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1. INTRODUCTION

This chapter considers the regulation of geoengineering, both as a distinctive form of climate technology, and as a technological product of the Anthropocene. Its aim is to show some of the constraints on that regulation which arise from embedded attitudes and pre-existing epistemic communities. The question is whether these attitudinal constraints are a welcome introduction of values and complexity into an otherwise over-technocratic approach to regulation, or whether they confuse and obstruct an optimal approach.

The first part of the chapter sketches an intuitive and simple approach to regulation, drawing on well-established ideas about the regulation of technology. The second part then moves away from this, and explores how geoengineering is regarded in public and policy discourse, and why. The conclusion then brings these together, showing how the values and attitudes represented in the discourse would not easily fit in the model of the first part. The embeddedness of technology in wider social politics complicates attempts to regulate it in a decontextualized way.

2. REGULATING GEOENGINEERING: A NAÏVE APPROACH

The Anthropocene is all about scale.[1] If humans are distinctively marking the Earth it is not so much because they are suddenly doing new things, but because they are now doing certain things to such an enormous extent that the impact begins to compete with, in the short term even to exceed, natural processes.[2] The emission of greenhouse cases is a perfect example.

As that scale implies, the actors involved in this emission, in climate change, are not just a few central powers but are multiple and diffuse, in fact most of humanity. Moreover, they have reasons for what they are doing: burning carbon fuels is something that brings enormous benefits, and only becomes problematic when too many people do it too much, as is now the case. Both of these considerations entail that addressing climate change is not realistically possible through a few simple decrees. Firstly, there are no bodies or persons with the kind of central power that would be required, and secondly, the interests involved are too complex and multi-facetted.[3] A rule 'the burning of oil is prohibited' is not going to happen, and would

[1] Paul J Crutzen, 'The "anthropocene"' (2002) 12(10) Journal de Physique IV, 1.
[2] Paul Crutzen and Will Steffen, 'How long have we been in the Anthropocene era?' (2003) 61(3) Climatic Change 251.
[3] Charles F Sabel and David G Victor, 'Governing global problems under uncertainty: making bottom-up climate policy work' (2017) 144 Climatic Change 15.

not be respected, except where it is the culmination of an intense prior process of regulation, and it is there that the real work is done. That prior process is one of management and manipulation, sometimes highly technical, sometimes less so, but always nudging, steering, and constraining.[4]

The law involved in regulating the Anthropocene is therefore not just the simple normative prohibitions of classic old-testament law or criminal law. It is rather social engineering, using both incentives and punishments to steer the behavioural supertanker that is humanity.[5] The question will be what should be incentivised, and what should be excluded, bearing in mind that the balance is part of law's effectiveness.[6] An overreliance on prohibition typically creates non-compliance. An overreliance on incentives typically creates a risk of unexpected and unwanted effects.

Geoengineering is a typically Anthropocenic phenomenon.[7] It actually aims at changing the natural environment on Earth, not just as a side-effect, as with greenhouse gas emissions, ecosystem destruction and pollution, but as a primary goal.[8] The Anthropocene is associated with global change as a side-effect, a product almost of humanity's carelessness, but it is logical that faced with the consequences of its own power humanity should then seek to take compensating actions. Stopping or limiting harmful actions is one obvious response. Developing techniques to counter their harm is another.[9] Prima facie, both are rational responses and the optimal balance between them is a case-by-case matter which, in a state of developing knowledge and technology, is not likely to be evident *ab initio*.[10]

Technology lawyers have long thought about this problem of regulating the new, addressing situations where the possibilities and consequences of technology are not yet fully clear, and are almost certain to change.[11] If the regulator waits to see how the technology develops and which risks emerge, then the risk is of being faced with a social and economic fait accompli, a status quo that is hard to change:[12] if society had been fully aware of some of the privacy, health and political risks that would emerge from the internet and social media, the regulator might have intervened early, when it was still possible, rather than letting apparently harmless entertainment facilities develop into part of the infrastructure of life, such that the public is

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[4] ibid
[5] Jessica C Lawrence, 'Managing the environment: Neoliberal governmentality in the Anthropocene' in Pasi Heikkurinen (ed), *Sustainability and peaceful coexistence for the Anthropocene* (Routledge 2017) 68; Louis J Kotzé, 'Rethinking global environmental law and governance in the Anthropocene' (2014) 32(2) Journal of Energy & Natural Resources Law 121, 146.
[6] Lawrence, Ibid; Kotzé, ibid; Gareth Davies, 'Privatisation and de-globalisation of the climate' (2013) 7(3) Carbon and Climate Law Review 187.
[7] Jeremy Baskin, *Geoengineering, the Anthropocene and the End of Nature* (Palgrave Macmillan 2019); Ina Möller, *The Emergence of Geoengineering: How Knowledge Networks Form Governance Objects* (CUP, 2023) chapter 4.3 'Anthropocene Narratives'.
[8] Ibid; Richard Owen, 'Solar radiation management and the governance of hubris' in RM Harrison and R Hester (eds) *Geoengineering of the climate system* (Royal Society of Chemistry, 2014) 212.
[9] See for discussion Möller, (n 7)
[10] Louis J Kotzé, 'Rethinking global environmental law and governance in the Anthropocene' (2014) 32(2) Journal of Energy & Natural Resources Law 121-156; Sabel and Victor (n 3).
[11] David Collingridge, 'The social control of technology' (St Martin's Press 1980); Audley Genus and Andy Stirling, 'Collingridge and the dilemma of control: Towards responsible and accountable innovation' (2018) 47(1) Research policy 61; See also Jack Stilgoe, 'Geoengineering as Collective Experimentation' (2016) 22 *Science and Engineering Ethics* 851; Jesse L Reynolds, 'Earth system interventions as technologies of the Anthropocene' (2021) 40 Environmental Innovation and Societal Transitions 132.
[12] Collingridge, ibid.

simultaneously aware of their dark side and unwilling to let them be constrained. The drug is out there.

On the other hand, if the regulator intervenes too early and too hard, then branches of science and technology that might have done great good for humanity are deprived of the chance of development.[13] A strong regulatory choice is an act of steering, away from certain kinds of development and towards others. Given that it is almost a premise, in a market-based society, and using a classically scientific mode of thinking, that the law-maker does not know everything, and that the products and technologies which will ultimately contribute and be valued are most effectively found through a process of experiment, that provides a reason to be cautious about banning or excluding new technologies, and to try and keep options open.[14]

A compromise is typically found in the use of generalisable normative constraints: general principles, reflecting values that, at least arguably, are not context specific. Taking medicine as an example, the regulator does not know which new therapies will ultimately be most effective, and does not take a stance on this. But nor does it just abdicate a regulatory role. Rather, any new medicines must comply with generalised rules on safety and effectiveness. It is then up to the essentially market-like structure of competitive research to explore the many different therapeutic paths, within that abstract framework of safety and effectiveness. The regulator does not choose the therapeutic pathway, but it sets the limits with which any and all pathways must comply.

Will the artificial and technology-based manipulation of the climate, via solar radiation management or absorption of atmospheric greenhouse gases, play any kind of significant or constructive role in dealing with climate change? It is, from any rational perspective, too early to tell. It depends partly on how the techniques themselves develop – or don't – and partly on how the alternatives – emissions reductions – progress.[15] Nobody currently has certain knowledge of either of these.

A naïve regulator might therefore seek to produce a generalised framework which does not preclude possibly positive developments, but does constrain them within normative limits. Following the medical example, they might require any use of geoengineering techniques to comply with safety and effectiveness constraints. These might be ratcheted up according to the stage of development, with no limits on purely theoretical discussions other than the peer review process, which de facto excludes public funding for essentially random and unsubstantiated claims, one degree of regulatory severity for initial field experiments, and a higher degree before approval of any at-scale usage. As with medicine, a hundred promising ideas may fail to meet the challenges of reality and be extinguished before they pass the last test. As with medicine, some may make it all the way and contribute to well-being. As with medicine, even for those approved as potentially beneficial, a cost-benefit analysis will be required before deciding whether the treatment is actually something we want to use. Expense, side-effects, effectiveness, and alternatives, are all part of the balance.

To some extent this is a banal frame, hard to argue with: normative constraints should encourage the positive while preventing the terrible. In the context of geoengineering the

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[13] ibid

[14] Alfred Nordmann, 'Responsible innovation, the art and craft of anticipation' (2014) 1(1) Journal of Responsible Innovation 87.

[15] See e.g. Patrick Moriarty and Damian Honnery, 'Renewable Energy and Energy Reductions or Solar Geoengineering for Climate Change Mitigation?' (2022) 15 *Energies* 7315.

discussion is framed in terms of governance, with a widespread insistence that adequate governance is a necessary prerequisite for geoengineering experiment and use.[16] However, the demands made of any governance framework determine whether it facilitates geoengineering, in practice blocks it, or something in between.[17] The striking fact about geoengineering governance discussions is the widespread desire for a level of governance intensity and quality that it would in practice exclude geoengineering from any serious role in climate responses in the coming years.[18] That can only be understood as the expression of an *a priori* preference that geoengineering not in fact be part of a climate change response package. Why?

3. GEOENGINEERING AS A POLITICAL ACT

3.1 Attitudes to Geoengineering

Geoengineering gets a bad press. It has a few who are openly supportive of it as an idea,[19] and a larger group who concede it might become a useful, if regrettable, tool at some point,[20] but the most dominant view in public and academic discussion is that both intellectual and scientific investment in it is a dangerous distraction from the essential and primary task of reducing greenhouse gas emissions.[21]

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[16] Aarti Gupta and others, 'Anticipatory governance of solar geoengineering: conflicting visions of the future and their links to governance proposals' (2020) 45 Current opinion in environmental sustainability, 10, 13-14; Jesse L Reynolds, 'Solar geoengineering to reduce climate change: a review of governance proposals' (2019) Proceedings of the Royal Society A, 475 2019.0255

[17] Gupta, ibid; Reynolds, ibid;

[18] Gupta, ibid; Reynolds, ibid.

[19] David W Keith, 'Geoengineering' (2001) 409 Nature 420; Edward A Parson, 'Climate policymakers and assessments must get serious about climate engineering' (2017) 114.35 Proceedings of the National Academy of Sciences 9227.

[20] Phillip Williamson and Ralph Bodle, *Update on Climate Geoengineering in Relation to the Convention on Biological Diversity: Potential Impacts and Regulatory Framework*. (Secretariat of the Convention on Biological Diversity, Technical Series No.84., 2016); Douglas G MacMartin, Ken Caldeira and David W Keith 'Solar geoengineering to limit the rate of temperature change' (2014) Phil. Trans. R. Soc. A. 372 2014.0134; Virgoe (n 20); Freiman (n 20); David G Victor and others, 'The Geoengineering Option: A Last Resort Against Global Warming?' (2009) 88(2) Foreign Affairs 64.

[21] Frank Biermann and others, 'Solar geoengineering: The case for an international non-use agreement' (2022) 13(3) Wiley Interdisciplinary Reviews: Climate Change e754; Jennie C Stephens and others, 'The dangers of mainstreaming solar geoengineering: a critique of the National Academies Report' (2023) 32(1) Environmental Politics 157; BK Sovacool, CM Baum and S Low, 'Determining our climate policy future: expert opinions about negative emissions and solar radiation management pathways' (2022) 27 *Mitigation and Adaption Strategies for Global Change* 58; Ryan Gunderson, Brian Petersen and Diana Stuart, 'A critical examination of geoengineering: economic and technical rationality in a social context' (2018) 10 Sustainability 269; Tina Sikka, 'Activism and neoliberalism: two sides of the geoengineering discourse' (2020) 31 Capitalism Nature Socialism 84; Kevin Surprise, 'Stratospheric imperialism: liberalism, (eco) modernization, and ideologies of solar geoengineering research' (2019) 3(1) Environment and Planning E: Nature and Space 141; Christopher H Trisos and others, 'Potentially dangerous consequences for biodiversity of solar geoengineering implementation and termination' (2018) (2) Nature Ecology and Evolution 475; James R Fleming, *Fixing the Sky: The Checkered History of Climate and Weather Control* (Columbia University Press; 2010); Clive Hamilton, *Earthmasters: Playing God with the Climate* (Allen & Unwin; 2013); Naomi Klein, *This Changes Everything: Capitalism versus the Climate* (Simon & Schuster; 2014) See for overview Reynolds (n 16) section 6. C.f. Gareth Davies, 'Climate change and reversed intergenerational equity: The problem of costs now, for benefits later' (2020) 10(3-4) Climate Law 266.

That hostility is prima facie a surprising reaction to an idea whose only apparent ambition is to use and develop science and technology to try and reduce the greatest current threat to humanity. One might, from a distance, think that such an attempt should be welcomed. Surely in such a crisis, anything that might help should be explored – or not?

The aim of this section is to unpack that hostility. The conclusion here is that the differences between advocates and opponents of geoengineering are best explained in terms of different values and preferences, different estimations of human behaviour, and, it will be suggested, different professional backgrounds.

To make that point, a parallel is drawn with the regulation of medical treatment. Health is a context where, as with climate change, human behaviour creates risks and causes harm. In those situations one can, as with climate change, focus on changing the harmful behaviour, or one can try and develop new techniques to reduce the harm it causes. The balance between these choices and the reasons for them involve the same kinds of consideration as with climate change: if we treat the symptoms, do we enable the underlying harmful behaviour? But if we don't, do we lead to more suffering?

The point of the comparison is not to show who is right, but to suggest that our collective responses to moral hazard – the risk that treating symptoms encourages the underlying harmful behaviour – vary according to context. Looking at the differences between the contexts might help us understand why there is more hostility to geoengineering than there is to, for example, blood pressure medication, and might reveal something about the dynamics of environmentalism and climate change policy-making.

3.2 The emergence of scientific 'solutionism'

The idea of geoengineering goes back to the last century.[22] The greenhouse effect was becoming more widely accepted and discussed, and the gravity of its consequences were gradually becoming apparent. Faced with a warming earth, it is hardly surprising that some scientists began thinking about whether there might be techniques available, or imaginable, that could counter this – just as they do when any threat to humanity or wellbeing emerges.[23] Whether it is a pandemic or an economic or refugee crisis, the range of experts and expertise in the modern world ensures that responses are always wide ranging and variable, from those who seek to address root causes, to those who have ideas that might mitigate some small part of the harm – making lifejackets available on dangerous migration routes, or having schools in refugee camps or delivering food to the immunosuppressed during covid.

The climate change threat has the important distinguishing feature that it is entirely a result of human behaviour, so that the most obvious response to it is to change that behaviour.[24] However, the distinction between natural crises and those created by humanity is more of a slippery, contestable and gradual continuum than a clear line. Whatever the nature of the problem, generally those who see a place for their skill try and use it there, whether they are addressing symptoms or causes.

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[22] Cesare Marchetti, 'On geoengineering and the CO2 problem' (1977) 1(1) Climatic Change 59. See also Stephen H Schneider, 'Geoengineering: Could—or should—we do it?' (1996) 33(3) Climatic Change 291.
[23] See Möller (n 7)
[24] Owen (n 8)

It is then not surprising that among those who first brought the idea of deliberate solar radiation management to prominence were not environmentalists, but rather a physicist, Cesare Micheletti, an engineer, David Keith, and, in particular, an atmospheric chemist, Paul Crutzen, whose 2006 article ignited the contemporary debate.[25] Nevertheless, he was not happy with the idea: he did not put it forward as a wonder-drug, since he could see that it brought considerable risks and uncertainties and was far from a perfect solution. Rather, he suggested just that it could be done – that inserting sulphur aerosols into the upper atmosphere was possible, and could, on the basis of fairly well understood atmospheric science be expected to have a cooling effect – and that given the dangers of global warming humanity might be wise to have this technique in reserve in case it ever became necessary to avert catastrophic temperature rise. It was an insurance policy, a second best, not a best practice policy choice.[26]

Since then, geoengineering ideas have expanded, with the pace of theoretical innovation picking up in recent years.[27] Some, like Crutzen, have focussed on the idea of reflecting more sunlight, using techniques from the highly speculative to the mundane, from mirrors in space to painting rooves white, with somewhere in between the suggestion of modifying clouds to make them more reflective. Alongside this, more and more scientists have begun to think about how Carbon Dioxide could be actively absorbed from the atmosphere: rather than stop the emissions, take them out of the atmosphere afterwards. Once again, the techniques vary from the everyday to the high-tech, with planting trees and restoring woodland at one end, and industrial CO2 capture installations at the other, passing through ocean fertilisation and enhanced rock weathering in between. Most importantly, what is distinctive about Negative Emissions Technologies, as they tend to be called at the moment, is that the potential scale of their impact is very variable. The major Solar Radiation Management techniques, which are the use of aerosols a la Crutzen, and cloud modification, are both suggested to be potentially enormously powerful, capable of creating multiple degrees of cooling.[28] By contrast, many NETs, such as restoring forests, protecting sea grass and seaweed growth, preventing soil degradation, and even the use of artificial trees, are accepted to have limits to their maximum effects.[29] At best they would make a small, if non-trivial, contribution to reducing CO2 levels. On the other hand, there have been techniques proposed of which it was suggested that they could be as impactful as SRM. Notably, within a lively discussion about ocean fertilisation it has been suggested that at best this could entirely absorb excess human CO2 emissions, and some have made similarly significant claims about the use of alkaline rocks to enhance CO2 absorption by the oceans, and about enhanced rock weathering - spreading rock powder on soil where it reacts with atmospheric CO2 and captures it.[30] Similarly, some have taken reforestation beyond the comfort zone of most, and discussed reforesting the Sahara, and similarly dramatic interventions, which, perhaps, if achieved, might absorb CO2 on a scale

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[25] Paul Crutzen, 'Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?' (2006) 77 Climatic Change 211.

[26] Virgoe (n 20); Freiman (n 20); Victor and others (n 20); Ryan Gunderson, Diana Stuart & Brian Petersen, 'The Political Economy of Geoengineering as Plan B: Technological Rationality, Moral Hazard, and New Technology' (2019) 24(5) New Political Economy 696. C.f. Augustin Fragniere and Stephen M Gardiner, 'Why geoengineering is not "Plan B"' in Christopher J Preston (ed) *Climate justice and geoengineering: Ethics and policy in the Atmospheric Anthropocene* (Rowman and Littlefield 2016) 15.

[27] For a moderately recent overview see Williamson and Bodle (n 20)

[28] Royal Society *Geoengineering the Climate: Science,Governance and Uncertainty* RS Policy document 10/09 (The Royal Society 2009); Jesse L Reynolds, *The governance of solar geoengineering: managing climate change in the Anthropocene* (CUP 2019).

[29] Royal Society, ibid

[30] ibid

that looks more like a solution than a mitigation.[31] This is, despite its low-tech nature, the kind of idea that is perhaps most deserving of the name geoengineering. It truly does reimagine what the planet might look like, and how humanity could consciously and deliberately intervene to realise those dreams.

At the same time, the name 'geoengineering' has certainly become tainted over the years, and particularly advocates of NETs, and particularly advocates of low-tech apparently 'natural' NETs tend to avoid it, and to describe their ideas in less controversial terms – better, from the perspective of professional acceptance, to emphasise how restoring soils or undersea forests to health can have a positive climate impact than to say you have an idea to engineer the planet - better to be an ecologist than a would-be master of the climate.[32] Hubris is not well-received.[33] On the other hand, there are also those who continue to be open about their desire to use technology to cure this planetary lifestyle disease, and this range of ideological perspectives has led to a fragmentation and proliferation of terms, from geoengineering to climate engineering to negative emissions technologies to climate restoration and, simply, mitigation. The label, sometimes the absence of a label, often indicates where the authors are positioning themselves in the debate.

3.3 Hostility to geoengineering

Yet something that links all these techniques is that where it is suggested that their impact on climate change could be very significant, a game-changing intervention, and where it is also suggested that this is the primary purpose of the measure, rather than just being a welcome side-effect of the restoration of nature – so that the label *geo*, with its implied planetary scale is deserved, as is the description as *engineering,* with its implied deliberateness and non-naturalness – then they are met with a very significant degree of hostility in public discourse.[34]

That discourse is public in the sense that it takes place in publicly accessible arenas, rather than that the public participate. Discussion of geoengineering has not entered popular debate, and nor are politicians touching the subject, even those involved in or committed to addressing climate change.[35] Discussion takes place in newspapers and blogs, and in academic journals, and is between environmentalists – meaning people involved in environmental issues but who are not officials in public institutions – policy academics, and

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[31] Leonard Ornstein, Igor Aleinov, and David Rind, 'Irrigated afforestation of the Sahara and Australian Outback to end global warming' (2009) 97 Climatic Change 409.
[32] See Joana Castro Pereira, 'Geoengineering, scientific community, and policymakers: A new proposal for the categorization of responses to anthropogenic climate change' (2016) 6(1) *SAGE Open*; Möller, (n 7)
[33] Owen (n 8)
[34] Ramit Debnath and others, 'Conspiracy spillovers and geoengineering' (2023) 26(3) Iscience 106166; Gerd Winter, 'Climate engineering and international law: Last resort or the end of humanity?' (2012) 20 Review European Community International Environmental Law 277; Stephen Gardiner, 'Is 'arming the future' with geoengineering really the lesser evil? Some doubts about the ethics of intentionally manipulating the climate system' in Stephen Gardiner and others (eds) *Climate Ethics: Essential Readings,* (OUP 2010) 284. See also note 21 above.
[35] Gupta and others (n 16) 16

scientists.[36] Of course a range of views are expressed,[37] including enthusiasm[38] and reasoned openness to research and experiment,[39] but the most dominant one is that proposed techniques for large scale manipulation of the climate should not be pursued, and to take them seriously is a dangerous and irresponsible choice.[40] A more apparently moderate, but in practice similar view, is that these techniques should only be investigated with extreme caution and after the establishment of extensive safeguards and global governance procedures.[41] This is not prima facie unreasonable, but the conditions are sufficiently demanding, in a messy global context, that in practice they amount to kicking the geoengineering research ball a long way off – a de facto moratorium.[42] A desire for caution and optimal governance would in most policy contexts be balanced against the urgency of the crisis and the need for solutions – the risk of haste being matched by the risk of slowness[43] – but this is something that the 'extreme caution' advocates tend not to do, adopting in substance a one-sided application of the precautionary principle.[44]

These views have had the chilling effect that there is almost no empirical research at scale into such techniques.[45] Thus while it is impossible to stop scientists thinking and speculating and producing theoretical papers, there have been no real experiments to assess the potential

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[36] ibid

[37] For overviews see Judith Kreuter, 'Technofix, plan B or ultima ratio? A review of the social science literature on climate engineering technologies' (2015) *Institute for Science, Innovation and Society Occasional Paper Series no. 2,* summarized in Williamson and Bodle (n 20) at 83; Duncan McLaren and Olaf Corry 'The politics and governance of research into solar geoengineering' (2021) 12 WIREs Clim Change e707; Gupta and others (n 16)

[38] David Keith *A case for climate engineering* (Review Books 2013).

[39] Williamson and Bodle (n 20); See also the several publications on this of the American National Academy of Sciences, available at nationalacademies.org, most recently; Committee on Developing a Research Agenda and Research Governance Approaches for Climate Intervention Strategies that Reflect Sunlight to Cool Earth et al, *Reflecting Sunlight Recommendations for Solar Geoengineering Research and Research Governance* (National Academies Press, 2021); Stefan Schäfer and others, *The European Transdisciplinary Assessment of Climate Engineering (EuTRACE): Removing Greenhouse Gases from the Atmosphere and Reflecting Sunlight away from Earth* (EuTRACE 2015); Ron Baiman, 'Our Two Climate Crises Challenge: Short-Run Emergency Direct Climate Cooling and Long-Run GHG Removal and Ecological Regeneration' (2022) 54(4) Review of Radical Political Economics, 435; Claudia E Wieners and others, 'Solar radiation modification is risky, but so is rejecting it: a call for balanced research' (2023) 3(1) Oxford Open Climate Change kgad002; Olúfẹ́mi O Táíwò and Shuchi Talati, 'Who Are the Engineers? Solar Geoengineering Research and Justice' (2022) 22(1) Global Environmental Politics 12; Marie-Valentine Florin, *Combatting climate change through a portfolio of approaches* (Lausanne, International Risk Governance Centre, 2021); 'Give Research Into Solar Engineering a Chance', editorial, (2021) 593 *Nature* 167; Jessie L Reynolds, Andy Parker and Peter Irvine, 'Five solar geoengineering tropes that have outstayed their welcome' (2016) 5 Earth's Future, 562.

[40] Discussing this phenomenon: Williamson and Bodle (n 20) 86; Clare Heyward and Steve Rayner S 'A Curious Asymmetry: Social Science Expertise and Geoengineering' (2013) Climate Geoengineering Governance Working Paper Series 007, Available at http://geoengineeringgovernanceresearch.org. For works taking this view, see notes 21 and 34 above; Mike Hulme, *Can Science Fix Climate Change: A Case Against Climate Engineering* (Polity Press 2014); Jennie C Stephens and Kevin Surprise (2020) 'The hidden injustices of advancing solar geoengineering research' (2020) 3 Global Sustainability e2; Klein (n 21); CIEL [Center for International Environmental Law], *Fuel to the Fire: How Geoengineering Threatens to Entrench Fossil Fuels and Accelerate the Climate Crisis* (CIEL, 2019).

[41] Sikina Jinnah and others, 'Governing climate engineering: a proposal for immediate governance of solar radiation management' (2019) 11(14) Sustainability 3954; Discussion in Gupta and others (n 16).

[42] See Gupta and others, ibid; Reynolds (n 16) section 7.

[43] Keith (n 38)

[44] E.g. European Commission, *A new outlook on the climate and security nexus: Addressing the impact of climate change and environmental degradation on peace, security and defence*, JOIN(2023) 19 final, 20. C.f. the more nuanced position of the UN Convention on Biodiversity in Williamson and Bodle (n 20).

[45] Anna-Maria Hubert, 'A Code of Conduct for Responsible Geoengineering Research' (2021) 12 Global Policy 82.

of Solar Radiation Management, or ocean fertilisation, the two techniques for which the most grandiose claims are sometimes made. The science remains at the stage of modelling - sketching how, on the basis of understandings of the chemistry and biology of the air and sea, it might work. However, as is conceded by all parties, these are complex systems, so in order to know how those theories play out in practice it would be necessary to experiment.

Were this a less politicised field of science, the logical next step would be to try modifying some clouds, distributing limited amounts of sulphur aerosols in a certain area, or fertilizing an area of ocean with iron to see what happened to algal growth and CO2 uptake. That's how science is done. Yet here, no government has allowed such 'outdoor' experiments to take place, and there is even discussion of how an international agreement can be reached on a moratorium on geoengineering experiments generally.[46] The sense that this path should not be followed has impacted on politicians, despite their lack of active engagement with the issue, suggesting that this lack of engagement is not a lack of interest, but a sense that it is far too sensitive and dirty to for any elected official to want to be associated with it. The politically safe path at this moment is unequivocally not to touch geoengineering with a bargepole, but to stick strictly to the emissions reduction message.

It is certainly striking that serious and well-intentioned ideas for how a global crisis might be reduced, put forward by qualified scientists, working at respected institutions, with no history of madness and no obvious radical or offensive agenda, and published generally in journals with peer-review, are met with the reaction 'this idea must not be considered, and should not even be researched!' It is hard – I have found it impossible – to think of any other context where something similar happens.[47]

Nevertheless, there are coherent and understandable reasons for that reaction. These are broadly of three types:[48] (i) geoengineering techniques are potentially incredibly dangerous; (ii) geoengineering techniques are all wildly speculative and unproven, and as such offer false promise – it is snake oil; and, relatedly to the preceding reason, and most importantly, (iii) allowing people to think that there is a technological solution to climate change will distract humanity from the essential task of emissions reduction, and thereby lead to doom. We can't afford wrong turnings and dead ends when the future of the planet is at stake.

It is worth considering each of these reasons in turn, in order to show that the last is where the crux lies.

3.4 Geoenginering is dangerous

This argument is particularly applied to SRM techniques, where it is noted that the atmosphere and weather are complex, and reflecting back 1% of the sunlight heading towards

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[46] See the open letter calling for non-use at https://www.solargeoeng.org/non-use-agreement/open-letter/; Biermann and others (n 21); ETC Group, *Geopiracy: The Case Against Geoengineering* Communique No 103 (ETC Group, 2010); Shinichiro Asayama and Mike Hulme 'Engineering climate debt: temperature overshoot and peak-shaving as risky subprime mortgage lending' (2019) 19 Climate Policy 937; Stephens and Surprise (n 40); Michael Zürn and Stefan Schäfer S, 'The paradox of climate engineering' (2013) 4 *Global Policy* 266; Albert C Lin 'The missing pieces of geoengineering research governance' (2016) 100 *Minn. Law Rev.* 2509. See the extensive discussion and citations in Reynolds (n 16) section 7.

[47] See Megan Herzog and Edward A. Parson, 'Moratoria for global governance and contested technology: The case of climate engineering' *UCLA School of Law, Public Law Research Paper* 16-17 (2016).

[48] There are sometimes others. See Aaron Tang, 'The Slippery Slopes of Climate Engineering Research' (2023) 80 Global Environmental Change 102674; Debnath and others (n 34); Stephens and Surprise (n 40).

earth does not result simply in a tidy reduction in temperature spread uniformly over the globe, but will affect wind flows and precipitation, and may cause floods or droughts or storms. The overall net temperature may decrease, but that average will mask diverse and complex effects, and we can be sure that even if humanity were to be a net winner from the overall resulting cooling effect, there would also be many losers.[49]

Oceanic interventions are considered particularly dangerous when they operate at scale. Even if ocean fertilisation led to CO2 reductions in the atmosphere, what would be the full effects on ocean ecosystems? Apparently benign interventions might turn out in the slightly longer term to have disrupted ocean biology on a scale or in a way that would perhaps cause dramatic harm – causing ocean death, human starvation, and even negative climate effects if the oceans' CO2 absorption capacities were ultimately reduced by these disruptions.[50] The complexity of oceans means that small scale experimentation can never provide conclusive evidence that large scale actions would not turn out to be disastrous, a gamble that cannot be taken with something so fundamental to global ecology.

Alongside these arguments, it is noted that the governance of geoengineering requires a degree of co-operation between governments that is generally not achieved, and seems implausible.[51] What temperature should humanity choose for the global thermostat, and most importantly, how should that decision be taken? If a few nations, or even private individuals, take measures which affect global temperature and ecology then the potential exists for international conflict – which aside from its human costs would also be unlikely to have a positive climate effect.[52]

Finally, the uneven distribution of geoengineering's potential harms, with the greater burden probably being for the poor, the south, the already vulnerable, means that its riskiness is also often perceived as a justice issue: geoengineering would be an act of exploitation or even colonialism.[53]

These arguments are powerful, but they also have two weaknesses. One is that they apply equally well to the emission of CO2, which in its effects is akin to a particularly destructive and unguided form of geoengineering.[54] It too does not create uniform warming effects, but

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[49] Royal Society (n 28); Williamson and Bodle (n 20).
[50] ibid
[51] David Victor, 'On the regulation of geoengineering' (2008) 24(2) Oxford Review of Economic Policy 322; Stephen H. Schneider, 'Geoengineering: Could We or Should We Make It Work?', (2008) 366 Phil. Transactions Royal Soc'y A, 3843, 3847; Virgoe (n 20); Reynolds (n 16); Shinichiro and Hulme (n 46); Owen (n 8); But see Thomas C Schelling, 'The Economic Diplomacy of Geoengineering' (1996) 33 Climatic Change 303.
[52] Victor, ibid; Daniel Bodansky, 'The who, what, and wherefore of geoengineering governance' (2013) 121 Climatic Change 539; Olaf Corry, 'The international politics of geoengineering: The feasibility of Plan B for tackling climate change' (2017) 48(4) Security Dialogue 297; Sam Adelman, 'Geoengineering: rights, risks and ethics' (2017) 8(1) Journal of Human Rights and the Environment 119. C.f. Holly J Buck, 'Environmental peacebuilding and solar geoengineering' (2022) 4 Frontiers in Climate 869774.
[53] Benjamin K Sovacool, Chad Baum and Sean Low, 'Climate protection or privilege? A whole systems justice milieu of twenty negative emissions and solar geoengineering technologies' (2022) 97 Political Geography 102702; Frank Biermann and Ina Möller, 'Rich man's solution? Climate engineering discourses and the marginalization of the Global South' (2019) 19(2) International Environmental Agreements: Politics, Law and Economics 151; Stephens and Surprise (n 40); c.f. Táíwò and Talati (n 39); Gareth Davies, 'Climate change and reversed intergenerational equity: The problem of costs now, for benefits later' (2020) 10(3-4) Climate Law 266.
[54] Gareth Davies, 'Framing the Social, Political and Environmental Risks and Benefits of Geoengineering: Balancing the Hard-to-Imagine Against the Hard-to-Measure', (2010) 46(2) Tulsa Law Review 261.

disrupts the climate, and it acidifies the oceans and slowly kills them, and as richer and more industrial nations cause climate harm whose greatest victims are poorer ones, it creates a frightening potential for local and global conflict and unmanageable migration. Danger is therefore only a decisive argument against geoengineering if it can be assumed that without it humanity will engage in timely and effective emissions reduction. That however is precisely the billion dollar question, not a plausible premise. To use risk to dismiss geoengineering is therefore to take a strong position on an essentially speculative issue of human behaviour: it is an apocalyptic gamble.

The second weakness is that risk is a common, almost ubiquitous, feature of policy solutions. Many medical treatments have side-effects, even potentially deadly ones. That is not a reason to dismiss them a priori, but a factor to balance against benefits. Relevant is the extent to which the side-effects themselves can be managed. Interventions can be complex and may require developed approaches to risk assessment and management, but this can be done for geoengineering as it is done in other fields.[55] A limitation to costless approaches to addressing climate change would paralyse policy, and be without precedent.

3.5 Geoengineering is speculative

Another critique of geoengineering is that none of the techniques have actually been shown to work. Holding them up as potential saviours is fundamentally dishonest since they are just theoretical sketches on paper.[56] It would be madness to make something so speculative and flimsy a serious plank of global policy.[57] It's equivalent to engaging in dangerous individual behaviour – smoking, say – on the basis that 'they'll probably find a cure in time'. They might, it's not impossible, but people who have taken this approach systematically to known harmful behaviour are more likely to be dead than lucky.

Nevertheless, despite it being often emphasised in critiques of geoengineering how unproven various ideas are, this does not obviously lead to the conclusion that is often drawn, which is that we should just forget the idea. Rather, it would seem to be an argument for research:[58] if someone has a theoretically non-ridiculous idea which might help, then the obvious reaction is to test it, see if it holds up in practice. Who knows? This is how science works, and to dismiss theoretical proposals because they haven't been proven is, on the face of it, a simple rejection of science, or the very least a misunderstanding of it. A survey of any field of applied science – medicine again – reveals how few proposals make it from initial theoretical enthusiasm to final application in practice. It also, however, reveals that some do, and that these are worth having. Since there is no means other than experiment to distinguish the effective from the ineffective, the speculative nature of untested geoengineering proposals is an irrelevance, or even a reason to speed up research.

The fear, however, is that such research will encourage the public to think that a solution is imminent, whereas in practice many a wonderful idea on paper goes through years and years

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[55] Benjamin K Sovacool, Chad Baum and Sean Low, 'Beyond climate stabilization: Exploring the perceived sociotechnical co-impacts of carbon removal and solar geoengineering' (2023) 204 Ecological Economics 107648; Táíwò and Talati (n 39); Florin (n 39).
[56] Owen (n 8) 212; Biermann and others (n 21); Fragniere and Gardiner (n 26)
[57] Winter (n 34)
[58] Philip Boyd and Chris Vivian, 'Should we fertilize oceans or seed clouds? No one knows' (2019) 570 *Nature* 155.

of testing in order to come to nothing. It is not the speculativeness as such of geoengineering that is the problem, but the risk that the public will over-estimate the chances of success and underestimate the time-frame for implementation and conclude that the crisis is nearly over. By the time they find out they are wrong, the situation is worse.

3.6 Taking geoengineering seriously undermines emissions reduction

This is essentially the third critique of geoengineering, and by far the most important, and it usually goes by the name of 'moral hazard', a term borrowed from insurance, where it refers to the risk that if someone is insured against a risk – wine on the carpet, house fires, unemployment – then they will make less effort to avoid that harm.[59] Ultimately this leads to a less responsible world in which welfare for all is reduced.

The idea that looking for technological solutions to global warming will distract from the safe, proven, and optimal approach of reducing emissions, by making it seem less important and less urgent, is a powerful argument.[60] If geoengineering experiments were carried out it would increase funding and attention, and there would soon be headlines about the potential of new SRM and ocean fertilisation techniques – and perhaps others too – that would indeed, imaginably, lead to cries that the climate crisis is on the edge of being solved, just as one can hear regularly on the news that cures for cancer are on their way – and one has been able to hear that for several decades now. The moral hazard risk is real.

On the other hand, moral hazard is ubiquitous in policy-making.[61] Wherever law addresses a risk – and that is surely the heart of modern regulation – it creates the new risk that the protected will take less responsibility upon themselves. That can be found in welfare, in security, in almost any field. Taking medicine again, the analogy with climate engineering is good: many diseases are overwhelmingly the product of lifestyle, and an optimal medical outcome would be that people change their behaviour. It is harder to persuade them to do this if treatment is available which blunts the risk their behaviour creates.[62] That treatment may be a suboptimal solution, for it is still generally better for quality of life to be healthy, but it makes it harder to find the motivation to make the choices required. Yet this is not seriously put forward as a reason to limit medical research in these fields. Where diseases exist, attempts to treat or cure them.

There are good reasons why moral hazard is not generally treated as a policy trump card. For one thing, it can be addressed by counter-measures – communication and policy co-ordination.[63] Medical research does not exclude preventative programmes, and geoengineering research does not exclude intensive communication combatting over-enthusiasm and emphasising the importance of emissions reduction. There are tensions,

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[59] Katelyn Tsipiras and Will J Grant, 'What do we mean when we talk about the moral hazard of geoengineering?' (2022) 24(1) Environmental Law Review 27

[60] Albert C Lin 'Does geoengineering present a moral hazard?' (2013) 40 Ecology Law Quarterly 673. Jesse L Reynolds 'A critical examination of the climate engineering moral hazard and risk compensation concern' (2014) 2(2) The Anthropocene Review 1.

[61] Gernot Wagner and Daniel Zizzamia, 'Green moral hazards' (2022) 25(3) Ethics, Policy & Environment 264.

[62] Jonathan Klick and Thomas Stratmann, 'Diabetes treatments and moral hazard' (2007) 50(3)The Journal of Law and Economics 519; Dhaval Dave and Robert Kaestner, 'Health insurance and ex ante moral hazard: evidence from Medicare' (2009) 9 International journal of health care finance and economics 367. C.f. Jay Bhattacharya and Mikko Packalen, 'The other ex ante moral hazard in health' (2012) 31(1) Journal of Health economics 135.

[63] Wagner and Zizzamia (n 61)

certainly, but policy-making in a complex field is usually about balancing tensions, not taking sides. Moreover, moral hazard remains in many contexts a speculative risk,[64] for whether people actually respond in practice as moral hazard theory suggests is an empirical question that is far from proven.[65] Do people drive faster with seatbelts, as was once feared, or do seatbelts remind them of the importance of safety and make them careful? Against moral hazard in climate an argument has been put forward that many people refuse to engage with climate change or even deny it, because admitting the truth even to themselves would inspire feelings of despair and guilt that they would struggle to process. This draws on the idea of cognitive dissonance, that faced with two conflicting ideas people will suppress one, in order to remove the unpleasant conflict.[66] It may be that the possibility of climate engineering would offer hope, helping to avoid 'doomism', and that this hope would increase engagement and preparedness to reduce emissions: perhaps this is a problem we can solve, in which case, let's get on with it! [67]

Social science has not yet settled the question of which of these dynamics is likely to be stronger, or whether geoengineering could persuade groups currently unreached by conventional discourse[68] that climate change is real and urgent.

That leaves moral hazard as an interesting and important factor in discussion of geoengineering, but one who's weight and impact is as speculative as the consequences of geoengineering itself. This then begs the question why, in this context, it appears to be taken uniquely seriously. Why are potential climate rescue techniques dismissed a priori on the basis of an unproven theory that in no other context carries nearly so much weight? What is there about geoengineering and its relationship to alternatives that is distinctive from other moral hazard contexts, and that can explain the distinctive reactions it inspires? I suggest below that there are two features worthy of note.

3.7 Geoengineering tries to rescue capitalism

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[64] Williamson and Bodle, (n 20) 96

[65] Royal Society (n 28); Wim Carton and others, 'Is carbon removal delaying emission reductions?' (2023) 14(4) WIREs Climate Change e826; Talbot M Andrews, Andrew W Delton and Reuben Kline, 'Anticipating moral hazard undermines climate mitigation in an experimental geoengineering game' (2022) 196 Ecological Economics 107421; Christine Merk and others, 'Exploring public perceptions of stratospheric sulfate injection' (2015) 130 Climatic Change 299; Benjamin Hale, 'The world that would have been: moral hazard arguments against geoengineering' in Christopher J Preston (ed) *Engineering the Climate: The Ethics of Solar Radiation Management* (Lexington Books/Rowman & Littlefield, 2012) 113; Christopher J Preston, 'Ethics and geoengineering: reviewing the moral issues raised by solar radiation management and carbon dioxide removal' (2013) 4 WIREs Climate Change 23; Adam Corner and Nick Pidgeon, 'Geoengineering, climate change scepticism and the 'moral hazard' argument: an experimental study of UK public perceptions' (2014) 372 Philosophical Transactions of the Royal Society A, 2014.0063.

[66] Cynthia M Frantz and F. Stephan Mayer, 'The Emergency of Climate Change: Why Are We Failing to Take Action?' (2009) 9 Analyses of Social Issues and Public Policy 205; Hank Jenkins-Smith and others, 'Geoengineering and Climate Change Polarization: Testing a Two-Channel Model of Science Communication' (2015) 658(1) The ANNALS of the American Academy of Political and Social Science, 192.

[67] See Frantz and Mayer, ibid; Rebecca Solnit and Thelma Young-Lutunatabua (eds), *Not Too Late: Changing the Climate Story from Despair to Possibility* (Haymarket Books, 2023); Anna Novoselov and Karlie Hayes, 'Sparking Emotions Conducive to Action Is Critical to Solving the Climate Crisis' (2022) 15(6) *Sustainability and Climate Change* 380.

[68] Astrid Dannenberg and Sonja Zitzelsberger, 'Climate experts' views on geoengineering depend on their beliefs about climate change impacts' (2019) 9(10) Nature Climate Change 769; Hale (n 65); Corner and Pidgeon (n 65).

One is that its success – assuming it was developed to the point that there was an importantly useful technique available – could be experienced as undesirable, since while it might alleviate global warming, it would also, by definition, enable the energy transition to be delayed or even, in the event of a radically successful NET technique, avoided. It is imaginable, if implausible, that geoengineering might undo the climate consequences of current industrial practices, and thereby remove the immediate need for them to change.[69]

Some might celebrate this – imagine, harmless fossil fuels! What a liberation![70] However, the burning of such fuels is not only a climate problem, but associated with a model of the economy that is often considered to be destructive and over-exploitative. Aside from its other environmental consequences, resulting from pollution, bad land use choices, and destruction of areas with natural resources, it has also traditionally been the motor of modern capitalism, which is often also considered to have created structurally exploitative societies.[71] Many environmentalists are to some extent left-wing, and issues of social justice and environmental protection are bound up in the preference for a socio-economic model less based on profit, exploitation, growth, and fossil fuels. Climate change is one reason for a new model, perhaps the most urgent reason, but not the only one. To take it out of the pack, by neutralising the climate impact of fossil fuels, could do, perhaps catastrophic, harm to attempts to make the world a fairer place and the economy less destructive.[72] From this perspective, geoengineering is a dangerous distraction if it does not work, but a dangerous palliative if it does.[73] The very attempt to make the fossil fuel economy harmless, rather than seeking to change that economy, is morally objectionable and in its own way dangerous.[74]

This is somewhat different from the medical situation. If some new breakthrough treatment meant that we could all enjoy as much cake or alcohol as we wanted without health consequences, that would certainly create a complicated situation for those committed to healthy lifestyles, but it would be hard to see it as a complete disaster. The moral objection to cake is that it causes ill health, not that it is tasty. If that objection is removed, it is possible to recategorize it as a non-guilty pleasure, alongside walking in the park and singing in the shower, without significant peripheral externalities. A world of unlimited cake, is not, unlike a world of unlimited fossil fuel use, inherently harmful for other reasons.

3.8 Geoengineering disrupts the professional status quo

The other, closely connected, distinctive aspect of geoengineering, or the discussion about it, is the professional population conducting that discourse. Where medicine and health are concerned, the most authoritative and dominant voices are those of medical expertise, and

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[69] Gunderson and others (n 26); Kevin Surprise and Jean Philippe Sapinski, 'Whose climate intervention? Solar geoengineering, fractions of capital, and hegemonic strategy' (2022) 0(0) *Capital & Class*; Möller (n 7)
[70] See discussion (not approving) in Möller (n 7)
[71] Klein (n 21); Saad, Aaron. *Worlds at Stake: Climate Politics, Ideology, and Justice*. Fernwood Publishing, 2022; Camfield, David. *Future on Fire: Capitalism and the Politics of Climate Change*. Fernwood Publishing, 2022.
[72] Surprise, K., & Sapinski, J. (2022). Whose climate intervention? Solar geoengineering, fractions of capital, and hegemonic strategy. *Capital & Class*, *0*(0); Klein (n 21); CIEL (n 40); Gunderson and others (n 26); Jean Philippe Sapinski, Holly Jean Buck and Andreas Malm, (eds) *Has It Come to This?: The Promises and Perils of Geoengineering on the Brink* (Rutgers University Press, 2020). See also Baiman (n 39).
[73] Andreas Malm, 'The Future Is the Termination Shock: On the Antinomies and Psychopathologies of Geoengineering. Part One' (2022) 30(4) Historical Materialism 3.
[74] Malm, ibid; Jennie C Stephens, 'Beyond Climate Isolationism: a Necessary Shift for Climate Justice' (2022) 8 Current Climate Change Reports 83.

these professionals are involved primarily in treatment and cure, not prevention. That is not to say that prevention is frowned upon, but there is an enormous professional investment in developing new treatments, and the structure of science means that there is professional advantage to coming up with new, breakthrough, ideas. The careers of those who are able to speak with expertise about disease are dependent on the pursuit of better treatments, and a strong role for moral hazard arguments in the discourse would be directly contrary to their personal and institutional – for universities need research too – interests.

By contrast, the position of vested authority in climate change discussion is occupied by those with expertise in environmental sciences, and those with expertise in emissions reduction. For the latter group, geoengineering as an object of research funding and eventual use is directly oppositional to their career interests and authority as a group.[75] For the former group, biologists, atmospheric scientists, and so on, that is not necessarily the case, although it may be the case that scientists and experts involved in climate change have come to form a coherent body, whose interests and world views are more or less aligned.[76] This could be fed by the structure of public and political discourse, where inevitably they have occupied similar positions for some time now, but also by institutions, which in seeking to make climate change policy will need a range of expertise, and so bring experts together and help create a sense of professional unity, an epistemic community with an inevitably path dependent world view which is built around emissions reduction and does not encompass geoengineering.[77] Shared ideologies and the cohesion of policy commitments are important to what makes such an epistemic community influential and robust.[78] The geoengineering idea that there might be a fundamentally different way to address the problem of climate change – at least to some extent – is however methodologically and ideologically challenging and disruptive to this group, and were it to be taken seriously and begin to show promise, it would be threatening.[79] From this perspective, the very heat of the opposition to it could be an indication that such threat is felt, and so, perhaps, an indication that experts consider – are afraid – that some schemes might work. If it was truly, inevitably, hopeless, it would hardly need attacking, and the easiest way of dealing with it might just be to let a few experiments go ahead and fail.

4. RETHINKING REGULATION OF GEOENGINEERING

Faced with a crisis of the magnitude of climate change, in which technology is inevitably important, be it better batteries, new energy generating techniques, or climate technology, a population of calm, calculating people would inevitably pursue all options that might be useful to the process of climate repair, and their regulator would set outer normative limits to experiments while leaving space to encourage innovation and out-of-the-box thinking.[80]

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[75] Daniel Maliniak, Eric Parajon and Ryan Powers, 'Epistemic communities and public support for the Paris Agreement on climate change' (2021) 74(4) Political Research Quarterly 866; Mai'a K Davis Cross, 'Rethinking epistemic communities twenty years later' (2013) 39(1) *Review of international studies* 137.

[76] Claire Gough and Simon Shackley, 'The respectable politics of climate change: the epistemic communities and NGOs' (2001) 77(2) International affairs 329; Cross, ibid.

[77] Cross, ibid; Sean Low, Chad Baum and Benjamin K Sovacool, 'Undone science in climate interventions: Contrasting and contesting anticipatory assessments by expert networks' (2022) 137 Environmental Science & Policy 249, on how IPCC methods are not well adapted to geoengineering assessment (c.f. McLaren and Corry (n 37) at 2.3); Benjamin K. Sovacool and others, 'Actors, legitimacy, and governance challenges facing negative emissions and solar geoengineering technologies' (2023) Environmental Politics, forthcoming.

[78] See n 75.

[79] Low and others, (n 77).

[80] Florin (n 39)

However, the real world of politics and power disrupts this. For one thing, the people are not trusted to resist false hope, so that there is pressure to only pursue the most understood and conservative pathways towards climate stability. In a radically anti-scientific move, many environmentalists are pushing the argument that they know *a priori* which lines of research and policy will lead to the best results, and others, geoengineering, should be ignored. There is an apocalyptic aspect to this point of view. The evidence seems to be that humanity is not reducing its emissions fast enough to prevent very harmful results. The resistance to developing alternative climate management techniques seems almost like New Hampshire machismo: live CO2 free or die.

Then there is the institutional and professional momentum that environmental science has created. Intellectual, financial and ideological investments in emissions reduction have created an expert community at the heart of climate discourse whose professional interests are opposed to the development of geoengineering. As technology lawyers have long known, if the regulator allows technology to develop without steering, then a status quo will emerge which is resistant to regulatory adjustment. In this case, the exercise of public power by universities and research funders has prevented geoengineering research moving to the phase of experiment, and so building up a critical professional mass or momentum. At the same time, law and funders have actively stimulated the development of emissions reductions technology of more conventional kinds. There is now an unbalanced status quo, and since the occupiers of that status quo are the same expert community who will have to be drawn upon for advice on future regulatory decisions, it is entrenched.

In any case, aspiring to regulate technology purely on its climate effects may be misguided.[81] Technologies which mitigate climate change are about more than climate – they are also about preservation or manipulation or disruption of a certain socio-economic system. Geoengineering may or may not have consequences for CO2 and temperature, but it also may have consequences for the development of capitalism. It is contestable, but not irrational, to take that into consideration, and on a view of environmental harm as resulting from modes of economic organisation there is a reason to see geoengineering as merely temporary symptom management, delaying more effective treatment in a way that may ultimately do harm. If combatting climate change is about politics, and not just climate science, then a broad view on climate technology is inevitable.

Regulating geoengineering will then never be easy. What can perhaps be hoped for at this stage is more unpacking of the values and ideas involved, which has been the aim of this chapter. Decisions about what to fund or allow will be, like all important collective decisions, the product of compromise between competing values and world views. The quality of that compromise is likely to be improved if some of the more simplistic arguments – it's dangerous, it's speculative, it brings moral hazard – are replaced by more nuanced and socially aware points of view.

[81] Sovacool, Baum and Low (n 55); Williamson and Bodle (n 20), 81-82.