Implementing the Precautionary Principle for Climate Engineering

*Elizabeth Tedsen and Gesa Homann**

The precautionary principle is used in arguments for, as well as against, climate engineering: On the one hand, the principle can suggest caution against climate engineering so as to minimize the (unknown) risks of proposed techniques to the environment and health. On the other, arguments can be made that climate engineering is a precautionary measure against the (known) risks of climate change. This article provides an overview of this debate and what the precautionary principle means in a climate engineering context. It explores, first, how the precautionary principle is interpreted in international law, examining its history, content, legal nature, and operationalization in other areas. Next, the authors consider how the principle can be applied in a climate engineering context, both generally and under existing legal instruments. Finally, the article offers reflections on how the principle can be further operationalized for climate engineering in a meaningful way.

I. Introduction

Climate engineering[1] has been defined as a "deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and/or its impacts through, *inter alia*, sunlight reflection methods or removing greenhouse gases from the atmosphere", although there is no uniform definition for the term.[2] Proposed climate engineering methods are commonly split into categories of either carbon dioxide removal (CDR) – techniques that remove greenhouse gases from the atmosphere, such as ocean fertilization, biochar, afforestation, and direct air capture –, or solar radiation management (SRM) – techniques that modify the Earth's radiation budget through albedo enhancement, including stratospheric aerosol injection, cloud whitening, space mirrors, and desert reflectors.[3]

As global greenhouse gas emissions continue to rise and climate change scenarios become increasingly severe, the concept of climate engineering has received growing attention. Climate change presents risks to the environment and human health – extreme temperatures and weather events, coastal inundation, threats to water and food supplies, spread of disease, and destruction of biodiversity –, and mitigation efforts continue to fall critically short of the level of action needed to avoid these impacts.[4] While climate engineering could potentially help to combat certain climate change impacts, these approaches present their own risks –

* Ecologic Institute, Berlin, Germany and Washington, DC; email: elizabeth.tedsen@eius.org; gesa.homann@ecologic.eu.

1 Also referred to as "geoengineering" or "climate remediation".

2 Secretariat of the Convention on Biological Diversity, *Geoengineering in Relation to the Convention on Biological Diversity: Technical and Regulatory Matters*, Technical Series No. 66 (Montreal: CBD, 2012).

3 See 245–284; Royal Society (UK), Geoengineering the Climate?: Science, Governance and Uncertainty (London: The Royal Society, 2009)Geoengineering the Climate: History and Prospect," 25 *Annual Review of Energy and the Environment* (2000), 245; Royal Society, *Geoengineering the Climate: Science, Governance and Uncertainty* (London: The Royal Society, 2009); Bipartisan Policy Center, *Geoengineering: A National Strategic Plan for Research on the Potential Effectiveness, Feasibility, and Consequences of Climate Remediation Technologies*, Task Force On Climate Remediation Research (Washington, DC: BPC, 2011).

4 IPCC, *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva: IPCC, 2007).

such as disruption of hydrological cycles, drought, flooding, and ozone layer depletion.[5] Most climate engineering options are as yet untested and the effects are highly uncertain.[6]

Regularly invoked in climate engineering debates, the precautionary principle – or precautionary approach – is a concept for guiding decision-making in the face of risk and uncertainty, often characterized by the adage "better safe than sorry". It has been used in arguments for, as well as against, climate engineering. On one hand, the principle can suggest that caution be applied in using climate engineering, so as to minimize the (unknown) risks to the environment and health. On the other, arguments can be made that climate engineering *is* a precautionary measure against the (known) risks of climate change. As such, application of the precautionary principle to climate engineering remains unclear. Less clear still is how to operationalize the principle. Although widely deliberated in climate engineering discourse, the principle's concrete application remains ambiguous.

This article provides an overview of this debate and what the precautionary principle means in a climate engineering context. It explores, first, how the precautionary principle is interpreted in international law, examining its history, content, legal nature, and operationalization in other issue areas. Next, the authors consider how the principle can be applied in a climate engineering context, both generally and under existing legal instruments. Finally, the article offers reflections on how the principle can be further operationalized in the context of climate engineering.

II. The Precautionary Principle in International Law

1. History and Development

The precautionary principle emerged as a response to concerns that environmental and health problems were outpacing society's ability to understand and respond to them.[7] While use of the term "precautionary principle" came later, the idea dates to at least the early 1970s.[8] The *Vorsorgeprinzip* originated in 1971 as a key principle of German environmental protection, although it translates as "foresight" rather than "precaution". The principle emerged widely on the international scene in the 1980s and 1990s,[9] where it was quickly accepted and taken up.

The principle was first endorsed internationally in the 1982 World Charter for Nature[10], although its first explicit use was in the 1987 Second International Conference on the Protection of the North Sea.[11] It has since been widely adopted in other international instruments such as the Montreal Protocol,[12] United Nations Framework Convention on Climate Change (UNFCCC),[13] Convention on Biological Diversity (CBD),[14] United Nations Fish Stocks Agreement,[15] London Protocol,[16] OSPAR

5 See, e.g., Bipartisan Policy Center, "Geoengineering", supra, note 3; Secretariat for the Convention on Biological Diversity, "Geoengineering", supra, note 2.

6 See, e.g., Royal Society, *Geoengineering the Climate*, supra, note 3.

7 David Freestone and Ellen Hey, *The Precautionary Principle and International Law: The Challenge of Implementation* (The Hague: Kluwer Law International, 1996), at 4; David Kriebel et al., "The Precautionary Principle in Environmental Science", 109 *Environmental Health Perspectives* (2001), 871.

8 Jonathan B. Wiener, *Whose Precaution After All? A Comment on the Comparison and Evolution of Risk Regulatory Systems* (Durham: Duke Law School, 2003).

9 Likely following a German proposal at the International North Sea Ministerial Conference in 1983, see Freestone and Hey, *The Precautionary Principle*, supra, note 7.

10 World Charter for Nature, UN Doc. A/37/51 (1982), 22 *International Legal Materials* (1983), 455.

11 Terry Iverson and Charles Perrings, *The Precautionary Principle and Global Environmental Change* (Nairobi: UNEP, 2011), at 4; Harald Hohmann, *Precautionary Legal Duties and Principles of Modern International Environmental Law* (London: Graham & Trotman/Martinus Nijhoff, 1994), at 333-334; Mary Stevens, "The Precautionary Principle in the International Arena," 2 *Sustainable Development Law & Policy* (2002), 13.

12 Montreal Protocol on Substances that Deplete the Ozone Layer to the Vienna Convention for the Protection of the Ozone Layer, Montreal, 16 September 1987, in force 1 January 1989, 1522 *United Nations Treaty Series* (1987), 3, Preamble.

13 United Nations Framework Convention on Climate Change, 9 May 1992, in force 21 March 1994, 1771 *United Nations Treaty Series* (1992), 107, Art. 3(3).

14 Convention on Biological Diversity, 5 June 1992, in force 29 December 1993, 1760 *United Nations Treaty Series* (1992), 79, Preamble.

15 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 4 August 1995, in force 11 December 2001, 2167 *United Nations Treaty Series* (1995), 107, Arts. 5(c) and 6.

16 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London, 7 November 1996, in force 24 March 2006, 36 *International Legal Materials* (1997), 7, Art. 3(1).

Convention,[17] Stockholm Convention on Persistent Organic Pollutants,[18] and Cartagena Protocol on Biosafety.[19] In 1992, the precautionary principle was laid down in the Maastricht Treaty of the European Union (EU). Through integration into the operational articles of primary EU law, it became a major principle of EU environment policy.

The most frequently used articulation of the precautionary principle comes from the 1992 Rio Declaration on Environment and Development, stating:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[20]

Over the past twenty to thirty years, a precautionary approach has served as a central element of nearly every relevant international agreement covering environmental protection, risk, and uncertainty.[21] As new and increasingly complex environmental issues have arisen, perception of the need for a precautionary approach has heightened and the principle has become further developed and articulated.[22]

2. Definition and Content of the Principle

Intuitive on its face, the precautionary principle is in fact hard to pin down and has no uniform definition or usage. Generally, two understandings of the precautionary principle exist: The first requires States to act with care and foresight when making decisions concerning activities that may have adverse impacts on the environment. This is also commonly understood as the preventative principle. Certain versions of the precautionary principle use precaution and prevention interchangeably, especially in the German law tradition. In this sense, some legal instruments require States to take precautionary measures to *prevent*, anticipate, or minimize risks.

Other references to the precautionary principle lead to an alternative interpretation: Here, the lack of scientific knowledge of risks cannot justify a failure to take appropriate action.[23] This version goes beyond prevention as it requires policymakers to address issues before impacts are clearly established.[24] The primary difference between these two meanings may be seen in that *prevention* applies to *known risks*, whereas *precaution* applies to *uncertainties*.[25] Trouwborst argues that this distinction is, however, difficult to operationalize, and that the precautionary principle should be regarded as the most developed form of the preventative principle, requiring States to act in spite of uncertainty.[26] In either case, environmental degradation is to be prevented, though the latter meaning is likely that which most legal authors and advocates have in mind when referring to the precautionary principle.

Following this understanding of precaution, there are additionally a number of different formulations of the principle. Wiener describes these versions as "uncertainty does not justify inaction"; "uncertainty justifies action"; and the "shifting of the burden of proof", meaning potentially risky

17 Convention for the Protection of the Marine Environment of the North-East Atlantic, 22 September 1992, in force 25 March 1998, 32 *International Legal Materials* (1993), 1072, Art. 2.

18 Stockholm Convention on Persistent Organic Pollutants, 22 May 2001, in force 17 May 2004, 2256 *United Nations Treaty Series* (2001), 119.

19 Cartagena Protocol on Biosafety to the Convention on Biological Diversity, 1 January 2000, in force 11 September 2003, 39 *International Legal Materials* (2000), 1027, Preamble, Art. 1; see also below.

20 Rio Declaration on Environment and Development, UN Doc. A/CONF.151/26, 31 *International Legal Materials* (1992), 874, Principle 15.

21 Markus Böckenförde, "The Operationalization of the Precautionary Approach in International Environmental Law Treaties – Enhancement or Façade Ten Years After Rio?", 63 *Zeitschrift Für Ausländisches Öffentliches Recht Und Völkerrecht* (2003), 313; Kriebel et al., "The Precautionary Principle", supra, note 7.

22 Claudia Saladin, "The Precautionary Principle in International Law", 6 *International Journal of Occupational and Environmental Health* (2000), 270, at 275.

23 Böckenförde, "Operationalization", supra, note 21; Philippe Sands, *Principles of International Environmental Law*, 2nd ed. (Cambridge: Cambridge University Press 2003), at 272; Arie Trouwborst, *Precautionary Rights and Duties of States* (Leiden: Martinus Nijhoff Publishers, 2006).

24 Roberto Andorno, "The Precautionary Principle: A New Legal Standard for a Technological Age", 1 *Journal of International Biotechnology Law* (2004), 11, at 17; Trouwborst, *Precautionary Rights*, supra, note 23.

25 See Jonathan Wiener, "Precaution", in Jutta Brunée, Daniel Bodansky, and Ellen Hey (eds.), *The Oxford Handbook of International Environmental Law* (Oxford: Oxford University Press, 2007), 597, at 603; Trouwborst, *Precautionary Rights*, supra, note 23.

26 Trouwborst, *Precautionary Rights*, supra, note 23.

activities are forbidden until it can be demonstrated that they pose no risk or an acceptable risk.[27]

There have been attempts to clarify the principle's meaning and make it easier to apply; for example, through a statement of scientists and policymakers at the 1998 Wingspread Conference and with common guidelines adopted by the European Commission in 2000[28] and later endorsed in a Council of the European Union Resolution.[29]

Interestingly, while many international documents refer to the precautionary principle, they often do not offer a definition of the term. Trouwborst proposes that the unspecified references indicate at least some common understanding of the principle's elements. Andorno identified, drawing from international legal and policy instruments, the following elements that are used in the adoption of precautionary measures: uncertainty of risk, scientific assessment of risk, proportionality, a shifting burden of proof,[30] and serious and irreversible damage.[31]

According to the European Environment Agency, a primary role of the precautionary principle is to facilitate discussion and public engagement in agenda-setting and decision-making.[32] Another component of some versions is that precautionary actions be "cost-effective" in preventing environmental harm, although valuations of direct and indirect impacts and of environmental commodities can be challenging.[33] Perhaps the most important element of the precautionary principle, however, is timing. The principle redefines rules on the control of environmental risks and environmental protection, bringing them into play at an earlier stage.[34]

3. Legal Nature

As a source of international law,[35] the precautionary principle is controversial and debate revolves around whether the principle is binding, on whom, and imposing what duties. The principle's status under customary international law – for which state practice and *opinio juris* is needed – has not been clearly established, but some authors identify purported state practice in this regard.[36] Views differ on this, particularly across the Atlantic: Whereas the United States tends to deny that the precautionary principle is a source of international law, preferring to use the term "approach", the EU has argued that it is, if not customary international law, at least a general principle of law.[37] Regardless, the precautionary principle has been widely affirmed in legal documents, invoked in international courts,[38] and regularly referred to in international environmental discourses, and its legal status can be seen as evolving and indeterminate.[39]

However, even if considered to constitute binding international law, the principle is not binding for private actors. With a few exceptions, individu-

27 David Hunter, James E. Salzman, and Durwood Zaelke, *International Environmental Law and Policy*, 3rd ed. (New York, N.Y.: Foundation Press, 2007), at 511; Wiener, "Precaution", supra, note 25.

28 European Commission, Communication on the Precautionary Principle, COM(2000) 1.

29 European Council, Conclusions of the Presidency, Nice, 7 to 10 December 2000, Annex III, available on the Internet at <http://www.europarl.europa.eu/summits> (last accessed on 30 March 2013).

30 However, in the recent *Pulp Mills* judgment, the International Court of Justice stated that while a precautionary approach may be relevant in treaty interpretation and application, it does not follow that it operates as a reversal of the burden of proof, see ICJ, *Pulp Mills on the River Uruguay (Argentina/Uruguay)*, Judgment, 20 April 2010, *ICJ Reports* (2010), at 61, para 164.

31 Andorno, "Precautionary Principle", supra, note 24.

32 European Environment Agency, *Late Lessons from Early Warnings: Science, Precaution, Innovation* (Copenhagen: EEA, 2013).

33 Iverson and Perrings, *Precautionary Principle*, supra, note 11, at 8.

34 Patricia Birnie, Alan Boyle and Catherine Redgwell, *International Law & the Environment*, 3rd ed. (Oxford: Oxford University Press, 2009), at 163.

35 Article 38(1) of the Statute of the International Court of Justice defines the commonly acknowledged sources of international law, which are: international agreements, customary rules, general principles of law recognized by civilized nations, and the subsidiary sources of judicial decisions and the teachings of the most highly qualified publicists.

36 Sands, *Principles*, supra, note 23.

37 See e.g., ibid., at 277. Nonetheless, although differing in terminology, in practice, the EU is not necessarily more precautionary than the United States, as each jurisdiction is more precautionary about certain risks and often employs different risk management approaches; see Jonathan B. Wiener, Michael D. Rogers, James K. Hammitt, and Peter H. Sand, *The Reality of Precaution: Comparing Risk Regulation in the United States and Europe* (Washington D.C.: Resources for the Future Press, 2011).

38 See *Pulp Mills on the river Uruguay*, supra, note 30; *Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to Activities in the Area (Request for Advisory Opinion submitted to the Seabed Disputes Chamber)*, 1 February 2008, Seabed Disputes Chamber of the International Tribune for the Law of the Sea, paras. 125-135.

39 See Hunter et al., *International Environmental Law*, supra, note 27, at 511; Alexander Proelß, "Raum und Umwelt im Völkerrecht", in Graf Vitzthum (ed.), *Völkerrecht*, 5th ed. (Berlin: Walter de Gruyter, 2010), at 464; Sands, *Principles*, supra, note 23.

als are not subject to international law, and states must instead pass on obligations to citizens within their jurisdiction. Thus, the actual legal nature of the precautionary principle, and states' responsibility, is not the final word. This aspect is pertinent for climate engineering debates, where there are fears of a "Greenfinger" – a single actor with the power to shape the global environment. In July 2012, for instance, an American entrepreneur, Russ George, carried out a private ocean fertilization experiment in the Canadian Pacific, followed by an enormous outcry in the media.[40] Nonetheless, there arguably was no breach of international law by George – neither under principles of international law nor under the climate engineering frameworks of the London Convention (LC) and London Protocol (LP), and the CBD (discussed below), which do not directly apply to George as a private actor and are additionally non-binding frameworks.

4. Operationalization

There are substantial challenges to determining how to operationalize the precautionary principle. Despite wide application in international treaties and declarations, the principle remains ill-defined and offers little practical direction for decision-making absent further steps to operationalize.[41] As Elliot notes, the principle standing alone leaves questions unanswered, such as the level and type of harm that would justify action, the amount of knowledge needed to justify action, the types of actions that would be appropriate as precautionary measures, and under what circumstances these would be appropriate.[42]

Most formulations of the principle either rule out action or describe reasons (e.g., lack of scientific certainty) for avoiding it. Or, if calling for precautionary action, the scope or content of such measures can vary from complete prohibition to increased oversight and monitoring. Often, activities are simply delayed until further scientific evidence can be gathered to demonstrate a lack of harm.[43] Other potential measures include impact assessment, labelling, pre-market testing, research, and insurance bonds.[44]

Some of the challenges for operationalization can be seen as related to a multiplicity of uncertainty and risks, and lack of guidance as to *which* of these should guide action. For example, Sunstein highlights how the principle can be "paralyzing" – dictating neither regulation nor non-regulation, particularly where there are opposing environmental issues.[45] Precaution against one type of risk can result in increases in other, countervailing risks.[46] This is highly relevant for climate engineering, where risks are weighed against climate change impacts.

The precautionary principle is commonly referred to in treaties' perambulatory provisions, in broad declarations without accompanying action, although concrete obligations may alternatively be imposed through operational provisions or protocols. For example, the CBD recognizes the principle generally in its preamble, but the principle is then operationalized, in certain aspects, in its Cartagena Protocol on Biosafety.[47] The Cartagena Protocol establishes a framework for the movement of genetically modified crops between countries, stating that a lack of scientific certainty should not prevent a party from taking a decision to restrict and import.[48] The Protocol instructs that decisions should be based on a risk assessment and sets forth principles and methodology guidelines for assessing risk, although no thresholds are specified.[49]

As another example, Article 6 of the UN Fish Stocks Agreement, which is binding and part of the treaty's operational provisions, details steps for a

40 Martin Lukacs, "World's Biggest Geoengineering Experiment 'Violates' UN Rules", The Guardian, 15 October 2012.

41 Kevin Elliot, "Geoengineering and the Precautionary Principle", 24 *International Journal of Applied Philosophy* (2010), 237, at 238.

42 Ibid., at 239.

43 Hunter et al., *International Environmental Law*, supra, note 27, at 511.

44 Ibid., at 516; Andorno, "Precautionary Principle", supra, note 24, at 18.

45 Cass R. Sunstein, "Beyond the Precautionary Principle," 15 *University of Pennsylvania Law Review* (2003), 1003, at 1020.

46 Jonathan B. Wiener, "The Real Pattern of Precaution", in Wiener et al. (eds.), *The Reality of Precaution*, supra, note 37, at 545.

47 See W. Bradnee Chambers, *Interlinkages and the Effectiveness of Multilateral Environmental Agreements* (Tokyo: United Nations University 2008), at 520; Böckenförde, "Operationalization", supra, note 21, at 314; Steve Maguire and Jaye Ellis, "Redistributing the Burden of Scientific Uncertainty: Implications of the Precautionary Principle for State and Nonstate Actors", 11 *Global Governance* (2005), 505, at 525.

48 Cartagena Protocol, Arts. 10(6), 11(8).

49 Art. 15, Annex III; see also Chambers, *Interlinkages*, supra, note 51, at 520.

precautionary approach to straddling fish stocks, including establishing reference points to guide action, as are further described in Annex II.[50] Article 6 provides that, *inter alia*, the absence of adequate scientific information should not be a reason for postponing or failing to undertake conservation measures; caution shall be undertaken when information is uncertain or inadequate; States shall determine on the basis of best scientific information stock-specific reference points and actions to be taken if exceeded; species of concern shall be subject to enhanced monitoring and measures revised accordingly; and new measures shall be adopted as soon as possible for new or exploratory fisheries and remain in force until there is sufficient data to assess stocks' long-term sustainability.

Rather than an instruction manual for risk regulation, the precautionary principle is intended to steer policy towards foresight and put in place preventative measures before waiting for absolute proof of harm to be established.[51] The principle is not concrete by nature, but can serve as a guide for careful governance.

III. The Precautionary Principle and Climate Engineering

1. General Considerations

For climate engineering, the precautionary principle has a dual nature: Where the principle may be seen to caution against climate engineering given its uncertainty and risk, it can also be understood to plausibly support climate engineering as a precautionary measure against climate change risks. The principle can be used in arguments against untested and potentially hazardous climate engineering, or alternatively, the severe risks of climate change and lack of effective mitigation can support an interpretation legitimizing climate engineering research and/or deployment.[52]

Application of the precautionary principle to climate engineering depends on the specific formulation of the principle as well as the special climate engineering option at issue.[53] Elliot argues that there are both so many different versions of the principle and so many potential climate engineering techniques that there cannot be a simple relationship between the two.[54] Just as the precautionary principle can be given multiple interpretations, the developing field of climate engineering covers a diverse, and greatly varied, range of concepts.

The potential impacts of proposed SRM techniques are frequently considered to be of both greater uncertainty and higher risk than those for proposed CDR techniques, resulting in stronger calls for precautionary governance measure for SRM than for CDR.[55] CDR is considered closer to traditional mitigation, and more likely to be favoured as a prospective measure against climate change, whereas SRM is largely considered as a future option to be used only should all other efforts fail and climate impacts grow sufficiently catastrophic.[56]

How the precautionary principle applies to climate engineering depends not only upon the version of the principle used and techniques addressed, but also on the stage of activity.[57] For instance, a

50 See Maguire and Ellis, "Redistributing the Burden", supra, note 47, at 522.

51 Robert V. Percival, "Who's Afraid of the Precautionary Principle?", 23 *Pace Environmental Law Review* (2006); Maguire and Ellis, "Redistributing the Burden", supra, note 47, at 522.

52 See e.g., William Daniel Davis, "What Does 'Green' Mean? Anthropogenic Climate Change, Geoengineering, and International Environmental Law", 43 *Georgia Law Review* (2009), 901, at 931; Lauren Hartzell-Nichols, "Precaution and Solar Radiation Management", 15 *Ethics, Policy & Environment* (2012), 159; Daniel Bodansky, "The Who, What, and Wherefore of Geoengineering Governance", 2012, available on the Internet at <http://ssrn.com/abstract=2168850> (last accessed on 15 March 2013), at 5; Ralph Bodle, "Geoengineering and International Law: The Search For Common Legal Ground," 46 *Tulsa Law Review* (2010), 305, at 311.

53 Elliot, "Geoengineering", supra, note 41; Hartzell-Nichols, "Precaution", supra, note 52, at 159; Davis, "What Does 'Green' Mean", supra, note 52.

54 Elliot, "Geoengineering", supra, note 41.

55 See e.g., Solar Radiation Management Governance Initiative, "Solar Radiation Management: The Governance of Research", 1 December 2010, available on the Internet at <http://www.srmgi.org/files/2012/01/DES2391_SRMGI-report_web_11112.pdf> (last accessed 15 March 2013).

56 Royal Society, *Geoengineering the Climate*, supra, note 3, at 58–59; M. Granger Morgan and Katharine Ricke, *Cooling the Earth Through Solar Radiation Management: The Need for Research and an Approach to its Governance* (Geneva: International Risk Governance Council, 2010), at 10; Elliot, "Geoengineering", supra, note 41, at 243-245.

57 Many proposals for geoengineering governance focus on research, rather than deployment, see e.g., Steve Rayner et al., "Memorandum on Draft Principles for the Conduct of Geoengineering Research", 2009, available on the Internet at <http://www.geoengineering.ox.ac.uk/oxford-principles/history> (last accessed on 15 March 2013); Asilomar Scientific Organizing Committee, *The Asilomar Conference Recommendations on Principles for Research into Climate Engineering Techniques* (Washington, DC: Climate Institute, 2010); Morgan and Ricke, *Cooling the Earth*, supra, note 56.

precautionary approach to research would differ from that for deployment. Long and Winkoff argue that a precautionary approach requires a moratorium on deployment of high-risk climate engineering technologies while research proceeds.[58] A distinction is commonly made between research and deployment; however, this is a simplification and it is unclear where a line is drawn between the two. "Research" can encompass activities ranging from modelling to outdoor field testing, with the implicit intention of investigating techniques. "Deployment" is seen to apply to larger-scale, programmatic activity designed to alter the Earth's climate system. Nonetheless, there is no clear threshold for a scale of activity that denotes deployment, and intention is subjective.

Proposals for a precautionary approach to climate engineering range from supporting increased research into potential hazards[59] to a complete ban on all activities.[60] Davis finds that the principle would likely lead to a ban on all climate engineering options, based on its prominence in international law as well as on the inability of climate engineering proponents to successfully demonstrate proposals' safety.[61] Bodansky suggests that, as consensus on climate engineering governance will be difficult to reach, the international community might opt for a ban on climate engineering "on grounds of 'precaution'" as it is "generally easier to prohibit an activity than to regulate it."[62] Rickels et al. write that the precautionary principle can help to weigh techniques' risks according to their relationship to climate change objectives, and suggest that it may be necessary to accept some degree of environmental damage in exchange for climate protection.[63] As a rule, the precautionary principle does not dictate a course of action for climate engineering decision-making and absent further operationalization, can only offer guidance and open the door to further questions.[64]

2. Linkages between the Precautionary Principle and Climate Engineering in International Law

Application of the precautionary principle may also be considered under specific instruments with – either explicit or implicit – application for climate engineering.[65] The UNFCCC covers the subject of climate change and explicitly incorporates the precautionary principle. UNFCCC Article 3(3) requires parties to "take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects" and instructs that "[w]here there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective." Precautionary measures should also "be comprehensive" and "cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation."[66] This provision was originally intended to prevent States from postponing mitigation measures based on a lack of scientific uncertainty regarding climate change.[67] Article 3(3) can, however, also be interpreted as supporting climate engineering where such approaches help mitigate the adverse effects of climate change. Embracing this interpretation, uncertainty regarding the risks and impacts of climate engineering techniques should not be used as a reason to delay use for mitigating climate change impacts, through removal of greenhouse

58 Jane Long and David Winickoff, "Governing Geoengineering Research: Principles and Process", 1 *Solutions Journal* (2010), 60.

59 See e.g., Elliot, "Geoengineering", supra, note 41.

60 See e.g., ETC Group, "Geoengineering's Governance Vacuum: Unilateralism and the Future of the Planet Prepared by ETC Group for the U.S. National Academies Workshop: Geoengineering Options to Respond to Climate Change – Steps to Establish a Research Agenda", Presentation at the U.S. National Academies Workshop "Geoengineering Options to Respond to Climate Change: Steps to Establish a Research Agenda", Washington, DC, 2009.

61 Davis, "What Does 'Green' Mean", supra, note 52.

62 Daniel Bodansky, "May We Engineer the Climate?," 33 *Climatic Change* (1996), 309, at 309, 319.

63 Wilfried Rickels et al., *Large-Scale Intentional Interventions into the Climate System? Assessing the Climate Engineering Debate* (Kiel: Kiel Earth Institute 2011), at 102.

64 Royal Society, *Geoengineering the Climate*, supra, note 3, at 38.

65 For a detailed review of the international legal framework as applied to climate engineering, see Ralph Bodle et al., Regulatory Framework for Climate-related Geoengineering Relevant to the Convention on Biological Diversity, UNEP/CBD/SBSTTA/16/INF/29, 2 April 2012.

66 UNFCCC, Art. 3(3).

67 Bodle, "Geoengineering and International Law", supra, note 52, at 310.

gases from the atmosphere (CDR) or through alleviating the effects of rising temperatures (SRM). Bodle writes that as Article 3(3) can serve as the basis for arguments both for and against climate engineering, it therefore does not resolve the conflict between two conflicting environmental objectives and risks.[68]

UNFCCC Article 4 does not expressly mandate a precautionary approach, but is also of relevance. Article 4(1)(d) requires parties to "[p]romote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases ... including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems", which could arguably support implementation of CDR projects such as ocean fertilization or biochar removal.[69] Article 4(1)(g) covers obligations for research cooperation to "further the understanding and to reduce or eliminate the remaining uncertainties" regarding climate change and response strategies," perhaps supporting climate engineering research collaboration.[70] Article 4(1)(f) requires parties to "employ appropriate methods" so as to minimize the adverse effects of climate change mitigation and adaptation measures on the economy, public health, and the environment, and could be construed as requiring caution in applying climate engineering if such strategies are interpreted as a mitigation or adaptation measure.[71]

The CBD, which adopts the precautionary principle in its Preamble, has expressly addressed climate engineering in a series of (non-binding) decisions by the Conference of the Parties (COP). The 2010 decision X/33 invites parties to ensure that, in accordance with a precautionary approach and CBD Article 14 (on impact assessment) and in the absence of science-based, global, transparent, and effective control and regulatory mechanisms, no climate engineering activities that affect biodiversity take place until there is an adequate scientific basis on which to justify activities and appropriate consideration of risks and impacts. An exception was made for small-scale scientific research studies conducted in a controlled setting, justified by the need to gather scientific data, and subject to impact assessment.[72] This de facto moratorium expanded the scope of an earlier decision on ocean fertilization.[73] In 2012, decision XI/20 reaffirmed decision X/33[74] and noted that the application of the precautionary approach, customary international law, and States' obligations, including for impact assessment, are relevant but form an incomplete basis for global regulation.[75]

The CBD's decisions followed and incorporated action under the LC/LP on ocean fertilization.[76] Resolution LC-LP.1 was adopted by the LC/LP contracting parties in 2008, who found that no ocean fertilization other than legitimate scientific research should be allowed given current knowledge and agreed to set up a framework for assessing scientific research proposals. This non-binding framework for assessment was adopted in 2010 and guides contracting parties in evaluation of ocean fertilization research proposals.[77] Proposals must assess risks and detail the experiment's characteristics, bounds, and anticipated or potential effects.[78] The section on risk management[79] includes mitigation, contingency planning, and monitoring and is based on a precautionary approach.[80] Decision-making also calls for a precautionary approach, instructing parties that "[i]f the risks and/or uncertainties are so high as to be deemed unacceptable, with respect to the protection of the marine environment, taking

68 Ibid., at 311.

69 Albert C. Lin, "International Legal Regimes and Principles Relevant to Geoengineering", in William C.G. Burns and Andrew Strauss, *Geoengineering the Climate: Law, Ethics and Policy Considerations* (Cambridge: Cambridge University Press, 2013); Rickels et al., *Large-Scale Intentional Interventions*, supra, note 64, at 102.

70 Ibid.

71 Bodle, "Geoengineering and International Law", supra, note 52, at 310.

72 Decision X/33, Biodiversity and Climate Change, Para. 8(w), UN Doc. UNEP/CBD/COP/DEC/X/33, 29 October 2010.

73 Decision IX/16, Biodiversity and Climate Change, Footnote 76, UN Doc. UNEP/CBD/COP/DEC/IX/16, 9 October 2008.

74 Decision XI/20, Climate-related Geoengineering, para. 1, UN Doc. UNEP/CBD/COP/DEC/XI/20, 5 December 2012.

75 Ibid., para. 11.

76 The treaty bodies have interpreted "dumping" under the LC/LP to include ocean fertilization activities.

77 Resolution LC-LP.2(2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization, 14 October 2010.

78 Ibid., Sec. 3.5, Annex 6.

79 Ibid., Sec. 3.6, annex 6.

80 Ibid., Annex 6

into account the precautionary approach, then a decision should be made to seek revision of or reject the proposal."[81] Since adoption of the framework, the LC/LP parties have begun consideration of incorporating marine-based climate engineering techniques other than ocean fertilization. It should be stressed that the LC/LP risk assessment framework is not binding; however, there are ongoing discussions between the parties to transfer it into binding international law.

IV. Reflections on Operationalizing the Precautionary Principle for Climate Engineering

A precautionary approach has become a fundamental component of modern international environmental law and appears often in discussions on climate engineering governance.[82] Yet the principle itself does not offer clear guidance for action. This is especially true in the context of climate engineering, where the principle's requirements prove elusive. However, as explained, the precautionary principle is not intended to be an instruction manual, but rather is a compass to guide implementing measures.[83] Thus, the most pertinent question is how can the principle help guide decision-making as to *when* to allow or prohibit climate engineering and *what* activities to allow or prohibit? Moreover, how can it support scientific certainty and decisiveness rather than create decision-making paralysis?

Following a strict version of the precautionary principle, as described by Wiener, potentially risky climate engineering activities should be limited until it can be demonstrated that they pose no *or* acceptable risk – as tailored according to assessed risks and knowledge. This, importantly, is distinguishable from a level of *no* risk. If all activities were prohibited on the basis of any evidence of harm, even small-scale climate engineering research could be outlawed.[84] Likewise, as decisions must ultimately balance risks in the face of some degree of scientific uncertainty,[85] an acceptable level of certainty must also be considered.

As observed by Elliot, there are both many formulations of the precautionary principle and many different methods of climate engineering.[86] Proposed methods vary significantly in terms of scientific understanding and risk. Likewise, there are critical variations in possible levels of activity (e.g., "small-" versus "large-" scale research or deployment, or "global" versus "regional" approaches). It is important to recognize these significant variations, rather than lump climate engineering activities into a single unit. Instead, precautionary measures should be tailored to techniques and activities. Given these differences, as well as evolving knowledge and conditions, a tailored and adaptive approach to risk regulation based on scientific assessment is needed, and one that can incorporate new information and changing circumstances, such as increased knowledge of techniques' risks (reducing uncertainty) and the need for action on climate change.

The LC/LP risk assessment framework uses an adaptive approach, allowing for individual assessments for each research proposal, evaluating known and unknown risks and calling for ongoing risk management, including monitoring. The framework provides the only concrete example of operationalizing the precautionary principle for climate engineering, prescribing a level of activity with acceptable risk/certainty ("legitimate research"), identifying steps for assessing impacts and risks, and instructing decision-makers to revise or reject proposals where risks are too high. It is limited, however, in scope, application, and the extent of operationalization. The framework, which has yet to be put to use, is non-binding and does not address techniques outside the scope of the LC/LP. Further, while the framework creates an assessment methodology, it does not set a threshold for evaluating *when* the risks of experiments are too high to permit research. The lack of a definitive threshold perhaps limits the framework's guidance and certainty; however, it also increases flexibility. While the CBD has not yet offered such an operationalizing framework, its parties have similarly shown support for risk assessment and implementation of regulatory frameworks.

81 Ibid., Sec. 4, Annex 6.

82 Hohmann, *Precautionary Legal Duties*, supra, note 11.

83 Percival, Who's Afraid", supra, note 53; Maguire and Ellis, "Redistributing the Burden", supra, note 47.

84 Elliot, "Geoengineering", supra, note 41; Davis, "What Does 'Green' Mean", supra, note 52.

85 Rickels et al., *Large-Scale Intentional Interventions*, supra, note 64, at 102, 103.

86 Elliot, "Geoengineering", supra, note 41.

To date, the CBD and LC/LP are the only international instruments to have expressly taken up climate engineering and both have chosen to invoke a precautionary approach in doing so.[87] Through these instruments, state actors have begun to operationalize and define this approach for climate engineering: requiring assessment of impacts to evaluate risks, limiting use of climate engineering (until greater certainty) to small-scale activities and research, and even excluding certain techniques from categorization as climate engineering (e.g. CCS under CBD decision X/33).

These actions also signal normative trends on climate engineering as part of the evolving international debate. While legally non-binding, the CBD and LC/LP decisions represent consensus by a large grouping of states and the normative precedent of these decisions is significant for climate engineering governance.[88] The development of climate engineering norms may help to eventually shape risk management frameworks and the course of climate engineering action.[89] In addition to state actors, norms can be developed through "bottom up" efforts.[90] Maguire and Ellis suggest that the precautionary principle has influenced both state *and* non-state actors in consideration of climate engineering risks.[91] The precautionary principle may have weak legal influence, particularly given its uncertain status under international law, but can still guide action and provide an evaluative standard by which to assess climate engineering activities.[92]

For climate engineering, the precautionary principle should consider not only the uncertainties and risks related to particular techniques, but also the risks they seek to reduce: those of climate change.[93] The types of risks associated with climate change are relatively known and certain. Within this context, the "preventative version" of the precautionary principle should be followed, seeking to prevent and minimize the risks of climate change. At this stage, this can and should include research. The literature demonstrates increasing consensus that further research is needed to improve understanding of climate engineering risks and feasibility, and to inform contemplated use, for example, should the climate reach a "tipping point".[94] Decision-makers may choose not to deploy climate engineering, but an informed choice between risks is preferable and a precautionary approach to climate change may entail investigating a further portfolio of options.[95] Clear guidance on evaluating uncertainty and risks could help to control and limit the effects of research, while also avoiding an excess of precaution that blocks innovation.[96]

There is, however, legitimate concern that climate engineering efforts, including research, present a moral hazard, potentially undermining climate mitigation and adaptation efforts.[97] It must be emphasized that climate change risk management should focus first on stringent action on mitigation, and that allowing for exploration of climate engineering should not permit deviation from this objective. There is still broad consensus that the best and most crucial preventative measures for climate change involve reducing greenhouse gas emissions.

87 In addition, carbon capture and sequestration (CCS) is debated as a climate engineering technique (ICITE) and has been addressed by both the LC/LP and the OSPAR Convention.

88 Ralph Bodle et al., Regulatory Framework, supra, note 65, para. 77; Lin, "International Legal Regimes", supra, note 69; Jason Blackstock and Arunabha Ghosh, "Does Geoengineering Need a Global Response – And of what Kind?", Working Paper of the Solar Radiation Management Governance Initiative Meeting in Kavli, 21 to 24 March 2011, at 10.

89 Gosh and Blackstock, ibid., at 14.

90 David G. Victor, "On the Regulation of Geoengineering", 24 *Oxford Review of Economic Policy* (2008), 322.

91 Maguire and Ellis, *supra* note 47.

92 John Virgoe, "International Governance of a Possible Geoengineering Intervention to Combat Climate Change," 95 *Climatic Change* (2009), 103, at 111; Bodansky, "The Who, What, and Wherefore", supra, note 52, at p. 6.

93 See also Rickels et al., *Large-Scale Intentional Interventions*, supra, note 64, at 102–103.

94 Edward Parson and Lia Ernst, *International Governance of Climate Engineering* (Los Angeles: University of California Los Angeles, 2012), at 16–17: "The second strong point of consensus in the literature on CE governance is that research is needed into the feasibility, effects, and potential risks of CE technologies – and that this should begin immediately".

95 Carolyn Kousky et al., *Responding to Threats of Climate Change Mega-catastrophes* (Washington, DC: World Bank, 2009), at 3.

96 Charles Weisse, "Can there Be Science-based Precaution?", 1 *Environmental Research Letters* (2006), 1.

97 Royal Society, *Geoengineering the Climate*, supra, note 3, at 39; Rickels et al., *Large-Scale Intentional Interventions*, supra, note 64, at 103.

V. Conclusions

Although frequently invoked in climate engineering discourse, the precautionary principle has received only preliminary operationalization in this context. Through the creation of the LC/LP assessment framework and, to a lesser degree, the CBD decisions, state actors have gradually begun operationalizing the principle and establishing norms for climate engineering. Following these steps, further operationalization can help reduce ambiguity and risks. Instead of addressing climate engineering – or even categories of SRM or CDR – on the whole, precautionary measures should be tailored to the particular scientific knowledge, risks, and conditions of individual proposals, like within the LC/LP framework.

The precautionary principle has many formulations and by itself offers no clear instruction for action, leading to criticism over its utility in practice. However, the principle's true intent and value is as a guide for action, to be further implemented. Rather than create an environment of decision-making paralysis, the precautionary principle once operationalized can guide decisions to better protect the environment and human health and well-being.