# 5 Ways of seeing power and authority

> There are parts of the climate science community who are convinced that climate science says there's a really big problem and they're convinced that the solution [decarbonisation] is pretty easy. There are [also] people in the oil industry that are convinced [decarbonisation] is really hard. And if you're honest, those two ought to be uncorrelated. They're completely different domains of human knowledge. If it's really true that there are a lot of people in the oil companies who sincerely think it's really hard to cut emissions… That just shows that these opinions can't both be right. Being really good at climate science doesn't tell you shit about the energy system, just as being really good at the energy system doesn't tell you shit about climate science.
>
> (Researcher 10)

## Introduction: 'climate engineering is undesirable, *ungovernable*, and unreliable'

Like climate change, climate engineering invokes questions and imaginations about the shape of the world people want to live in. Would you, the reader, for example, want to live in a world in which the *global* climate has a thermostat that is in the hands of scientists, or some corporation or government? Can we justify using large swaths of lands for carbon capture crops when many people around the world are still in hunger? Almost all proposed climate engineering technologies will have serious political consequences. Stratospheric aerosol injection, as the emblematic solar radiation management (SRM) technology, promises unequal effects across the globe—even if it succeeds in bringing down the average global surface temperature. Most proposed ways to capture carbon have serious implications for land-use pressures and/or marine ecosystems. Imagining to 'engineer' the climate is an inescapably political act because it necessitates a debate about the future shape of the world. For opponents of climate engineering, this political debate is crucially important. To them, climate engineering technologies might be fundamentally ungovernable (Hulme, 2014), because a sustained democratic cooperation on an issue as sensitive as climate control is impossible (Bellamy, 2016; Stilgoe, 2015; Szerszynski *et al.*, 2013). Even if a durable form of governance was conceivable, moreover, it is unlikely to be just (Gardiner, 2013; Jamieson, 1996; Preston, 2013; Scott, 2012). Climate engineering will line the pockets of the rich and powerful, while the poor and powerless would be subjugated to climate colonialism and imperialism (Baskin, 2019; ETC Group, 2010; Heyward, 2014). These are real and pressing concerns. More often than not, new technologies act as what Dan Sarewitz calls 'force-multipliers' of inequality (Parthasarathy and Stilgoe, 2019). Science and technology express the personal, social, and political dreams of societies and their people—and of their socio-economic systems. They organise societies along their predominant *self-imaginations* (Ezrahi, 2012; Foucault, 1994), 'co-producing' science, technology, and social order along those lines (Jasanoff, 2004; Jasanoff and Simmet, 2017). Climate engineering is no different. It is a quintessential example of 'post-normal science' (Funtowicz and Ravetz, 1993); values are always in dispute and uncertainty is a central feature. As such, climate engineering research is in constant conversation with imaginations of power and authority. Because climate engineering is a technological fix to the industrial damages of a deeply unequal world—where industrialised countries continue to deny mitigation responsibilities, looking instead to outsource their responsibilities via negative emissions—it is crucial to ask who gets to imagine an 'optimal' implementation of climate engineering and on what basis.

In this chapter, I sketch how views on the political nature of climate engineering shape its development. Of course, political debates also shape the debates about the knowability of climate and the role of climate engineering 'post-Paris' in Chapter 4 implicitly. Crucially, this chapter is about *who* might get to imagine and control climate engineering research, development, and implementation—and on *what* basis. It addresses how climate engineering researchers view questions of power and authority in climate engineering research and development, depending on their research cultures, personal preferences, and cultural specificities.[1] Such debates are multifaceted, but typically revolve around a series of political questions:

- What should be the role of scientific expertise in addressing climate change—and, correspondingly, what should be the political role of science and technology in society at large?
- What sort of governance institutions should be in place for carbon dioxide removal (CDR) and SRM?
- Who would (and should) get their hands on the metaphorical global thermostat?
- Is climate engineering, particularly SRM, compatible with democratic decision-making?

Underlying these questions are a host of (implicit) views on political power and authority. Let's take the metaphorical thermostat as an example. It immediately evokes questions about how a thermostat for the Earth should be understood and conceptualised, but also raises geopolitical concerns *who* gets to control (aspects of) the global climate. At the same time, it reduces a complex question about local effects, political configurations, and power disparities to a two-dimensional metaphor about global average surface temperatures over time. In this chapter, I unpack several political debates, such as the hypothetical thermostat and 'moral hazard', the fear climate engineering research would forestall conventional mitigation. In doing so, I show how underlying views on power, politics, and (epistemic) authority lead to incommensurable differences of opinion about not only the *governability* of climate engineering technologies but also their *feasibility*. And how technical feasibility and reliability—as well as the knowability of the climate system—axiomatically connect to visions of the political feasibility and desirability of SRM or CDR.[2] Here, I outline how political questions connect to debates about what conceptions of the climate are the right conceptions.

The first of the political concerns this chapter addresses, and possibly the most urgent, is the relationship between climate engineering and mitigation. A major issue in climate engineering is the fear of a moral hazard; might climate engineering (research) lead to less conventional mitigation? This ties into disagreements about the risk of a technological 'lock-in' into climate engineering resulting from expectations about the success of such measures. Nowhere, perhaps, is this more clearly visible than in the reliance upon NETs in the newer IPCC models and the imaginations of using SRM to 'shave the peak' of global warming. Captured under the header 'who controls the thermostat?', this chapter also looks at questions of governance and decision-making on climate engineering. I first focus on disagreements about the role of scientists in the decision-making on climate engineering. In the following section, I turn to questions of politics and governance. These two sections on the question of the 'thermostat' highlight researchers' worries about politics of expertise, their role in imagining climate engineering, and issues of technocracy, democracy, and geopolitics. This also speaks to issues concerning the temporal scale of climate engineering. How can we safeguard responsible and politically sustainable governance mechanisms into the future? Taken together, these questions all culminate in two major concerns: who gets to decide the future of climate change and climate engineering? And who gets to shape the climate engineering discourse and imaginaries?

## Climate engineering and the mitigation problem

In the aftermath of its Fourth Assessment Report (2007), the IPCC introduced its new representative concentration pathways (RCPs) (Moss, Babiker, *et al.*, 2008). These RCPs superseded the previous tool the IPCC had used, the Special Report on Emissions Scenarios (SPES). Where the SPES had been a representation of projected *emissions*, the RCPs were imagined to 'facilitate coordination of new integrated socioeconomic, emissions, and climate scenarios' (Moss, Babiker, *et al.*, 2008, p. ix). Effectively, these new RCPs inverted the order of climate policy design. Rather than starting out from projected emissions pathways it deemed achievable, RCPs presented emissions pathways to correspond to specific levels of global warming. If the world wants to keep global warming below certain thresholds, these RCPs tell us, it needs to adhere to these emissions pathways. Despite the authors asserting that they 'shouldn't be considered policy prescriptive' (Moss, Babiker, *et al.*, 2008, p. x), these new RCPs have become deeply influential in shaping climate policy (Lövbrand, 2011). They have become the most important piece of scientific evidence for the feasibility of the 1.5°C and 2°C—and legitimise climate engineering technologies such as carbon capture and storage (Beck and Mahony, 2018). In designing RCP 2.6, which corresponds to the 2°C climate goal, climate scientists collaborated closely with the European Union, which had championed such a 2°C target for years (Lövbrand, 2011). As it provided the scientific 'proof' that it would still be possible to keep global warming below 2°C, this RCP 2.6 became a hugely important figure in the run-up to the 2015 Paris Agreement. The RCP 2.6 scenario, however, is not explicitly designed using seemingly feasible emissions scenarios. Rather, it *started out* from a projected 2°C goal—back-casting the necessary emissions pathways. As a result, the political pathways to this goal are narrow. The vast majority of the feasible pathways to 2°C included negative emission technologies as a means of reaching the desirable carbon concentrations (Anderson and Peters, 2016). As we have seen in Chapters 3 and 4, the more recent IPCC report on the 1.5°C Paris goal includes significant negative emissions in *all* of its scenarios. In doing so, the Paris Accord has legitimised climate engineering research, particularly negative emissions. It is now possible to talk about 'overshoot' scenarios in which societies emit more carbon dioxide now as long as there is a 'carbon negative world' in the future. Based on speculative, mathematical assumptions about carbon capture at scale, these scenarios present negative emissions technologies as an economically expedient option that would allow future generations to draw down the excess carbon emissions (Anderson and Jewell, 2019; EASAC, 2018).

The switch from SPES to RCPs has had three important consequences. First and foremost, the 'magical thinking' (Rayner, 2016) inherent in the Paris Agreement about how to reach RCP 2.6 has altered the political conversation about climate change. Not only did it galvanise political momentum for climate policy, it also, as I addressed in Chapter 3, reified the political imaginary of a *global* carbon market and solutions on a global scale. In this view, the complex challenges of climate change are reduced to two indicators of risk: average global surface temperature and carbon concentrations. It creates a political imagination of both a 'carbon commons', a remaining carbon budget to be balanced by international collaboration—and to which negative emissions and CDR can contribute—and a 'temperature commons', a threshold below which global average surface temperatures ought to be kept—a goal to which, hypothetically, SRM could contribute.

Secondly, the switch from SPES to RCPs has changed the role of scientists (and science), who are now asked to provide evidence and legitimation for climate policy (Anderson and Peters, 2016; Beck and Mahony, 2018; Lövbrand, 2011). For Oliver Geden, a political scientist connected to the SPP, this is problematic because it is not self-evident that the message of the scientists comes across clearly. This may lead to a dangerous reliance on speculative technologies such as NETs. Geden asserts that

> if consistency of talk, decisions, and actions cannot be assumed, then concepts like *evidence-based policymaking* become essentially devoid of meaning. Simply delivering the best available knowledge to policymakers might even have counterintuitive effects. In the future, policy-driven climate researchers and advisors must critically assess how their work is actually being interpreted and used in policymaking processes.
>
> (Geden, 2016, p. 790)

Thirdly, the Paris Accord and its corresponding focus on 2°C and 1.5°C goals have altered the conversation *within* the climate engineering community. By introducing negative emissions as essential to reaching the 2°C and 1.5°C targets, the RCPs and the Paris Agreement have legitimised climate engineering research. By introducing the idea of overshoot and carbon negative worlds, even SRM technologies have started to appear more appealing. Two main political objections to SRM have consistently been the fear that it would weaken mitigation commitments and that once started, SRM would have to be continued indefinitely. Both these objections lose rhetoric force if a carbon negative world is already accounted for anyway.

Underlying the popularity of negative emissions technologies in the RCPs and the post-Paris climate change debate is a particular form of economic reasoning. In most countries, climate policy continues to play second fiddle to *economic* considerations. Growth remains the central political aim—at least, it was pre-COVID-19—depoliticising other issues as a function of this growth.[3] The reluctance to forsake growth as the organising myth of the Western capitalist society[4] means that, above all, climate mitigation has to be *economically* feasible. Ever since the 1988 summer of climate, economic reasoning has remained the predominant logic of climate change politics. Starting with William Nordhaus' DICE model, the first economic model to put a price on both mitigation *and* climate damages in the early 1990s, climate mitigation has been weighed as a trade-off between damages to economic growth and the monetary cost of carbon mitigation. Depoliticising decisions such as how and when to mitigate to such economics logic is problematic. Most economic modelling severely underestimates the costs of climate change—even in GDP costs, let alone in real human suffering.[5] As a result, it has often presented mitigation targets clearly well outside of 'safe levels of warming'. The famous climate economist William Nordhaus still proposed a 3°C warming as the optimal mitigation pathway when he received his *2018* Nobel Prize for his work on modelling climate change economically (Nordhaus, 2018). Both Nordhaus' optimal mitigation pathways *and* the prominence of negative emissions technologies in recent RCPs result from particular applications of an economic tool of calculations called the 'discount rate', which mathematically weighs the relative economic weight of the present against that of the future. Like gross domestic product (GDP), the discount rate is stylised along the economic assumption that economic growth ought to be the main aim of policy and politics (Deringer, 2018). Despite being a rather crude instrument, the discount rate is a critical component of mitigation pathways (Rosen, 2015, 2016).[6] It has become a central mechanism for modelling future economic scenarios. It also features centrally in the IPCC's RPCs, in which deep emissions cuts *in the present* appear prohibitively expensive compared to the (discounted) future (Anderson and Jewell, 2019). Through the discount rate, future use of negative emissions seems *economically reasonable*. Assuming that technological progress will reduce the costs of carbon capture in the future, negative emissions in the discounted future are more economically expedient than emission cuts in the present. As a result, all the IPCC scenarios 'that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century' (IPCC, 2018, p. 17). Despite criticism that 'betting' on negative emissions (Fuss *et al.*, 2014) risks distracting from mitigation in the present, bioenergy carbon capture and storage (BECCS) and other negative emissions technologies are now part and parcel of the 'policy envelope' (Pielke Jr., 2018). This is problematic, because it is unclear whether negative emissions could deliver. At the moment, CDR is often presented as too expensive or impractical to warrant significant implementation (House *et al.*, 2011; National Research Council, 2015).[7] The full extent to which carbon *could* be captured is also debated (Lawrence *et al.*, 2018). As a result, the European Academies Science Advisory Council (EASAC) warns that 'placing an unrealistic expectation on such technologies could thus have irreversibly damaging consequences on future generations in the event of them failing to deliver. This would be a moral hazard which would be the antithesis of sustainable development' (European Academies Science Advisory Council, 2018, p. iv). Because of the predominance of economic reasoning in the climate change debate, however, political debates on climate engineering often continue to revolve around economic affordability.

Unlike for CDR technologies, where economic affordability plays a major role—especially in relation to the costs of conventional mitigation—the economic affordability of SRM is not in direct dispute. Across the spectrum, climate engineers agree that the *direct* monetary costs of most SRM measures probably aren't prohibitively high. Hypothetically, more optimistic climate engineers insist, SRM even has a 'free driver' problem, because it might be so cheap to implement that almost any country could do so (Weitzman, 2015).[8] Moreover, to them the expensiveness of carbon removal and conventional mitigation is a reason to take SRM measures seriously. Most economic calculations do not include what Gernot Wagner (a former director at the David Keith Group) and Martin Weitzman (Wagner and Weitzman, 2015) call 'the fat tail of climate change', the unlikely event that climate change turns out to be much *worse* than current predictions. As such, it is economically prudent to research SRM, because it could stave off the catastrophic consequences of climate change or at least mitigate them somewhat.[9] At the same time, all climate engineering researchers agree that *economic* considerations should never be the main driver of SRM, because it is too politically and ethically controversial.

Many climate engineers feel deeply uncomfortable about their work being drawn into the climate change debate on economic grounds. In the eyes of many critics, this economic reasoning risks to *naturalise* climate engineering as a solution to climate change. Many SPP researchers are critical about the use of economic scenarios to legitimise future carbon capture. In their eyes, economics should be used (at most) as a tool for assessment, not a justification in itself. They fear economic comparisons obscure political concerns such as human suffering and ecosystem damages, and facilitate further exploitation and displacement of agricultural groups. Moreover, they feel that economic forecasts underestimate (or render invisible) the significant uncertainties around the technical feasibility and safety of CDR measures.[10] For most SPP researchers, discussions about BECCS, other land-intensive carbon capture, and even ambient air capture shouldn't primarily be economic. To the SPP, sceptical about both the technical feasibility of climate engineering technologies *and* the applicability of economic reasoning, monetary costs and market forces are not an accurate or desirable way to approach climate engineering. Many in the David Keith Group agree with such fears. By and large, however, its ecomodernist research culture accepts economic reasoning as the best available proxy to quantify the real costs and damages of climate change (and climate engineering). As such, it privileges a culturally induced faith in a market system, combined with scientific positivism and techno-optimism. Often, the Keith Group promotes a market vision of climate engineering, in which it is cheaper (and hence possibly more desirable) than conventional mitigation.[11] Such differences of opinion on the applicability of economic reasoning to the climate engineering debate at least partially reflect an underlying difference in the ways that political and economic concerns are perceived by climate engineers. A clear example of these differences is visible in the ways the SPP and the Keith Group approach the issue of moral hazard. As I show in Section 5.3, here too a difference between an economic view, based on aggregate *individual preference*, and a more constructivist view that prefers *social preferences and aggregates* surfaces. This section turns to the question: how do climate engineers see the risks climate engineering research poses to the willingness to mitigate?

## The many faces of a moral hazard: individualism and constructivism

In the predominantly ecomodernist David Keith Group, many researchers expect people will not be willing to forsake economic growth for climate mitigation. In their eyes, people will be unwilling to make sacrifices to their lifestyles. They will not want to give up their personal mobility, their air travel, their meat, or their technological gadgets. Mitigation is not only energetically difficult; socially it is also very inconvenient. In this view, climate engineering can complement and insure against the inevitable delays in mitigation resulting from this unwillingness to sacrifice. Economic metrics, including GDP and the discount rate, are the best available indicator for how to limit the pain of such sacrifices. The problem is that complementing conventional mitigation with innovative solutions—or even safeguarding against climate catastrophe with prescient research—might inadvertently *replace* emissions cuts with speculative promises about future technologies. To many climate engineers, this is the ultimate worry: that their research actually ends up damaging mitigation commitments.

Let me start with a story of an extreme manifestation of that fear, in which those in power try to use climate engineering as a way to continue business as usual. In the case of climate engineering, one person, Newt Gingrich, has become an emblematic example. In June 2008, Gingrich published a letter decrying a proposed environmental bill in the influential conservative news outlet *Human Events*. In the letter, Gingrich attacked the Lieberman-Warner Climate Security Act, which would eventually flounder, for giving 'more handouts to lobbyists and special interests' (Gingrich, 2008). Leaving aside the acidic irony of Newt Gingrich complaining about lobbyists and special interests—the ideology of the hard right wing of the Republican Party to which Gingrich belongs, after all, consists of strengthening the propertied class at the expense of the rest of their country and the world (MacLean, 2018)—Gingrich's letter is interesting. To Gingrich, conventional climate mitigation is problematic because 'increasing the pain level isn't the way to go'.[12] Tackling climate change, if it even exists, needs 'innovation, not regulation. We need motivating incentives, not punishing pain. Our message should be: Bring on the American Ingenuity. Stop the green pig'. For many climate engineers, Gingrich's words have come to symbolise their principal fear about their research. Resembling Robert Frosch's words in Chapter 3, Gingrich's words tie into the promise of technological ingenuity and economic growth that also underlie the RCPs and embedded assumptions about negative emissions technologies. In doing so, Gingrich encapsulates the most direct form of moral hazard. Why should aggressive mitigation be undertaken if there are more convenient technological solutions? Why should more energy, money, and sacrifices be asked of the taxpayers and consumers, corporations, or developing economies—whoever you privilege in your political narrative?

The fear that climate engineering might limit mitigation commitments is one of the main reasons that climate engineering remains controversial—as I showed in Chapters 3 and 4. According to Mark Lawrence and Paul Crutzen (2017), reflecting back on Crutzen's 2006 intervention, the scientific community opposed climate engineering research for four major reasons, moral hazard featuring prominently among them.[13] As we also saw in Chapter 3, fears about a moral hazard[14] also kept a lid on the early *adaptation* debate—and still plagues the debate around adaptation, as reactions to the 2021 Climate Adaption week in Groningen, the Netherlands show. Talking about adaptation to the adverse consequences of climate change would, so it was thought, limit the willingness to mitigate. Here too, the fear was that adaptation would (a) seem to suggest that mitigation was not urgently needed and (b) divert the political focus away from correlated issues such as ocean acidification, which cannot be solved by adaptation but will still have profound and lasting consequences. Simply put, climate engineering research might 'create the impression that there's some technological fix and that we don't need to do conventional mitigation' (Researcher 5). The *extent* of these worries about the moral hazard of climate engineering varies across different climate engineering communities. For some, such concerns are very urgent. To them, moral hazard is an inevitability. One SPP researcher involved in the original funding application of the program, for example, expressed that 'from the very first moment, I thought, "Oh God, if we start getting involved in this kind of activities then this will have a negative impact on classical mitigation"' (Researcher O). Others certainly share such concerns, yet are more inclined to view moral hazard as an open question. Typically, such differences of opinion about moral hazard result from different *interpretations* of how to interpret moral hazard rather than differences in opinion about how likely moral hazard is to occur.

The most profound difference between interpretations of moral hazard is a difference between *positivist individualism* and *constructivist collectivism*. Some view moral hazard as an individual process, in which individuals become less willing to mitigate because climate engineering exists as an option. Often closely connected to economic rational choice theories, in this view individuals would simply not be willing to sacrifice more than they need to—'increasing the pain level isn't the way to go'. The collectivist view, on the other hand, sees moral hazard as a social and political process, in which climate engineering measures slowly, tacitly become embedded in expectations of climate policy. Although these two views aren't necessarily mutually exclusive, climate engineers often focus specifically on one—often, it seems, because this aligns with their view on the relationship between the individual and the political. In the David Keith Group, for example, moral hazard features extensively as a possibility, not a certainty. For the David Keith Group, moral hazard is bound up with individual preference.[15] Based on a variety of studies in behavioural economics, including several studies by SPP member Christine Merk and collaborators (Merk *et al.*, 2015; Merk, Pönitzsch and Rehdanz, 2016), they argue there is no empirical *evidence* that SRM poses a moral hazard. Coinciding with an economic view that sees politics as the aggregate of individual preferences, moral hazard features in the David Keith Group as the risk that individuals reconsider mitigation because they hear of climate engineering. In this view, moral hazard becomes a collective action problem, in which individual preferences are leading—much like individual willingness to make lifestyle changes. Keith Group researchers stress that as yet there is little evidence 'that people will react in a moral hazard way'. 'A lot of people may react that way', but others 'might actually grow more concerned about climate change', wanting a 'more aggressive take on mitigation' because climate engineering makes 'climate change dangers feel more urgent'. SRM might even be such a scary idea 'that people never want to see it done and therefore start getting more aggressive on mitigation or carbon dioxide removal' (Researcher 2).

For most SPP members, on the other hand, moral hazard is not primarily an individual choice. It is more systemic, related to a fear of 'how they do politics'. Expressing the adoption of her research by the Keith Group and the more techno-optimist parts of the climate engineering community, Christine Merk, for example, adamantly says she wants 'to avoid that people think I'm doing market research of climate engineering'. She may have found no evidence 'that people reduce their mitigation effort when they learn about stratospheric aerosol injection', but remained apprehensive about moral hazard. To allay fears her research would be appropriated by proponents of climate engineering development, 'we [the researchers] were very careful of stating that this isn't a field study', stressing that 'we're not sure whether we can generalise it to the actual real-world behaviour of future situations'. Nonetheless, 'some people actually took it as proof that there was no moral hazard'. Partially, this appropriation may have been because it was a convenient research outcome, but it simply also fit well with the individualist views that many techno-optimists such as Keith and many of his close collaborators hold. For many in the SPP, such a reading misses the point. Climate engineering does not just present a risk to conventional mitigation as a consequence of individual preferences shifting. Individual preference is malleable and fickle. A snapshot of these preferences is never a solid foundation for policy or research programs. It simply doesn't give a good indication of the real risk of moral hazard. Social preferences are often cultivated, by vanguard visions, political leaders, activists, and media environments. They matter, but only to a limited extent. Behavioural economics research of the kind that Christine Merk does is certainly valuable, but it describes only a small part of the moral hazard of climate engineering. The real moral hazards that climate engineering presents, to many members of the SPP, are creeping procedural, cultural, and political processes—such as the gradual embedding of negative emissions into the climate policy envelope. The mere prospect or promises of carbon capture or even SRM may, as has already happened in the case of the RCPs, deter hard policy choices in the present.

### *Moral hazard as a political tool*

There is another, widely shared fear about moral hazard. Rather than inadvertently changing individual mitigation preferences or creeping delays in climate policy choices, climate engineering might be *wielded* as a political tool to weaken mitigation resolve—a fear all climate engineers share. For many, Newt Gingrich's 2008 call for 'American ingenuity' instead of meaningful climate policy exemplifies this attempt to present climate engineering as a more reasonable, cheaper, and fairer policy option than climate mitigation.[16] Climate engineering may provide the 'merchants of doubt' we met in Chapter 3 with another weapon in their arsenal. The ETC Group, a techno-sceptical activist NGO opposing speculative technologies, for example, feared that the 'Trump presidency opens [the] door to planet-hacking geoengineering experiments' (Lukacs, 2017), anticipating that 'a big beautiful wall of sulphate in the sky could be a perfect excuse to allow uncontrolled fossil fuel extraction'.[17] Such fears are not exclusive to techno-sceptical action groups. Rather, they are central to the climate engineering debate. In both the Keith Group and the SPP, as well as many other conversations I have participated in, these fears were prominent. Climate engineers fear that 'people, when they frame the moral hazard problem, they frame it awfully narrowly'. The real danger is that climate engineering is adopted as a 'deliberate communication strategy'. The real danger is 'if merchants of doubt become the merchants of alternatives' (Researcher 4).

Although this fear is widespread within the climate engineering community, there is no agreement about the extent to which climate engineers should *concern* themselves with this possibility. For some, mostly techno-optimist proponents of research and development, the appropriation of climate engineering by climate change deniers can happen 'whether we're doing the research or not' (Researcher 4). Tying into the more individualist reading of the moral hazard, this view sees adoption of climate engineering as a deliberate tactic mostly as a risk to public commitment to climate mitigation policies. The more constructivist view of climate engineering's moral hazard, however, fears that denialist tactics might slowly normalise climate engineering as a part of climate policy. Doing climate engineering research provides such an approach with ammunition, because it shows how climate engineering may be feasible—as the IPCC's recent report have started to do for carbon capture. The gradual implementation of CDR measures in the IPCC's accounting, for example, has not escaped the notice of the CDR community of the SPP. Palpably uneasy about speculating on negative emissions, they see counting on negative emissions as a prime example of moral hazard. These technologies are *speculative*, in the sense that it is unclear they can work on the scales that IPCC models now assume they will. Such fears are less prominent in the Keith Group. Keith himself is not overly concerned about the moral hazard of carbon removal. As we saw in Chapter 4, he views direct air capture (DAC) technologies 'more like an energy technology than a form of geoengineering'. In fact, because DAC is more akin to conventional mitigation, it should not be associated with that form of moral hazard. Keith, who also runs a DAC company called Carbon Engineering, even sees his 'advocacy of solar geoengineering research' as 'contrary to the interests of Carbon Engineering', because of 'the potential for solar geoengineering to weaken mitigation policies', which he doesn't see as a major concern for DAC technologies (Keith, 2018). For those who view CDR technologies as speculative, and the reliance on them in model projections and climate policy as dangerous, such statements sound wilfully naive. To many of the more sceptical climate engineers, moreover, both CDR and SRM are *technofixes* that may impede meaningful structure changes. Researching them risks reifying the imagination that technological progress will solve the climate crisis—rather than systemic change. Because of this, some SPP researchers even explicitly approach their research from the opposite angle: to provide scientific evidence *against* counting on climate engineering. Such disagreements between views of climate engineering's moral hazard as a collective process and seeing it as an aggregate of individual preferences connect to fears about becoming *dependent* on climate engineering technologies.

### *Lock-in*

The warning by EASAC that 'placing an unrealistic expectation' on negative emissions could 'have irreversibly damaging consequences on future generations' earlier in this chapter reflects the fear that counting on future negative emissions would *lock in* their future use. After all, less mitigation in the present on the assumption that we can capture carbon in the future means that we *have* to capture carbon in the future to avoid catastrophic levels of global warming—or even accept more invasive temperature controls such as SRM. This fear of being locked into the use of climate engineering is a particular flavour of moral hazard. In the eyes of EASAC, the moral hazard exists in not mitigating enough—certainly the major fear of climate engineers too—but there are more ways that climate engineering potentially locks in its use. Technologically, environmentally, *and* politically, a confluence of investments, political expectations, and technological systems might make the use of climate engineering technologies inevitable. Expectations and economically *imagined* futures bring into being structures that self-perpetuate (Beckert, 2016; Borup *et al.*, 2006; Lente and Rip, 1998). Tacit policy expectations around negative emissions are just one example of how climate engineering research might, inadvertently, become self-driving or self-perpetuating. The most evocative, and scary, shape such a lock-in risk could take is the self-perpetuating necessity at the heart of SRM that scientists call 'termination shock'. If SRM technologies become used to keep temperatures down, such a technologically induced form of climate stability would need to be kept in place indefinitely (Parker and Irvine, 2018).[18] As long as $CO_2$ would remain high, global temperatures would shoot up rapidly if people ever stopped masking the warming those $CO_2$ concentrations should have caused. Within a decade, or a couple decades at most, this 'termination shock' would radically transform the global climate, leaving ecosystems and human societies almost no time to adapt (Trisos *et al.*, 2018). Effectively, this means that once started, SRM would have to be continued indefinitely (or phased out *very* slowly)—even if wars, famines, or other developments might make this nearly impossible. Partially for this reason, most researchers and observers think SRM could never be an indefinite solution—and many think the idea is 'bonkers' to begin with.[19] Of course, climate engineering lock-in does not have to be so brutally dangerous. Lock-in might also happen gradually, as investments in negative emissions create economic expectations about the profitability of large-scale carbon capture systems. Once institutions are built around a specific technology, be it temperature management or carbon capture, or investments have been made, the political, social, and economic momentum for development might become unstoppable. Many companies have *already* patented CDR technologies, and many people hold commercial stakes in further development—David Keith is one of them. Many rightly fear that such a reliance on NETs is only a first step. If NETs at scale don't work or prove problematic—which is quite likely (e.g. Anderson and Peters, 2016; Fuss *et al.*, 2014; Gasser *et al.*, 2015; Lawrence *et al.*, 2018)—the corresponding delay in serious mitigation could bring SRM technologies into view.[20] Eventually, the fear is that climate engineering may develop as a self-driving system, slowly creating its own conditions for further development.

As Barbara Tuchman once wrote about policy decisions, 'once a policy has been adopted and implemented, all subsequent activity becomes an effort to justify it' (Tuchman, 1984, p. 245). Such fears about technological lock-in deserve to be taken seriously. By and large, they correspond to a *collectivist* reading of the moral hazard, in which creeping technological assumptions—and powerful lobbies—about climate engineering slowly come to pervade the climate change debate.[21] A particular worry in this collectivist reading is that climate engineering technologies might work to normalise *each other*. Already, arguments about 'shaving the peak' of climate change justify researching SRM on the assumption that carbon capture at scale will be successful. Simultaneously, the increasing political reliance on NETs may make SRM seem inevitable if carbon capture at scales fails or proves prohibitively expensive or controversial. The classical 'individualist' moral hazard may also happen: a majority of people might come to believe in climate engineering technologies to 'solve' climate change—locking in further research, development, and implementation. This fear about a 'lock-in' to climate engineering makes the reticence about the moral hazard of climate engineering research all the more salient. To many, it raises the question if research on climate engineering technologies—especially SRM, because the need for negative emissions is slowly becoming a commonplace assumption—is worth the political risk of normalisation and lock-in. This doesn't necessarily mean climate engineering research is out of the question. For many climate engineering researchers, insisting on 'assessment, not development' (the SPP mantra) might limit the risk of technological lock-in. In the long run, however, they question whether such a stance is tenable—or even intellectually honest. Even within the SPP itself, many found 'assessment, not development' 'a distinction that's very difficult to fully justify'. Although 'explicitly at least we're not doing any development', it is clear that 'if you improve understanding, of course this facilitates development'. Despite not 'developing any device that spreads sulphur aerosol or sulphur into the stratosphere', climate engineering research is not honest in the long run if you don't 'also make clear how or how not to implement' (Researcher K).

Because fears about moral hazard and lock-in are so salient—and because they are so consequential—climate engineering research consistently grapples with the political consequences of their research. One question of particular importance is *who* gets to shape the conversation (and research) around climate engineering and, correspondingly, who would control it. Specifically, such worries focus on how climate engineering is and should be received in the wider political and cultural sphere. In Sections 5.4 and 5.5, I turn to the question of decision-making and climate engineering, starting with the role scientists see for themselves followed by visions on political decision-making.

## Who controls the Thermostat I: on the authority of science

The question of what moral hazard climate engineering poses directly ties into the question of how climate engineering should be governed, both in terms of research and in terms of implementation. Because climate engineering is premised on the idea that technological advances can provide some measure of control over the Earth's climate system, such questions are often tied to the question of *who* would be in control—and who should have the power to steer climate policy in certain directions. Whose hands, climate engineers ask, would be on the thermostat (e.g. Heyen, Wiertz and Irvine, 2015; Hulme, 2014; Rickels *et al.*, 2018; Stilgoe, 2015)? Like the idea of a moral hazard, the thermostat metaphor implicitly describes different aspects of the climate engineering debate.[22] In this section and Section 5.5, I focus on two important aspects of who controls that metaphorical thermostat. In this section, the thermostat metaphor relates to what the rightful place of science is in the climate change debate, raising difficult questions about technocracy and the authority of scientists to make speculative claims about the future. This matters, because who controls the sociotechnical futures of climate engineering—and correspondingly, whose concerns matter most—matters for the political and technological road *to* climate engineering. Simply put, this section outlines different positions on the role of scientists and engineers in the design, maintenance, and decision-making of climate engineering technologies. In this section, then, I focus on disagreements about the desirable role of the climate engineering researcher—and views on how their expertise should be validated and utilised in the climate change debate. In Section 5.5, I address the (geo)politics of climate engineering. Who could rightfully govern climate engineering technology? And how could that be done? These connected sections bring out specific views on political power, the authority of science, and the politics of climate change.

### *Reluctance and resolve: the science arbiter and the issue advocate*

In modern societies, science holds an almost singular authority as the provider of facts and truth (Ezrahi, 1990; Porter, 1996). It holds *epistemic* authority, authority over truth claims. As Thomas Gieryn notes, however, 'it is a little misleading to speak of the "epistemic authority of science" as if it were an always-already-there feature of social life'. Authority, rather, is a social process, 'enacted as people debate (and ultimately decide) where to locate the legitimate jurisdiction over natural facts' (Gieryn, 1999, p. 15). Climate engineering research is a constant site of such debates. As a site for 'post-normal science', climate engineering is a field of research in which facts are uncertain, values are always in dispute, and the legitimate jurisdiction about natural facts—and which natural facts matter—is continuously debated. A particular site for this contestation, among many others that have appeared throughout this book, is the *role* of the scientists themselves in the climate engineering debate. Climate engineers are aware their research might turn out to be deeply consequential—even though many feel their influence *should* be limited. Between them, the SPP and the Keith Group have different strategies to deal with their increasing prominence in the climate change debate. Although both committed to 'open science', wanting to increase democratic debate about their research and the political implications of climate engineering, they adopt different roles in the climate engineering debate. In understanding these differences, a useful place to start is Roger Pielke's distinction between four different types of scientific engagement with public issues. According to Pielke, scientists engage with public affairs differently according to whether scientists believe in the linear model of science, which views science as producing knowledge that subsequently flows into the public sphere, or the stakeholder model of science, where knowledge production is also a social and political process (Gibbons *et al.*, 2010). In his 2007 book *The Honest Broker*, Pielke identified four ways in which scientists can conduct themselves in public debates. First, there is the *pure scientist*, who believes that science develops in a linear direction moving from basic science to applications in society. Researching what she likes, the pure scientist is simply someone researching questions that intrigue her. The *science arbiter*, secondly, also believes in the linear model of science. She sees her role as disseminating the best available knowledge to the policymakers, such as in the form of advisory committees, who then use this knowledge for decision-making. The third type, the *issue advocate*, argues for a particular course of action, narrowing down public opinion and the range of possible policy choices in a particular direction, the issue for which she is advocating. The final category is the *honest broker of policy alternatives*; this scientist takes an active role in clarifying and expanding the range of scientific options and in broadening the range of possible (policy) alternatives[23] (Pielke Jr., 2007).

Of course, any such generalisation is necessarily reductive, yet Pielke's classification provides a useful heuristic to address differences in the way climate engineers conceive of their roles in the climate change debate—and the role of other climate engineers. To most techno-optimist climate engineers, climate engineering research expands the range of possible climate policies—providing additional options in the form of climate engineering. Not too concerned about lock-in and moral hazard, they argue that SRM and CDR might provide plausible *expansions* of the climate change policy envelope. In the David Keith Group, this ties into a conviction that the world faces a range of problems. Climate scientists 'can be a little too monomaniacal on climate', and they 'have this way that tends to under-appreciate the real trade-offs that the world faces' (Researcher 10). Climate engineering, and by extension the Keith Group's research, broadens the range of trade-offs that the world could make on climate change. As such, climate engineers should not feel too apprehensive about introducing climate engineering into the public debate. By providing knowledge about this broader range of policy options, climate engineers, in this view, should act as *Honest Brokers*, clarifying the options that climate engineering provides and makes visible the climate trade-offs that the political world will face. For more sceptical researchers, however, it is unclear when such honest brokering gives way to *issue advocacy*—and pretty clear that Keith Group researchers cross that line, actively normalising *their* vision of climate engineering by narrowing down the range of alternatives.[24] Part of this unease stems from SPP members' apprehension about their own role and that of other scientists. Collectively, the SPP struggled to find an appropriate public voice on climate engineering. The 'assessment, not development' mission statement reflects this apprehension. Broadly interpreted as a mandate to build a body of scientific evidence from which policymakers and politicians can draw, the SPP (as a research collective) constructed its role as a *science arbiter*. In their view, SPP's contribution to the climate change debate comes from providing evidence on important climate engineering questions—such as the comparison between different climate engineering technologies (their ComparCE project), liability issues (their CELARIT project), and the general feasibility of these technologies in larger systems (the projects CE-LAND+ and LEAC-II)—and making that evidence available. Often, those most opposed to climate engineering as a whole stay furthest from the policy debate. Attempting to *disprove* the viability of climate engineering, many of them insist that 'the decision of what to do is absolutely not a scientific task to the scientist. Absolutely, not' (Researcher K). This reluctance to engage with policy concerns typically ties into a tacit belief in the linear model of science, carrying with it a belief that scientists make knowledge available to the public and political spheres. It also means that many of them feel that more activistic researchers (such as David Keith) conflate their role as scientists with their roles as issue advocates—abusing the perceived epistemic authority they enjoy as renowned scientists to unduly influence the public perception of climate engineering.[25] Such apprehension about what the role of the scientist should be in the climate engineering debate and, correspondingly, *whose* visions and facts should matter most in the public debate feeds into other questions of *decision-making* in climate engineering. Because the amount of techno-scientific expertise needed for decision-making, implementation, and maintenance of climate engineering technologies is high, many fear that climate engineering will inevitably lead to centralised technocratic decision-making. This will, in turn, elevate the role of the scientist to a central pillar of decision-making. Although many climate engineers feel uncomfortable about this idea because 'I'm not elected by anyone' so 'it wouldn't be up to me' to make such decisions, they admit that 'researchers have the responsibility to shout when a decision [on climate engineering] is near' (Researcher N). In Section 5.5, I turn to precisely the question of who will and *should* end up controlling technological development and climate engineering implementation, both (geo) politically and technocratically.

## Who controls the Thermostat II: geopolitics, power, and socioeconomic structures

In June 1996, as the debate on climate change and the reliability of climate science was gathering steam, a group of high-ranking officers in the U.S. Air Force presented their report 'Weather as Force Multiplier: Owning the Weather in 2025'. The report's directive was to 'examine the concepts, capabilities, and technologies the United States will require to remain the dominant air and space force in the future' (House *et al.*, 1996, p. ii). It listed a wide range of weather interventions potentially available to the U.S. Air Force. Such options included enhancing or limiting precipitation, modifying storms, altering weather and space conditions to disrupt communications, and detecting hostile weather activities. The United Nations' Environmental Modification Convention (ENMOD) of 1977 which forbids the military application of environmental modification techniques, notwithstanding, *Weather as a Force Multiplier* argued that weather control for military purposes should be (a) actively sought and (b) possible by 2025. Clearly, the dreams of weather control dreamt in the Cold War (see Chapters 2 and 3) had not disappeared. According to the report, 'technology advancements in five major areas are necessary for an integrated weather-modification capability: (1) advanced nonlinear modelling techniques, (2) computational capability, (3) information gathering and transmission, (4) a global sensor array, and (5) weather intervention techniques' (House *et al.*, 1996, p. vi). In its search for military control of the weather, the U.S. Air Force searched the same advancements that climate engineers now look to for SRM. This similarity between military interests in weather and climate modification and the civilian interest in climate engineering as a response to climate change is widely noted (Fleming, 2010). For many, the risk of military control of climate engineering technologies exacerbates pre-existing fears about lock-in, moral hazard, and the undemocratic adoption of climate engineering. Although it is unclear whether SRM could be controlled well enough to target specific regions for economic or military purposes, many observers, such as Alan Robock (Robock, 2015; Robock, Jerch and Bunzl, 2008) and Jim Fleming (2010), have expressed their concern about military applications.[26] These worries are important and consequential. But even where military application of climate control *isn't* an immediate concern, there are plenty of reasons to worry about the (geo)politics of climate engineering. In a world where countries haven't been able to solve the question who needs to mitigate what and when, the prospect of climate intervention seems a political powder keg.[27] The (geo)politics of climate engineering are deeply problematic. SRM almost inevitably invites some sort of centralised decision-making on a global level—or unilateral action by a rogue nation. It will also almost certainly exacerbate power imbalances in the world, centralising more power in the hands of those powerful enough to control the radiation management in the first place (Szerszynski *et al.*, 2013). It raises serious questions about liability for damages,[28] about for who the climate might be optimised, and global trade-offs between regions better off and those worse off. Negative emissions on the other hand could be implemented on a national or even local scale, even as part of a national or regional mitigation strategy. At the same time, however, negative emissions technologies also face their own governance issues. They need to be tied into a larger system of carbon accounting (Gasser *et al.*, 2015). They still risk the displacement of vulnerable agricultural communities through land grabs, extensive use of local water supplies, and other ways of marginalising vulnerable peoples and ecosystems. Although unlike SRM carbon capture might not serve centralised 'imperial' power, it might still facilitate a neo-colonial form of extractivism in which rich countries exploit poorer countries through land grabbing for negative emissions technologies.[29]

For climate engineers, such concerns are ever-present. At the same time, there are serious disagreements about how to address those concerns—and how worried one should be about climate engineering's governance risks. This disagreement is exemplified by the debate on SRM technologies. To opponents, it is almost inevitable that such deliberate climate control will exacerbate pre-existing tensions between countries, potentially leading to wars (preparations of which are evidenced in the *Weather as a Force Multiplier*).[30] Not all agree such tensions are inevitable. Science journalist Oliver Morton (2016), whose political views are decidedly techno-optimist, for example hypothesised that while powerful countries would never allow each other to control the global climate, they might tacitly accept clandestine experimentation by developing countries. In such a scenario, Morton thinks, it is not impossible that a consortium of countries comes to share responsibility for SRM implementation. Many techno-optimistic climate engineers are partial to such an argument. They also think that *influence* on SRM decisions might be combined with stringent mitigation commitments. Such ideas have circulated in the climate engineering community, much to the dismay of other researchers. Making inclusion in SRM decisions contingent on extensive mitigation, they fear, exacerbates already strained relationships between SRM and democracy. It might also raise disagreements between climate mitigation obligations. Again, these differences can be traced back to irreconcilable world views—particularly the difference between a *positivist individualist* view, which views both states and public opinion as the aggregate of measurably self-interested individuals, and a *constructivist collectivist*, which views decision-making as a complex, multi-layered interaction between values, cultural shifts, and actors. To individualists, conceiving of a state as rational self-interested actors—known in international relations theory as a *Realist* position—both *explains* the intractability of the climate change debate and makes climate engineering politics seem solvable. Climate change is a classic 'free-rider' problem, in which it is no state's self-interest to take the lead. Climate *engineering*, on the other hand, might start to be in everyone's self-interest once climate change gets bad enough. For more constructivist researchers, these views dangerously underestimate both the human ability to collaborate *and* the political risks of climate engineering assumptions. A debate in which this is particularly visible is the question whether climate engineering, specifically SRM, can co-exist with democracy. To many, 'solar radiation management and democracy won't mix', because it almost inevitably leads to technocratic and highly centralised decision-making (Szerszynski *et al.*, 2013).[31] Others, several members of the Keith Group among them, see no inherent conflict between democracy and SRM. To them, SRM 'lacks innate political characteristics and predetermined social effects' (Horton *et al.*, 2018, p. 5). Such discussions again hint at different perceptions of what political concerns are predetermined and structural. For many of the researchers at Harvard, relatively optimistic about the knowability and controllability of the climate (as seen in Chapter 4), both the structure and effects of climate engineering—both of SRM and CDR—might be designable. As such, the international political community might be able to solve political questions around implementation of these technologies. Technocratic, anti-democratic decision-making in any case is not *inherent* to SRM—although it may be a risk of it. To these researchers, such political concerns might actually be more solvable than the 'free rider' politics of climate mitigation where all countries attempt to minimalize their responsibilities. More reluctant climate engineers, more sceptical about the technical potential of both SRM and CDR, are far more concerned about the political ramifications of the various technologies. These technologies will inherently have to embed certain political consequences into their design—and this political debate might be highly volatile.

### *5.5.1 Intimations of distrust*

Questions about *how* to govern SRM and CDR technologies—and how volatile and just such governance systems are likely to be—always tie into questions about *who* governs and controls the research and development of climate engineering before its implementation. For many climate engineering researchers, this is the most urgent question: who has the power to *shape* climate engineering—politically, and in terms of discourse and the political imagination—how and why? Of particular urgency to most researchers is the question of *funding*, as this determines the directions that research can take, the amount of public oversight, and who has the right/power to appropriate climate engineering research. For European researchers, the SPP in particular, government funding for SRM research and (most) CDR research is a prerequisite, as it is (in their eyes) the best way to safeguard public accountability and limit commercial power of development. For the Keith Group, such public accountability and 'open science' are also crucially important, but public funding (at least in the United States or China) is decidedly *not* the best safeguard. Of course, such differences arise from a well-documented civic tradition of government distrust and, importantly, deep-seeded militarisation of the connections between government, science, and technology in the United States (Geiger, 2004; Leslie, 1993)—and corporate distrust in Europe. As a result, the urgent fear for Keith Group researchers was the appropriation of their research by governmental interests, specifically the military. As such, it was crucial that 'it's all privately funded, so the government does not have any claim to anything' (Researcher 9). Because climate engineering, especially SRM, is so contentious, one PhD student remarked that 'sometimes I feel like I'm working on the Manhattan Project',[32] because 'who knows what will happen with this technology?'. The government simply shouldn't have a right to the research because 'the way that governments work is that they serve themselves. They are here to protect the United States or whatever country they're associated with' (Researcher 9). Government funding, in the eyes of this Keith Group researcher, risks pitting an imagined *national* community against a *global* community of people trying to avoid the worst of climate change. David Keith himself has repeatedly stated he will not accept federal funding under a government that does not explicitly focus on conventional mitigation, fearing its deliberate use to weaken mitigation resolve.

For most SPP members, on the other hand, government funding was a *precondition* for climate engineering research, as it would provide climate engineering research with a modicum of democratic legitimacy. Of course, Europeans also feared governmental and military appropriation of climate engineering research, but, coming from a far less militarised continent, they see this only as a distant possibility. To them, it is commercial development of technologies or private funding for research that is anathema. In their eyes, private interests might try to frame the climate engineering debate in ways that benefit those interests—and, resembling moral hazard, to continue business as usual as long as possible. As such, the leadership of the SPP was 'very glad' to 'have the possibility of [public] funding'. Public funding 'ensures that taxpayers could ask us what we do with our money', which means that there is 'an automatic control built in'. Private funding does not automatically oblige researchers to such transparency, which means that 'some of these privately funded projects are not transparent' (Researcher A). Public funding, to European researchers, was a far better guarantee of transparency. At any given time, the SPP's philosophers argued, 'we would have to debate about the political economy of solar radiation management. What kind of business model? What kind of patenting? What kind of connection with the military complex? Who is doing this?' (Researcher F). Might there be a chance that 'this is a macro rebound of the fossil fuel industry, the coal industry, the chemical industries'? Mostly, however, SPP members saw in the private funding the same fears that Keith's researchers see in disingenuous government interest in climate engineering. They fear that 'this might be only a strategy to avoid… change to a more greener, more sustainable society', 'a defence against change… undertaken by a specific variety of capitalism' (Researcher F).[33] Such fears from both the Keith Group and the SPP are not ill-conceived. As research by Nancy Maclean (2018), David Michaels (2008), and Naomi Oreskes and Eric Conway (2010) has shown, particular societal groups are immensely adept and scrupulous at framing debates. In their pursuit of their aims, which typically amounts to continuing business as usual, they use any means available, including the deliberate manufacture of doubt and the crippling of democratic decision-making. The appropriation of climate engineering research and development by such groups is entirely conceivable (and one of the major 'moral hazard' risks). *Both* government and private interests can do so, although the most salient fears are different. The number one concern for government is military appropriation, for private interests it is profiting and racketeering over current climate concerns. Such fears take various shapes—fear of commercialised CDR by energy companies to continue the emissions of carbon dioxide, government use of SRM for geopolitical gain or even military applications, patents on any of the technologies that make them inaccessible or expensive for common use—but all revolve around fears that the technologies are used in unseemly ways.

## Conclusion: discursive power and the shape of an imaginary

One of the major risks is that climate engineering's moral hazard provides an escape hatch for a *corporate business as usual* scenario. It is likely that climate engineering will be mobilised by the climate change denial industry, to continue business as usual for as long as possible. While it requires some political manoeuvring and a tacit acceptance of climate change, this would be nothing new. ExxonMobil, BP, and Shell, for example, have been aware of climate change for decades, whilst simultaneously holding the position that 'the science is still out' or hiring 'deniers-for-hire' (Oreskes and Conway, 2010). Traces of this world are already seen in the rising numbers of climate engineering patents, predominantly for carbon capture technologies as well as for SRM technologies (Oldham *et al.*, 2014), but also in the projected scenarios pushed by large corporations. Royal Dutch Shell, for example, has published several scenarios on future energy needs. In its 'ambitious goal to achieve net-zero emissions by 2070 within techno-economic possibilities', negative emissions play a major role (Shell, 2018). Might this move towards negative emission scenarios signify a move away from climate change denialism towards ecomodernist projections of future climate policy?

Even the staunchest opponents of climate engineering, both inside of academia and outside of academia, admit that it seems *technically* possible to manipulate the climate. Technically, both drawing down carbon and 'managing' solar radiation seem possible. The real disputes are about at what cost and what risk this is possible. In Chapter 4, I addressed the disagreements about the technical *reliability* climate engineering measures. There, worries such as the potential that a climate engineering technology 'pushes the climate system into a different equilibrium' (Researcher 5) took centre stage. This chapter added to those concerns a series of *political* questions about the desirability and governability of climate engineering. Might counting on negative emissions not delay conventional mitigation? Could SRM be implemented and governed in fair and safe ways?

Here, it became clear that, while important, technical feasibility will not be the main determinant of the role climate engineering can and should play in the mitigation portfolio. Instead, political imaginations about who controls the thermostat, when it is legitimate to count on climate engineering, and what the political consequences of climate engineering research might be animate the climate engineering debate even more strongly. Fundamentally important in this development is *whose visions* of the political future of climate engineering can be made to count. The views and opinions of contemporary climate engineering researchers will co-constitute discourses that will shape the imaginaries of climate engineering in the years to come. The political visions and interpretations of contemporary climate engineers should therefore be taken extremely seriously. After all, they determine, or at least attempt to determine, the discursive playing field for the (future of the) climate engineering debate. Of course, they do not do so in a vacuum. The epistemic authority of the IPCC greatly influences the normalisation and legitimisation of certain climate engineering technologies, making negative emissions technologies seem inevitable and economically prudent forms of climate mitigation. Powerful activists such as the ETC Group and Greenpeace also weigh in, providing their own metaphors and visions on moral hazard and whose hands will and should be on the thermostat.[34]

In their own ways, both the SPP and the David Keith Group try to shape the discursive space around climate engineering, based on their own views on political issues. Techno-optimist views of climate engineering politics connect to a *positivist* and *individualist* view of political developments in societies, with rational actors and rational states. Techno-pessimist views counter such narratives with *constructivist* and *collectivist* views on the politics of climate engineering, insisting that issues such as the moral hazard of climate engineering and the geopolitical power struggle cannot be accurately captured by individualist readings—and are, as such, much more intractable, unpredictable, and, like the climate in Chapter 4, *unknowable*. In advocating their position, Keith and his group are particularly entrepreneurial, advocating for their individualist view to raise the scientific and political prestige of SRM and its potential. Emphasising that carbon capture has a rightful place in the climate policy envelope—that DAC isn't too different from conventional mitigation—is part of this strategy. In their (successful) attempts to normalise climate engineering, they have over the years painted an increasingly positive picture of climate engineering. As the idea of climate engineering has gained traction, their message has become less cautious. The SPP is much less entrepreneurial in its attempts to popularise the climate engineering debate. They host citizen juries on climate engineering to see if people can be meaningfully informed, searching for input on climate engineering's desirability. They conduct research on the moral hazard of climate engineering research and development. They also question the potential geopolitical organisation of SRM and CDR technologies. But they do not present climate engineering as a viable option, nor do they attempt to convince a wider audience that their position on climate engineering is the right one. By and large, they remain committed to the scientific debate rather than the public debate. Many in the SPP use their scientific research to build a compelling collection of evidence *against* engineering the climate—especially because they feel there needs to be a respected scientific voice countering the overt and dangerous climate engineering advocacy of people like David Keith.

Different positions on the politics of climate engineering—on the way moral hazard manifests and what the role of science and politics should be in the decision-making process about climate engineering—will play decisive roles in determining the future of climate engineering research, both the future of its research and its place in the climate policy envelope. Specific views on how to govern climate engineering technologies will influence the stability of climate engineering governance *and* assessments of the technical feasibility of particular technologies. These visions differ depending on the outlook from which climate engineers start. It is too early to tell whether climate engineering will be imagined on the basis of economic discourses, on the basis of discourses about climate risks, or about the risks of climate engineering itself. Preliminary observations, however, seem too suggest a continued predominance of narrowly technocratic and economic metrics. Visions on the economic feasibility and desirability of CDR and even SRM continue to dominate the discussion. Nuanced discussions on how the metaphors of the thermostat, and the two central metrics of climate change (average global surface temperatures and carbon dioxide concentrations), might facilitate an imagination of climate engineering as a feasible and politically desirable road are still lacking in the public debate. The question then becomes, which ways of seeing and imagining (the future) of climate engineering will win out in the long run? Imaginations about the economic costs and benefits, climate risks, and individual responsibility for moral hazard rely on particular visions of power, politics, and authority. They risk removing moral and ethical questions from view, even though climate engineering should always remain a *normatively* political discussion. Inevitably, they *naturalise* implicit normative assumptions about the political organisation of the world. Economic metrics, for example, presenting climate politics as a series of monetary and individualised trade-offs, rest on the normative assumption that economic growth equals prosperity—and that monetary costs are the appropriate measure for climate mitigation. Which discourses on the politics of climate engineering feed into the *imaginaries* of the future climate will determine which issues present themselves to us as normative and moral questions—and which, importantly, are simply inevitable and natural.

## Notes

1 Societies have different political and cultural traditions, and civic epistemologies—culturally specific ways of knowing by which a nation's citizens come to know and understand things in relationship to the conduct of politics (adaptation of: Jasanoff, 2007, p. 9)—that shape the perception and governance of science and innovation within society. Such underlying views on politics of innovation co-produce culturally specific ways in which both researchers and the general public relate to 'knowledge-in-the making' and proposed innovations (Epstein, 1998; Jasanoff, 2007; Miller, 2008). They also shape the perception and (non-)acceptance of technological risks. In Europe, for example, civil society has famously resisted a push for the implementation of genetically modified crops, whereas the United States has been more open to GMO foods (Jasanoff, 2007).

2 There is a clear sociological difference, however, between the disagreements about politics and those about climate. Climate engineers regard 'the climate' as a real object of study and debates about their discursive approximations of the climate as debates about the best possible *representation*. For many, politics and authority are more ephemeral. Being mostly *positivists* about natural phenomena, climate engineers regard discussions about climate knowledge as debate about 'knowledge', while they often see debates about politics as distinct debates about 'values'.

3 Effectively, growth is imagined as the main predictor of prosperity and happiness, often displacing other political concerns. This myth of growth as the ultimate aim of politics is increasingly criticised, by post- and de-growth scholars (Kallis, Kerschner and Martinez-Alier, 2012) and by ecological economists (Costanza *et al.*, 2015). Growing parts of the Western societies are also dissatisfied with the measure as, despite steady 'growth' in developed economies, inequality has soared and median spending power has not increased (Piketty, 2014, 2020).

4 I use the term 'myth' here not to refer to growth untruth or fallaciousness, but rather in the structuralist reading of Claude Levi-Strauss (1964), who argued that myths signify and organise the structure of human reality. 'Growth' in this way signifies 'progress', 'prosperity', 'happiness', and 'power'. Herbert Marcuse's

(1991) reading of how media and society organise collective self-understanding also informs my usage.

5 A loss of 2% GDP in 2050 through climate change isn't merely because people decide to build or spend less. Such a 2% GDP loss is augured in by storms, droughts, floods and other extreme weather events. It is augured in by real human and non-human suffering and changes to the way people can relate to their environments.

6 Of course, fundamental disagreement exists about how to quantify the costs of climate change versus the costs of mitigation.

7 Although recent breakthroughs by Carbon Engineering, a company co-founded by David Keith, suggest that carbon capture from ambient air (DAC) might indeed be a lot cheaper than previously thought. According to Keith and his co-authors, previous estimates of $1,000 per captured ton of $CO_2$ from the atmosphere might be reduced to $94–$232 per ton (Keith *et al.*, 2018). Despite these reductions in price, however, other renowned scientists, such as James Hansen, still view this as a prohibitively great expense to burden future generations with (Hansen and Kharecha, 2018).

8 Whereas in climate change mitigation countries piggyback off the mitigation efforts of others (a rational way to reduce costs, according to mainstream economics), SRM might prove so cheap (somewhere in the region of 8–10 billion dollars a year) that a country might start to do SRM on its own—provided the costs of implementation are expected to be less than the damages of climate change (Morton, 2016; Wagner and Weitzman, 2015). In this sense, the question of how to *prevent* SRM becomes a more pressing concern than how to prevent freeriding.

9 Thereby, of course, reducing the chance of catastrophic economic damages through that 'fat tail of climate change'.

10 The *SPP-affiliated* researchers Olivier Geden and Felix Schenuit, for example, have focused extensively on the effects of embedded model expectations for carbon capture, fearing the self-justifying dynamic around CDR technologies (Geden, 2016; Geden and Schenuit, 2020).

11 Both for SRM technologies—which should be researched as a cheap 'back-up' option in case conventional mitigation fails—and for CDR technologies—in which David Keith himself is financially invested and does private research (Keith, 2018; Keith *et al.*, 2018).

12 Although David Keith is fundamentally abhorred by Gingrich's disingenuous use of climate engineering technologies, there are intriguing parallels between Keith's observations about people being unwilling to make sacrifices to their lifestyles and Gingrich's assertion that 'increasing the pain level isn't the way to go'.

13 The other three major reasons were as follows: (a) the distraction from other risks of carbon dioxide such as ocean acidification, a distraction that could be seen as a form of moral hazard in its own right; (b) the fear of a slippery slope, in which systems slowly get locked into the use of climate engineering, which also connects closely to the moral hazard argument; and (c) a general contention about technofixes, to which I turn in Chapter 6.

14 Moral hazard as a term originates in insurance policy. The concept describes how insurances almost imperceptibly lead to more risk-seeking behaviour. People who have car insurance, for example, statistically tend to behave more recklessly than people who don't. Although this behaviour might individually be irrational, this phenomenon still occurs—even when insurances introduce risk premiums (Pauly, 1968; Rowell and Connelly, 2012).

15 This focus on individual preference being at odds with climate mitigation, which is a widely shared view, brings into focus and sharp relief a third aspect of the mitigation problem, namely the issue of personal responsibility. Again a matter of

much dispute, many have written books and articles about why climate change is such a tenacious problem. These attempted explanations range from approaches in cognitive psychology and behavioural economics that suggest that climate change does not correspond to typical ways people operate in the world (Marshall, 2015), works in science communication and cultural theory that have tried to explain why (or why not) people adopt scientific findings as reasons for acting (Kahan, Jenkins-Smith and Braman, 2011; Kahan *et al.*, 2012), to works of anthropology and sociology that have tried to explain the social and narrative aspects of collective self-imagination that impede individual and collective action on climate change (Norgaard, 2011). As a result, many books have been written with titles such as *The Great Derangement* (Ghosh, 2017), *Living in Denial* (Norgaard, 2011), *Don't Even Think About It* (Marshall, 2015), and *Why We Disagree About Climate Change* (Hulme, 2009).

16 Often, especially in the United States, appeals to technofixes such as climate engineering to limit mitigation will be explicitly tailored to fit into a national imagination, in which the imagined community of the nation stands in opposition to the imagined community of the world (as is seen in Gingrich's plea for American ingenuity as the solution to climate change). In general, this culture of ingenuity as the driver of scientific and political success is deeply prominent in the United States, while Germany often holds to an imagination of being more technologically apprehensive and cautious (Burri, 2015; Jasanoff, 2007).

17 Whether or not the fears about the Trump administration's approach to climate change are justified (and they may well be), the relationship between the Keith Group and Trump's administration that is insinuated in the article were to my knowledge non-existent. As it stands, David Keith and his group do not want federal funding, and they certainly would oppose any significant investment in SRM methods without significant emissions cuts.

18 Although, as Parker and Irvine also note, it may be possible to avert the worst risk of termination shock, even after significant SRM implementation, through designing and setting up the resilient sociotechnical systems aimed to withstand political shocks. The system, especially if controlled by a few powerful countries, might then be resilient against 'all but the most extreme catastrophes' (Parker and Irvine, 2018, p. 456).

19 David Keith's arguments about using SRM to 'slow the rate of change' or 'shave off the peak' of global warming are also a response to the risk of a termination shock.

20 Importantly, such lock-in processes are also aided by prevailing sociotechnical imaginations of technological solutions for environmental problems.

21 *Individualist* readings of moral hazard also leave room for the risk of such technological lock-in, but corresponding to their more positivist outlook often see this only as a risk if (a) delays in mitigation make climate engineering 'necessary' or (b) the majority of people come to support climate engineering technologies.

22 One effect of the thermostat metaphor is a reduction in discursive complexity. A thermostat typically only has two basic dimensions: temperature and time. In doing so, it makes the complexity of climate engineering governance concerns easier to grasp, facilitating a shared understanding and discourse—at the risk of oversimplifying (and presenting as solvable) something that is immensely complex.

23 These views also tie to views on democracy. Science arbiters and honest brokers hold an elite view of decision-making, where policy is, in the end, driven by the competition between elites groups. The interest group pluralism of pure scientists and issue advocates, on the other hand, holds that there is a more open access to power and influence through interest groups.

24 The insistence that people will not want to sacrifice their lifestyles for climate change mitigation is one such form of discursive closure. In insisting people will

not want to change their lifestyles, high-tech solutions such as increased energy efficiency and climate engineering technologies become the only reasonable alternative.

25 To other researchers, especially those more amenable to the idea of some form of climate engineering in future climate policy, a more active (even entrepreneurial) role of the *SPP* would be warranted. In their eyes, the *SPP* should act as a honest broker, actively but critically engaging with and opening up policy options around climate engineering.

26 This book probably underestimates the importance of the academic military-industrialist collaboration, and of the surveillance imperative, in climate engineering. While Jim Fleming's book *Fixing the Sky* already provided a wonderful insight into the world of weather warriors, a full understanding of the techno-political entanglements of climate engineering, especially in its second coming, is still sorely lacking. Scientists today, however, are, more often than not, unconnected to the academic military apparatuses, and often unaware of the deep entanglement. It was beyond *my* scope here to answer these questions, but that doesn't mean they shouldn't be answered. The picture of climate engineering arising from such an investigation may look very different.

27 Typically, the conversation about the geopolitical risks of SRM focuses on countries competing for global dominance via climate, climate terrorism ('greenfinger'), or a rogue state starting to implement on its own accord. According to Lockley (2016), however, there are many more things to be concerned about, such as civil wars, bilateral conflicts, internecine conflict, or even ideological conflicts about climate engineering. For more extensive treatment, see Lockley (2016).

28 As the *SPP*-1689's ComparCE-2 project researched.

29 I owe this comparison to Jeremy Baskin, who presented this line of reasoning at the annual conference of the *European Association for the Study of Science and Technology* (EASST) in Lancaster, July 2018, and elaborated on it in his book *Geoengineering, the Anthropocene, and the End of Nature* (2019). For Baskin, the difference between these two agendas, between imperial and colonial thinking, is that they facilitate a different mode of governance and vision. Imperial thought promotes a highly centralised form of governance, in which the 'empire' (whoever this is) controls vast swaths of territory and holds the ultimate authority. SRM would be imperial, in that it involves a highly centralised, technocratic form of global climate governance, with explicit questions over 'who controls the thermostat'. Colonial thinking, not necessarily unconnected to imperialism, doesn't always feature empire building, but it does involve the explicit construction of a centre that benefits from extractivism that displaces environmental degradation to the periphery. CDR, BECCS, and CCS in particular, in this sense, can be seen as a displacement of mitigation obligations in developed countries to developing countries.

30 It is good to remind ourselves here that, as we saw in Chapter 2, Edward Teller already predicted that war over weather and climate control might be the last war on the Earth.

31 The main reasons why democracy and SRM couldn't mix are as follows: (a) it needs a technocratic decision-making apparatus inaccessible to most; and (b) once started, it is unlikely that it could easily be stopped, effectively forcing future citizens of the world to accept SRM as a given rather than be able to make decisions about it.

32 This was a telling allusion to the development of the atomic bomb, because (a) it reflects the fear that climate engineering *as a technology* is or at least should be as controversial as the atomic bomb, and (b) it is the quintessential example of 'government-led' science aimed to further military aims.

33 Of course, such preferences are never absolute. One German researcher admitted that 'I was really against private funding or foundation funding, and I thought it should be funded by the taxpayer only. But now I think it could have also instruments to make foundations transparent' (Researcher A). At the same time, Keith himself also repeatedly admitted that public funding guarantees a form of oversight on climate engineering that private funding cannot.

34 Another NGO, the Environmental Defence Funds in Washington, DC, is enlisted by the David Keith Group as a (critical) ally.

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