management and Carbon Dioxide Removal" (2013) 4:1 Wiley Interdisciplinary Reviews: Climate Change at 23–27. See also A Lin, "Does Geoengineering Present a Moral Hazard" (2013) 40 Ecology LQ at 673–712. For an empirical assessment of the moral hazard argument, see D Kahan et al, "Geoengineering and Climate Change Polarization: Testing a Two-channel Model of Science Communication" (2015) 658:1 Ann Am Acad Pol & Soc Sci at 192–222.

12 See NAS SRM Report, *supra* note 4, Recommendation 4; NAS CDR Report, *supra* note 4, Recommendation 2. See also D Keith, R Duran & D MacMartin, "Field Experiments on Solar Geoengineering: Report of a Workshop Exploring a Representative Research Portfolio" (2014) 372 Philosophical Transactions Royal Soc'y A 2031.

13 "A Charter for Geoengineering", Editorial, (2012) 485 Nature 415 (describing controversy around SPICE project). See also N Craik, J Blackstock & AM Hubert, "Regulating Geoengineering Research through Domestic Environmental Protection Frameworks: Reflections on the Recent Canadian Ocean Fertilization Case" (2013) 7:2 Carbon & Climate L Rev 117 (discussing controversy over privately funded ocean fertilization experiment).

14 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 7 November 1996, 36 ILM 1 (1997) (entered into force 24 March 2006) [London Protocol].

15 Contracting Parties to the London Protocol, 8th Mtg, 18 October 2013, Res LP.4(8) (not in force), online: <dcgeoconsortium.org/wp-content/uploads/2014/07/resolution_lp_48.pdf>. The parties to the Convention on Biological Diversity (CBD) at the ninth meeting of the Conference of the Parties (COP) in 2008 passed a resolution calling on the parties "to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities…with the exception of small scale scientific research studies within coastal waters"; COP to the CBD, 9th Mtg, 9 October 2008, "Biodiversity and Climate Change", UN Doc UNEP/CBD/COP/DEC/IX/16 at para 4, online: <dcgeoconsortium.org/wp-content/uploads/2014/07/CBD-COP-9-Resolution.pdf>.

16 R Bodle & S Oberthur, *Options and Proposals for the International Governance of Geoengineering* (Berlin: Umweltbundesamt, 2014); Anna-Maria Hubert & David Reichwein, *An Exploration of a Code of Conduct for Responsible Scientific Research Involving Geoengineering: Introduction, Draft Articles and Commentaries* (Berlin: Institute for Advanced Sustainability Studies, 2015).

17 IPCC, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, "Climate Change 2014: Synthesis Report" (Geneva: IPCC, 2014) at 89.

18 Paris Agreement, *supra* note 2, para 21.

19 IPCC, Scoping Meeting for the IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (15–18 August 2016) "Scoping Meeting Background Document" at 5, 8–10, online: <www.ipcc.ch/report/sr15/pdf/sr15_scoping_background_doc.pdf>.

The Paris Agreement and Climate Engineering

As a preliminary point, it is noted that the Paris Agreement, when it comes into force, is a legally binding treaty and, as such, would be interpreted in accordance with the requirements of the Vienna Convention on the Law of Treaties;[20] namely, that the agreement be interpreted in light of its ordinary meaning, the context and the intention of the parties.[21] The Paris Agreement is not identified as a protocol under article 17 of the UNFCCC, but the Paris Agreement conforms to the basic requirements of article 17 in that only parties to the UNFCCC may be parties to the protocol (article 20(1)). While the precise relationship between the UNFCCC and the Paris Agreement is not specified, both agreements share common institutions and the preamble makes it clear that the Paris Agreement is intended to meet the objectives and principles of the UNFCCC. The latter point is of particular significance insofar as incorporation of climate engineering into the broader UNFCCC framework requires that international cooperation on climate engineering be subjected to the underlying principles of equity and "common but differentiated responsibilities and respective capacities."[22]

Under the Kyoto Protocol, the quantified emission reductions commitments are tied to a specific time frame, the first of which has expired; a second is not in force. In contrast, the core obligations under the Paris Agreement do not expire, but commit states to targets and processes over an extended period of time. The architecture is explicitly progressive (articles 2, 4(3)), and contains provisions, referred to as global stocktaking, which require, *inter alia,* the parties to measure actual emission reduction efforts against the purpose and long-term goals expressed in the agreement (article 14). Where those efforts fall short, the structure of the Paris Agreement forces a reckoning that may broaden the discussion of the types of responses to include climate engineering technologies. If the current Paris architecture remains in place, a central issue moving forward will be the extent to which climate engineering technologies, as part of the complete portfolio of responses to climate change, become subject to oversight through the Paris Agreement and its associated mechanisms.

Preamble

Under international law, preambular language in a treaty is generally not legally binding.[23] However, such provisions serve the important role of helping to interpret the intention of the parties to an agreement.[24] In the context of climate engineering, the Paris Agreement notably provides that the "Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights."[25] Thus, the parties have signalled that measures to address climate change, which could include climate engineering, should take into consideration the potential threats such responses might pose to vulnerable individuals and groups in the pursuit of aggregate social benefits.[26] This would presumably include consideration by the parties of whether climate engineering interventions would comply with specific human rights protections under both customary international law and treaties.[27]

Article 2

Article 2 sets out the objectives of the Paris Agreement, which specifies, in connection with mitigation, the goal of holding the global average temperature increase to well below 2°C, while pursuing efforts to limit that increase to 1.5°C. The vast majority of modelled scenarios that could achieve CO_2 concentration levels

20 Vienna Convention on the Law of Treaties, 23 May 1969, 1155 UNTS 331, 8 ILM 679 (entered into force 27 January 1980) [Vienna Convention]. See Bodansky, *supra* note 1.

21 Vienna Convention, *supra* note 20, art 31.

22 UNFCCC, 9 May 1992, 1771 UNTS 107, 31 ILM 849 (entered into force 21 March 1994), art 3(1).

23 Makane Moïse Mbengue, "Preamble" in *Max Planck Encyclopedia of Public International Law* (New York, NY: Oxford University Press, 2016), online: <opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1456>.

24 *Ibid.*

25 Paris Agreement, *supra* note 2, Preamble.

26 Simon Caney, "Climate Change, Human Rights and Moral Thresholds" in Stephen Gardiner et al, eds, *Climate Ethics* (New York: Oxford University Press, 2010) at 73–90, online: <www.humphreyfellowship.org/system/files/Caney_Climate_Change_Human_Rights%20_Moral_Thresholds.pdf>; Frédéric Mégret, "Nature of Obligations" in Daniel Moeckli, Sangeeta Shah & Sandesh Sivakumaran, eds, *International Human Rights Law,* 2nd ed (New York, NY: Oxford University Press, 2010) at 129.

27 William CG Burns, "The Paris Agreement and Climate Geoengineering Governance: The Need for a Human Rights-Based Component", CIGI, CIGI Paper No. 111, October 2016.

consistent with the 2°C goal rely upon the use of technologies (mostly BECCS) that remove carbon from the atmosphere.[28] For the 1.5°C goal, even greater reliance is required.[29] For example, S. Fuss and others examine the IPCC Fifth Assessment Report scenarios, noting that 101 of 116 of the scenarios consistent with 2°C (the 430 to 480 parts per million (ppm) pathways) require net negative emissions (that is, more CO_2 is being removed from the atmosphere than is being placed into it) starting after 2050.[30]

The literature on the use of CDR to meet the 2°C target identifies several key challenges associated with the use of these technologies. First, there is a high level of uncertainty in relation to the development and implementation of the key technologies, which will require significant research and financial support. Second, each CDR technology implemented at a scale contemplated to meet the Paris Agreement goals is accompanied by significant environmental, social and economic costs. For example, delivery of a relatively modest three gigatons of carbon dioxide equivalent negative emissions annually could require a land area of approximately 380 to 700 million hectares in 2100, translating into seven to 25 percent of agricultural land and 25 to 46 percent of arable and permanent crop area. This could result in threats to food security by restricting supplies and raising prices, displacements from land and drawdowns of water in areas where it is already a scarce resource.[31] Third, managing these impacts and securing these costs will require new governance capabilities, institutions and regulatory frameworks.[32]

The stringent conditions for meeting the 2°C target, even with CDR, raises the prospect of global average temperatures well in excess of the Paris targets. For example, the current emission reduction pledges, as contained in existing intended NDCs, will exceed the 2°C target, a fact acknowledged in the Paris Decision.[33] J. Horton, D. Keith and M. Honegger have indicated that uncertainty associated with climate sensitivity alone (the relationship between GHG concentrations and global average temperature) ought to give rise to further consideration of SRM technologies in order to achieve these targets.[34] Unlike CDR technologies, which are very clearly on the table at present, the degree to which SRM technologies become a central aspect of future international climate negotiations may depend upon the success of the global responses contained in the Paris Agreement. Despite this contingency, there appears to be a growing willingness among some countries to support further research activities in SRM to better understand the viability of these technologies.[35]

Article 2, to be clear, does not mandate or otherwise authorize CDR or SRM. Rather, the pathways to achieving these targets and the associated challenges implicate other provisions of the Paris Agreement (as outlined below). As a consequence, there will be, in our view, increasing pressure on policy makers to more explicitly consider how CDR technologies factor into the Paris commitments. SRM may continue to sit uncomfortably as the

28 T Gasser et al, "Negative Emissions Physically Needed to Keep Global Warming Below 2°C" (2015) 6 Nature Communications 7958, DOI: <10.1038/ncommm8958>. See also S Fuss et al, "Betting on Negative Emissions" (2014) 4 Nature Climate Change 850.

29 Glen Peters, "The 'Best Available Science' to Inform 1.5°C Policy Choices" (2016) 6 Nature Climate Change 646 at 648, online: <www.nature.com/nclimate/journal/vaop/ncurrent/pdf/nclimate3000.pdf>; Sivan Kartha & Kate Dooley, "The Risks of Relying on Tomorrow's 'Negative Emissions' to Guide Today's Mitigation Action" (2016) Stockholm Environmental Institute Working Paper No 2016-08 at 19, online: <https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2016-08-Negative-emissions.pdf>.

30 Fuss et al, *supra* note 28.

31 Pete Smith et al, "Biophysical and Economic Limits to Negative CO_2 Emissions" (2016) 6 Nature Climate Change 42 at 46. See also Phil Williamson, "Scrutinize CO_2 Removal Methods" (2016) 530 Nature 153 at 154; Scott Barrett, "Solar Geoengineering's Brave New World: Thoughts on the Governance of an Unprecedented Technology" (2014) 8:2 Rev Envtl Econ 249 at 254; Lorenzo Catula, Nat Dyer & Sonja Vermeulen, "Fuelling Exclusion? The Biofuels Boom and Poor People's Access to Land, International Institute for the Environment and Development and Food and Agriculture Organization" at 14, online: <pubs.iied.org/pdfs/12551IIED.pdf>; Pete Smith, "Soil Carbon Sequestration and Biochar as Negative Emission Technologies" (2016) 22:3 Global Change Biology 1315 at 1321.

32 Smith et al, *supra* note 31; see also Fuss et al, *supra* note 28; Williamson, *supra* note 31. Detlef van Vuuren, M van Sluisveld & A Hof, *Implications of Long-term Scenarios for Medium-term Targets (2050)*, (2015) Netherlands Environmental Assessment Agency.

33 Paris Agreement, *supra* note 2, para 17; see also UN Environment Programme, Emissions Gap Report, online: <web.unep.org/emissionsgapreport2015>; Rogelj et al, *supra* note 2.

34 J Horton, D Keith & M Honegger, Implication of the Paris Agreement for Carbon Dioxide Removal and Solar Geoengineering (2016) Policy Brief, Harvard Project on Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School.

35 NAS SRM Report, *supra* note 4; Adrian Cho, "To fight global warming, Senate calls for study of making Earth reflect more light" Science (19 April 2016), online: <www.sciencemag.org/news/2016/04/fight-global-warming-senate-calls-study-making-earth-reflect-more-light>. US Global Change Research Program, *Draft Triennial Update to The National Global Research Plan 2012–2021* (30 November 2015), online: <www.globalchange.gov/sites/globalchange/files/USGCRP_Update_FullDocument_PublicReview.pdf>; Zhe Lui & Ying Chen, "Impacts, risks and governance of climate engineering" (2015) 6:3-4 Advances in Climate Change Res at 197–201.

elephant in the room, but as one that will be harder to ignore as the challenges associated with achieving the Paris targets become more apparent, in particular if more stringent emission reduction commitments are not made in a timely fashion. Where the disjuncture between national efforts and the Paris targets is likely to become evident is through the IPCC Special Report on 1.5°.[36]

Article 3

The fundamental architecture of the Paris Agreement provides for each state to determine for itself its contribution (NDC) to addressing climate change, subject to the procedural requirements of the Paris Agreement. Article 3 identifies that the NDC will include a state's contributions in relation to mitigation (article 4), adaptation (article 7), climate finance (article 9), technology development and transfer (article 10), capacity building (article 11) and transparency (article 13). The bottom-up architecture allows states to identify and include climate engineering measures in their NDCs as long as they are consistent with the underlying articles. In relation to CDR, this opens the possibility of individual states integrating some CDR technologies into their reduction commitments since removals of CO_2 are expressly contemplated as an element of mitigation under article 4. There is limited scope for integration of SRM activities into NDCs, as SRM technologies are not likely to fall within the scope of NDCs as contemplated by the Paris Agreement. However, as discussed below, some of the procedural mechanisms could be leveraged to promote greater transparency of state intentions and activities in relation to SRM research.

Articles 4 and 5

Article 4(1) implements the 2°C target by identifying the aim of reaching peak global GHG emissions "as soon as possible" with rapid emission reductions to follow, in order to "achieve a balance between anthropogenic emissions by sources and removals by sinks" (net emissions neutrality) after 2050.[37] In order to achieve these objectives, states are required to pursue domestic mitigation measures, as identified in their NDCs. The mitigation measures are intended to reflect each state's "highest possible ambition"[38] and be progressive in their stringency over time. The wording of article 4 is consistent with the modelling projections discussed above — namely, that attaining the 2°C target will involve a mixture of emission reductions and GHG removals. One legal issue that potentially arises is the degree to which CDR technologies will be viewed as meeting the progressive mitigation requirements under article 4.

The UNFCCC definition of mitigation, which is imported into the Paris Agreement by virtue of article 1, includes national policies and measures "limiting...anthropogenic emissions of greenhouse gases and protecting and enhancing...greenhouse gas sinks and reservoirs."[39] The acceptability of including CDR as a mitigation option under the Paris Agreement turns to some degree on the definition of "sinks." The UNFCCC definition of sinks broadly encompasses "*any process, activity or mechanism* which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere."[40] This definition, by its terms, is not restricted to naturally occurring processes. Similarly, the definition of "reservoir" includes geological and biological storage of GHGs, which would include the forms of storage contemplated by CDR technologies.

Moreover, the Vienna Convention provides that treaty provisions should be interpreted "in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in light of its object and purpose."[41] The ordinary meaning of the term "sinks" in the climate science community, again, includes *any* process, activity or mechanism that removes a GHG from the atmosphere.[42] Deployment of any potential CDR technology would also appear to align with the object and purpose of the UNFCCC and the Paris Agreement, given that the overarching objective of both treaties is to stabilize atmospheric concentrations of GHG emissions at a level that prevents "dangerous anthropogenic interference with the climate

36 IPCC, *supra* note 19. See also the IPCC 1.5 website, online: <https://www.ipcc.ch/report/sr15/>.

37 Paris Agreement, *supra* note 2, art 4(1).

38 *Ibid*, art 4(3).

39 *Ibid*, art 4(2)(a).

40 *Ibid*, art 1 [emphasis added].

41 Vienna Convention, *supra* note 20, art 31(1).

42 Fifth Assessment Report, *supra* note 2 at Glossary, online: <https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_Glossary.pdf>. See also Sinkswatch, Carbon Sinks 101, online: <www.sinkswatch.org/campaign/carbon-sinks-101>.

system."[43] The Vienna Convention's provisions on treaty interpretation also provide that states may take into account subsequent agreements and practice of the parties in relation to the application of a treaty to aid in interpretation.[44] In 2011, the parties to the UNFCCC agreed to include carbon capture and sequestration, a technology for capture and storage of carbon dioxide emissions, and a component of BECCS, under the ambit of the Clean Development Mechanism of the Kyoto Protocol.[45]

On the other hand, article 5 addresses sinks and reservoirs specifically, with the direction that parties should "conserve and enhance" sinks and reservoirs, which might suggest an intention to limit sinks and reservoirs to natural processes. However, at the very minimum, this would not preclude the use of CDR approaches that seek to amplify natural sink processes, including BECCs, mineral weathering on land and in the oceans, and ocean iron fertilization.

Drawing a distinction between CDR and other forms of GHG removal on a technological basis, as the term climate engineering as a distinct category of climate response suggests, is difficult to maintain. The concerns respecting inclusion of CDR relate less to its technological form, and more to the uncertainty and feasibility of its development, its scale and the precision by which removals may be accounted.

The question of the extent to which an unproven technology ought to be relied upon is more complicated. A legitimate concern is that states might seek to justify unambitious emission reduction actions on the basis of future CDR activities. This is not an abstract concern since many of the representative concentration pathways involve emission overshoot scenarios — that is, where GHG concentrations temporarily exceed critical thresholds before being reduced to less dangerous levels. From an economic efficiency standpoint, some reliance on future CDR may be warranted, but overreliance in the face of uncertainty creates risks that NDCs may rely excessively on technologies that cannot deliver predicted results. One issue that could potentially arise here is the extent to which the parties seek to manage the balance of net emissions in order to ensure reductions are privileged over removals within NDCs.

This concern may emerge in relation to the principle of progressive commitments in NDCs, where some states and non-state actors may interpret the non-regression principle as requiring a continual reduction in emissions, as opposed to greater reliance on removals through CDR technologies. The current wording of article 4(1) in relation to the emission neutrality goal does not indicate a minimum level of reduction commitments within the balance. Specifying such an approach might arguably undercut the bottom-up approach that is fundamental to the Paris architecture. On the other hand, while article 4(2) requires successive NDCs, and article 4(3) requires that each successive NDC of the parties constitutes a "progression" beyond current contributions, there is no requirement that the progression be primarily effectuated through reductions in emissions.

A supplementarity requirement that privileges emission reductions could be employed as an implementation strategy. While the dynamic is not exactly the same, concerns that overreliance on market mechanisms would lead to a de-emphasis on emission reductions led the parties to the Kyoto Protocol to include a requirement for Annex 1 states to use the market mechanisms in a supplemental fashion.[46] A similar approach could be adopted in relation to the balance between emission reductions and removals in NDCs.

An additional potential approach would be a strong reading of the call in article 4(1) for the parties to aim to use "best available science"[47] to achieve rapid reductions in emissions. Similar language also appears in the Preamble to the Paris Agreement ("best available scientific knowledge"[48]). This could serve to limit NDCs to the use of well-tested technologies. It should be noted that the term "best available science" is not defined in the Paris Agreement. However, in the context of environmental policy making, such

43 Paris Agreement, *supra* note 2, art 2(1); UNFCCC, *supra* note 22, art 2.

44 Vienna Convention, *supra* note 20, art 31(3)(b).

45 UNFCCC, COP serving as the meeting of the Parties to the Kyoto Protocol, *Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities*, 7th Sess, Dec 10/CMP.7, UN Doc FCCC/KP/CMP/2011/10/Add.2 (15 March 2012) at 13–30.

46 Kyoto Protocol to the United Nations Framework Convention on Climate Change, 11 December 1997, 2303 UNTS 148, 37 ILM 22 (1998) (entered into force 16 February 2005), art 6(1).

47 Paris Agreement, *supra* note 2, art 4(1).

48 *Ibid*, Preamble.

a mandate requires that policies be adopted on the basis of accurate and reliable scientific data.[49] Reliance on unproven technologies contravenes this principle and can be viewed as a violation of the precautionary principle (a central pillar of the UNFCCC), although it should be noted that the precautionary principle is not expressly included in the wording of the Paris Agreement.

A final interpretive question that arises in relation to the inclusion of CDR technologies in NDCs is whether developing states will object to overreliance on CDR on "the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."[50] The argument here will depend on the degree to which the burdens associated with large-scale CDR implementation fall on developing countries and constrain development in those countries. The wording of article 4(1) suggests that the balance between reductions and removals will need to be justified in light of developing country development aspirations, but how this qualification is implemented in light of the bottom-up nature of the NDCs remains an open question.

It would be much more difficult to make a case that SRM options could constitute a form of "mitigation" for the purposes of meeting article 4 commitments. SRM approaches clearly would not seek to limit anthropogenic emissions of GHG emissions (rather, most of them seek to limit incoming solar radiation). Moreover, these options do not directly seek to serve as a sink by removing CO_2 from the atmosphere or storing GHGs. However, a plausible argument could be made that SRM technologies, if successfully deployed, might protect or enhance sinks by potentially returning temperatures back toward pre-industrial levels. For example, one study modelling the potential impacts of SRM deployment concluded that these technological options could lower atmospheric CO_2 levels by 110 ppm by volume by 2100, compared to a business-as-usual scenario.[51] Thus, it might be possible to argue that SRM could be a form of mitigation. However, it should also be noted that other studies have found a much more modest, and decadally variable, impact on climate sinks, emphasizing the potential difficulty of quantifying this purported benefit.[52]

Article 6

Market mechanisms are recognized as playing a potential role in the Paris Agreement, with article 6 identifying broad mechanisms for emissions trading, referred to as "internationally transferred mitigation outcomes,"[53] and the use of offsets, through a sustainable development mechanism (article 6(4)). Negotiations on the details for implementing these mechanisms have started in the agreement's subsidiary bodies, with the contemplation of subsequent adoption by COP serving as the meeting of the parties to the Paris Agreement. As with article 4, the question regarding climate engineering relates to the degree to which CDR technologies will be integrated into market mechanisms.

Market mechanisms will likely be a central element in the development of CDR, as the technologies are expensive and the scale will likely require private sector involvement. The demand for including CDR technologies as part of a state's NDCs will be accompanied by a corresponding demand to integrate CDR into national and international market mechanisms. There will be a need for clear signalling of whether CDR technologies are to be integrated into global carbon markets, as there have been instances of private actors proposing and carrying out ocean fertilization experiments with a stated, but ill-conceived, objective of generating tradable carbon credits.[54] Given the potential environmental and social concerns associated with CDR implementation, it will be important to clarify these expectations for private actors.

49 See PJ Sullivan et al, "Defining and Implementing Best Available Science for Fisheries and Environmental Science, Policy, and Management" (2006) Marine Sciences Faculty Scholarship, 31:9 Fisheries 460 at 462; US, Bill HR 3824, Threatened and Endangered Species Recovery Act of 2005, 109th Cong, 2005, s 3(a)(2)(A), online: <https://www.congress.gov/bill/109th-congress/house-bill/3824/text>.

50 Paris Agreement, *supra* note 2, art 4(1).

51 H Damon Matthews & Ken Caldeira, "Transient Climate-Carbon Simulations of Planetary Geoengineering" (2007) 104 Proceedings Natl Acad Sci at 9949–54. See also David P Keller, Ellias Y Feng & Andreas Oschlies, "Potential Climate Engineering Effectiveness and Side Effects During a High Carbon Dioxide-Emission Scenario" (25 February 2014) Nature Communications at 3, DOI: <10.1038/ncomms4304>.

52 JF Tjiputra, A Grini & H Lee, "Impact of Idealized Future Stratospheric Aerosol Injection on the Large-Scale Ocean and Land Carbon Cycles" (2016) 121 J Geophysical Research: Biogeosciences at 17–18, DOI: <10.1002/2015JG003045>.

53 Paris Agreement, *supra* note 2, art 6(2).

54 See Craik, Blackstock & Hubert, *supra* note 13.

Market mechanisms facilitate the asymmetric distribution of mitigation activities in relation to mitigation responsibilities, making credibility of removals critical. The specific challenges will relate to developing reliable accounting methodologies, including addressing issues of permanence that arise in relation to carbon sequestration. As indicated above, these issues are not unfamiliar in climate regimes, as the treatment of carbon capture and storage under the Clean Development Mechanism has been the subject of fairly extensive technical and legal discussion.[55] Given the bottom-up architecture of the Paris Agreement, market rules and methodologies are likely to play an important element in driving domestic and international policy on CDR development, and legal and policy disagreements over CDR could play out over the negotiation of these rules.

As currently conceived, market mechanisms are directed toward mitigation of emissions (whether effectuated through reductions of emissions or removals by sinks) but are not contemplated to address reductions in incoming solar radiation, which would be the objective in deployment of SRM technologies. Market-based approaches will likely be less critical for SRM than for CDR, since economic efficiency is not anticipated to be a significant barrier to SRM deployment. In any event, there is little scope under the Paris Agreement for the advancement of market mechanisms to incentivize SRM development.[56] Similarly, article 6(8) provides for the use of non-market mechanisms by the parties to help achieve their respective NDCs, but, again, the focus is on mitigation of GHG emissions and not on reduction of incoming solar radiation.

Articles 7 and 8

Article 7 addresses international cooperation on climate adaptation. The article recognizes adaptation as a global challenge and provides for a number of avenues for increased cooperation, including providing for enhanced financial resources to be directed toward the adaptation efforts of developing countries (see also article 9(4)). Article 8 addresses loss and damage associated with climate change through "cooperation and facilitation."[57] Whereas adaptation is prospective in that it seeks to avoid or minimize harmful climate impacts, the thrust of loss and damage is retrospective, focusing on impacts associated with harms that cannot be reasonably averted.[58] This distinction is blurred to some degree by the wording of article 8(4), which includes prophylactic measures, such as early warning systems, emergency preparedness, and risk assessment as loss and damage measures.

Adaptation, as an object of regulation under the Paris Agreement, is not defined under the agreement or under the UNFCCC. The IPCC, which addressed adaptation extensively through its Working Group II, defines adaptation as "[t]he process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects."[59]

While SRM technologies can be understood as being adaptive in the broad sense of seeking to moderate the harm from increased atmospheric GHG concentrations, the Paris Agreement should not be interpreted as addressing SRM, either in an enabling or restrictive fashion, through articles 7 or 8. As a technical matter, SRM addresses climate change itself by influencing the radiative energy balance, as opposed to the effects arising from that change. In this regard, it addresses a distinct stage of climate response. In any event, the intention of the parties was to address in-country responses to the effects of climate change, such as sea level rise, drought and extreme weather, not SRM.

Some commentators have suggested that SRM technologies could be viewed as an emergency response measure,[60] potentially bringing them under the ambit of article 8. However, again, such a reading would appear to strain both the wording of the Paris Agreement and the intentions of the parties to focus on mitigation of GHG emissions to effectuate its long-term objectives.

55 Horton, Keith & Honegger, *supra* note 34.

56 *Ibid.*

57 Paris Agreement, *supra* note 2, art 8(4).

58 William CG Burns, "Loss and Damage and the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change" (2016) 22(2) ILSA J Intl & Comp L 415 at 416–17.

59 Fifth Assessment Report, *supra* note 2 at Glossary, online: <https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_Glossary.pdf>.

60 J Horton, "The Emergency Framing of Solar Geoengineering: Time for a Different Approach" (2015) 2:2 Anthropocene Rev 147, DOI: <10.1177/2053019615579922>.

If, as this report suggests, SRM technologies do not have a clear entry point within articles 7 or 8 (nor within article 4), the question remains whether SRM and, in particular, more near-term SRM research cooperation and regulation, can or should be addressed through the procedural and institutional mechanisms of the Paris Agreement or be left outside of the framework entirely. The inclusion of loss and damage provisions in the Paris Agreement signals a broader commitment to address the entire portfolio of climate responses within the context of a binding legal framework, as opposed to within non-binding mechanisms adopted through COP decisions. Prior to the Paris Agreement, the binding commitments of the parties focused primarily on mitigation, but the scope of the matters addressed through the NDCs and through other provisions of the Paris Agreement is wider.

Given the controversy surrounding SRM, there may be pressures for the UNFCCC bodies, including the Paris Agreement decision-making bodies, to address SRM oversight. Looking at the trajectory of ocean fertilization regulation, the prospect of field experiments in the high seas provoked resolutions from COP of the CBD (IX/16; X/33; XI/20), including what amounted to a moratorium on "geo-engineering activities that may affect biodiversity," with the exception of "small-scale experiments" (X/33).[61] There was a similar reaction within the London Protocol that eventually led to an amendment of the protocol prohibiting ocean fertilization as a form of ocean dumping, but providing for a process to authorize field experiments.[62] There are increasing calls for atmospheric field experiments directed toward resolving uncertainties in connection with various SRM technologies, which could create increased demand for regulation under the UNFCCC and the Paris Agreement. This might include a clear statement by the parties that SRM technologies should not be deployed at a scale that could alter the climate until such time as the scientific and governance uncertainties are resolved.[63]

Any mandatory regulation of SRM activities by states would require an amendment to the Paris Agreement, but, as outlined below, the parties could take advantage of COP and other mechanisms under the Paris Agreement to promote cooperation and transparency around SRM experimentation, as well as to signal the international communities' intentions in relation to SRM deployment.

Articles 9, 10, 11 and 12

The Paris Agreement contains a variety of implementation and facilitation provisions addressing climate finance (article 9); technology development and transfer (article 10); capacity building (article 11); and education, public awareness, public participation and access to information (article 12). The potential impacts on CDR and SRM from these provisions are indirect, in the sense that recourse could be made to these provisions to facilitate climate engineering measures. CDR technologies, as part of a broader mitigation response, are the most likely to be the subject of the cooperative measures anticipated in these provisions. Given the need for widespread implementation of CDR technologies, and the need for a significant increase in research on the development and potential impacts of these technologies, the measures incorporated into the Paris Agreement are critical to meeting the 2°C target.

Estimates of the levels of investment needed to deploy CDR technologies at scales consistent with the 2°C range are significant. One study estimates costs associated with BECCS to be in the order of nine percent of total global energy investments by 2050 (approximately US$160 billion per year).[64] The allocation of significant amounts of climate finance to CDR may not be viewed by some developing countries as being in accordance with the "needs and priorities of developing countries" (article 9(3)),[65] especially in light of the environmental and development impacts associated with CDR. On the other hand, some developing countries might consider such investments salutary if they believe that the investments could prevent serious climatic impacts, many of which will disproportionately affect such states. In the context of article 9, this could facilitate developed-country parties'

61 COP to the CBD, 10th Mtg, 29 October 2010, "Biodiversity and Climate Change", UN Doc UNEP/CBD/COP/DEC/X/33, online: <https://www.cbd.int/climate/doc/cop-10-dec-33-en.pdf>.

62 Contracting Parties to the London Protocol, *supra* note 15.

63 See NAS SRM Report, *supra* note 4, Recommendation 3. See also E Parsons & D Keith, "End the Deadlock on Governance of Geoengineering Research" (2013) 339 Science 1278 (recommending a moratorium on large-scale SRM activities).

64 Smith et al, *supra* note 31.

65 Paris Agreement, *supra* note 2, art 9(3).

financing of CDR projects in developing countries as part of their obligations to effectuate mitigation.

Under article 10, the provisions establishing a technology framework, and an associated technology mechanism, could support climate geoengineering research, assessment development or technology transfer under the rubric of the agreement. Article 10(6) provides for strengthening cooperation on technology development and diffusion, which could help ensure that developing-country parties have more of a voice in the context of climate geoengineering.

Given the environmental and social concerns associated with CDR, particular attention ought to be paid to article 12, which recognizes the importance of public participation and access to information for enhancing actions under the Paris Agreement. Article 12 is facilitative, not directive, requiring parties to "Cooperate in taking measures."[66] However, it could form the basis for developing a multi-state strategy for consultation and deliberation on the development and deployment of CDR technologies.[67]

Article 12 has similar relevance for SRM. The wording of article 12 is not restricted to mitigation or adaptation, but rather relates to "climate change," which would provide an opening for similar deliberations on SRM field research. The US NAS, in its review of SRM, recommended the initiation of a deliberative process to examine the types of research governance that would be required for SRM research and the types of research that would require such governance.[68] While certain forms of small-scale research may be governed nationally, there will be a need for international cooperation if, and when, experimentation scales up.

To be clear, the Paris Agreement and UNFCCC framework is one possible forum for promoting an open, scientifically informed dialogue on SRM, but it is not the exclusive forum. A "club" approach, involving a narrower group of states with interests in conducting SRM research, is an alternative approach in the near term,[69] but over time a fully inclusive governance approach, be it through the UNFCCC or another global forum, will be required, given the global implications of SRM. With the importance of SRM research developments to the broader discussions on climate responses that will arise under the Paris Agreement, developing some mechanism by which parties can be informed of SRM research is consistent with the overall aims of the Paris Agreement and with research transparency norms.[70]

Article 13

The Paris Agreement contains a dedicated transparency provision, which is intended to facilitate the monitoring, reporting and verification of NDCs, as well as adaptation responses and support. As the transparency requirements apply specifically to "removals by sinks,"[71] CDR activities could be included in the transparency requirements, which will require the development of agreed-upon accounting methodologies. This latter requirement may present a significant challenge as accounting methodologies for different forms of carbon removal and storage currently involve high degrees of variability and uncertainty.[72]

Article 14

The global stocktaking process facilitates the requirement for progression in commitments over time. The intention here is to provide a mechanism that allows the parties to assess their progress in light of the objectives in article 2, which will inform "updating and enhancing"[73] NDCs. The wording in article 14 refers to the "collective progress"[74] of the parties, which indicates that the global stocktaking will not be used to single out individual states (transgressions will be addressed under the compliance mechanism in article 15), but rather will assess progress from a universal perspective. The stocktaking process will account for mitigation, adaptation and climate finance

66 *Ibid*, art 12.

67 William CG Burns & Jane Flegal, "Climate Geoengineering and the Role of Public Deliberation: A Comment on the US National Academy of Sciences' Recommendations on Public Participation" (2015) 5 Climate L at 252–92.

68 NAS SRM Report, *supra* note 4, Recommendation 6. See also S Rayner et al, "The Oxford Principles" (2013) 121:3 Climatic Change at 499–512.

69 J Hovi et al, "Climate Change Mitigation: A Role for Climate Clubs?" (2016) Palgrave Communications, DOI: <10.1057/palcomms.2016.20> (describing club-type governance in relation to mitigation).

70 N Craik & N Moore, "Disclosure-based Governance for Climate Engineering Research", CIGI, CIGI Papers No 50, 28 November 2014.

71 Paris Agreement, *supra* note 2, art 13.

72 Lomax et al, *supra* note 7.

73 Paris Agreement, *supra* note 2, art 14.

74 *Ibid.*

measures, and, insofar as mitigation commitments include recourse to CDR, some assessment of the efficacy of CDR approaches to contributing to achievement of the Paris targets is possible. In particular, a key aspect of the NDCs of which the international community could take stock is the balance between emission reductions and removals through CDR technologies. This may provide an opportunity for assessment of the technological readiness of CDR approaches that are proposed or necessarily relied upon to achieve the Paris targets with a view to ensuring that the balance reflects technological realities, as well as concerns respecting equity and human rights.

There is further potential for the global stocktaking to address SRM research. Paragraph 100 of the Paris Decision elaborates on the potential sources of input into the global stocktaking exercise, which includes reports from the IPCC and subsidiary bodies. The IPCC has, in particular, shown a willingness to assess the current state of SRM (and CDR) research, which, if it continues, might feed into the global stocktaking process. The sources of input should be constructed in such a way as to allow for other international processes of climate engineering technology assessment to inform the global stocktaking process, if and when they arise.

The Paris Institutions

The Paris Agreement and Decision identify a number of new and existing institutional bodies that will manage the agreement over time. Chief among these is the "COP serving as the meeting of the parties to the Paris Agreement" (CMA), which will be the central decision-making body for the parties to implement the agreement. As the Paris Agreement itself makes no explicit mention of climate engineering technologies, the CMA will have discretion over the development of rules and processes respecting climate engineering and their integration into the Paris framework, including the format of the NDCs (article 4(8)) and accounting guidance (article 4(13)). The default rules of procedure for the CMA are those currently used by COP (article 16(5)), and one expects that the parties will continue to make decisions by consensus. Generating consensus around climate engineering technologies, either CDR or SRM, may be a significant challenge, and partially explains the ambiguity around the inclusion of CDR in the Paris Agreement. That said, COP under the CBD has similar voting procedures, and has managed to craft (non-binding) decisions on climate engineering that have been accepted by the parties.

It is also likely that the UNFCCC's Subsidiary Bodies for Implementation and Scientific and Technological Advice, incorporated into the Paris Agreement (article 18(1)), would play a role in any consideration of climate engineering by the regime. For example, the subsidiary bodies have recently convened a forum that is tasked with, *inter alia,* assessment of the impacts of the implementation of climate response measures, and engendering cooperation by the parties on response strategies.[75] Under the terms of reference, the forum could develop guidance to the parties and the subsidiary bodies in terms of climate engineering, as well as facilitate ongoing sharing of information.[76]

As noted, other international conventions, such as the CBD and the London Protocol, have sought to address aspects of climate engineering governance. However, climate engineering technologies, including associated research activities, could potentially be addressed under a number of different regimes, such as the Vienna Convention for the Protection of the Ozone Layer (given the potential for stratospheric aerosols to impact ozone), the Convention on Long-range Transboundary Air Pollution (again, in relation to stratospheric aerosol injection), and the United Nations Convention on the Law of the Sea (for marine-based geoengineering). The demand for cross-regime coordination has been recognized through the creation in 2001 of the Joint Liaison Group between the secretariats of the UNFCCC, CBD and the Desertification Convention, which provides a forum for information sharing and some limited joint action. Given that climate engineering has already been the subject of regulation in other regimes, there appears to be some demand for a coordinating mechanism.

75 UNFCCC, Forum on the impact of the implementation of response measures, online: <unfccc.int/cooperation_support/response_measures/items/7418.php>.

76 UNFCCC, *Forum and Work Programme on the Impact of Implementation of Response Measures,* COP21, Dec 11/CP.21 (2015) at 24.

Conclusions

The Paris Agreement signals a new approach to global climate governance that moves away from a binary distinction between developed and developing state obligations and gives states more autonomy to determine for themselves the level and form of climate response commitment they will undertake through NDCs. The Paris Agreement also consolidates a number of distinct climate responses that have been the subject of international discussion — namely, mitigation, adaptation, and loss and damage, as well as measures for implementation, under a single legal framework. Within this framework, climate engineering is unmentioned but present in its practical implications. The key points of significance addressed in this report arising from the nexus of climate engineering in the Paris Agreement are as follows:

- The potential role of climate engineering under the Paris Agreement arises most directly from the agreement's objectives themselves, which are likely achievable only with significant recourse to climate engineering. As currently modelled, achieving the 2°C limit is driven by a mixture of emission reductions and removals of CO_2 through CDR technologies.
- CDR technologies fall within the language of article 4, which include CO_2 removals, as part of the mitigation commitments expected from parties through their NDCs.
- Inclusion of CDR technologies by states in their NDCs will raise legal issues respecting technological readiness and equity implications of a balance between emission reductions and removals, which could, in turn, give rise to questions of the supplementarity of CDR approaches.
- The NDCs, which are largely at the discretion of states, provide little purchase for the regulation of CDR technologies. However, the eventual need to use market incentives to realize the development and scaled deployment of CDR technologies will likely require international cooperation to address the inclusion of CDR technologies in market mechanisms. The Paris Agreement institutions and procedural mechanisms, as well as the emphasis on capacity building, transparency and public consultation, provide a basis for future deliberations on the implementation of CDR technologies.
- It is questionable whether legal regulation of SRM technologies, on the other hand, can be accommodated within the existing Paris framework. Nevertheless, the procedural mechanisms of the Paris Agreement have some potential to satisfy SRM research governance demands for transparency and public deliberation.

One final consideration that the bottom-up architecture of the Paris Agreement gives rise to is the increased likelihood that international cooperation on climate engineering will reflect this decentralized structure. The legal challenge here is one of coherence and integration, as the Paris architecture makes it more likely that states will adopt multiple pathways and approaches to climate engineering technologies, reflecting individual state interests, as well as risk preferences. The building blocks for an internationally integrated approach to climate engineering law and policy are faintly present in the Paris Agreement's procedural and institutional capacities. As research activities generate a clearer understanding of the feasibility of CDR and SRM technologies, bringing the science to bear on the normative commitments to equity, human rights and the nature of climate change as an issue of common concern will be critical to realizing a broader coherence in global climate policy under the Paris Agreement.

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