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Geoengineering’s Move from Margins to Mainstream: The Politics of Representation and the Construction of Legitimacy

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Geoengineering's Move from Margins to Mainstream:
The Politics of Representation and the Construction of Legitimacy

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy

in

Sociology

by

Brynna A. Jacobson

Committee in charge:

Professor Charles Thorpe, Chair
Professor Kelly Gates
Professor Isaac Martin
Professor Hugh Mehan
Professor Kwai Ng

2018

The Dissertation of Brynna A. Jacobson is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego
2018

DEDICATION

This dissertation is dedicated to my mom, Addie.

EPIGRAPH

I think we're challenged,
as mankind has never been challenged before,
to prove our maturity and our mastery,
not of nature but of ourselves.

Rachel Carson, 1963

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Chapters One, Two, and Five, in part, include material as it appears in "Constructing Legitimacy in Geoengineering Discourse: The Politics of Representation in Science Policy Literature." 2018. *Science as Culture*. Forthcoming. Jacobson, Brynna. The dissertation author was the sole investigator and author of this paper.

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Brynna Jacobson. 2018. “Constructing Legitimacy in Geoengineering Discourse: The Politics of Representation in Science Policy Literature.” *Science as Culture*. Forthcoming.

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FIELDS OF STUDY

Major Field: Sociology

Environmental Sociology
Professor Charles Thorpe

Political Economy
Professors Charles Thorpe and Isaac Martin

Sociology of Law
Professor Kwai Ng

ABSTRACT OF THE DISSERTATION

Geoengineering's Move from Margins to Mainstream:
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by

Brynna A. Jacobson

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Professor Charles Thorpe, Chair

The entrenchment of certain discursive strategies promotes public reception and political support for contested technologies, influencing the future prospects of the technology. Geoengineering, the idea of addressing climate change through large-scale technological projects, is a unique example of a contested emerging technology. It stands out in the degree to which both its scope of possibilities and its premise are characterized by global existential risks. Despite controversy due to inherent and perceived risks, this field has been

shifting toward mainstream consideration. Drawing upon the concepts "politics of representation" and "the politics of unsustainability," this research applies critical discourse analysis to three genres of geoengineering discourse: science policy reports, journalism, and Congressional hearings. In particular, discursive strategies and trends recurrent in these genres construct notions of normalcy, legitimacy, and imperative around the notion of geoengineering.

Science policy reports on geoengineering from distinguished and respected scientific societies have both reflected and promoted the mainstreaming of geoengineering. Discursive strategies used by scientists advocating support for geoengineering research construct legitimacy and contribute to the mainstreaming of geoengineering within scientific, political and public discourse. News coverage of geoengineering has increased since 2006, coinciding with important publications from the scientific community, with scientific publications used to indicate the mainstreaming of geoengineering as well as offering topical insight. Moreover, recurrent narratives within popular media contribute to the mainstreaming of geoengineering through presenting its trajectory as moving from fringe origins through serious consideration. As demonstrated through four congressional hearings on the subject, geoengineering has garnered political support from both major political parties in the United States, but for different reasons and with different interpretations of the role it might have to play in climate policy. Certain geoengineering researchers and advocates are particularly prolific and influential in affecting the deliberation and presentation of geoengineering within science publications, popular media, and policy discourse. These three genres of science policy reports, news media, and political hearings reinforce one another in reflecting and advancing the mainstreaming of geoengineering.

CHAPTER 1 — Introduction: Modernity, Climate Politics, and Geoengineering Climate Change and "Plan A"

Climate change with its associated global risks is a quintessential, and existential, dilemma of "high modernity" (e.g., Beck 2009; Giddens 1990; Thorpe and Jacobson 2013). As such, how global society addresses climate change and the processes through which this is determined are important social questions. To date, with few exceptions, climate politics have been exemplary of the "politics of unsustainability," characterized by "general acceptance that the achievement of sustainability requires radical change in the most basic principles of late-modern societies" and a simultaneous presumption that such radical change is politically impossible (Blühdorn and Welsh 2007: 198; Blühdorn 2011; Blühdorn 2007). In regard to climate change and global politics, "sustainability" has been all but absent from the discourse, with the more narrow notion of "mitigation" declared the objective, as in mitigating the range of possible temperature change through reducing emissions and mitigating the human toll of climate change through adaptation efforts. Since 2006, the already contentious politics around climate change have been further complicated by the increasing attention given to geoengineering among the "portfolio of options" to address climate change (National Research Council 2015b; National Research Council 2015a).

Distinct from mitigation efforts that would adjust human and economic behavior in light of anthropogenic climate change, geoengineering includes a range of "techno-fix" proposals intended to modify the functioning of the climate itself. Recurrent climate summit negotiation failures have created the political conditions for climate engineering to emerge within scientific, science policy, political, and media discourse as a potential "Plan B." However, with "Plan A" (i.e., emission reduction) at odds with entrenched political-economic interests so that it has not gained full commitment from governments beholden to powerful economic interests (Foster 2011; Foster, York and Clark 2009), a gap has been left through which Plan B has begun encroaching upon Plan A.

As climate scientist James Hansen unequivocally contends, climate change puts Earth "in imminent peril" (Hansen 2009: ix). To date, however, international efforts to address climate change and mitigate its effects have failed by most accounts. There is an overwhelming indication that the primary way to address climate change must be through limiting carbon emissions, primarily from reducing use of fossil fuels (e.g., National Research Council 2015b: 17; Royal Society 2009: ix; IPCC 2014: 17-18; Melillo, Richmond and Yohe 2014: 13, 649; Wuebbles *et al.* 2017: 31-32). As science journalist Michael Specter succinctly articulates the dilemma in *The New Yorker*:

> The best solution, nearly all scientists agree, would be the simplest: stop burning fossil fuels, which would reduce the amount of carbon we dump in to the atmosphere. That fact has been emphasized in virtually every study that addresses the potential effect of climate change on earth—and there have been many—but none have had a discernible impact on human behavior or government policy. (Specter 2012: 100)

The challenge of climate change, and employing the obvious solution of emissions reductions, has been particularly intractable due to the extent to which carbon emissions are a core externality of the global energy economy. Adequately reducing emissions would require extensive restructuring of the energy economy and all carbon-intensive industries, a course which has been thoroughly challenged by powerful political-economic interests (Schnaiberg 1980; Foster 2002; Gould, Pellow and Schnaiberg 2008; McCright and Dunlap 2010; Urry 2011; Harris 2013; Klein 2014).

Describing the long-experienced reluctance of nations to make meaningful efforts on containing emissions as a kind of tragedy of the commons, political scientist Paul Harris contends: "The problem lies in the convenient but pernicious reality that everyone is free to use the global atmosphere as a dumping ground […] everyone is free to pollute the atmosphere, and we have done so with abandon for hundreds of years" (2013: 4). For most of industrial history carbon pollution has been entirely an externality with no real costs incurred by those creating the pollution. This basic tenet of industrial development has shaped the formation of our energy-economy and all the infrastructure, goods and lifestyles surrounding it.

A further challenge to emissions reductions has been the competitive posturing of nation-states, which have been the primary unit involved in negotiations (Harris 2013). Many nations, especially the largest polluters, have been loath to incur economic competitive disadvantages or the costs that would be associated with reductions, causing a stalemate in reduction efforts for several decades (e.g. Harris 2013; Giddens 2009: 14; Victor 2011: xxx, 62, 263; Foster 2002: 13-16). Political scientists Frank Biermann and Klaus Dingworth write:

> global environmental change increases the mutual dependence of nation states, thereby further undermining the idea of sovereignty as enshrined in the traditional Westphalian system […] No exit option remains for the nation state: the modern complex ecological interdependence binds all nations, which creates a new dependence of individual nation states—even the largest, most powerful ones—on the community of all other nations. (Biermann and Dingworth 2004: 2-6)

The framework of national interest, however, prevents these new "interdependencies" from finding cooperative articulation. In this way, climate change expresses a contradiction within the capitalist world-system between the global character of production, including its environmental impacts, and the division of the world into nation states as the units with primary governing authority.

For almost two decades following the 1997 Kyoto Protocol, international summits aimed at emissions reductions have failed to secure meaningful agreements, or even a significant semblance of progress (Victor 2011; Blühdorn 2011; Harris 2013). Until the 2015 Paris Accord, the post-Kyoto climate summits have been considered resounding failures by almost any measure. The Paris Summit may be the exception that proves the rule. The Paris conference in late 2015, widely heralded as the most successful negotiation to date, resulted in a non-binding (until further ratified) agreement to curb warming through mitigation. However, as explained in the *New York Times*: “The new deal will not, on its own, solve global warming. At best, scientists who have analyzed it say, it will cut global greenhouse gas emissions by about half enough as is necessary to stave off an increase in atmospheric temperatures of 2 degrees Celsius or 3.6 degrees Fahrenheit” (Davenport 2015). Andreas Malm notes that “Hardly had the leaders […] flown home from Paris before the warming took a sudden leap: in February 2016, the average temperature on earth stood at an estimated 1.5°C above pre-industrial levels – exactly where it should not be, according to the pledge two months earlier” (Malm 2018: 8-9). Moreover, he explains that according to a *Nature* article from July 2016, Paris targets were likely beyond reach,” with the planet “already doomed ‘to a mean warming over land greater than 1.5°C’, according to this particular study” (Malm 2018: 9; citing Huntingford and Mercado 2016).

Looking at the critical example of the United States, the world’s largest cumulative and second largest annual carbon-emitting nation, major challenges to mitigation over this time period have been political and socio-cultural. Sociologists Aaron McCright and Riley Dunlap argue that the American conservative movement has effectively used the “second dimension of power” to confine the scope of climate policy decision-making within the federal government “to only those issues that do not seriously challenge their subjective interests” (McCright and Dunlap 2010: 106; see also Lukes 2005). This has included challenging impact science and scientists, invoking favorable political procedures, and affecting public opinion through invoking media bias (McCright and Dunlap 2010). This political analysis fits with other trends of cultural staging of climate risks. Since perception affects how the public responds to risks, the ways in which risks are staged and defined have real effects upon the potential unfolding of that risk (Beck 2009: 16, 20).

Historians Naomi Oreskes and Erik Conway (2010) find that shaping public perception of risks has become a profitable business strategy. In *Merchants of Doubt*, they examine the manipulation of science, message, and media used to distort public perceptions of risks. The tobacco industry discovered and capitalized on the strategy of invoking uncertainty to sow doubt by using "*normal* scientific uncertainty to undermine the status of actual scientific knowledge" (Oreskes and Conway 2010: 34). While tobacco developed this art, it persists today with the most striking example being the disproportionate impact of climate change denial. Tracing the historical circumstances that contributed to the downplaying of global warming in the decades following its discovery, Oreskes and Conway underscore the manipulation of and by the media that has contributed to public confusion and doubt (2010: 170-215). By providing "fair and balanced" presentation of climate change with equal attention to both the majority scientific view and the minority dissenting view, as if it was as issue of scientific controversy, the media has distorted the impression of climate change in favor of skeptics and deniers (Oreskes and Conway 2010: 214; cf., Perrow 2011: xxxviii).

Frederick Buell similarly refers to the "enormously successful anti-environmental disinformation industry" that sprang up in opposition to the environmental trends that emerged in the 1970s (2003: 3). This new industry "helped midwife a new phase in the history of U.S. environmental politics, one in which an abundance of environmental concern was nearly blocked by an equal abundance of antienvironmental contestation […] Despite scientific evidence and even, in a number of cases, virtual scientific consensus to the contrary, issue after issue was contested" (Buell 2003: 4). The contested issues included the ozone hole, food and population crises, the effects of chemical pesticides like DDT, and global warming. Buell identifies the pseudoscience performed by conservative, ideologically-driven think tanks and others as the "counterscience movement." This movement has been "devoted to countering the findings of environmental science with the creation of a body of antienvironmental science," which is not "science" in the conventional sense, but models itself in the guise of academic-style articles filled with statistics and documentation, which are often unreliable, and "references to fellow counterscience writers, most of whom were not scientists but anti-environmental journalists, economists, and ideologues" (Buell 2003: 5). Buell places these antienvironmental efforts within the context of the new conservative movement that arose in the 1980s.

This movement continues today, now institutionalized as a mainstream political influence with successful entrenchment within state politics and the U.S. Federal Government, as demonstrably manifested within the executive branch during the presidencies of George W. Bush and Donald Trump as well as within Congress (as will be discussed in Chapter Four). Despite the near unanimity among the scientific community (Oreskes 2004), politically climate change has been systematically thwarted from achieving unhampered attention, let alone meaningful mitigation policies. By maintaining a semblance of doubt, skeptics reframe the issue and divert politics away from solutions. Moreover, politicians are able to express doubt, premised on supposedly ongoing debates regarding the existence of climate change, and thereby challenge mitigation at various levels of government.

Resulting from the successful entrenchment of the conservative anti-environmental movement within government, one obstacle to fulfilling the United States' commitments to the

Paris Agreement has been internal polarization and contention within the US polity, with various disputes arising between state governments, Congress, the Supreme Court, and the Executive branch. For example, in response to mitigation policy enacted by the Obama administration, twenty-nine states jointly filed lawsuit in 2015 against the most important components of the federal efforts to reduce greenhouse gasses in the case *State of West Virginia, State of Texas, et al. v. United States Environmental Protection Agency*. In this case, the Supreme Court unprecedentedly issued a stay on the new federal regulations for coal-fired power plants “before review by a federal appeals court” (Liptak and Davenport 2016). Such challenges aside, some independent assessments conclude “even if the [Obama] administration [had] executed all its existing and planned policies with maximum effect, and the most optimistic forecasts for technological development and forest sink capacity were borne out, the United States would still not hit the target” (Porter 2016).

Tumultuous United States politics in the post-Obama years compound the challenges to mitigation, with a reversal of the executive branch from fostering climate mitigation policy to proactively opposing it. The Trump-Pence administration has pursued a general crusade against environmentalism. A former Exxon Mobil executive was appointed Secretary of State and a climate change denier placed in charge of the Environmental Protection Agency (EPA). Within his first month in office, Trump declared his intention to spur coal, oil and gas extraction and commerce in the US, cut investment in climate change research, reduce environmental regulation, and defund the EPA. In March 2017, he signed an executive order to dismantle Obama’s Clean Power Plan. Mitigation of climate change is being proactively challenged by the executive branch, marking an abrupt shift from the Obama administration’s efforts and international achievements, including the benchmark 2015 Paris accord and the 2016 US-China bilateral climate agreement.

The United States Federal Government's 2017 reversal on climate policy has shaped a new political context. At least rhetorically, the response to the Trump administration's actions has been an upswell in international commitment to climate mitigation efforts. Following the July 2017 Group of 20 (G20) Summit, the 19 members other than the United States reaffirmed commitment to climate mitigation and specifically to the Paris Accord (see European Commission 2017). Domestically in the United States, there are also increased mitigation efforts percolating up from local and state levels. A Climate Alliance, founded by the states of California, New York and Washington, has at least thirteen participating states "committed to achieving the U.S. [Paris Accord] goal of reducing emissions 26-28 percent from 2005 levels and meeting or exceeding the targets of the [Obama era] federal Clean Power Plan" irrespective of federal policy (Inslee 2017). In the face of uncertain US federal policy, these local, state and international actors proceed down the historically challenging path of instituting meaningful carbon mitigation commitments.

Drastically reducing carbon emissions in response to climate change would require major adjustments to the political-economic system as a whole. Political scientist David Victor argues: "Tinkering at the margins of the energy system won't make much of a difference. Deep cuts in CO_2 will probably require a massive re-engineering of modern energy systems […] And because this transformation will require new technologies and business models that do not yet exist the political interest groups that can keep the process on track do not yet exist" (Victor 2011: 4). As such, political will to address the problem in a meaningful way has been conspicuously lacking. For his part, Victor argues for a rethinking of diplomatic approaches to be more "realistic"

(Victor 2011: 242). He also argues for pursuit of geoengineering, as will be discussed in subsequent chapters of this dissertation. Geoengineering, which adds a new layer to the "politics of unsustainability" (Blühdorn 2007; 2011), will be discussed presently.

Geoengineering

In the face of increasingly visible effects of climate change and continued challenges to mitigation efforts, the notion of geoengineering (also called "climate engineering" or "climate intervention") has shifted toward mainstream attention in recent years. As defined by the Intergovernmental Panel on Climate Change (IPCC): "Geoengineering refers to a broad set of methods and technologies operating on a large scale that aim to deliberately alter the climate system in order to alleviate the impacts of climate change" (IPCC 2014: 89). Geoengineering reflects a culture of technological exuberance characterized by optimism in the ability of technology and innovation to overcome environmental challenges, including those problems created themselves by technology and innovation (cf. Huesemann and Huesemann 2011). Distinct from mitigation efforts to adjust human and economic behavior, geoengineering "techno-fix" proposals aim to modify functioning of the climate itself, involving scales of technology with profound planetary effects.

The concept of geoengineering encapsulates various potential schemes to modify climate through intentional manipulation. There are two main categories of geoengineering aimed at addressing climate change: (1) albedo modification (also known as "albedo enhancement," "solar geoengineering," or "solar radiation management," SRM) and (2) carbon dioxide removal

(CDR). There have been other proposals that could be considered geoengineering,[1] but for the most part, albedo modification and carbon dioxide removal are the primary categories of geoengineering proposals that have been shifting toward serious consideration. Albedo modification would involve: "Intentional efforts to increase the amount of sunlight that is scattered or reflected back to space, thereby reducing the amount of sunlight absorbed by the Earth" in order to "to produce a cooling designed to compensate for some of the effects of warming associated with greenhouse gas increases" (National Research Council 2015b: 25, 28). CDR proposals seek to capture atmospheric carbon on a massive scale and redirect it into various repositories, including soil, vegetation, oceans or underground storage.

The modern idea of science-based weather modification has been pursued at least since the 1960s (National Research Council *et al.* 2003: 1; Goodell 2010: 70; Fleming 2010) and the concept of geoengineering specifically in regard to climate change has a history dating back to 1965 when anthropogenic climate change first emerged as a policy issue. The 1965 Report of the Environmental Pollution Panel of the President's Science Advisory Committee presented a compelling overview of the greenhouse effect and projected climate change in coming decades, with the sole policy recommendation to President Johnson that the United States should be pursuing albedo modification as a possible response to climate change (Environmental Pollution Panel 1965: 126-7). At the time, the terminology had not yet been created, so there is no reference to "geoengineering" but rather conceptual descriptions of albedo modification:

> The climatic changes that may be produced by the increased CO_2 content could be deleterious from the point of view of human beings. The possibilities of *deliberately bringing about countervailing climatic changes* therefore need to be

[1] For example, the 1993 publication in *Climate Change* that suggested "the effects of global warming could be countered by increasing the radius of the Earth's orbit around the Sun" (Hamilton 2013: 3).

> thoroughly explored. *A change in the radiation balance in the opposite direction* to that which might result from the increase in CO_2 could be produced by *raising the albedo, or reflectivity, of the earth*. (Environmental Pollution Panel 1965: 127, emphasis added)

The recommendation of albedo modification in this 1965 report as the solution to pursue for addressing climate change reflects the instrumental relationship with nature that characterized United States environmental politics prior to the emergence of the environmental movement about five years later (cf. Kirsch and Mitchell 1998; Lindseth 2013). The instrumental treatment of nature, and the idea of mastery over it, reflected in the 1965 report were in step with concurrent weather modification efforts in the United States, premised upon a human intention to "control" nature, a cultural conception with a long history (Fleming 2010: 3-10).

As with other technological ventures in the period since World War II, the United States military has been particularly involved in the pursuit of weather modification for strategic purposes (Fleming 2010: 165-188). In the same era that the 1965 Science Advisory report was recommending climate control through albedo enhancement to counteract global warming, the US military was commencing use of weather modification for purposes of war. Cloud seeding to generate rain was used "between 1966 and 1972 in the jungles over North and South Vietnam, Laos and Cambodia" (Fleming 2010: 179). Despite public backlash regarding the use of weather control efforts in the Vietnam War (as exposed post hoc), at least thirty years later weather modification remained a component of military pursuit as demonstrated by a 1996 report to the Air Force, which claimed that by 2015 "US aerospace forces can 'own the weather' by capitalizing on emerging technologies and focusing development of those technologies to war-fighting applications" (House *et al.* 1996: vi).

While the initial Science Advisory report on climate change emphasized albedo modification, in subsequent years, at least since the 1992 United Nations Framework Convention on Climate Change, the emphasis of public political discourse on addressing climate change has focused on mitigation through emissions reductions and adaptation efforts. In recent years, however, there has been renewed interest and attention given to geoengineering strategies to address climate change through “deliberate, large-scale intervention in the climate system designed to counter global warming or offset some of its effects” (Hamilton 2013: 1). The mounting evidence and concern regarding climate change, the limited scope of mitigation efforts to date, and social fascination with novelty and technological development has pushed the concept of geoengineering onto the radar of the broader public. Advocates for pursuing, or at least considering, geoengineering options include a sub-set of engineers, climate scientists, economic and political interests, and even environmentalists.[2]

Terminology has shifted over time in regard to geoengineering and its subtypes. The term “geoengineering” is attributed to a 1977 article by physicist Cesare Marchetti (Keith 2001: 497; Marchetti 1977). The term “solar radiation management” was coined by climate scientist Ken Caldeira in 2006 as an alternative to speaking of “geoengineering” (Hamilton 2013: 76). Notably in the 2015 National Research Council (NRC) of the National Academy of Sciences two-volume report on geoengineering, the authoring committee conscientiously changed the discourse through intentional terminology and word choice. They reject the terms geoengineering and climate engineering, explaining that not only do these terms lack specificity, but “the term ‘engineering’ implies a more precisely tailored and controllable process than might be the case for these climate interventions” (National Research Council 2015b: 1).

[2] Exemplifying collaboration between engineers, scientists and environmentalists on the topic of geoengineering, the Solar Radiation Management Governance Initiative’s “Solar Radiation Management” (2011) report was jointly published by the Environmental Defense Fund (EDF), The Royal Society, and TWAS (the academy for sciences for the developing world).

The NRC report also rejects the terms “solar radiation management” (SRM) and “albedo enhancement,” in favor of the more neutral term “albedo modification.” This choice of terminology is not explained except to say “the Committee chose to avoid the commonly used term of ‘solar radiation management’ in favor of the more physically descriptive term ‘albedo modification’ to describe a subset of such techniques that seek to enhance the reflectivity of the planet to cool the global temperature” (National Research Council 2015b: x). While the Committee did not expand on this statement, steering away from “SRM” signified a move toward establishing more neutral terminology in regard to these technologies. Unlike “solar radiation management,” the phrase “albedo modification” is descriptive without imparting a value judgment or implying a level of feasibility or control of the practice as, arguably, is suggested by the term “management.”[3] The NRC’s choice of more neutral terminology will be primarily adopted in this dissertation. However, the various terms that have been used historically for these concepts will be used interchangeably at times to reflect the original terminology within sources discussed.

Albedo modification, the idea of proactively increasing the percentage of solar radiation reflected away from Earth, is the more controversial proposed form of geoengineering. The most influential science policy reports, including those by the Royal Society and NRC, recommend that research be pursued, but that “Albedo modification at scales sufficient to alter climate should not be deployed at this time” (National Research Council 2015b: 7). Albedo modification is inherently high-risk and would constitute a global real-world experiment with large-scale risks

[3] The term solar radiation management implies that it may be feasible, necessary and/or appropriate to subject the sun’s rays to human management. This implication of beneficial human management of solar radiation is problematic considering that albedo modification proposals are *prima facie* indicative of a failure of human management of the atmosphere.

of changing ecosystems, hydrological systems, regional climates, and other essential earth systems (cf. Macnaghten and Szerszynski 2013; Stilgoe 2016; Owen 2014; Krohn and Weingart 1987; Levidow and Carr 2007). As broadly articulated by the NRC Committee, “Introducing albedo modification at scales capable of substantial reductions in climate impacts of future higher CO_2 concentrations would be introducing a novel situation into the Earth system, with consequences that are poorly constrained at present” (National Research Council 2015b: 7).

CDR, on the other hand, is treated as less controversial and has been recommended for implementation by esteemed scientific organizations. The Royal Society concluded that “Carbon Dioxide Removal methods that have been demonstrated to be safe, effective, sustainable and affordable should be deployed alongside conventional mitigation methods as soon as they can be made available” (Royal Society 2009: xi). The 2014 IPCC report markedly included CDR as an assumed element of carbon mitigation going forward. The authors note that “a large proportion of the new scenarios [in the present report] include Carbon Dioxide Removal (CDR) technologies” (IPCC 2014: 21). The NRC report’s second recommendation, after that of continuing mitigation efforts, is: “The Committee recommends research and development investment to improve methods of carbon dioxide removal and disposal at scales that matter” (National Research Council 2015a: 91).

While CDR is less controversial than albedo modification and generally expected to become part of the mitigation program along with intended emissions reduction efforts, it is emblematic of a persisting paradox of approach in addressing climate change. The axiom, usually attributed to Benjamin Franklin, that “an ounce of prevention is worth a pound of cure” is apt to understanding this paradox of pursuing carbon dioxide removal technologies while continuing to burn fossil fuels at the current rate. Since physical systems tend toward entropy or disorder (i.e., molecules will tend to spread out such that energy needs to be expended to contain them), keeping carbon in the ground as opposed to attempting to remove it from the ambient air after the fact is inherently more efficient (cf. Huesemann and Huesemann 2011: 79-82). In line with the common understanding that CDR will be evaluated on costs, Douglas MacMartin, an engineer who studies albedo modification, states in his Congressional testimony on geoengineering that air capture technology "is almost certain to be technically feasible, but right now probably too expensive. It's almost certain to be cheaper to not put it in in the first place than to take it out after you've put it in" (Congressional Hearing 2017). Moreover, CDR techniques, even if advanced and scalable, are not tantamount to emissions reductions. For example, climate models indicate that even with "massive CDR interventions," CDR cannot restore pre-industrial conditions in the ocean by reducing the atmospheric CO_2 concentration back to its pre-industrial level" (Mathesius *et al.* 2015). As stated by Earth system scientist, Steven Davis, "We can't think that we should be able to make up for poor decisions today by buying negative emissions later […] It's going to be a lot easier, cheaper and less risky to just tackle these emissions before they're in the atmosphere" (quoted in Upton 2015).

Furthermore, in terms of processing carbon dioxide in the atmosphere, there is a certain irony (or, to put it more strongly, irrationality) in the attempt to invent machines that can absorb carbon dioxide contemporaneously to the current situation of high rates of deforestation, especially of tropical forests which are primary to the natural processing of CO_2. The replacement of natural systems with artificial carbon systems is analogous to the idea of "artificial life on a dead planet" in which "Life" is "radically abstracted, resituated, and reconfigured" as "broader nature" is devalued and "becomes a sink for pollution and other 'externalities'" of production (Thorpe 2016: 67, 80). So long as deforestation of older forests subsists concurrently, even the relatively benign and "sensible" land management options categorized as CDR[4] like reforestation and afforestation contend with paradoxes of entropy (the move toward disorder as carbon stored in mature forests is released into the atmosphere) and latency (delayed effectiveness as a carbon sink since young forests cannot absorb as much CO_2 as mature forests). Furthermore, "fragmentation of tropical forests is likely to increase emissions of CO_2 and other greenhouse gases above and beyond that caused by deforestation per se" due to ecological changes to remaining forest stands that lead to increased tree mortality and higher risks of forest fires (Laurance, Laurance and Delamonica 1998; Laurance, Vasconcelos and Lovejoy 2000).

Paralleling the physical entropy of redistributing and dispersing carbon into the ambient air is the social redistribution of the burden for that carbon pollution. Much debated policy proposals for pricing carbon emissions would place a cost on emissions incurred by the producer (and ultimately consumer) of those emissions. In contrast, CDR is modeled after the tradition of public appropriation of externalities wherein private entities profit from production, but the broader public incurs the environmental costs of that production.

Geoengineering has often been described as a "Plan B" to mitigation. CDR has come to be considered a more immediate option to pursue alongside other mitigation efforts, while albedo enhancement is still most often discussed in terms of a Plan B scenario (as will be discussed in Chapter Two). However, this categorization is misleading in a way since Plan B presumes a Plan A, in this case mitigation; yet the Plan A of mitigation has not been seriously and fully pursued due to obstruction by powerful economic and political interests.

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[4] Variants of the word "sensible" are often used in reference to reforestation and afforestation CDR approaches (e.g. National Research Council 2015b: 88; Mathiesen 2015).

Furthermore, as a Plan B, it is an illusory alternative, since it is encumbered with similar political challenges to those that have hampered mitigation efforts to date. As geoengineering research advocate, the cosmologist and astrophysicist Lord Martin Rees (who was President of the Royal Society between 2005 and 2010) recognizes:

> Geoengineering would be an utter political nightmare: not all nations would want to adjust the thermostat the same way. There could be unintended side-effects. Regional weather patterns may change. Moreover, the warming would return with a vengeance if the countermeasures were ever discontinued; and other consequences of rising CO_2 (especially the deleterious effects of ocean acidification) would be unchecked. (Rees 2013)

As he indicates in terms of regional effects and potential arguments over setting "the thermostat," various regions of the globe are likely to be differentially effected should albedo modification be pursued. In the execution of geoengineering, there are likely to be winners and losers in terms of climatic effects. For example, models have indicated that global albedo modification may significantly impact the reliability of Asian and African monsoons on which those regions' agriculture depends (e.g. Goodell 2010: 9, 132; Hamilton 2013: 64; National Research Council 2015b: 46). Irrespective of specific climatic interests, there will be individuals, networks, and nations opposed on principle (e.g. ETC Group 2010).

Given the globality of proposals as well as the extent of risks and concerns, it can be reasonably presumed that the same techno-political barriers that have obstructed mitigation efforts would also hamper implementing geoengineering in a multilateral fashion, as advocates insist would need to be the case. Legitimate pursuit of geoengineering is indicated as requiring "international" collaboration and cooperation (e.g. Royal Society 2009; National Research Council 2015b). Furthermore, just as would be necessary for mitigation, careful monitoring and regulation of greenhouse gas emissions would be required in order to pursue climate engineering based on real-world conditions. In short, geoengineering poses new challenges of international cooperation and coordination without solving old ones.

Another common concern regarding geoengineering is moral hazard, which is "a term derived from insurance, and arises where a newly-insured party is more inclined to undertake risky behaviour than previously because compensation is available" (Royal Society 2009: 37). The Royal Society describes the risk as follows: "In the context of geoengineering, the risk is that major efforts in geoengineering may lead to a reduction of effort in mitigation and/or adaptation because of a premature conviction that geoengineering has provided 'insurance' against climate change" (Royal Society 2009: 37). Similarly, as articulated by the NRC: "There is a risk that research on albedo modification could distract from efforts to mitigate greenhouse gas emissions" (National Research Council 2015b: 8, cf. 6, 147). Both influential organizations writing on the matter, however, ultimately dismiss the moral hazard concern in terms of pursuing geoengineering research. The NRC concludes that "as a society, we have reached a point where the severity of the potential risks from climate change appears to outweigh the potential risks from the moral hazard associated with a suitably designed and governed research program" (National Research Council 2015b: 8). The Royal Society further poses a counter-argument to the moral hazard concern, contending "there is little empirical evidence to support or refute the moral hazard argument in relation to geoengineering, (although there has been little research in this area), and it is possible that geoengineering actions could galvanise people into demanding more effective mitigation action" (Royal Society 2009: 39).

Despite the dismissal of moral hazard concerns on the part of these major research institutions, such concerns are consistent with the broad consensus that geoengineering, particularly albedo modification, is deeply fraught with material, ecological, and social risks. As phrased by the NRC, “Proposed albedo modification approaches introduce environmental, ethical, social, political, economic, and legal risks associated with intended and unintended consequences” (National Research Council 2015b: 5). Furthermore, since albedo modification would create completely novel climatic conditions, risks are joined by unknowns. Again, as stated by the NRC, “Intervening in the climate system through albedo modification therefore does not constitute an ‘undoing’ of the effects of increased CO_2 but rather a potential means of damage reduction that entails novel and partly unknown risks and outcomes” (National Research Council 2015b: 35). In regard to these novel circumstances, a caveat is made regarding the limitations of knowledge inherent in the proposed research, including models: “This real system has far greater complexity than does any model, and thus no model of this system can provide a quantitatively reliable detailed prediction of how Earth will respond to a novel occurrence” (National Research Council 2015b: 39). There is general agreement that “Albedo modification presents a number of risks and expected repercussions” (National Research Council 2015b: 6). These include ecological harms, changes to the hydrological system, changes to precipitation patterns, potential effects on agriculture and human health (e.g., National Research Council 2015b: 6, 28, 33-35, 46, 53).

Due to the complexities discussed above, including interacting environmental and technological risks, international and national politics, economic interests, and public perceptions and responses, this topic, besides being of pressing contemporary material concern, represents a sociologically rich intersection of scholarship themes from the realms of science and technology studies, risk society, modernity, environmental sociology, and political economy. The following literature review section explores in greater depth these interconnected areas of scholarship related to risk, climate politics and geoengineering.

Literature Review

<u>Sociology literature on risk, environment and economics</u>

Late modern society is characterized by awareness of risk and uncertainty as key aspects of the human relationship with the natural environment on which we depend. Some scholars argue that the risk we face is unprecedented in its scale and magnitude. At the beginning of the 1970s, when the environmental movement was becoming increasingly socially and politically influential, one of its key intellectual leaders, the biologist Barry Commoner, stated the dangers posed by environmental degradation starkly: “To survive on the earth, human beings require the stable, continuing existence of a suitable environment. Yet the evidence is overwhelming that the way in which we now live on the earth is driving its thin, life-supporting skin, and ourselves with it, to destruction” (1971: 14). More recently, Anthony Giddens has argued that global climate change is unlike any other challenge we have faced before due to the enormity of its potential disaster and its global scale (2009: 2). Similarly, according to Ulrich Beck, in modern society, we are faced with risk of “self-destruction of all life on earth due to human interventions” (Beck 2009: 27).

For the last century, modern society has tested the boundaries of risks from chemical toxins, industrial pollutants, nuclear reactors, deforestation, and mineral extraction, including new forms of fossil fuel extraction such as deepwater drilling and chemical fracking. The ecological ramifications include localized and globalized pollution, climate change, glacial and icecap melting, sea rise, ocean acidification, and loss of biodiversity with “exceptionally high” rates of extinction (Pimm *et al.* 2014; IPCC 2014). The prospect of geoengineering adds a new dimension to risk, since its environmental impacts would include intentionally and reflexively instituted risks as well as incidental risks.

As will be discussed in this section, various schools of thought within environmental sociology have addressed environmental risks and their dynamic with human society. Ecological modernization theory (EMT) stands out as unique in its optimism regarding the potential of economic and technological development to reduce society's ecological footprint. Contrastingly, other approaches emphasize the ways the global economic system puts pressure on the environment. The "treadmill of production" theory is exemplary in its methodical and systemic assessment of the ways that modern production processes impact the environment (Gould, Pellow and Schnaiberg 2008; Schnaiberg 1980). Another school of environmental-economic thought, Eco-Marxism, identifies the "metabolic rift" between society and its ecological basis that has expanded over time from the regional level of soil degradation, as originally discussed by Marx, to the global level as manifested in climate change (Foster 1999). In terms of theorizing the relationship between modern society and the risks it both creates and endures, Ulrich Beck developed the concepts of "reflexive modernization" and "risk society," which suggest that society's technological intervention in nature produces increasingly large-scale and complex risks that, in turn transform society (Beck 1992; 1995; 1997; 2009). Likewise, Anthony Giddens theorizes society's changing relationship with nature.

Giddens argues that modern societies have "broken away from nature" (Giddens 1990: 63). He contends that "what used to be natural is now either the product of, or influenced by, human activity" (Giddens 1998: 58). However, despite traditional notions of nature changing or disappearing, nature arguably remains an important conceptual category (Dickens 1999: 102-104; Thorpe and Jacobson 2013: 117). Giddens regards the human relationship with nature as a critical locus of ontological insecurity in modernity (see Thorpe and Jacobson 2013: 103-105, 118; cf. Beck 2009: 121). Ontological security means the ability to remove from consciousness the existential dilemma of "how should we live?", relying on received authoritative frameworks for making sense of, and establishing boundaries around, everyday life. Initially in modernity (or what Giddens calls "simple modernity"), science and technology replaced tradition as the primary basis of ontological security (see Thorpe and Jacobson 2013: 103-105, 118; cf. Beck 2009: 121). The ability to control nature and thereby force it into the background of quotidian social life has been an important dimension of ontological security in modernity. However, as modern societies come to be faced with the destructive ecological consequences of modern technological means of controlling nature, risk becomes reflexive (as our very attempts to contain risk produce new risks) and modern societies are forced into a state of reflexivity with regard to risk (recognizing the potentially unruly unintended consequences of the modern attempt to control nature and no longer able to bracket risk from everyday life) (see Beck, Giddens and Lash 1994).

Climate change is a key (arguably, the most important) instantiation of this reflexivity of risk. Climate change problematizes the conception of external nature as intrinsically "natural" elements such as weather become affected by human intervention. This heightens "the ontological insecurity of high modernity" as "ecological problems such as climate change re-open the existential contradiction under conditions in which this is no longer adequately mediated by social institutions" (Thorpe and Jacobson 2013: 117-118). While the distinction becomes blurred, nature does not disappear or become entirely submerged into society. Rather, as Andreas Malm argues, "climate change sweeps back and forth between the two regions traditionally referred to as 'nature' and 'society'" (Malm 2018: 15).

Beck argues that while humanity has always faced risk, what distinguishes modern risks beyond their global scale and magnitude is the means of their creation. Within the paradigm of risk society, corresponding with late modernity, we are "concerned no longer exclusively with making nature useful, or with releasing mankind from traditional constraints, but also and essentially with problems resulting from techno-economic development itself" (Beck 1992: 19). The risks we face today "are a product of human hands and minds, of the link between technical knowledge and the economic utility calculus" (2009: 25). While some risks are timeless, modern risks are distinct in being generated by "conscious decisions" and "calculations for which hazards represent the inevitable downside of progress" (Beck 2009: 25). Beck argues that "In advanced modernity the social production of *wealth* is systematically accompanied by the social production of *risks*" (1992: 19). Hence, Beck proposes that modern society ails from its "triumphs" (rather than its defeats) because its successes bring with them new risks (2009: 8, 22-23, 30).

Beck's theory of the risk society as a new formation replacing an earlier form of modernity draws, to a certain extent, on predictions of a post-industrial society in the 1960s and 1970s. Post-industrial society theorist Daniel Bell had observed that technological advancements can have "deleterious side effects, with second-order and third-order consequences that are often overlooked and certainly unintended" (Bell 1973: 26-7). According to Beck, "The gain in power from techno-economic 'progress' is being increasingly overshadowed by the production of risks" which have expanded from "latent side effects" to global issues of "central importance" (Beck 1992: 13). Climate change is a clear example of such a modern global risk resulting directly from economic progress. Climate change "is a product of successful industrialization," one that constitutes a new global risk that is delocalized, incalculable and non-compensable (2009: 8, 52). "Risks can no longer be dismissed as side effects" of modernization (Beck 2009: 194).

While society has created these new global risks, conversely and reflexively people are in turn affected by these environmental risks on multiple levels beyond the direct material threats. Giddens and other social theorists have recognized that the human relationship with nature represents a critical component of ontological insecurity in modernity (Giddens 1991; Giddens 1981; Thorpe and Jacobson 2013: 103-105, 118; Norgaard 2006: 380). Giddens theorized that first modernity facilitated the suppression of existential dilemmas through replacing existential contradictions with social relationships and structural contradictions lubricated by the routinization and predictability of everyday life (Giddens 1981). Security came to depend on trust in "abstract systems" of technology and scientific expertise (Giddens 1990: 92-3, 112-3; Giddens 1994: 80). However, existential crisis reemerges as global risks such as climate change problematize the sense of security and the sequestration of risk.

The existential crisis, raised by climate change and other global risks, does not occur just despite the efforts of modernity, but rather as a byproduct of modernity (Beck 2009). Giddens argues that "in conditions of high modernity, crisis becomes normalised" (Giddens 1991: 184). "The crisis-prone nature of late modernity thus has unsettling consequences" for society and individuals both in terms of fueling uncertainty and threatening "the very core of self-identity" (Giddens 1991: 184-5). There is a central need for ontological security, meaning "the confidence that most human beings have in the continuity of their self-identity and in the constancy of the surrounding social and material environments of action" (Giddens 1990: 92). The "transformation of nature introduces a new kind of ontological insecurity" with "global warming as an example of this new unpredictability arising not from brute nature but from the unintended consequences of industrial society" (Thorpe and Jacobson 2013: 105).

Ecological politics are demonstrative of "reflexive modernization" (Giddens 1994; Beck, Giddens and Lash 1994; Beck 1992; Giddens 1990; Thorpe and Jacobson 2013). As argued previously:

> The emergence of ecological politics demonstrates that modernity is no longer able to bracket the existential contradiction rooted in human beings' relationship to nature. A key dimension of the reflexivity of high modernity is that we can no longer treat the problem of nature as progressively solved through instrumental control. Instead, how we, as conscious agents, relate to nature becomes again a problem of morality and meaning as well as of scientific understanding. (Thorpe and Jacobson 2013: 104-5)

Beck indicates that modern reflexive risks are the objects of new forms of political action, which he calls subpolitics, such as environmentalism, which operate outside and, in a certain sense, beneath the activity of the centralized institutions of representation and government (Beck 1997). Relatedly, Giddens' concept of "life politics […] concerns disputes and struggles about how (as individuals and as collective humanity) we should live in a world where what used to be fixed either by nature or tradition is now subject to human decisions" (Giddens 1994: 14-5). However, in regard to climate change, the central ecological crisis of modernity, Giddens retreats from engagement with life politics (Giddens 2009; Thorpe and Jacobson 2013). The extent to which climate change resurfaces ontological insecurities complicates its relationship to life politics.

While environmental activism and life politics remain centrally important to climate politics, there has also been a trend of "collective avoiding" (Norgaard 2006). This means that, despite knowledge and concern regarding climate change, people avoid thinking about its catastrophic risks in order to protect themselves from the psychological toll of the unpleasant and troubling emotions involved in grappling existential crisis (Norgaard 2006). Climate change specifically has the potential to fundamentally alter the material basis of human society in dramatic and intractable ways. “At the deepest level,” according to Norgaard, it threatens “people’s sense of the continuity of life” (2006: 380) and as such it also poses a potential existential crisis within modern society. People cope with these risks in various ways. One coping mechanism is suppression or avoidance. Norgaard’s (2006) study of informed and educated Norwegians found that people avoid thinking about the catastrophic risks of climate change despite, or perhaps because of, belief in its actuality and knowledge of its risks. She calls this process, the “social organization of denial” which is a form of collective emotional avoidance despite intellectual understanding. This form of denial helps toward explaining the relative lack of action on the issue of climate change despite knowledge and concern over it.

A contrasting form of suppression is that which occurs for the sake of self-interest rather than emotional self-preservation. Climate change denial and so-called skepticism fit in this category. As discussed previously, Oreskes and Conway (2010) trace the historical circumstances that have contributed to the downplaying of global warming (2010). Groups with a climate denial agenda were able to influence discourse on the issue such as to cause public confusion and doubt regarding the level of scientific consensus. This was especially facilitated through the two-sided presentation of climate change “debate” within media that displayed climate change as an issue of scientific controversy, effectively distorting the impression of climate change in favor of skeptics and deniers (Oreskes and Conway 2010: 214; c.f., Perrow 2011: xxxviii). The continued questioning and distortion of climate science has contributed toward maintaining inertia and lack of political will to act on climate change.

At an institutional level, two primary challenges have stood in the way of effective climate politics. The first, as discussed, is the need for global cooperation and the conflicting interests that complicate it. According to Beck, global risks can only be addressed through international cooperation fostered by the “cosmopolitan moment” that such risks present (2009: 15, 55-56). The very nature of global risks, and the mutual sense of vulnerability they present, has potential to “open up a moral and political space that can give rise to a civil culture of responsibility that transcends borders and conflicts” (Beck 2009: 57). He points to *cosmopolitan real politik* as the hybrid fusion of state interests and the cosmopolitan moment, which compels the inclusion of cultural others, as the political tool for addressing global risks (Beck 2009: 66, 56). Of course, the need for international cooperation on global environmental risks is clear and frequently articulated. In *The Politics of Climate Change*, Giddens sees nations as paramount in addressing climate change, but argues that “effective response must involve nations working together, even countries whose interests in other respects might seem opposed” (Giddens 2009: 14). However, as discussed, global collaboration has been challenged to date by competition between nation-states (Harris 2013; Victor 2011) and other economic interests invested in the existing energy economy.

The other core challenge is the scope of changes to the world economic system that would be necessary to effectively mitigate climate change. This system is defined by an emphasis on indefinite growth and has been characterized by environmental sociologists as “the treadmill of production” (Gould, Pellow and Schnaiberg 2008). Constant growth is a central component of the economic system and is necessary to avert economic crises (Harvey 2010; Harman 2010) but can, in turn, lead to environmental crises. In contrast to economic activities characterized by growth, the ecosphere is characterized by cyclical processes, balance and some intrinsic limits to growth: “One can argue whether the ecosphere, in its pre-human, natural condition or in its present one, operates near its intrinsic limit; but that there is some limit, and that the system’s operation does not permit indefinitely continued growth, is undeniable”

(Commoner 1971: 120-121). Commoner calls this the "fundamental paradox of man's life on the earth: that human civilization involves a series of cyclically interdependent processes, most of which have a built-in tendency to grow, except one—the natural, irreplaceable, absolutely essential resources represented by the earth's minerals and the ecosphere" (1971: 122-123).

This paradox of growth, along with the increased intensification of environmental degradation resulting from patterns of emerging technologies, is closely related to Allan Schnaiberg's theory of "the treadmill of production" (Gould, Pellow and Schnaiberg 2008; Schnaiberg 1980). Like Commoner, environmental sociologists Kenneth Gould, David Pellow and Allan Schnaiberg point to political-economic factors to explain environmental impact. Their treadmill of production theory emphasizes technology and production (rather than consumption) as the critical variables in explaining environmental impact starting in the third quarter of the twentieth century (Gould, Pellow and Schnaiberg 2008: 19). According to these authors, too much emphasis has been placed on consumer behavior, obscuring the actual productive mechanisms, and dynamics of power, driving technological change (Gould, Pellow and Schnaiberg 2008: xi, 20-21). They propose that "[c]ontrary to classical and neoclassical economic theories that posit that consumer preferences determine the contour of markets, consumer behavior is consciously being shaped by industry" (2008: 21).

According the treadmill of production theory, economic change was the primary driving factor in escalating environmental impacts. Following World War II, capital investment changed quantitatively and qualitatively as more capital was accumulated and it was increasingly allocated to "replacing production labor with new technologies to increase profits" (Gould, Pellow and Schnaiberg 2008: 7; cf. Commoner 1971: 177). These new technologies were more environmentally disruptive, requiring greater energy and chemical inputs (Gould, Pellow and

Schnaiberg 2008: 7). Since the investments constituted sunk capital requiring sustained or increased production levels to justify, "capital investment led to greater demand for natural resources, for a given level of social welfare" (Gould, Pellow and Schnaiberg 2008: 11). Profits came to be "increasingly invested in new technologies rather than in expanding employment or raising the status of workers" (Gould, Pellow and Schnaiberg 2008: xii).

This process was self-perpetuating as investment necessitated further investment: "each round of socially dislocating growth generated increased, rather than decreased, social support for allocating investment to accelerating the treadmill of production" (Gould, Pellow and Schnaiberg 2008: 12). A central trend of "modern technology has been to displace human labor in goods production, and substitute physical capital and inanimate energy supplies" resulting in increased production and profits as well as increased environmental impact and displacement of workers (Schnaiberg 1980: 415-6). As technology displaced labor, it came to be thought that further growth was the only possible course for maintaining employment levels. Hence, ironically, "[e]conomic growth was viewed as the primary solution to the negative social impacts of economic growth" (Gould, Pellow and Schnaiberg 2008: 12). According to this theory, social progress is thwarted as society remains on the economic treadmill, figuratively "running in place," as social efficiency is decreased, resulting in "increased rates of ecosystem depletion (resource extraction) and ecosystem pollution (dumping of wastes into ecosystems)" (Gould, Pellow and Schnaiberg 2008: 12).

Like treadmill theorists, Commoner (1971) made a compelling case for the predominance of technology in affecting the major qualitative and quantitative shifts of environmental impact since WWII.[5] According to Commoner, the environmental crisis, at least in the United States, has been largely tied to the transformation of productive technology in which "productive technologies with intense impacts on the environment have displaced less destructive ones. The environmental crisis is the inevitable result of this counterecological pattern of growth" (Commoner 1971: 177). Similarly disputing the overemphasis on population rather than production, Allan Schnaiberg concludes that "[p]roduction, rather than reproduction, is the crucial factor in biospheric disorganization" (1980: 98). In the 25 years following WWII, Commoner points out that the United States achieved a 126% rise in GDP but also a rise in environmental pollution that grew at ten times that rate (1971: 146). The difference is explained by externalities.

Externalities refer to the costs of production that are not internalized by the firms involved, including environmental or social consequences borne by the public. The internalization of benefits (profit), with the externalizing of costs (social dislocation and environmental degradation) drives the tendency to pursue economic advancement at the cost of society: "Ecological irresponsibility can pay—for the entrepreneur, but not for society as a whole" (Commoner 1971: 267). As Giddens states, the "environmental costs entailed by economic processes often form what economists call 'externalities' – they are not paid for by those who incur them" (2009: 5). For example, with the absence of a pricing scheme for carbon emissions, the release of greenhouse gasses is an externality. Firms get to internalize the profits incurred through production, but they externalize the environmental costs, such as carbon pollution, which affect the broader public and the environment. Charles Perrow argues that the

[5] The standard formula used to discuss environmental impact is IPAT, standing for: (Environmental) Impact = Population x Affluence x Technology.

free-market capitalism promoted since the Reagan/Thatcher era has exacerbated the problem of externalities and contributed to "global warming at an increasing rate" (Perrow 2011: xxix).

Externalities are often considered a market failure, which could be corrected with appropriate policy. Giddens argues that the "aim of public policy should be to make sure that, wherever possible, such costs are internalized – that is, brought into the marketplace" (2009: 5). This objective, however, is complicated by technical considerations of how to measure and price pollutants as well as knowledge asymmetries favoring business, power dynamics and political interests. Perrow argues for public policy that includes regulation as well as decentralization of power and a reduction in the scale of high-risk operations (Perrow 2011: 35-6, 318-321). Regulation of industries, with jurisdictions free to increase (but not decrease) standards, is a more direct method of limiting the consequences of externalities than through pricing mechanisms. Often, however, proposed solutions to the externalities problem include a combination of regulation and pricing mechanisms.

Foster challenges the notion of internalizing externalities into the market. He identifies the standard position of environmental economics as aimed "at the creation of markets to solve problems of pollution and environmental degradation" (Foster 2002: 29). This can be pursued through "imposition of taxes or subsidies that will increase the costs of inflicting environmental damage and the benefits of environmental improvements" or through the imposition of new markets "such as tradable pollution permits" (2002: 29-30). However, Foster is skeptical of both approaches due to their strategy of "turning the environment into a set of commodities" and "overcoming the so-called market failures of the environment by constructing replacement markets for environmental products" (2002: 30). "Nature," he argues, "is not a commodity produced to be sold on the market according to economic laws of supply and demand" (2002: 30).

A generation earlier, Karl Polanyi, in his pivotal *The Great Transformation*, argued that land, along with labor and money, constitutes a "fictitious commodity" (Polanyi [1944] 2001). Land, labor and money are essential to the functioning of markets, but they are not commodities created for the sake of exchange. Polanyi warns that including land (i.e., nature) and labor (i.e., people) "in the market mechanism means to subordinate the substance of society itself to the laws of the market" ([1944] 2001: 75). Marion Fourcade's (2011) contemporary analysis of valuation of nature in response to oil spills speaks to the complexity of placing pecuniary value onto elements of nature.

Foster further argues that ecological sustainability "can be undermined not only through the economy failing to take environmental costs into account (the externalization of costs to the environment), as is commonly supposed, but also by the attempted incorporation of the environment into the economy—the commodification of nature" (Foster 2002: 30). By this logic, there is a flipside to externalities that can be traced to commodification of nature, which also promotes ecological degradation and exploitation. According to Foster, this can be more pernicious than the problem of externalities: "It is not so much the failure to internalize large parts of nature into the economy that is the source of environmental problems, but rather that more and more of nature is reduced to mere cash nexus and is not treated in accordance with broader, more ecological principles" (Foster 2002: 33). Similarly, John Urry finds that "as a consequence of neo-liberalization, sustainability has often been reformulated as 'sustainable development', with an astonishing array of industries and developments seen as contributing to what is 'sustainable'" (Urry 2011: 27).

While economic and technological changes have been important factors in modern production trends and the correlating environmental effects, these changes do not exist in a vacuum. For Schnaiberg, the treadmill of production is driven by institutional factors, including social structures and class dynamics. The constituencies of capital, labor and the state each have their own interests in regard to production expansion (Schnaiberg 1980: 211). He refers to these three influential social sectors as the *growth coalition*. Ultimately, then the treadmill is socially constructed but with substantial environmental consequences:

> The logic of the treadmill is that of an ever-growing need for capital investment in order to generate a given volume of social welfare […] From the environment, it requires growing inputs of energy and material to create a given level of socioeconomic welfare. When resources are constrained, the treadmill searches for alternative sources rather than conserving and restructuring production. The treadmill operates in this way to maintain its profits and its social control over production. (Schnaiberg 1980: 418)

The perpetuation is geared by social structures and the interests of various groups with economic power and political influence.

Due to the inherent dynamic of capitalist economics and the environment, Foster argues against those who see capitalism as containing “within itself the solution to global environmental problems” (2002: 22). A key example of attempts to handle ecological problems within the framework of capitalist relations and institutions is Giddens’ *The Politics of Climate Change* (2009). Here, Giddens suggests that “[m]ore of the same will be needed, not less, if we are seriously to confront the problems of climate change” (2009: 6). In this sense, Giddens suggests that increased technical innovation is what is necessary to solve the global environmental crisis of climate change.

His argument is similar to those put forth by proponents of EMT in suggesting that environmental issues could be best addressed “by drawing them into the existing framework of social economic institutions, rather than contesting those institutions” (Giddens 2009: 70). EMT stands in stark contrast to most social analyses of climate change in its optimism that sustainability can arise “from a combination of economic development, technological innovation, and institutional reform” (Thorpe and Jacobson 2013: 112; Dryzek 2005: 167-179). EMT emphasizes the potential of technology and economic trends in cure environmental ills, as opposed to causing them (see Mol and Sonnenfeld 2000). There are two components underlying this optimism. The first component is the notion that new technology will solve the problems created by old technology.

Critiquing this component, chemical engineer Michael Huesemann and statistician Joyce Huesemann argue that “Techno-optimism is pervasive in our society but hardly justified […] Despite the serious shortcomings and consequences of past technologies, the public often uncritically accepts new technology, believing that additional and more advanced technology will eventually provide satisfactory solutions” (2011: xxiii). One form of such technological solutions is what they call “counter-technologies, which are technologies specifically developed to oppose and neutralize the negative effects created by other technologies” (2011: 72). Geoengineering schemes proposed to counter climactic effects of excessive carbon emissions exemplify this.

Secondly, is the notion advanced by EMT theorists that production will become less environmentally disruptive as technologies improve (e.g. Mol and Spaargaren 2000; Mol and Sonnenfeld 2000; for an overview and critique, see York and Rosa 2003). This idea that further innovation can create solutions for environmental problems includes the hypothesis of dematerialization, which suggests that through increased efficiency and technological innovation it is possible to decouple “economic growth from the use of energy and materials and from waste flows into the environment, reducing the environmental impact of each additional monetary increment of GDP" (Foster 2002: 22). Marking a departure from his previous work (Thorpe and Jacobson 2013), this perspective is adopted by Giddens in his climate change study, in which he asserts that "greater energy efficiency *ipso facto* reduces emissions" (Giddens 2009: 107).

Foster, however, counters this assumption arguing that dematerialization is a "dangerous myth" (2002: 24). He points to empirical trends of increased consumption of environmental resources as well as increased waste outflows within the most advanced economies as evidence against the notion of dematerialization. Furthermore, to the extent that increased efficiency has been achieved, it "has been invariably accompanied through the history of industrial capitalism by expansion in the scale of the economy […] and hence widening environmental degradation" (Foster 2002: 23). This critique is consistent with the Jevons paradox, based on the finding that technological efficiency improvements that reduce marginal consumption of fuel per unit output leads to overall fuel use *increasing* rather than decreasing (Jevons 1866: 122-137), as well as Richard York and Eugene Rosa's challenge to EMT proponents to demonstrate whether the "pace of increase in efficiency exceeds the pace of increase in overall production" (York and Rosa 2003: 273).

Foster contends that technology cannot solve the environmental problems we face largely because within the capitalist system, "technological change is subordinated to market imperatives" (2002: 38). For example, he points to vested interests standing in the way of increased efficiency such as in the automotive (and corresponding petroleum) industry. From Foster's perspective, integrating environmental issues into the current economic system is a stopgap at best and more likely the source of new problems that arise from commoditizing the environment and subjecting it to the rules of the market (2002: 38-9). The commoditization of nature, according to Foster, necessarily leads to its overexploitation (2002: 39).

For Foster, the capitalist system is inherently incompatible with environmental sustainability (2002: 9-12). Part of this incompatibility, according to Foster, stems from a discordance of temporality. While capitalist investment must be realized within a definite and calculable period of time, issues of biospheric sustainability cannot be incorporated into a short-term temporal perspective (Foster 2002: 10-11; cf. Adam 1998). Furthermore, Foster illustrates the longstanding conflict between powerful economic interests and the environment in which even modest regulation, for instance of greenhouse gasses, have been adamantly resisted (2002: 13-22). Since carbon emissions are an intrinsic factor of our energy economy, drastically reducing these emissions challenges the core premise of a capitalist growth economy, at least one built upon fossil fuel energy sources.

Along these lines, Blühdorn and Welsh suggest that the "reassuring belief in the compatibility and interdependence of democratic consumer capitalism and ecological sustainability has become hegemonic" stifling other viewpoints, especially those that are inconvenient (2007: 186). They argue that we have entered a "post-ecologist era," which coincides with a general trend of technological and managerial optimism that coexists with "a fixation on economic growth" and "the normalisation of environmental crisis" (Blühdorn and Welsh 2007: 187). Not only do the "key principles of consumer capitalism, i.e., infinite economic growth and wealth accumulation, which ecologists have always branded as fundamentally unsustainable, remain fully in place," but capitalism has been rebranded as a solution to the ecological crisis (Blühdorn and Welsh 2007: 187). The politics of unsustainability is not characterized by the "denial of environmental problems;" on the contrary, rhetoric and acknowledgment of environmental crises have intensified in recent years (Blühdorn and Welsh 2007: 187). According to Blühdorn and Welsh:

> the politics of unsustainability is unfolding amidst the simultaneity of, on the one hand, a general acceptance that the achievement of sustainability requires radical change in the most basic principles of late-modern societies and, on the other hand, an equally general consensus about the non-negotiability of democratic consumer capitalism – irrespective of mounting evidence of its unsustainability. (Blühdorn and Welsh 2007: 187)

This simultaneous coexistence of paradoxical notions requires either actual or dramaturgical reconciliation.

Given this fundamental contradiction, Blühdorn finds that in the post-ecologist era, the longstanding understanding of "symbolic politics" is insufficient to explain the dynamics of eco-politics (2007: 253). Rather he argues that a new "discourse of seriousness […] adds an *additional layer* of performance" (Blühdorn 2007: 253). He offers the concept of *simulative politics* as an alternative to the more simplistic idea of symbolic politics to describe modern eco-politics. He finds that "despite their vociferous critique of merely symbolic politics and their declaratory resolve to take effective action, late-modern societies have neither the will nor the ability to get serious" (Blühdorn 2007: 253). Hence the performance of symbolic politics through *simulative politics* is the new mode of trying to "sustain what is known to be unsustainable" (Blühdorn 2007: 272).

The turn from ecologism to post-ecologism is explained as part of a larger shift within politics and society. Blühdorn notes that in "late-modern consumer societies" the trend of materialism has resurfaced in conjunction with both a transversal of *risk society* to *opportunity society* and a transition toward democratic disillusionment following an era of social movements undertaking democratic revolution (2007: 260-1). This convergence of factors has contributed to the emergence of post-ecologism in which the seriousness of ecological threats is recognized, but neither politicians nor constituents can imagine a viable alternative to the unsustainable system. According to Blühdorn, despite political recognition of present environmental threats, even calls for real action are a masquerade since there is no real intent to change the unsustainable system. Rather, a form of simulative politics is played out with the effect, and Blühdorn suggests the tacit intent, of sustaining the unsustainable a little longer.

Extrapolating from Blühdorn, it is posited here that geoengineering constitutes a new strategy toward trying to "sustain what is known to be unsustainable" with the increasingly mainstreamed discussion of geoengineering within the political arena exemplifying "simulative politics" (Blühdorn 2007). With mounting sense of urgency around the environmental threat of climate change, it can no longer be ignored politically although society has largely demonstrated a collective lack of will "to get serious" (Blühdorn 2007: 253) in terms of making fundamental changes to the carbon-intensive economic system. In the meantime, the prospect of geoengineering also allows for a new manifestation of the political strategy of delaying action pending more research. Moreover, despite protestations by its scientific advocates that it is meant to complement rather than replace emission reductions, geoengineering proposals have the potential to legitimize the de-prioritization of emission abatement, thereby facilitating the continuance of the carbon-intensive energy economy, while fostering a new market for technological research and development. As such, geoengineering is harmonious with the dominant paradigm of continual economic growth (cf. Gunderson, Petersen and Stuart 2018).

As discussed, climate change is a quintessential modern risk in its scale, scope and creation, being caused as a byproduct of the human economy. Geoengineering adds a new dimension of risk. It is unique in that the global risks it would bring with its execution would not be the byproduct of other activities but directly related to its implementation. An acceptance of its inherent risks would be required as part of the process. However, like other risks of modernity, geoengineering schemes, despite the detailed research that would inevitably precede them, would be characterized not just by known risks but also “unknown unknowns.” According to Beck “What differentiates the old nation-state security agenda of the first modernity from the new postnational security agenda of the second modernity is […] the regime of non-knowing, or even worse, not just of known, but above all of unknown non-knowing – of ‘unknown unknowns’” (Beck 2009: 40). Despite the common notion that the modern era is a sort of “knowledge society,” Beck contends that:

> Talk of the ‘knowledge society’ is a euphemism of the first modernity. World risk society is a *non*-knowledge society in a very precise sense. In contrast to the premodern era, it cannot be overcome by more and better knowledge, more and better science; rather precisely the opposite holds: it is the *product* of more and better science. Non-knowledge rules in the world risk society. Hence, living in the milieu of manufactured non-knowing means seeking unknown answers to questions that nobody can clearly formulate. (Beck 2009: 115)

Intervening in complex planetary systems would necessarily involve such “unknown unknowns.”

Contributing a layer of nuance to the discussion of modernity, which is less suggestive of a linear process, Ian Welsh introduces the term “peak modernity” to refer to the mid-century period during which “there was substantive symmetry between the ambitions and aspirations of both political and scientific elites” who “were united behind visions of the planned transformation of society by rational, scientific means” (Welsh 2000: 18). While building upon the theories of Giddens and Beck, Welsh challenges their theories’ subordination of “human intervention in major risk domains to science” such that “the importance of the associated cultural practices, social relations and values are effectively sidelined” (Welsh 2000: 24-25). Based on his study of nuclear technology, Welsh finds that “science and technology arise through the efforts of a scientific social movement” and social response, including “ambivalence and more committed public opposition is based in social, cultural, and moral attributes as well as scientific and technical ones” (2000: 31).

How society responds to climate change is and will continue to be emblematic of its relationship to global modern risks and to the idea of “reflexivity” characteristic of “high modernity.” The shift seen in the work of Giddens is exemplary of a larger trend in climate politics as it:

> represents a retreat from the reflexivity of high modernity that Giddens theorized in his earlier work. Rather, the approach to climate change in [*The Politics of Climate Change*] reflects the characteristic orientation of simple modernization (Giddens 1994: 5, 42, 80-7): an instrumental approach to nature, faith in technological progress and abstract systems of expertise, and the exclusion of ambivalence and uncertainty. (Thorpe and Jacobson 2013: 100)

Part of this retreat from reflexivity seen in Giddens’ scholarship includes his shift away from “life politics” (Thorpe and Jacobson 2013). Giddens’ original concept of life politics included “lifestyle decisions that *limit, or actively go against, maximizing economic returns*” (Giddens 1994: 102). While formal politics have moved away from the principle of sacrifice for the sake of a collective purpose, social movements arguably remain the vanguard of the types of values or “life politics” relevant to addressing climate change through social behavior. Environmental social movements have been pivotal in bringing, and maintaining, attention to climate change. Yet, the representative organizations and alliances have largely been left out of official channels of climate politics. While climate activists have generally been kept outside the walls of the various United Nations climate summits, the politics on the inside have been characterized largely by nationalistic maneuvering as opposed to realization of a cosmopolitan moment, simulative politics, and an instrumental approach toward nature indicative of a “retreat from the reflexivity of high modernity” playing out in climate politics (Harris 2013; Beck 2009; Thorpe and Jacobson 2013: 100).

To the extent that post-ecologism characterizes the social relationship with nature, it exhibits a retreat from the reflexivity of high modernity toward a resurgence of an instrumental and dominating approach of first modernity. Geoengineering reflects this instrumental approach premised on the possibility of controlling nature and a culture of technological exuberance in which “there is a remarkable confidence that science and technology will solve the major problems facing humanity, including those created in the first place by technologies. Environmental counter-technologies presumably will solve the problems created by polluting technologies” (Huesemann and Huesemann 2011: 144). However, technological fixes create new risks on top of the contemporary risks that emerged as byproducts of modernity, technology and progress (Beck 2009; Giddens 1991).

Analyses of Geoengineering from Science and Technology Studies

This dissertation adds to a growing field of social science literature considering the progression and implications of geoengineering’s trajectory. Geoengineering discourse as articulated by advocates has been addressed in regard to industry trade publications (Nerlich and Jaspal 2012) and materials of conservative NGOs and think tanks (Sikka 2012). Tina Sikka analyzes discourse justifying geoengineering of advocates within and affiliated with conservative think tanks or similar NGOs. She considers these organizations “agenda-setting bodies” that can influence media, corporations and government (Sikka 2012: 163). She identifies the importance of discourse as a form of power and the fact “that because geoengineering is such a complex scientific and technological field, dominated by experts and the so-called experts, it tends to make public interventions into the debate extremely difficult” (Sikka 2012: 166). Moreover, Sikka argues that “discursive strategies have been used to construct geoengineering research and practice as necessary, commonsensical and natural” (Sikka 2012: 166).

Nerlich and Jaspal’s discourse analysis of industry trade publications, including from within the energy and utilities sectors, focuses on metaphors that frame geoengineering. The metaphors in their corpus of study were primarily used in favor of pursuing geoengineering. The master argument they identify is that of "catastrophe" and the need for geoengineering as a possible solution: "In the small corpus of trades articles studied here, metaphors, analogies and arguments were mainly used to frame geoengineering as a last resort technology that has to be adopted in a context of impending catastrophe" (Nerlich and Jaspal 2012: 142). The three "conceptual master metaphors" they identify are: the planet is a body, the planet is a machine, and the planet is a patient/addict. From there, they identify other discourse metaphors related to these concepts. "Using metaphor analysis, [they aim] to explore the way geoengineering was framed, or, as one might say, linguistically engineered, between 1988 and 2010" (Nerlich and Jaspal 2012: 132). Like other authors, they argue that "geoengineering metaphors and arguments […] seem to be closing down debates about geoengineering and, in the process, debates about climate change mitigation, rather than opening them up […] This rhetoric limits social and ethical reflection on the issue of geoengineering by implicitly establishing the boundaries of 'legitimate' debate" (Nerlich and Jaspal 2012: 142-3; cf. Bellamy *et al.* 2012: 597).

Rob Bellamy and colleagues have analyzed the presentations of existing assessments and appraisals of geoengineering proposals (Bellamy 2013; Bellamy *et al.* 2013; Bellamy *et al.* 2012). Their analysis identifies the shortcoming that "appraisals have almost exclusively focused on assessing single geoengineering options […] or on developing internal comparisons between geoengineering options" (Bellamy *et al.* 2013: 927). Such appraisals have "consistently isolated geoengineering proposals from their decision context by omitting the wider portfolio of options for responding to climate change, spanning mitigation and adaptation" (Bellamy *et al.* 2013: 927). When the geoengineering proposals are considered within a wider context of climate change strategies, they "often performed less well compared to more established options for mitigating climate change" (Bellamy *et al.* 2013: 935). However, appraisal "in contextual isolation […] produces a limited range of decision options […] and could ultimately contribute to the closing down of governance commitments" and risk "lock-in" or path dependence in pursuing particular technologies (Bellamy *et al.* 2012: 597, 610-611). This is a critical issue as geoengineering proposals are commonly isolated from the broader context within scientific, policy, and public discourse.

Geoengineering science policy reports represent a manifestation of climate engineering's shift toward mainstream consideration and serve an important role in setting the discursive tone for discussion of the climate crisis and consideration of geoengineering. Nils Markusson aptly stated: "One of the main manifestations of public discourse on geoengineering has been the production of a range of often cited, high profile reports" that are "more public than internal scientific publications, more substantive and detailed then most traditional media output or oral presentations, and more formal than most social media content" (Markusson 2013: 9). The Royal Society report stood out as "the preeminent reference point for debates about geoengineering and its governance" (Stilgoe 2015: 103) from the time of its 2009 publication at least until the emergence of the more extensive National Research Council report in 2015. Jack Stilgoe notes that publication of the Royal Society report "raises the question of how a topic that had been considered unthinkable in polite scientific company only a few years before became worthy of consideration by the world's oldest science academy" (Stilgoe 2015: 103). Science policy reports simultaneously articulate the state of research within the field of geoengineering, represent the development of the field, construct and reinforce particular socio-technical imaginaries, and influence public and political perceptions in regard to geoengineering.

Markusson argues that, in part, "the geoengineering imaginary is […] about the creation of a new scientific space for the conversion of climate science into applied, experimental technology, and that the boundaries and the very desirability of this space are contested" (Markusson 2013: 3). His analysis considers high profile geoengineering reports as "articulations of the geoengineering imaginary" that "construct framings of geoengineering as part of attempts at building support for, opposition to and re-shaping the imaginary" (Markusson 2013: 4). His research focus is on the tensions within and between these "authoritative document that exemplify a wide range of perspectives on geoengineering" (Markusson 2013: 9). Diversity results from different opinions and "attempts at persuasion to particular viewpoints" while ambivalence within documents "is caused by groups of authors trying to seek agreement on a text, and express a coherent framing in spite of their differences [or as] the result of trying to pre-empt or entice responses from expected and imagined audiences" (Markusson 2013: 7). The diverse and ambiguous presentation of geoengineering themes within reports would be expected as a multitude of contributors are represented. Yet, despite this, there is an expectation of authority and clarity from these institutions. For example, "The Royal Society is a scientific institution to which many people would look for the authoritative, and singular, voice of science" (Stilgoe 2015: 123).

Science and Technology Studies (STS) scholars have given attention to the Royal Society report (Stilgoe 2015; Gardiner 2011; Owen 2014; Markusson 2013) and other reports related to the genre of geoengineering science policy including the Oxford Principles, Bipartisan Research Center Principles, Asilomar Principles (Owen 2014), and the Arctic Methane Emergency Group report (Markusson 2013). There is little published analysis to date providing in-depth discourse analysis of the National Research Council's two-volume report, which has superseded previous science policy reports as the most extensive document within the genre. The Science Policy Report analysis chapter of this dissertation contributes an in-depth analysis of the NRC report, while expanding upon analysis of the Royal Society report and drawing comparison between the two.

News media publications have been a prolific genre of geoengineering discourse and serve the important role of staging the technology for public consumption. Since "geoengineering is still at an early stage" in terms of public consideration and debate, it is of particular "interest to explore how it enters public knowledge and how it is presented to this audience" (Luokkanen, Huttunen and Hildén 2014: 967). Moreover, because of the novelty and complexity of the field, "the terminology and conceptualization are important in influencing the basic understanding of the issue" (Luokkanen, Huttunen and Hildén 2014: 967). However, analysis to date on news media covering geoengineering has been limited. An exception is article by Matti Luokkanen, Suvi Huttunen and Mikael Hildén (2014), which analyzes metaphors used in relation to geoengineering as presented in *The New York Times* and *The Guardian* from 2006-2011. Their focus was specifically on metaphors as was Nerlich and Jaspal's (2012) study of trade literature. Distinct from trade literature, within mainstream media, metaphors are used toward a range of normative implications, including positive, neutral and negative. While Luokkanen *et al*. (2014) considered geoengineering in news media, their study was limited to the two newspapers within a narrow time span. The news media chapter of this dissertation expands upon the study of geoengineering discourse within the broad public domain as encapsulated in the universe of English-language print news media through 2016.

On the reception side of considering geoengineering discourse, Adam Corner and colleagues have analyzed public engagement with geoengineering discussion presented at public dialogue workshops (Corner, Parkhill and Pidgeon 2011; Corner *et al.* 2013) and Macnaghten and Szerszynski (2013) have engaged focus groups on the issue. Over time, "public consent" has been increasingly recognized as an "essential element" in the "successful stabilisation" of technological fields (Healey 2014: 12; cf. Markusson 2013: 17). Moreover, the process of interacting with the public has changed over the years. Corner, *et al*. differentiate between the "deficit hypothesis" of "public engagement" centered on scientists explaining concepts to the public with the assumption "that if only people knew more about a technology, they would come to see its benefits as outweighing its risks" thus reducing public opposition to technologies presumed to be based on lack of understanding and the currently favored "process of dialogue between scientists and the public" (Corner, Parkhill and Pidgeon 2011: 7).

Despite the transition to dialogic engagement, public explanation of contested technologies risks becoming public perception management and amelioration as opposed to genuine two-way dialogue soliciting stakeholder and public perceptions. As articulated by Adam Corner, *et al.*, "there is a danger that participatory public engagement is still implicitly undertaken as a means to avoid societal dissent, '…educating and pacifying unruly publics resistant to top-down information'" (Corner, Parkhill and Pidgeon 2011: 24; Felt and Fochler 2010: 221). Civil society engagement may still be used for the sake of managing public perceptions as opposed to genuinely including stakeholders in decision-making. The extent to which discursive strategies are used to quell potential public dissent will speak to this question.

Analyses of public reception and interpretation (e.g., Corner, Parkhill and Pidgeon 2011; Macnaghten and Szerszynski 2013) speak to the significance of discursive framing of an emerging technology like geoengineering. As will be discussed, certain observations in these participant observation studies are particularly relevant to the discursive strategies observed in geoengineering policy reports and media presentation. These include the importance of perceived naturalness, imagery that normalizes the technology, presentation that invites comparison of the "pros and cons" of the various technologies, and confidence in scientific, technological and governing structures (Corner, Parkhill and Pidgeon 2011; Corner *et al.* 2013; Corner, Pidgeon and Parkhill 2012; Macnaghten and Szerszynski 2013).

Discourse Analysis and Methods

In political deliberation focused on "the question of action" responding to a crisis, which narratives "come to prevail will strongly affect" the resulting strategies, policies and outcomes (Fairclough and Fairclough 2012: 6, 17). Discourse around a topic like geoengineering is particularly salient. Other than a limited number of experiments to date, the concept is still manifested primarily within discourse and imaginaries (Stilgoe 2015; Markusson 2013). Moreover, the framing and conceptualization of geoengineering is subject to asymmetrical power relationships and knowledge claims. It has been noted that the framing of emerging or "upstream" technologies like geoengineering can significantly affect their reception among the public (Luokkanen, Huttunen and Hildén 2014; Bellamy 2013; Bellamy *et al.* 2012). Hence, discourse is central to the politics of geoengineering.

This dissertation is a qualitative research project aimed at understanding the trajectory of geoengineering within scientific, political, and public spheres in terms of ideation, understanding, meaning and consequences. Examination of the relevant discourse on the subject within and between these spheres contributes to understanding its shifting role in society and politics as well as the material interests and ideological beliefs underlying the dynamic unfolding process. The public nature of this issue lends itself well to content analysis, integrating principles of historical analysis and critical discourse analysis to examine the documents that both reflect and drive the trajectory of geoengineering, including influential science policy reports (especially the Royal Society and National Research Council reports), journalistic articles (news reports, expository reports, editorial commentary), as well as written records and video-recordings of United States Congressional hearings on the subject.

The approach to discourse analysis here is based upon the constitutive theory of language and discourse, which understands language, its conventions, and uses as not only expressing thoughts and ideas about objects but also affecting, redefining, and constructing such objects and their related contexts (see Mehan, Nathanson and Skelly 1990: 135; Foucault 2010). In this way, discourse embodies an intersection of communication, understanding and action. Discourse guides decision-making and material outcomes, but is also itself shaped by social and political interests. Language should therefore be understood as "an active political force composed of conventions or 'practices which systematically form the objects of which they speak'" (Mehan, Nathanson and Skelly 1990: 135; quoting Foucault 1972: 49). The "competition over meaning" in which "proponents of various positions […] attempt to capture or dominate certain modes of representation" has been called the "politics of representation" (Mehan and Wills 1988: 364).

The politics of representation approach, developed primarily by academics in the US, has an affinity with Critical Discourse Analysis (CDA) pioneered by Norman Fairclough in the UK. Both treat discourse as inherently contestable and examine how social and political interests operate through discursive claims and strategies and how interests shape and become embedded in forms of discourse. However, an important difference between the two approaches concerns the overall social ontology within which discourse analysis is contextualized. The politics of representation approach has tended to take a relativist position whereby the constitutive nature of language means that social reality is constituted by and inextricable from discourse. CDA, on the other hand, is closely associated with critical realism whereby social structures are taken to have an independent reality, so that the analysis of discourse operates in relation to a theoretical account of social structure and discourse may be criticized as masking structural social realities.

The question of realism versus relativism is particularly salient with regard to climate change, since anti-environmentalist discourse has operated through undermining scientific realism or claims to the reality of anthropogenic climate change. There is, therefore, a danger that adopting a non-realist position in relation to climate change, far from being neutral, would reinforce anti-environmental discourse of the type that has strategically sought to problematize the reality of climate change (e.g., see Buell 2003; Oreskes and Conway 2010; McCright and Dunlap 2010). It is understood here that the discourse of denial has real social and political effects (as would be expected within the politics of representation's constitutive theory of discourse) and that these, in turn, result in material environmental effects due to influencing policy considerations (e.g., McCright and Dunlap 2010). However, the position taken here is that the effectiveness of denialist discourse in influencing political policy does not merit engaging in "debate" on the ontologically real status of anthropogenic climate change.

The underlying framework of this study simply treats climate change as a real physical phenomenon and takes a realist account of the social forces and material interests producing climate change and opposing environmental action. Moreover, the question of the reality of anthropogenic climate change is not centrally contested within geoengineering discourse. With notable exceptions in Congressional political discourse (as will be discussed in Chapter Four), advocates of geoengineering accept the reality of climate change, which is indeed the premise for considering geoengineering. Therefore, for the most part, the ontological (as reality) and epistemological status (as knowable) of climate change is not itself in question within geoengineering discourse.

Hence, operating from the perspective that regards the denial of climate change as more problematic, more distorting of reality, and more laden with political interests than claims for the reality of climate change, this study is not "symmetrical" on considering the merits of claims in regard to climate change in the relativist sense adopted by the Sociology of Scientific Knowledge (SSK). In this manner, it is more congruent with the critical realist approach related to CDA. However, in contrast to climate change itself, geoengineering discourse is understood here as an arena of active social, ethical, and political contestation in which there are competing notions of legitimacy and visions for the future vying for dominance. As such, the approach taken to studying geoengineering discourse and the competing narratives within it draws upon the politics of representation's constitutive approach of understanding discourse as influencing "ways of thinking and ways of acting" as well as highlighting the "competition over meaning" in which "proponents of various positions […] attempt to capture or dominate certain modes of representation" (Mehan, Nathanson and Skelly 1990: 137; Mehan and Wills 1988: 364).

Discourse analysis is used to examine framing, staging, narrative construction, and argumentation within texts and how certain narratives "come to prevail" and, hence, influence policy and outcomes (Fairclough and Fairclough 2012: 1, 6). Political discourse analysis "is based on a view of politics in which the concepts of deliberation and decision-making in contexts of uncertainty, risk and persistant disagreement are central. This is a view of politics in which the question of *action*, or *what to do*, is the fundamental question" (Fairclough and Fairclough 2012: 17). Language affects outcomes and "political struggles have always been partly struggles over the dominant language" (Fairclough 2000: 3).

Hugh Mehan, *et al*. describe public political discourse as “conversational or dialogic in that voices in interaction mutually influence each other and reciprocally react to one another,” while unique to ordinary conversation, among other reasons, because “power and authority are at stake” and also because “discourse transcends […] temporal and spatial boundaries” in which “participants are not co-present” and perhaps not even acknowledged (Mehan, Nathanson and Skelly 1990: 135-6). These concepts can be applied to emerging technologies, especially since which narratives prevail and how the technologies are staged is an important element in affecting the trajectory of relevant politics, policies and public reception.

The research in this dissertation involved discourse analysis based on close readings of relevant geoengineering documents. Unlike studies focused on the discourse of advocates (Sikka 2012; Nerlich and Jaspal 2012), this research analyzed influential mainstream discourse, influential in staging geoengineering for public and political consideration. Particular consideration was given to how concepts are framed, presented, and contextualized. Discursive themes were identified and tracked for all relevant documentation, including discursive communication techniques such as analogies, metaphors, and juxtaposition as well as other discursive approaches, themes, and patterns such as forms of narration and argumentation, substantive material, including individual actors, organizations, reports, and events, as well as scientific research processes, projections and findings. To facilitate this, the tracking tools in the qualitative analysis software, Nvivo, were utilized to notate and keep track of over 300 thematic, conceptual and subject matter components as well as 85 organizations and 175 individual actors referenced within over 100 documents. The documents studied included science policy reports, journalistic articles, and official records from Congressional hearings.

Focusing on these three different genres of material over the full course of relevant time periods provides insight into geoengineering discourse coexisting with social and cultural values while responding to and interacting with various policy agendas, structural political challenges, evolving technical authority, and shifting balances of political power over time. The evolving or solidifying discursive strategies and conventions, including how various policies and potential endeavors are framed, analogized, and presented, are of particular interest. Specific methodological details will be presented within the empirical chapters.

Overview and Preview

In terms of theoretical grounding, the sociological theories of scholars like Anthony Giddens and Ulrich Beck can be applied to this modern phenomenon with potentially meaningful implications in regard to understanding and reevaluating society's relationship to modernity especially in terms of their concepts of reflexivity and reflectivity. This topic provides a window through which to examine the notions of how society engages with global risk. The extent of risks involved in both climate change and geoengineering, as a potential response to it, cannot be overstated. Both concern matters fundamental to humanity's ontological security. As argued in reference to climate change:

> Risks of climate change need to be understood sociologically in relation to the radical ontological insecurity that arises from the way in which the existential contradiction [of the human relationship with nature] has returned in a new form. Since climate change is not only a problem of risk, but also poses an existential dilemma, it cannot be merely managed at a technical and pragmatic policy level. The reflexive ethical orientation of life politics is essential if society is to cope with the challenge of climate change. (Thorpe and Jacobson 2013: 101)

These issues become all the more pertinent when applied to geoengineering, which involves new risks of global magnitude. As mentioned, climate change exemplifies an unintended, although critical, side effect of economic activity. The prospect of geoengineering the planet, however, takes modern risks to a new level. Unlike previous environmental effects that have been mostly externalities to economic activities, geoengineering directly and intentionally aims to reorient and manipulate environmental processes. As such, the analysis of geoengineering constitutes a unique niche of risk literature.

Through a broad and in-depth focus on discourse analysis of mainstream and influential geoengineering reports and articles, this project contributes a new angle on the topic. Ian Welsh argues that science cannot be understood as a "unified set of institutions, practices and techniques," but rather "it is crucially important to pay attention to the particular discourses which are constructed around particular technologies. The extent to which a technological narrative articulates sympathetically with other ascendant discourses plays a crucial role in determining its success" (Welsh 2000: 4). Extrapolating Welsh's assertion, which he made in regard to the case study of nuclear technology, an individual field of science such as geoengineering can be understood as constituting "a particular scientific social movement seeking to transform society through the acceptance of particular sets of knowledge claims and acceptance of the associated social and technical practices" (Welsh 2000: 5). Analyzing discourse facilitates better understanding such knowledge claims, the intersections of ideology and science, and the diffusion of ideas between technical experts and the public.

Chapter Two focuses on an in-depth analysis of the two most important geoengineering science policy reports, those by the Royal Society in 2009 (UK) and the National Research Council of the National Academy of Sciences in 2015 (US). Science policy reports translate scientific knowledge and ideas into language that informs political action. They put forward policy proposals but in "objective" tones of the "voice of science" (Mukerji 1990). These reports construct conceptualizations of geoengineering and influence its trajectory of research and development due to their central positions in informing policy makers, news media and, in turn, public perception. The Royal Society and National Academy reports are particularly important because of their members' scientific esteem and the extent to which governments look to these institutions for guiding science-related policy. Imbued with authority (Hilgartner 2000: 3; Stilgoe 2015: 104-108), these reports hold a privileged position within the politics of representation of public political discourse where "power and authority are at stake" (Mehan, Nathanson and Skelly 1990: 136). They represent a manifestation of climate engineering's shift toward mainstream consideration and serve an important role in setting the discursive tone for discussion of the climate crisis and consideration of geoengineering. The chapter will particularly consider the discursive strategies used within these reports which construct notions of legitimacy and normalcy related to geoengineering.

While science policy reports represent the translation of geoengineering imaginaries into language assessable to political decision makers, news media bring these concepts to a broad audience. Chapter Three examines discourse in the public sphere primarily through analyzing trends present in 94 unique geoengineering-focused public-audience newspaper and magazine articles. In spite of a broad range of voices, vantage points, opinions, framings, and highlighted facts represented in this corpus, the analysis hones in on various discursive themes that become conventionalized in public discourse on geoengineering. These conventions uphold certain narratives that construct public conceptualization of the "sociotechnical imaginaries" involved in geoengineering (Jasanoff 2015; Bellamy *et al.* 2012; Stilgoe 2016; Healey 2014; Markusson 2013; Corner *et al.* 2013).

Chapter Four focuses on contentious political discourse and expert testimony within Congressional hearings. There are two elite classes of actors, expert witnesses and Congressional representatives, present and asserting authority within the confines of these generally polite and formal proceedings. Within this setting, discursive participants are co-present and interacting, but there is also an engagement with external material and context that gets drawn into the hearings despite their clear and specific purposes delineated within each hearing charter. In the case of geoengineering hearings, the politicized contention over climate change gets interwoven into the discussion along with politicians contending for legitimacy in the staging of broad ideological values such as environmental protection, economic development, and the appropriate scope of government regulation. The United States House of Representatives has conducted four hearings on geoengineering from 2009 through 2016. Chapter Four examines the dramaturgical performances within these hearings and analyzes which elements of discursive enactment remain consistent over time and what changes occur over the seven-year time period.

The final chapter returns to the theoretical themes raised in the introduction and considers the place of geoengineering in relation to world risk society, reflexive modernity, life politics, and the politics of unsustainability. As an alternative to the original "Plan A" of emissions reductions, geoengineering provides a particularly salient lens through which to analyze these issues. It addresses global risks but also brings its own risks, known and unknown. It inherently involves a great extent of human knowledge and ingenuity, but problematizes the complex questions of social reflexivity in the face of the global risks of modernity. It also adds new dimensions to Blühdorn's concepts of post-ecologism, simulative politics and the politics of unsustainability both in its own right as a contested field, but also in its positioning in relation to other climate solutions. The opposite of an instrumental and technocratic approach can be seen in the life politics and values promoted by environmental social movements, as discussed in the final chapter.

Each chapter also engages with a particular theoretical theme. Chapter Two's analysis of science policy reports highlights the role of discursive strategies and conventions in constructing legitimacy and promoting public acquiescence. Chapter Three's analysis engages more with how certain narratives and socio-technical imaginaries come to be reinforced or reconstructed through news media's translation and repackaging of complex technical concepts for public consumption. Chapter Four's government testimony analysis allows for consideration of contentious political discourse in which speakers are co-present and interacting directly, while they simultaneously draw upon ideological and contextual framings external to the proceedings.

All the empirical chapters engage with the issue of legitimacy in regard to geoengineering. The analysis of science policy reports focuses on the construction of legitimacy and development of narratives that attribute legitimacy to certain practitioners and practices. The news media chapter addresses how certain notions of legitimacy are relayed and amplified to a broader public. The government testimony analysis considers the competition for legitimacy that occurs in dialogic policy debate comprised of two fields of elite actors, members of Congress and expert witnesses.

Furthermore, the roles and influence of core individuals active in shaping geoengineering discourse will be considered throughout the dissertation. As will be discussed, a small group of individuals has been particularly influential in setting the boundaries of debate, framing geoengineering, and articulating dominant narratives. These influential individuals have been coined the "geoclique" by science journalist Eli Kintisch in his book *Hack the Planet* (2010: 8). As subsequent chapters of this dissertation will demonstrate, the influence of the geoclique has continued to grow.

Chapter One, in part, includes material as it appears in "Constructing Legitimacy in Geoengineering Discourse: The Politics of Representation in Science Policy Literature." 2018. *Science as* Culture. Forthcoming. Jacobson, Brynna. The dissertation author was the sole investigator and author of this paper.

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CHAPTER 2 — Constructing Legitimacy in Geoengineering Discourse: The Politics of Representation in Science Policy Literature

Introduction

Proposed geoengineering schemes involve scales of technology that would have profound effects at a planetary level. Due to the scale and risk, geoengineering inherently involves science crossing over into international law and policy. This chapter explores the intersection of science and policy in respect to geoengineering. The research employs discourse analysis of key scientific reports that are designed to inform policy debates on the potential strategies of countering climate change through climate engineering. Science policy reports translate scientific knowledge and ideas into language that informs political action. They put forward policy proposals but in the "objective" tone of the "voice of science" (Mukerji 1990). These reports construct conceptualizations of geoengineering and influence its trajectory of research and development due to their central positions in informing policy makers, news media and, in turn, public perception. Despite underlying reluctance and ambiguities, geoengineering policy reports contribute to the mainstreaming of geoengineering though constructing notions of legitimacy.

The constitutive theory of discourse understands language, its conventions, and uses as not only expressing thoughts and ideas about objects but also affecting, redefining, and constructing such objects and their related contexts (Mehan, Nathanson and Skelly 1990; Foucault 2010). The "competition over meaning" in which "proponents of various positions […] attempt to capture or dominate certain modes of representation" has been called the "politics of representation" (Mehan and Wills 1988: 364). In political deliberation focused on "the question of action" responding to a crisis, which narratives "come to prevail will strongly affect" the resulting strategies, policies and outcomes (Fairclough and Fairclough 2012: 6, 17). In regard to scientific research communities, Sarah Parry observes that "by analysing the discursive regularities and strategies within scientists' accounts we can understand not only how specific argumentation is constituted but also how such argumentation produces and is produced by particular social and cultural values" (2009: 94). Discourse around a topic like geoengineering is particularly salient as the concept is still bound to discourse and imaginaries (Stilgoe 2015; Markusson 2013). Particularly, the framing of emerging or controversial technologies can significantly affect their reception (Luokkanen, Huttunen and Hildén 2014; Bellamy 2013; Bellamy *et al.* 2012; Selin 2007; Parry 2009; Rubin 2008; Brown and Michael 2003; Brown, Kraft and Martin 2006).

Geoengineering is controversial for a number of reasons, including its novelty and the magnitude of its risk. Indicative of the level of risk encapsulated in geoengineering proposals, David Keith, who is among the most influential proponents of albedo modification geoengineering, has been quoted as stating: "it is hyperbolic to say this, but no less true: when you start to reflect light away from the planet, you can easily imagine a chain of events that would extinguish life on earth" (quoted in Specter 2012). Few technologies parallel this extent of global risk, one being nuclear weaponry. As will be discussed, discursive practices can promote legitimation of such technologies, making them more palatable and acceptable to the public notwithstanding existential risks.

Discourse conventions were of central importance in managing public acceptance of United States nuclear policy during the Cold War, especially the conventions of framing nuclear weapons as being for deterrence and for the containment of Soviet expansionism (Mehan, Nathanson and Skelly 1990: 134). The convention of deterrence was developed in response to recognized mutual vulnerability to nuclear weapons and justified policy "to maintain a strategic retaliatory capability so horrifying in its destructive force that no aggressor would dare launch a strike in the first place" (Mehan, Nathanson and Skelly 1990: 134). Through examining the backlash to their breach, Hugh Mehan, *et al*. highlight how important these discourse conventions were in facilitating broad public acquiescence of nuclear policy. Breach of discursive conventions "enables us to see how the public's acquiescence to nuclear experts and policy-makers was conditional upon their observance of the convention of deterrence" (Mehan, Nathanson and Skelly 1990: 135). When officials within the Reagan administration breached the deterrence convention by talking "publicly about nuclear weapons as a way to win a nuclear war", they "set in motion a chain of events which deprived them of discursive control over nuclear weapons and made it possible to question the fundamental assumptions of the cold war" (Mehan, Nathanson and Skelly 1990: 133, 135).

The importance of establishing and maintaining public acceptance is also clear in the cases of other contested or emerging technologies. This was manifestly evident in the case of genetic modification (GM) of food crops in Europe where some forms of GM technologies were more accepted by the public while others were fiercely contended (Healey 2014; Poortinga and Pidgeon 2007). Over time, "public consent" has been increasingly recognized as an "essential element" in the "successful stabilisation" of technological fields (Healey 2014: 12; cf. Markusson 2013: 17). For example, Healey points to the efforts made by proponents of nanotechnologies to learn from what they "saw as the public relations disaster of GM foods" (Healey 2014: 25).

In the case of nuclear armament, discursive conventions developed and entrenched over years of consistent usage came to be paramount in maintaining public acquiescence. Emerging technologies do not have the longevity within public discourse for conventions to have become ossified to the same extent. However, within emerging technological fields, certain discursive strategies nevertheless can become recurrent and central to the narrative presentation of these technologies. Science and Technology Studies (STS) scholars have identified a range of narratives and framings that construct the legitimacy of particular emerging technologies.

For example, Cynthia Selin (2007) identifies ways in which nanotechnology promoters engage with the presentation of temporality and the relationship between present and future as discursive strategies that enhance legitimacy of their technological project. Drawing upon the concept of expectations as well actor-network theory, Selin's analysis is premised on the notion that technology is "the culmination of competing material and linguistic resources in which the technological artifacts (including their representations) have a role in mutually constituting strategies and in aligning interests and visions of the future" (2007: 199). She argues that "the making of a new technological domain is complex and emergent, and is mutually constituted by networked actors who are members of different enclaves in the domain" (Selin 2007: 207). In the case of nanotechnologies, different representations of the technology's future compete for legitimacy and funding.

STS scholars also analyze the importance of discursive presentation at the science-policy interface in regard to biomedical research. Nik Brown and Mike Michael identify the framing of "temporal representations of change and the future" in regard to medical research on xenotransplantation and also note the "metaphor of the 'breakthrough'" as a "pervasive discursive method for organizing narratives about science" (2003: 7-8). Other research points to ways in which the field of blood stem cell research is discursively refreshed over time to emphasize possibilities and differentiate current research from past failures (Brown, Kraft and Martin 2006). As with nanotechnology, discursive presentation of temporality, through expectations, anticipation, and the rhetoric of promise, serves to promote the legitimacy of emerging biomedical fields.

In other bioscience cases, research agendas are promoted by discursive strategies that emphasize technicality, therapeutic potential, and novel cures. For example, Beatrix Rubin identifies how emphasis on "therapeutic promise" and the potential for "novel cures" in the framing of human embryonic stem cell research is used to garner support and stability for this research field (2008: 13). Also within the field of stem cell research, Sarah Parry analyzes how framing strategies, particularly scientisation through "[r]eframing the embryo question as a technical issue rather than a societal one", served to legitimate and endow with perceived authority the work of some scientists over others (2009: 89). As seen in these cases, discursive strategies can materially affect policy and research funding allocation.

Scholars analyzing the field of geoengineering have likewise identified certain discursive strategies and dominant narratives employed by scientists and proponents. For instance, Tina Sikka finds that geoengineering advocates within conservative think tanks employ four discursive frames "to generate support" for the technology: "a claim to scientific neutrality", "technological determinism", "exceptionalism", and "a focus on market-driven solutions as the only way to deal with the impending social, environmental, political and economic fallout of global warming" (Sikka 2012: 167). Likewise, within the ostensibly apolitical discourse of geoengineering assessments, Rob Bellamy identifies the dominance of framings premised on "insufficient mitigation" and the risk of a "climate emergency," which both “posit a central role for geoengineering in tackling climate change” (2013: 1). Moreover, the tendency of assessments to place geoengineering’s consideration in “contextual isolation” from alternative approaches to addressing climate change, along with narrow problem definitions and privileging of certain values and assumptions, “produces a limited range of decision options which seem preferable given those framing effects that are privileged, and could ultimately contribute to the [premature] closing down of governance commitments” (Bellamy *et al.* 2012: 597; cf. Bellamy 2013; Corner, Parkhill and Pidgeon 2011).

Critiquing the “Experiment Earth” dialogue project, Adam Corner, *et al*. identify the role of discursive practices in framing the presentation of geoengineering to public dialogue group participants. These include focusing on “pros and cons of the various technologies” before broaching broader questions of overall desirability, use of the “climate catastrophe” framing, and imagery and language that normalize the technology, minimize the sense of novelty, and purvey a sense of naturalness (Corner, Parkhill and Pidgeon 2011: 12-15, 25-26; Corner *et al.* 2013). As will be discussed, these various discursive practices continue in contemporary geoengineering discourse and are present within geoengineering policy reports along with other discursive strategies that contribute to constructing particular notions of legitimacy within the field.

The most influential policy-oriented scientific reports on geoengineering to date are the 2009 United Kingdom’s Royal Society Report *Geoengineering the Climate: Science Governance and Uncertainty* and the United States National Academy of Sciences’ two-part report released in 2015 by the National Research Council (NRC) Committee on Geoengineering Climate, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration* and *Reflecting Sunlight to Cool Earth.* The Royal Society and National Academy of Sciences reports are particularly important because of the scientific esteem they are accorded and the extent to which governments look to these scientific institutions for guiding science-related policy. The Royal Society, founded in 1660 and chartered by the British monarchy in 1663 (Royal Society 2016), has a longstanding role in informing policy and advising decision-makers on scientific matters. Similarly in the United States, the National Academy of Sciences was chartered by Congress in 1863 with a mandate to "advise the federal government on scientific and technical matters" (National Research Council 2015b: front matter). The two volumes of the National Academy's *Climate Intervention* report were produced at the request of the United States government (National Research Council 2015b: ix).

Due to its central role in climate science policy, relevant reports from the Intergovernmental Panel on Climate Change (IPCC) will also be considered and included, as pertinent, in the comparison. The topic of geoengineering has surfaced in IPCC reports to some degree since 1990 and explicitly since 1996 and has received increasing attention in recent reports (see Petersen 2014). The IPCC reports are intended to explain the current state of climate science and provide forecasting based on current knowledge. IPCC has made clear in its many reports the importance of mitigation to minimize the most severe impacts of climate change (Intergovernmental Panel on Climate Change 1990; 1995; 2001; 2007; 2014). Geoengineering—or specific forms of it— have been referenced in a number of IPCC reports (2014; Intergovernmental Panel on Climate Change 1995; 2001; 2013). Several of IPCC's scenarios in the 2014 report rely on the assumption of CDR technologies. While the NRC and Royal Society geoengineering reports are the focus of this analysis, relevant content from IPCC reports will be considered as applicable.

The prestige of these institutions as well as the make-up of individuals on the committees producing the reports imbues them with a sense of legitimacy and authority. Unlike other reports undertaken by think tanks, research centers, and other non-governmental collaborations, these reports were commissioned by the governments they were written to inform. Imbued with authority (Hilgartner 2000: 3; Stilgoe 2015: 104-108), these reports hold a privileged position within the politics of representation of public political discourse where "power and authority are at stake" (Mehan, Nathanson and Skelly 1990: 136). These reports synthesize current scientific research and knowledge related to geoengineering while also providing policy recommendations as to its future. The earlier Royal Society report made an appreciable material impact on the course of geoengineering funding, research and debate in the United Kingdom (e.g., see Owen 2014: 222-3; Markusson 2013: 9; Stilgoe 2015: 103-124). The NRC report could have similar repercussions in years to come. Both of these seminal reports represent a manifestation of climate engineering's shift toward mainstream consideration and serve an important role in setting the discursive tone for discussion of the climate crisis and consideration of geoengineering.

Previous studies have identified certain discursive practices common in presenting and appraising geoengineering proposals, including within the Royal Society report. Nils Markusson analyzes the Royal Society and other high profile geoengineering reports with consideration of ambivalence within individual reports and diversity between documents in terms of issues like geoengineering's relationship to mitigation as well as its novelty and feasibility. He argues "that ambivalence, together with diversity, is […] indicative of attempts at forging new relationships around the geoengineering imaginary" (Markusson 2013: 4). Richard Owen surveys a selection of geoengineering reports and principles, arguing that "the boundary work of experts (e.g. through their visions and judgements) and learned societies (e.g. through their reports), has attempted to legitimise SRM research as an object of governance, specifying certain normative principles and thresholds" (2014: 217). Stephen Gardiner reviews the Royal Society report in regard to issues of ethics, finding that the report "is predicated on a particular account of the ethical context and rationale for geoengineering" and that its "evaluative assumptions […] make substantive differences to policy" (2011: 164). Jack Stilgoe asserts that, despite Royal Society staff and working group members being "admirably open-minded, the issue became scientised in some important ways through their endorsement" (Stilgoe 2015: 15, 94).

While the Royal Society report has been subjected to such analysis, the newer and more extensive NRC report has not yet received comparable analysis. This chapter therefore turns attention to the NRC report, examining how discursive strategies are used to construct and reinforce notions of legitimacy in regard to pursuing geoengineering research. Discursive strategies are taken here as communicative devices promoting certain meanings and courses of action, which are motivated by social and material interests. While the question of intents is not part of this analysis, it is acknowledged that actors are not necessarily intentional or reflective in regard to potential secondary outcomes. For example, discursive strategies may be used by actors to promote support of a research program that advances a technology's development even as they remain ambivalent or reluctant about that technology's deployment. It is found that, despite reluctance and ambivalence found in geoengineering reports (see Markusson 2013), the Royal Society and NRC reports advance the legitimization, normalization, and mainstreaming of geoengineering.

In reference to discourse and language, the NRC report volumes are not only key documents relevant to this topic, but also have the advantage of being explicitly conscientious and intentional about their use of language. They reject the terms geoengineering and climate engineering, saying that not only do these terms lack specificity, but "the term 'engineering' implies a more precisely tailored and controllable process than might be the case for these climate interventions" (National Research Council 2015b: 1). They also reject the terms Solar Radiation Management (SRM) and Albedo Enhancement, in favor of the more neutral term Albedo Modification. This choice of terminology is not explained except to say "the Committee chose to avoid the commonly used term of "solar radiation management" in favor of the more physically descriptive term "albedo modification" to describe a subset of such techniques that seek to enhance the reflectivity of the planet to cool the global temperature" (National Research Council 2015b: x). While the Committee did not expand upon the topic, these linguistic decisions by the authoring Committee demonstrate a reflexivity about language use that implies word choices are conscientiously made in these reports and thus the discourse is indicative of the authors' meaning and intention.

This chapter identifies and examines discursive framing strategies within geoengineering reports, with particular attention to the NRC report. The analysis focuses on consideration of the discursive strategies that construct notions of legitimacy and normalcy related to geoengineering, including the relative legitimation of actors and approaches, differentiating research from deployment, elevating particular methods through comparative evaluation, and the normalizing and naturalizing of geoengineering proposals through analogy. Drawing upon this analysis, the following questions are addressed: To what extent does the report advocate for a particular agenda and how is this agenda displayed and advanced through discursive strategies? How might these discursive strategies influence public and political perceptions and consideration of scientific endeavors related to geoengineering? In what ways does the NRC report display continuity or divergence with the earlier Royal Society report, which had previously been considered “geoengineering’s core document” (Healey 2014: 32)?

Based on this analysis, this chapter will argue that public perception management is a recognized consideration in the construction of geoengineering discourse and that certain discursive techniques are used toward a goal of advancing research that would be relevant in the case of eventual implementation of climate engineering, despite the explicit caveats, and underlying reluctance of the authors, regarding such implementation. The NRC geoengineering policy report builds upon discursive strategies present in the Royal Society report. The repetition, deepening and entrenchment of these discursive practices contribute to the legitimization, normalization, and mainstreaming of geoengineering research.

Defining/Framing the Problem and Matching the Solution

At a basic level, how the problem is defined affects what solutions are considered and how they are evaluated. Of course, to define a problem, it has to first be acknowledged as a problem. While there remains political argumentative discourse that attempts to question the seriousness of anthropogenic climate change, this politically and economically motivated argumentation commonly known as climate change denial is relevant to scientific discourse only to the extent that if forces scientists to repeatedly reassert that indeed there is a problem to be solved, which is seen in these and other reports (Oreskes 2004). The political discourse of denialism has been critiqued and analyzed by others (e.g., Oreskes and Conway 2010; Buell 2003; McCright and Dunlap 2010). While it is outside the purview of this chapter on science policy reports, the interaction of climate change denial discourse with political consideration of geoengineering will be discussed in chapter four of this dissertation.

Within the scope of science policy discourse there are a number of potential problem-framing options that could be employed. The four framings listed in Table 2.1 are non-exhaustive, but give an idea of the scope and how framing the issue might influence what solutions are considered. For instance, if the problem is defined as global warming, within that narrow scope, then albedo modification is a logical engineering solution to consider. If the goal is to counter temperature rises rapidly and globally, most evaluations agree that albedo modification would likely effectively meet this goal. For example, the Royal Society states that although technological readiness for deployment may take some time, "Atmospheric temperatures, however, would respond quite quickly (within a few years) once they were in place" (Royal Society 2009: 32; citation attributed to Matthews and Caldeira 2007; see also National Research Council 2015b: 31).

Table 2.1: Examples of ideal type problem framing and correlated solutions

Problem Framing or Phrasing:	**Solutions Include:**
"Global Warming"	Albedo modification
"Climate Change"	Regional adaptation
Elevated Atmospheric CO_2	Carbon Dioxide Removal & Sequestration
Anthropogenic Emissions	Reducing emissions

The reports also, however, emphasize that there are substantial risks and unknowns that could have extreme environmental impacts, including on ecosystems, hydrological cycles, and other earth systems that could adversely affect humans and other species significantly. According to the NRC report, "Deploying albedo modification could produce a generally cooler climate, but would introduce risks of a different type. Compensation by albedo modification is only approximate, and some manifestations of high CO_2 concentrations are not addressed at all" (2015b: 33).

This leads to another recurrent caveat that albedo modification obviously has no effect on carbon concentrations. For example, the NRC report states clearly "Albedo modification techniques mask the effects of greenhouse warming; they do not reduce greenhouse gas concentrations" (National Research Council 2015b: 1; cf. 3, 6, 33, 34, 145). Specifically, it is often mentioned that albedo modification cannot help with the problem of ocean acidification that comes along with global warming as a result of high carbon levels. For example, the 2014 IPCC report states "SRM would not prevent the CO_2 effects on ecosystems and ocean acidification that are unrelated to warming" (2014: 102). Similarly, the NRC Committee makes repeated note of the caveat that "albedo modification does not address the ocean acidification problem" (National Research Council 2015b: 34; see also 2, 6, 145, 146). The Royal Society states "It would be risky to embark on the implementation of any large-scale Solar Radiation Management methods, which may not be sustainable in the long term, and which would do nothing for the ocean acidification problem, without a clear and credible exit strategy" (2009: xi).

While a focus on warming can be correlated with albedo modification, on the other end of this range, if we consider the problem to be excessive greenhouse gas emissions, then the obvious solutions include reducing emissions through converting energy system away from fossil fuels and other lifestyle changes especially in regard to consumer practices. A slight adjustment in framing from emphasis on emission activities to the product of these emissions, as in "Elevated Atmospheric CO_2" on Table 2.1, opens space for CDR to supplement or supplant emission reduction as a potential solution. "Climate Change" seems to leave room for the most local of responses, regional adaptation, contrasting from the globality of albedo modification or CDR which sandwich it on Table 2.1. However, both the problem framing and solutions need not be mutually exclusive and might overlap of be pursued simultaneously, as will be discussed.

In the major science policy reports, including those advancing knowledge on geoengineering, the problem framing tends toward the broader framing. For example: “At the root of the problem, anthropogenic greenhouse gas emissions to the atmosphere continue to increase, a substantial fraction of which diffuse into the ocean, causing ocean acidification and threatening marine ecosystems” (National Research Council 2015b: ix). Elsewhere, the report states “Approaches that limit or reduce levels of CO_2 in the atmosphere address the major cause of human-induced climate change, whereas albedo modification attempts to counter some effects of high greenhouse gas concentrations without addressing the causes” (National Research Council 2015b: 35; see also 3, 145). This framing is consistent and representative of the framing in the major policy reports. The Royal Society points to carbon concentrations as “root cause of climate change and its consequences” (2009: 49; see also ix, x, 9). The Royal Society further states: “Increasing atmospheric concentrations of greenhouse gases (chiefly CO_2, with small contributions from N_2O, CH_4, ground level O_3 and CFCs), are the main human causes of warming of the physical climate system” (2009: 9).

However, despite this broad framing of the problem, the geoengineering reports tend to shift the discourse when turning from explaining the problem to the realm of potential solutions. First and foremost, all the reports emphasize that mitigating emissions is paramount. Ultimately, however, the geoengineering reports recommend pursuing CDR and advancing research on SRM to make that option available and to aid informed decision-making “should it ever be deemed desirable" (National Research Council 2015b: 150) or "necessary" (Royal Society 2009: ix, x, xii, 36, 47, 52, 57, 60).

The emerging narrative that becomes quite explicit in the NRC report is the need for a "portfolio" of responses. In their framing of geoengineering options to be considered within the "portfolio" of climate solutions, the NRC Committee says: "…CDR methods have more affinity with solutions aimed at reducing net anthropogenic CO_2 emissions […] whereas albedo modification approaches aim to provide symptomatic relief from only some of the consequences of high greenhouse gas concentrations" (National Research Council 2015b: 18). The medical metaphor of "symptomatic relief" aids in bridging the divide from the clearly laid out problem (emissions) to a serious consideration and advancement of a solution that does not address this problem, but rather addresses one of multiple "symptoms." The medical metaphor provides a sense of legitimacy by drawing upon another respected scientific discipline in which it is understood among practitioners and the public that treating symptoms is an acceptable norm.

In regard to CDR technologies, the closer fit between problem and solution framing is emphasized by the Royal Society report when it states that: "All of the CDR methods have the dual benefit that they address the direct cause of climate change and also reduce direct consequences of high CO_2 levels including surface ocean acidification" (2009: 21). The Royal Society report defines the problem in terms of "atmospheric concentrations of CO_2 and other GHGs (2009: 9, 24, 31, 45, 49) as opposed to "emissions," however emissions are considered a pivotal concern (e.g., Royal Society 2009: v, ix, x, 9, 10, 44, 45, 56, 57). In short, the last two framings listed on Table 2.1, elevated atmospheric carbon and anthropogenic emissions, are used to present the problem being discussed in these reports, yet albedo modification (corresponding to the more narrow framing focused on increased global temperature) remains a major part of the discussion of potential solutions being considered.

Plan B Albedo Modification

The recurrent narrative of geoengineering as a possible "emergency solution […] worth researching" in case society is faced with a "climate catastrophe" has been noted by earlier studies as setting up a premise for geoengineering that closes down on deliberation (Corner, Parkhill and Pidgeon 2011: 13). Corner, *et al*. argue: "Presenting geoengineering as a possible response to a climatic emergency is problematic, especially if linked to the need to conduct research at an early stage, as it provides a very strong framing of necessity, which could artificially enhance the acceptability of conducting research into these technologies" (Corner *et al.* 2013: 945). Rob Bellamy argues that the dominant framings within geoengineering discourse, which emphasizes "insufficient mitigation" the risk of a "climate emergency" tends to "posit a central role for geoengineering in tackling climate change" and place its consideration in isolation from alternative approaches of addressing climate change (Bellamy 2013: 1; cf. Bellamy *et al.* 2012). As will be discussed here, this dominant narrative, which emerged in earlier geoengineering discourse has remained central in the seminal science policy reports.

Despite the risks, uncertainties and limitations involved with it, according to the NRC Committee, "There are a number of hypothetical but plausible scenarios in which deployment of albedo modification might be considered" (2015b: 32). Therefore advancing the research around albedo modification is advocated to make the option available. In the words of the Royal Society: "because Solar Radiation Management techniques offer the only option for limiting or reducing global temperatures rapidly they should also be the subject of further scientific investigation to improve knowledge in the event that such interventions become urgent and necessary" (Royal Society 2009: 18). Similarly, the NRC report on albedo modification argues for its technological advancement in case of a "climate emergency" in which case "society would face very tough choices regarding whether and how to deploy albedo modification until such time as mitigation, carbon dioxide removal, and adaptation actions could significantly reduce the impacts of climate change" (National Research Council 2015b: 8).

The risk exists that by investing in Plan B, it could become a self-fulfilling prophecy. This is often attributed to the concept of moral hazard, the "risk that research on albedo modification could distract from efforts to mitigate greenhouse gas emissions" (National Research Council 2015b: 8). However, the NRC report asserts: "The Committee argues that, as a society, we have reached a point where the severity of the potential risks from climate change appears to outweigh the potential risks from the moral hazard associated with a suitably designed and governed research program. Hence, it is important to understand whether and to what extent albedo modification techniques are viable" (National Research Council 2015b: 8). Particularly the risk exists that the longer it takes to make progress on other climate solutions, the more important speed of execution becomes. Lower risk options require longer lead time, therefore over time, the range of solutions contracts and the argument for albedo modification becomes more compelling. As the NRC report indicates: "Should it ever become important for society to cool Earth rapidly, albedo modification approaches (in particular stratospheric aerosol injection and possibly marine cloud brightening) are the only ways that have been suggested by which humans could potentially cool Earth within years after deployment" (National Research Council 2015b: 31).

This theme that albedo modification technology should be developed in case it "should […] ever become important" or "necessary" is a recurrent motif in the justification of furthering albedo modification research. The Royal Society similarly asserts: "because Solar Radiation Management techniques offer the only option for limiting or reducing global temperatures rapidly they should also be the subject of further scientific investigation to improve knowledge in the event that such interventions become urgent and necessary" (Royal Society 2009: x). Such research is intended to inform decisions of people and their governments to make informed choices regarding potential deployment and improve the quality of deployment techniques if implemented. For instance, the authors of the NRC report assert: "If future decision makers reach a point that they are contemplating adopting albedo modification, or assessing such an adoption by others, they will need to assess a wide range of factors, both technical and social, to compare the potential benefits and risks of an albedo modification deployment" (National Research Council 2015b: 9, 152). Furthermore, the authors state: "if society ultimately decides to intervene in Earth's climate, the Committee most strongly recommends any such actions be informed by a far more substantive body of scientific research—encompassing climate science and economic, political, ethical, and other dimensions—than is available at present" (National Research Council 2015b: 155).

It is emphasized that plausible scenarios in which albedo modification may be deployed include short-term execution. The Royal Society asserts that "Solar Radiation Management methods may provide a potentially useful short-term backup to mitigation in case rapid reductions in global temperatures are needed" (Royal Society 2009: 59). According to the NRC Committee:

> There are a number of hypothetical but plausible scenarios in which deployment of albedo modification might be considered. One scenario is a response to sudden and severe climate change, which is sometimes referred to as a "climate emergency." If, for example, global warming resulted in massive crop failures throughout the tropics […], there could be intense pressure to temporarily reduce temperatures to provide additional time for adaptation. In such circumstances, there could be demands for immediate deployment of albedo modification, even in the absence of a rigorous assessment of the implications or an adequate monitoring system. (National Research Council 2015b: 32)

This statement reinforces that "back-up" concept that albedo modification could be reserved for a "climate emergency" defined as "sudden and severe climate change" that causes direct effects on human society such as adverse effects on agricultural production. Here, again, it is suggested that such deployment would be a temporary measure to provide time for adaptation. It is implied that it might be pressure from below that would push for deployment and that such push may occur irrespective of the state of development of the technology, monitoring systems, and risk assessment. This is related to another central theme in geoengineering discourse, the argument that research should be pursued by legitimate actors particularly due to the risk of presumably illegitimate pursuit of albedo modification technology by others, as will be discussed presently.

Relative Legitimation of Actors and Research

Both the Royal Society and, especially, the NRC report consistently and pointedly advocate for further research on both climate change in general *and* the potential role of climate engineering. The authors unequivocally support research advancing scientific knowledge related to geoengineering despite recognizing risks of lock-in, vested interests, and moral hazard (e.g. National Research Council 2015b: 123, 125, 129; Royal Society 2009: 45). While advocating for the advancement of research overall, the NRC report constructs an implicit hierarchy of relative legitimacy within this research field. Certain protocols and practices related to geoengineering research or potential execution are indicated or implied to be endowed with legitimacy while others are conversely treated as illegitimate. Closely related is the presentation of relative legitimacy among scientists, national actors, or other groups undertaking such actions. In short, some research and researchers are considered more legitimate than others.

On one end of the legitimacy spectrum, the ideal type would be government-sponsored scientific research, especially "multiple benefit research" with implications for "basic climate science" as well as advancing geoengineering knowledge, conducted using "best practices" and maximum public "transparency" (National Research Council 2015b: 8-9, 11, 112-114, 123, 129, 134, 140, 149-150, 152, 154-155, 209). The other extreme is implied to be rogue actors pursuing albedo modification technology and willing to deploy it unilaterally particularly to benefit their geographic locality while putting others at risk for environmental harms (National Research Council 2015b: ix-x, 24, 32-4, 73, 123, 152). The mid-spectrum areas would include, for example, private sector actors that have vested interests yet adhere to international norms (National Research Council 2015b: 125, 139-40). These various categories of geoengineering actors and practices are conceptualized and presented in ways that indicate their relative legitimacy.

Multiple Benefit Research

Perhaps because it is particularly controversial, the NRC's discussion of albedo modification research employs several framing techniques with potential to garner support for albedo modification research. One is its strong emphasis on "multiple benefit research" that contributes to the advancement of climate engineering "while simultaneously contributing to the understanding of climate change and other basic research topics" (2015b: 113; see also 8-9, 11, 149-150, 152, 155). Explicitly: "The Committee recommends an albedo modification research program be developed and implemented that emphasizes multiple benefit research that also furthers basic understanding of the climate system and its human dimensions" (National Research Council 2015b: 152). This language justifies further exploratory work on geoengineering by framing this work in terms of the uncontroversial notion that the climate system, climate change and potential solutions all require further research and positioning geoengineering as part of that research (cf. Stilgoe 2015: 120-1). This discursive framing neutralizes arguments against geoengineering by presenting its advancement in the form of research, particularly intersecting basic science research, rather than the more controversial framing of implementing a technological program. In this language, geoengineering is brought under the realm of science in its most ostensibly neutral manifestation - basic research - presented through the epistemically privileged "voice of science" (Mukerji 1990).

The notion of multiple benefit research is used to support the case for furthering albedo modification research by emphasizing the benefits apart from geoengineering. For example, the report states:

> Much of the required research on albedo modification overlaps considerably with basic scientific research that is needed to improve understanding of the climate system. Most notably, research on clouds and aerosols has the potential to advance climate research while also contributing to understanding of the

> effects and unintended impacts of albedo modification approaches. A number of actions can promote such "multiple benefit research"—research that can contribute to a better understanding of the viability of albedo modification techniques and a better understanding of basic climate science […]. (National Research Council 2015b: 149-50)

Such emphasis on the breadth of its utility advances arguments for pursuing albedo modification-relevant research.

Due to existing and foreseen objections to pursuing albedo modification, building a case in favor of the controversial research is presumably aided by advocating multiple benefit research, characterized as "research that contributes to albedo modification capabilities while simultaneously contributing to the understanding of climate change and other basic research topics assuming albedo modification is never deployed" (National Research Council 2015b: 113). This emphasis on multiple benefit research particularly speaks to the contingent of the climate science and policy community who have opposed consideration of geoengineering on the basis of its potential to distract and detract from climate mitigation efforts. By including advancement of basic science and climate knowledge, the NRC Committee makes the argument that researching and developing technology relevant to albedo modification "is a no-regrets policy that will be valuable even if albedo modification is never deployed" (2015b: 113).

While emphasis on multiple benefit research enhances the argument for albedo modification research, not all albedo research and technology can be classified as multiple benefit. Despite the emphasis on multiple benefit where relevant, the NRC authors also argue unreservedly for furthering research applicable only to albedo modification:

> In addition, there is research that is specific to learning about albedo modification techniques (e.g., mechanisms for delivering sulfate aerosol precursors to the stratosphere) that would not fit under this description of multiple benefit, and is therefore unlikely to be supported without a research

> program focused on climate intervention. The Committee argues that these research topics specific to albedo modification should also be identified and prioritized as part of a larger research effort on albedo modification, and tasked to the relevant federal agencies for possible support within existing or expanded programs. Focusing on basic science related to albedo modification will hopefully minimize fears that resources are being used to support a potential near-term albedo modification deployment plan. (2015b: 150)

While clearly these arguments for advancing geoengineering research are no doubt based upon genuine concern regarding the risks of unabated climate change, underlying the concerns regarding maximizing climate response options, the scientist authors have a fundamental interest in furthering scientific research as well as a professional culture supporting the notion of scientific knowledge as intrinsically valuable (cf. Stilgoe 2015: 16). This in itself could largely explain the strong advocacy of a research agenda encompassing both multiple benefit and geoengineering-specific research. However, as will be discussed further below, the final sentence of the above-quoted passage indicates an effort to manage public perceptions while advancing an albedo modification research agenda. While a research agenda is not tantamount to a deployment agenda, the language demonstrates an effort to further albedo modification research and garner public or political support for it through highlighting other potential research applications.

<u>The Layout of Legitimacy</u>

Beyond the classification of research as multiple benefit or specific to climate intervention, the portrayed legitimacy of research is connected to certain notions of how and by whom it is conducted. In this regard, the reports employ terms such as “best practices,” “governance,” and “international coordination.” The need for best practices is referenced by the NRC without expounding its meaning. What is clear is who is to lead: “The United States should help lead the development of best practices or specific norms that could serve as a model for researchers and funding agencies in other countries and could lower the risks associated with albedo modification research" (National Research Council 2015b: 11; 2015a: 11). In this manner, the purported legitimacy of scientists working on geoengineering is modeled upon existing structures of global power and influence, premised on the assumption that the US is a globally responsible upholder of "norms" in the international arena.

Multilateralism is presented as essential for legitimate pursuit of albedo modification, contrasted by the illegitimacy of unilateral pursuit. Although the NRC Committee acknowledges several times that "an international forum for cooperation and coordination on any sort of climate intervention discussion and planning is lacking" (2015b: 7, 148), they indicate that international cooperation will be necessary. For instance, the report summary states: "For the outcome to be as successful as possible, any climate intervention research should be robust, open, likely to yield valuable scientific information, and international in nature" (2015b: 12).

In regard to private sector involvement, especially of for-profit actors, the National Research Council report discusses both perceived benefits and risks. The authors point to "known benefits" of private sector involvement in research, including the ability to "spur innovation, attract capital investment, lead to the development of more effective and lower cost technologies at a faster rate, and produce commercial spin-offs" (2015b: 139). To support this position, they draw on the example of space exploration, saying: "the involvement of private industry contributing to space exploration has generally been viewed quite positively" (2015b: 140). This comparison is given without any explanation or discussion of its applicability. Presumably space exploration is a fitting analogy in terms of ambitious technical and scientific undertakings within disciplines related to engineering, and physics. However, there is no acknowledgement of the limitations of such an analogy in terms of the risks and contested desirability of geoengineering, let alone commercial spin-offs, as compared to less controversial aeronautics and space exploration.

The Committee also raises a number of concerns about private sector involvement, with "the greatest concern [being] that an industry with product lines targeted towards albedo modification would create a group with a vested financial interest in deployment" (2015b: 140). The report quotes the influential *Oxford Principles* stating foremost that geoengineering is "to be regulated as a public good" and that:

> While the involvement of the private sector in the delivery of a geoengineering technique should not be prohibited, and may indeed be encouraged to ensure that deployment of a suitable technique can be effected in a timely and efficient manner, regulation of such techniques should be undertaken in the public interest by the appropriate bodies at the state and/or international levels. (National Research Council 2015b: 125; quoting House of Commons Science and Technology Committee 2010; Rayner *et al.* 2013)

In this way, the risks of vested interests steering the climate engineering agenda are acknowledged and functionally dismissed by delegating such concerns to the realm of a vaguely construed governance protocol that would putatively ensure "public interest."

Moreover, irrespective of concerns including vested interests in deployment, the NRC report indicates that there may be desirability in incentivizing private sector participation, stating:

> A substantial acceleration of albedo modification research would likely require additional incentives, such as public subsidies, GHG emission pricing, ownership models, intellectual property rights, and trade and transfer mechanisms for the dissemination of the technologies (Bracmort and Lattanzio, 2013). These incentives will determine not only whether but how the private sector engages with albedo modification. (National Research Council 2015b: 140)

This discussion of private involvement is closed with the suggestion that: “It would be preferable for the public to have substantial discussion as to what outcomes are desirable before determining what incentives to offer” (National Research Council 2015b: 140). Again, stated risks are functionally dismissed through reference to hypothetical social involvement of public participation to guide policy, even as the terms of deliberation are being set in such a way that poses challenges to this very public involvement.

Risk of Unilateralism

Contrasting with the implied legitimacy of a multilateral research program is the risk of unilateral albedo modification-pursuit. Emphasis of this risk is recurrent, with the NRC using variants of the term “unilateral” in 20 instances throughout the *Reflecting Sunlight* report. It is highlighted that albedo modification, unlike CDR or mitigation “could be done unilaterally” (2015b: 3, 145; cf. Royal Society 2009: 40). The Committee emphasizes that “A single nation, or even a very wealthy individual, could have the physical and economic capability to deploy albedo modification with the intention of unilateral action to address climate change in a geographic region” (National Research Council 2015b: 122; see also 32). The indication is that there are illegitimate actors who would irresponsibly wield albedo modification technology, implicitly compared to responsible legitimate actors.

Echoing the Royal Society’s argument that a research moratorium would bind legitimate actors, but have no effect on illegitimate actors (Royal Society 2009: 37), the NRC report quotes the argument of David Victor *et al*. (2009):

> …a taboo would interfere with much needed scientific research on an option that might be better for humanity and the world’s ecosystems than allowing unchecked climate change or reckless unilateral geoengineering. Formal prohibition is unlikely to stop determined rogues, but a smart and scientifically

> sanctioned research program could gather data essential to understanding the risks of geoengineering strategies and to establishing responsible criteria for their testing and deployment. (National Research Council 2015b: 123-4; quoting Victor *et al.* 2009: 75)

Reference to "rogues" is reminiscent of the concept of legitimate and illegitimate holders of nuclear technology (O'Gorman and Hamilton 2011; Chang and Mehan 2008: 459-461). The loaded political term "rogues" implies entities expected to operate outside of and without approval from the core network of powerful nation-states.

The NRC, like the Royal Society before it, does not explicitly identify who constitutes a rogue threat for geoengineering. However, other government documents highlight China, India and Russia in hypothetical scenarios (e.g. Committee on Science and Technology 2010: 9, 21, 100, 127, 317, 318) and the *Foreign Affairs* article, cited by the NRC in the above excerpt, elsewhere references China and India as nations that may need convincing "not to prematurely deploy poorly designed geoengineering schemes" (Victor *et al.* 2009: 70). Such a portrayal of legitimacy both reflects and reinforces structures of unequal power in international relations. It is implied that while "rogues" would be irresponsible— indeed "reckless"— with the technology, "a smart and scientifically sanctioned research program" could be trusted to be "responsible" (National Research Council 2015b: 123-4). It juxtaposes the political notion of "rogues" with the presumably politically neutral category of "smart" and "sanctioned" science as practiced within those nations Victor *et al*. propose should be pursuing geoengineering, although without explicating who potentially fits into each category.

The risk of unilateralism has entered and persisted in geoengineering discourse, with certain individuals driving its meaning. David Victor and M. Granger Morgan have been particularly influential in guiding discourse on this theme. They have integrated the theme of unilateral deployment into related scholarship (e.g.,Victor 2011), used it as a premise for advocating for geoengineering advancement (Victor *et al.* 2009), and presumably contributed their perspectives on this topic while serving as Committee member (Morgan) and reviewer (Victor) for the NRC report. M. Granger Morgan also served as a panelist for a Congressional hearing on geoengineering ("Geoengineering III: Domestic and International Research Governance" on March 18, 2010), which will be discussed in chapter four.

David Victor, an advocate of geoengineering development, has written about geoengineering and the risk of unilateralism and has come to be called upon as an expert on the subject, being cited frequently (see Tables 3.2 and 3.3 in the following chapter)– as author or interviewee – when risk of unilateral climate engineering is discussed. Science policy reports synthesize and reformulate existing discourse, particularly academic but also public discourse, on the topic into the unique package of science policy considerations. On the topic of unilateralism, David Victor appears in science policy reports, reproduced further as an expert. The Royal Society, notably comments that: "Concern about the possibility of unilateral implementation has already been expressed by several commentators (eg, Victor 2008)" (Royal Society 2009: 38). Notable here is that David Victor is the only example given for the reference to "several commentators" such that his position is highly represented, perhaps disproportionately so, in carrying the debate on the relevance of unilateralism in geoengineering concerns and policy. The National Research Council report acknowledges David Victor as a reviewer (2015b: xi). In this report, Victor is cited in multiple instances on the topic of unilateralism as well as the related argument that the need for the United States to be on the forefront, setting the norms of geoengineering research (National Research Council 2015b: 23, 123, 124, 140).

The emphasis on potential unilateralism reframes risk, away from the inherent dangers of AM and instead toward the threat of unilateral pursuit of it. This framing bolsters the case for advancing AM research by certain actors through implicit contrast with potential bad actors. It is the climate engineering equivalent of the “if guns are outlawed, only outlaws will have guns” argument. The implication is that albedo modification research by legitimate actors must be supported lest we risk illegitimate actors unilaterally pursuing albedo modification with the mainstream political and scientific community powerless to stop it. This reorients the conception of risk in regard to geoengineering from *what* to *who*. Rather than the primary risk being deployment and its adverse consequences (known and unknown), the risk is redefined from deployment itself to unilateral deployment.

The NRC Committee argues that due to the risk of unilateral deployment, research should be pursued even if—perhaps especially if— albedo modification is assessed to be undesirable because the research to develop the technology is also necessary to identify its use by unilateral actors. For example, within their policy recommendations, the Committee promotes development of a new generation of space-based instruments that “would significantly improve understanding of the effects of clouds and stratospheric aerosols on climate, improve the ability to predict the effects of albedo modification, and provide an ability to detect large-scale albedo modification by rogue actors” (2015b: 152). Thus the argument for advancing research and technological development can be supported by either the potential benefit of pursuing albedo modification or conversely the risk of albedo modification and the benefit of detecting its use by others.

Differentiating Research from Deployment

A central way public perceptions are managed and the legitimacy of geoengineering action supported is through the discursive differentiation of research and deployment. Within the proposed forms of geoengineering, a full research program would necessarily blur lines between research and deployment (Stilgoe 2016: 858-9; Robock *et al.* 2010; Hulme 2014: 95). However, studies of public attitudes toward geoengineering have shown that people "tend to make a distinction between research and deployment" and be more favorable "to the idea of researching geoengineering, while holding significant reservations about ever deploying it" (Corner *et al.* 2013: 941). Hence, simultaneously advocating for research (that would be necessary for deployment) while cautioning against deployment, increases the potential of advancing research with minimized impediment. The Royal Society contributed toward developing a narrative distinguishing between research and deployment (Owen 2014: 223). The NRC report significantly deepens the distinction.

The discursive strategy of differentiating research from deployment specifically encourages the advancement of technology while simultaneously discounting the need for social acceptance of its eventual use. Especially in regard to albedo modification, the reports advocate for further research while discouraging deployment "at this time." Therefore, social acceptance of research *not* deployment is encouraged, although that research would create the technological basis for deployment. Focusing the question of social acceptance onto the narrower realm of research pushes the question of social acceptance of deployment to a later date when the technology would be more developed. Moreover, due to geoengineering proposals' global scale of intended consequences, the full extent of consequences would be unveiled only through the global experiment of deployment (Stilgoe 2016: 858-9; Robock *et al.* 2010; Hulme 2014: 95; Owen 2014: 16).

The NRC report consciously differentiates albedo modification research from deployment. The Committee explicitly distinguishes its research advocacy from its position on deployment, with the core recommendations on the subject being:

> Recommendation 3: Albedo modification at scales sufficient to alter climate should not be deployed at this time…
>
> Recommendation 4: The Committee recommends an albedo modification research program be developed and implemented that emphasizes multiple benefit research […]. (National Research Council 2015b: 7-9)

In these sequential recommendations, the Committee distances itself from the topic of deployment while advocating development of a research program that would be the basis of deployment. As discussed, the emphasis on "multiple benefit research" helps to reconcile this juxtaposition.

Throughout the NRC *Reflecting Sunlight* report, this strategy of differentiating research from deployment is central and recurrent, including explicit statements such as: "The Committee reiterates that it is opposed to large-scale deployment of albedo modification techniques, but does recommend further research" (2015b: 155). The chapter on research governance opens by stating this official position: "The focus of this chapter is on the issue of governing research, because research is the only albedo modification-related activity that the Committee believes should be considered at this time" (121).

Reinforcing this discursive decoupling of research and deployment is the introduction of the concept of "large-scale deployment." The Committee states: "There are many research opportunities that would allow the scientific community to learn more about the risks and benefits of albedo modification, knowledge which could better inform societal decisions without imposing the risks associated with large-scale deployment" (2015b: 8). Elsewhere the Committee reiterates that "it is opposed to large-scale deployment of albedo modification, but does recommend further research" (2015b: 155). In this way, the differentiation between research and deployment is subtly shifted to the differentiation of research and "*large-scale* deployment." While there is "large-scale deployment," there is not corresponding reference to *small-scale deployment*, but rather: "Small field studies" (2015b: 151), "small-scale field experiments" (9, 152), "small-scale projects that inject materials into the stratosphere" (81), "small-scale controlled emissions studies" (102), "small-scale experimental studies" (127), and "small-scale experiments" (132, 139).

Only once is the term "deployment" paired with the concept of "small-scale." The Committee states that recommended "research encompasses a range of activities from the innocuous, such as modeling, to the more invasive, such as controlled small-scale test-deployments for experimentation purposes" (2015b: 121). While this statement in one sense bridges the gap between research and "large-scale deployment," it also emphasizes the differentiation of research and deployment, especially as it immediately follows a reiteration that only research is being advocated. This research, however, includes "small-scale test-deployments," which are treated as "research" not "deployment," despite their simultaneous presentation as both. The framing emphasizes that these "test-deployments" would be "controlled" and for "experimentation purposes," indicating that this type of experiment would be considered within the research category rather than the deployment category. In this way, the Committee is able to assert the broad take-away point that "at this time" they advocate for research but not deployment, implicitly defined as "large-scale deployment," while subtly introducing the notion of "small-scale test-deployments" within the category of research despite the nebulous boundaries between this type of research and deployment.

The ambiguous relationship between the concept of deployment and categories of scale can be seen elsewhere when the Committee implies that small-scale deployment, though not phrased as such, must pave the way to actual deployment:

> Any albedo modification, if deployed, should start with an intervention of small magnitude […] in order to gain experience with the consequences of a more modest intervention and its impacts on both to the shortwave energy balance and to other aspects of the system before making a decision as to whether the risks involved in scaling to larger values are tolerable. (2015b: 108)

This *if-should* phrasing allows the authors to maintain two contradictory positions: they are not advocating deployment, but rather specifying necessary mechanisms and requirements *if* deployment were to occur, while advocating the achievement of those same deployment prerequisites as necessary research independent of the pursuit of deployment. In this way, even while indicating that the forms of research advocated are those that would be necessary in order to achieve deployment, the authors are able to maintain the explicit decoupling of research and deployment, diminishing the sense that pursuing research would necessarily advance deployment.

Promoting relevant research while simultaneously cautioning against its deployment is at face value—as presumably intended— a pragmatic and moderate position. However, another function for the recurrent differentiation of research (promoted) and deployment (not promoted "at this time") is public perception management. As mentioned previously, this intent is overtly revealed within the NRC report wherein explaining the emphasis on multiple benefit research, the Committee states that "Focusing on basic science related to albedo modification will hopefully minimize fears that resources are being used to support a potential near-term albedo modification deployment plan" (2015b: 150). This does not say that the focus on basic science would be due to the unlikelihood or undesirability of deployment, but rather that it would "minimize fears" presumably among the public. (Notably, the more condescending term "fears" is used to characterize potential negative response from the public rather than the more neutral term "concerns." The term "fears" is generally indicative of an emotional and often irrational response while "concerns" would conversely imply some extent of rational consideration of potential negative outcomes.) This statement indicates an effort to promote albedo modification research while distancing it from the obvious corollary of potential deployment in order to minimize public concern, which is, of course, essential in minimizing opposition.

This framing of research versus deployment may reflect lessons learned in the aftermath of the Royal Society report and subsequent proposed experiments, such as the planned (and ultimately canceled) Stratospheric Particle Injection for Climate Engineering (SPICE) technical experiment, which drew considerable public opposition (see Owen 2014: 236). This experiment would have involved the seemingly benign spraying of water into the atmosphere to test what dispersion might look like in albedo modification scenarios, but despite the idea that it would be an "uncontroversial" experiment, it was cancelled after significant internal deliberation and also an outpouring of opposition from the public, which culminated in a petition from over fifty organizations voicing opposition (Specter 2012; Stilgoe 2015). Opposition included concern over vested interests, especially the involvement of scientists holding patents for relevant technology as well as concern over the moral hazard issues related to the advancement of geoengineering pursuits to the potential detriment of mitigation efforts (Specter 2012; Lukacs 2012; Cressey 2012). Similarly, within the category of CDR, public outcry has directly affected the moratorium on ocean fertilization experiments and caused the cancellation of specific experiments (e.g., Goodell 2010: 154-8; Kintisch 2010: 140-8). Concern regarding vested interests that would have a stake in the eventual deployment of these technologies as well as concern that experimentation adds to the likelihood of deployment has been central to public opposition to field experiments related to both SRM and ocean fertilization. In the wake of such public opposition, the subsequent NRC report, written collaboratively with scientists interested in advancing research and experimentation, explicitly decoupled research from deployment of geoengineering methods.

While the NRC Committee displays mindfulness of public perception in its decoupling of research and deployment, the earlier Royal Society report treated the distinction in more pragmatic scientific terms. Although also advocating research and not deployment, the corollary relationship was more directly recognized. Research, not deployment, was promoted in large part because research would be needed prior to potential deployment. Regarding CDR, the authors state pragmatically that "Significant research is […] required before any of these methods could be deployed at a commercial scale" (Royal Society 2009: 21). The report similarly acknowledges the relationship between albedo modification research and deployment, stating: "None of the principal proposals are yet ready to be put into operation. Further research and development of the individual approaches (including, in some cases, pilot-scale trials) would be needed to assess uncertainties about effectiveness and undesired side effects and to identify any preferred approach" (Royal Society 2009: 34). Likewise: "None of the methods assessed are yet ready for deployment, and all require significant research including in some cases, pilot scale trials, to establish their potential effectiveness and effects on climatic parameters" (Royal Society 2009: 36). The relationship here between research and deployment is that research is a necessary stage to either become ready for deployment or to make educated decisions about deployment. The Royal Society's framing is distinct from the more recent NRC report, in which consistent use of discursive decoupling serves to minimize the corollary thread between research and deployment readiness.

Evaluation by Comparison

Within geoengineering discourse, there is a recurrent trend of comparative evaluation between methods (cf. Bellamy *et al.* 2012: 608; Corner, Parkhill and Pidgeon 2011: 12, 25). Evaluation by comparison redirects discussion from broader questions of whether geoengineering options may be feasible or fundamentally desirable toward ranking and comparing various options, thereby obfuscating the non-action option (cf. Bellamy *et al.* 2012; Bellamy *et al.* 2013; Bellamy 2013; Corner, Parkhill and Pidgeon 2011). It occurs both through comparing albedo modification to CDR and also by comparing specific methods within these categories.

While the reports urge separate consideration of albedo modification and CDR (National Research Council 2015b: 18; Royal Society 2009: ix; Stilgoe 2015: 121), in practice they tend to draw comparisons between the categories, delineating relative advantages and drawbacks. The Royal Society's "blob chart," a visual representation comparing geoengineering proposals from both categories, has been identified as a problematic component of the report (Stilgoe 2015: 115-120). Choosing two particular axes—"affordability" and "effectiveness" from a number of plausible options— to visually compare possibilities from both categories of geoengineering proposals resulted in a diagram that implied a clear frontrunner among proposals, whereas choosing other equally relevant X and Y axes would have resulted in conflicting impressions (Stilgoe 2015: 115-120; Maynard 2009).

Both volumes of the NRC report use a comparative table, “Overview of general differences between Carbon Dioxide Removal (CDR) proposals and Albedo Modification proposals” (2015b: 3, 145; 2015a: 3). Distinct from the Royal Society’s “blob chart” that visually suggests a hierarchy of preferable proposals, this table lays out a comparative pros and cons list for the broad categories of albedo modification and CDR. In this table and elsewhere, the authors explicitly state that CDR will be judged mostly on the basis of cost while albedo modification will be judged based on risk. Costs of albedo modification deployment tend to be dismissed as negligible despite the costs of monitoring and evaluation as well as albedo modification’s risks potentially translating to costly deferred liabilities.

Within each geoengineering category, many specific comparisons made on the bases of costs, timelines and risks inform the relative assessment of particular methods and justify the elevation of some proposals over others. Both reports elevate stratospheric aerosols as among the “most promising” options within the albedo modification category. The Royal Society uses the phrase “most promising” three times in regard to stratospheric aerosols. For instance: “Of the Solar Radiation Management methods considered, stratospheric aerosols are currently the most promising because their effects would be more uniformly distributed than for localised Solar Radiation Management methods, they could be much more readily implemented than space-based methods, and would take effect rapidly” (Royal Society 2009: xi). This notion of “most promising” methods reorients the framing from risk (negative) to gradations of promise or potential (positive).

The NRC report builds upon the previous elevation of particular methods, including stratospheric aerosol. In justifying which albedo modification strategies the report covers, they explain: “Rather than discuss every potential means of modifying Earth’s albedo that has been proposed, this report will focus on the two strategies that have received the most attention and which may most feasibly have a substantial climate impact: stratospheric aerosol injection and marine cloud brightening” (National Research Council 2015b: 37). In the albedo modification technical evaluation chapter, the Committee reiterates that they focus on these two proposals “because studies suggest they have the potential to produce a significant cooling and/or they have been discussed more widely in the literature” (2015b: 39). This demonstrates how the elevation of certain proposals may be perpetuated over time based on the degree of previous attention paid to them in addition to the privileging of particular assessment criteria (in this case estimated efficacy at cooling).

In regard to CDR, the NRC report elevates two methods above others based on their relative “potential” despite significant challenges. According to the report: “It is important to emphasize that both BECCS [biomass energy with carbon capture and sequestration] and DACS [direct air capture and sequestration], which are the CDR approaches that appear to have the greatest potential for carbon dioxide reduction given the current state of knowledge, depend on the availability of geologic reservoirs capable of accepting and reliably storing massive amounts of CO_2” (2015a: 86). Describing these proposed CDR methods as having the “greatest potential,” implicitly ranks them in frontrunner positions even as this status elevation is prelude to the methods’ significant lack of scalable sequestration options, a challenge that would “require a thousand-fold scale-up of the current CCS [carbon capture and storage] activities that take place today” (National Research Council 2015a: 86). Despite its magnitude, this obstacle, like others, is treated as an engineering challenge solvable through further research and technological development.

The authors seem optimistic about the potential for research and development to solve such challenges, as well as other limitations and costs facing CDR proposals. The report optimistically concludes that "CDR is at an early development stage, and further research and development and emerging technologies may greatly lower costs and increase capacity and deployment readiness, and may thus significantly alter the above conclusions" (2015a: 86). This commentary demonstrates how particular techniques are elevated relative to other options, giving the sense of high potentiality of their realization despite serious limitations and challenges, some of which are comparable to the challenges facing international action on mitigation that have contributed to the current situation.

There is a theme in geoengineering discourse, which can be likened to a decoy effect: inclusion of more extreme or controversial proposals, which by comparison tend to elevate the proposals being advanced by the implicit suggestion that these are relatively moderate or reasonable. The decoy effect will be further discussed in the following chapter as it is a core discursive theme in general audience literature on geoengineering. Within science policy reports, the decoy effect is more subtle and nuanced than within popular media while remaining relevant. Lord Rees' forward to the Royal Society report makes note of the range of options often presented:

> Many proposals for geoengineering have already been made—but the subject is bedevilled by much doubt and confusion. Some schemes are manifestly far-fetched; others are more credible, and are being investigated by reputable scientists; some are being promoted over-optimistically. In this report, the Royal Society aims to provide an authoritative and balanced assessment of the main geoengineering options. (Rees 2009: v)

Rees thus hints at the extreme or decoy options by obliquely referencing the "manifestly far-fetched" schemes that provide a comparison point by which "others are more credible" (Rees 2009: v). This serves to both acknowledge what is here called the decoy effect to a certain extent while also perpetuating it through Lord Rees' own reorientation of the range of options from "far-fetched" to "more credible," thus elevating some options prima facie based upon their relative credibility rather than necessarily their inherent strengths alone. Consistently, the presentation of a range of options broadened by inclusion of decoy or "far-fetched" option choices makes the favored options seem more reasonable by comparison. Furthermore, the broad range of options provides a sense of honing-in on a direction of pursuit.

Internal Evaluation and Iterative Knowledge Claims

The 2014 IPCC report, among its plethora of caveats on geoengineering, explains the exclusion of some proposals from examination with the statement that "The scarcity of literature on other SRM techniques precludes their assessment" (IPCC 2014: 102). This begs the question as to whether a proliferation of literature in itself increases legitimacy of geoengineering itself or particular methods within and actual ability to evaluate, ultimately steering further research and even potential deployment. Within geoengineering-focused reports we also see specific methods elevated precisely due to their having been better researched to date. Those topics that are the most researched become favored for further research.

This pattern is evident within both volumes of the NRC geoengineering report. Reasonably the Committee states that while "Other approaches have been suggested," their report "focuses […] on techniques for which there is sufficient information to make a preliminary assessment" (National Research Council 2015a: 34). Then, when honing in on favored methods, in addition to evaluation by comparison to alternative methods, the extent of attention a method has received by scientists affects its positioning. For instance, in the *Reflecting Sunlight* report, in setting up the favored options for consideration, the Committee states: "Two more realistic strategies (stratospheric aerosol injection and marine cloud brightening) are then discussed in greater detail because studies suggest they have the potential to produce a significant cooling and/or they have been discussed more widely in the literature" (National Research Council 2015b: 39). While the first reason presented would explain the elevated status of these methods within consideration as well as the increased attention, they add the second reason, having "been discussed more widely in the literature," as an equally pertinent reasoning using the "and/or" conjunction. Similarly later in the technical analysis section: "The Committee's discussion will focus primarily on injection of sulfate aerosols or their precursors into the lower stratosphere. This is the most-studied technique, and is also the one that most closely mimics the way large volcanic eruptions cool the climate" (National Research Council 2015b: 55). The criteria of being the "most-studied" serves as justification for the continued privileging of the method in this report and future consideration.

In these reports the scientists want to focus on existing knowledge rather than speculating on less studied alternatives. While it is reasonable to provide attention accordingly to those methods most studied, this practice has the effect of perpetuating the privileged or elevated positions of certain proposals, contributing to the sense of their heightened legitimacy. This may translate into a risk of insular lock-in as existing courses of study within the community reinforces the direction of research and potential deployment. This process is perpetuated by the fact that science policy analyses rely on the research within the community and the members and advisors are in close relationship

Normalizing Proposed Techniques

Geoengineering is controversial, among other reasons, because of its novelty. This is especially pronounced for albedo modification methods that would involve global experiments intentionally shifting Earth's radiation-balance, changing global climate to completely novel conditions. Many proposed CDR approaches are also novel with far-reaching repercussions. However, studies of public perception have found that people are more favorable to geoengineering projects that are perceived to be more "natural" (Corner *et al.* 2013; Corner, Parkhill and Pidgeon 2011: 20-22, 26). Hence, framing and contextualizing geoengineering methods in ways that minimize the sense of novelty and normalize the concepts through comparison to common phenomena or activities would be expected to facilitate a more favorable reception.

Corner, *et al.* argue that the framing of naturalness has such a strong effect on public reception that "there is a need to ensure that technologies are not associated with the positive notion of 'naturalness' by analogy if, in fact, they are highly artificial" (Corner, Parkhill and Pidgeon 2011: 26). Yet, such framing is recurrent and persistent in geoengineering reports, which make frequent comparisons between climate engineering techniques and natural phenomena. CDR is normalized through emphasizing similarity to natural carbon cycles and processes (cf. Corner, Parkhill and Pidgeon 2011: 21). Two primary analogies normalize the concept of albedo modification: first, comparison to the natural phenomenon of volcanic eruptions and, second, analogy to the mundane experience of pollution.

The favored albedo modification proposal, Stratospheric Aerosol Albedo Modification (SAAM), which would involve spraying a layer of sulfur-based aerosols into the stratosphere, relies heavily on analogy to the effects of volcanic eruptions. Variants of the terms volcano/volcanoes/volcanic are used 102 times in the NRC (2015b) *Reflecting Sunlight* report main text and appendices. Volcanoes are evoked in two primary manners. First, the volcano analogy is a useful scientific tool because major volcanic eruptions are the closest "natural experiment" that can inform the scientific basis and understanding of SAAM's potential effects. As the NRC explains, "Some volcanic eruptions have injected large amounts of sulfur dioxide gas into the stratosphere, and observations of these eruptions and their impact on climate can serve as natural experiments for testing our understanding of albedo modification processes" (2015b: 59). Secondly, comparison between proposed human-engineered albedo modification and natural volcanic eruptions may function to normalize and abate fears of albedo modification's novelty and risks.

Beyond being useful analogies, the observed effects of volcanic eruptions have directly influenced, even inspired, the conceptualization of SAAM. According to the NRC:

> The observed cooling following large eruptions provided much of the initial stimulus for the idea that albedo modification could help offset effects of warming due to anthropogenic CO_2 increase, and attempts to model the observed effects of volcanic eruptions can provide some insight into the complexity of the processes and some of the unknowns that still need to be addressed. (2015b: 59)

Similarly, the Royal Society states: "global cooling has been produced in the past by volcanogenic sulphate aerosols, providing direct evidence that these particles would have a cooling influence" (2009: 29). It is understandable, then, that the volcanic analogy has been particularly important in developing SAAM. The observed effects of past volcanoes, particularly the 1991 eruption of Pinatubo, inform the idea of SAAM and are referenced frequently and often described at length. Scientist authors also display eagerness to amass further data from future volcanic eruptions, which "provide an excellent opportunity to test and improve our understanding of relevant physical processes" (National Research Council 2015b: 59).

In the "Technical Analysis of Possible Albedo Modification Techniques" chapter of the NRC report, the effects of volcanic eruptions are discussed at length. The authors report that:

> Very large eruptions—the size of El Chichón (1982) or Pinatubo (1991)—produce a detectable climate response that can be used to test simulations of both aerosol forcing and the consequent response of climate, but even smaller eruptions—the size of the Sarychev eruption (2009)—can provide a useful test of our ability to observe and to simulate stratospheric aerosol processes. (National Research Council 2015b: 60)

Effects on climate, especially temperature, are emphasized since this is the main objective of volcanic-modeled albedo modification methods. The authors also consider several other effects, including those on the ozone layer, precipitation, photosynthesis, and cirrus cloud variations (National Research Council 2015b: 60-62). These effects, on balance, are treated as neutral, positive, or uncertain and in need of further research.

In this key chapter, however, the potentially catastrophic human risks from albedo modification are relegated to a footnote: "Other eruptions, such as Tambora in 1815, caused global climatic anomalies that led to widespread crop failure and famine" (National Research Council 2015b: 60). This risk of "widespread crop failure and famine" is also referenced elsewhere in the report. However, in both instances within the main text where "crop failure and famine" resulting from the Tambora eruption are mentioned, the subsequent sentence emphasizes limitations of the volcanic analogy:

> Large volcanic eruptions are by their nature uncontrolled and short-lived, and have in rare cases led to widespread crop failure and famine (e.g., the Tambora eruption in1815). However, effects of a sustained albedo modification by

> introduction of aerosol particles may differ substantially from effects of a brief volcanic eruption. (National Research Council 2015b: 6)

And:

> Other eruptions, such as Tambora in 1815, caused global climatic anomalies that led to widespread crop failure and famine. Overall, it is difficult to compare the injection of an aerosol plume from a single volcanic eruption to repeated aerosol injections that result in a more sustained albedo modification. (National Research Council 2015b: 143)

In these cases, following reference of human suffering resulting from volcanic eruptions changing albedo, the limitations of the analogy are emphasized.

In the NRC report, then, volcanic eruptions are treated as a useful analogy for discussing intended or positive outcomes of SAAM, yet the analogy's relevance is downplayed or dismissed in regard to some major risks. The potential for SAAM to mimic volcanic eruptions in achieving the intended outcome of reduced global temperatures is confidently communicated. In contrast, the potential for disastrous human consequences – namely global famine—is consistently linked to a caveat declaring the limitations of the analogy. Hence, the communication of the volcanic analogy is biased toward the potential positives, while downplaying the potential dangers.

A second recurrent comparison, that of inadvertent pollution, is also employed to the effect of normalizing the idea of albedo modification. Addressing concerns about deliberately introducing particulates into the atmosphere through stratospheric aerosol injection, the most elevated option of albedo modification, parallel is drawn between the pollution resulting from SAAM and inadvertent atmospheric pollution. What is unique to albedo modification compared to other forms of large-scale global pollution is its intentionality. This intentionality is a premise for critique, yet, society has become increasingly normalized to the everyday experience of pollution.

Discursively, by linking the intentional release of particulates into the atmosphere with the normalized experience of existing air pollution, there is potential for a subtle shift in the perception of albedo modification's risk or novelty. Indeed, this comparison is emphasized toward the purpose of normalizing the pollutant effect of albedo modification methods, particularly stratospheric sulfate injection. The NRC section on the technical analysis of SAAM begins as follows:

> Climate intervention using realistic strategies involves atmospheric injection of aerosols or aerosol precursors. Aerosols (solid or liquid particles suspended in the air) of natural and anthropogenic origin are found everywhere in the atmosphere. They affect the planet's energy budget by scattering and absorbing sunlight, and by changing cloud properties […] Humans have changed the amount of aerosols in the atmosphere through pollution emissions, and by changing natural aerosol sources through land and water use. (2015b: 54)

Thus, the discussion of SAAM is framed by the premise that aerosols, both "of natural and anthropogenic origin" are ubiquitous. From ubiquity, it is not a far shift to mundaneness. With this framing, the discourse is flipped, from SAAM as a novel global experiment to a discussion of a commonplace topic—aerosols—employed in a new manner. The result is the normalization of SAAM and changed dynamics in the discussion of risk and novelty.

Similarly emphasizing the ubiquity of sulfate aerosols, the Royal Society's report specifically overviewing stratospheric aerosol states:

> Sulphate aerosols are always found in the stratosphere. Low background concentrations arise due to transport from the troposphere of natural and anthropogenic sulphur-bearing compounds. Occasionally much higher concentrations arise from volcanic eruptions, resulting in a temporary cooling of the Earth system (Robock 2000), which disappears as the aerosol is flushed from the atmosphere. (Rasch *et al.* 2008: 4009)[6]

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[6] This was a review specific to proposed geoengineering with stratospheric sulphate aerosols published a year previous to the release of the Royal Society's "Geoengineering the Climate" report in *The Philosophical Transactions of the Royal Society A.*

This framing of relevant background information begins with the premise of ubiquity, with an implication of mundaneness, while simultaneously normalizing increased sulfate concentrations with the volcanic analogy in conjunction with the ubiquity framing.

In discussion of the environmental impacts of stratospheric sulfur injection, the NRC Committee states: “Introduction of stratospheric aerosols is likely to slightly increase the acidity of the snow and rain reaching the surface. The effect is estimated to be a very small fraction of the acidity increases associated with industrial pollution today. Thus, any important effects might be counteracted by controlling anthropogenic emissions within the troposphere” (2015b: 75). In this way, environmental impacts of the resultant pollution are minimized by comparing them to environmental harms already occurring as a result of human activity. Furthermore, it is suggested that the effects of increased pollution intentionally released by albedo modification could be counteracted by reducing unintentional forms of pollution. This is ironic since the impetus for pursuing albedo modification in the first place is society’s inability or unwillingness to adequately control inadvertent pollutions to date.

Analogy to a specific form of existing pollution— ship tracks— is used by the NRC Committee to explain and normalize the effects of another favored SRM technique, marine cloud brightening. The analogy of ship tracks functions similarly in the discursive and conceptual construction of marine cloud brightening (MCB) as does the analogy of volcanoes to SAAM. Scientific analysis of ship tracks has occurred for decades (e.g., Twomey 1977; Conover 1966) and, like the volcano comparison, ship tracks serve not just as a useful comparison in providing relevant data translatable to proposed MCB projects, but ship tracks research has influenced the very conceptualization of MCB.

Just as reports employ discursive framing that normalizes albedo modification concepts, similarly CDR techniques can be framed to emphasize their "naturalness." Earth's atmosphere is constantly cycling gas compounds through respiration, photosynthesis, geologic weathering and other natural processes. While CDR proposals model such processes, they differ in being human-engineered with intended outcomes that would redefine the state of balance between relevant natural phenomena.

The NRC report recurrently emphasizes the "naturalness" of CDR proposals by closely aligning them with natural processes. For example: "nature already performs 'CDR' by removing the equivalent of more than half of our emissions from the atmosphere each year" (2015a: 23). Here, CDR is in quotation marks, subtly marking that the analogous natural processes are distinct from the CDR of geoengineering, yet with phrasing that minimizes the distinction. Elsewhere, the Committee comments: "This existing uptake and removal of CO_2 from air, natural 'CDR', already moderates the impacts of human emissions on atmospheric CO_2 levels and global climate" (2015a: 25). In this way, the NRC report forges a discursive alignment between the CDR of geoengineering and the natural carbon cycle.

The NRC report continues the theme of emphasizing similarity to natural processes, which was established in the Royal Society report. The Royal Society summary, a critical place for framing concepts since policy makers and others may rely heavily or exclusively on it, emphasized natural processes upon which certain proposed geoengineering techniques are premised, or to which they might contribute, using the word "enhancement:"

> Enhancement of natural weathering processes to remove CO_2 from the atmosphere…
>
> The enhancement of oceanic uptake of CO_2, for example by fertilisation of the oceans with naturally scarce nutrients, or by increasing upwelling processes…

Enhancement of marine cloud reflectivity […]. (Royal Society 2009: x)

In these instances, the term "enhancement" emphasizes the similarity of these geoengineering proposals to natural processes, minimizing the novelty of the particular endeavors.

Likewise emphasizing the similarity of CDR proposals and natural processes, the NRC states:

> There are several CDR approaches that seek to amplify the rates of processes that are already occurring as part of the natural carbon cycle […] Actions that enhance the reduction of these natural emissions or that increase the natural CO_2 removal from air have the potential to lower atmospheric CO_2. These strategies are variously employed in land management practices, such as low-till agriculture, reforestation (the restoration of forest on recently deforested land), and afforestation (the restoration of forest on land that has been deforested for 50 years or more); ocean iron fertilization; and land- and ocean-based accelerated weathering. (2015a: 28)

Framing CDR as attempts to simply "amplify" and "enhance" natural processes, the NRC continues the discursive trend seen in the Royal Society report. In this selection, the Committee further emphasizes the "naturalness" of CDR by disproportionately including details about the least controversial approaches, namely responsible land management, while leaving the more controversial forms worded with vague technical language. Particularly, reforestation and afforestation are detailed as to what they involve, despite the fact that these terms are likely already more intuitive to a non-specialist audience. Contrastingly, ocean iron fertilization and accelerated weathering are listed without explanation, providing the non-specialist reader less information to make an assessment and requiring them rather to rely on the authors' indication of naturalness. While subsequent chapters of the report further explain these topics, upon the point of arguing their naturalness, they remain abstract.

Transparency, Multilateralism, and Public Participation

There is broad acknowledgement in Science and Technology Studies (STS) literature that public acceptance and consent beyond the community of experts is essential for the successful advancement of technological fields in democratic societies (e.g., Nowotny, Scott and Gibbons 2001; Wilsdon, Wynne and Stilgoe 2004; Stirling 2008; 2014; Healey 2014). Yet, a changing societal relationship to expertise, including the so-called “crisis in public confidence,” has led to “a new institutional body language for science, including consensus conferences, public participation exercises, science shops and, most notably, the language and rhetoric of transparency” (Brown and Michael 2002: 262). Moreover, as discussed in the introduction chapter, the process of interacting with the public regarding scientific and technical issues of social importance has changed over the years from the earlier “deficit hypothesis” of “public engagement” centered on scientists explaining concepts to the public with the assumption “that if only people knew more about a technology, they would come to see its benefits as outweighing its risks” thus reducing public opposition to technologies presumed to be based on lack of understanding and the currently favored “process of dialogue between scientists and the public” (Corner, Parkhill and Pidgeon 2011: 7).

Whether genuine two-way dialogue is established or not, science policy reports in regard to climate intervention and its research governance repeatedly emphasizes the importance of transparency, multilateralism and public participation in the process (e.g., National Research Council 2015b; Asilomar Scientific Organizing Committee 2010: :Royal Society, 2009 #378). These terms are problematic in being vague and subjective. It is unclear what criteria would be used for evaluating the success of these objectives. However, the act of repeatedly articulating them as requirements for ensuring a legitimate process toward climate intervention acts to claim that legitimacy through stated intent, while implying that there is some other illegitimate alternative process (presumably the oft-referenced although never reified unilateral deployment threat) from which the proposed research differs.

No doubt, the discussion of transparency, multilateralism and public participation is to some extent to be taken at face value, namely that these elements are important for "best practices" and ensuring motivations and outcomes that maximize utility and minimize harm. For instance, the NRC report states: "Given the perceived and real risks associated with some types of albedo modification research, open conversations about the governance of such research, beyond the more general research governance requirements, could encourage civil society engagement in the process of deciding the appropriateness of any research efforts undertaken" (National Research Council 2015b: 10, 153). Furthermore, the Committee indicates that "Ultimately, the goal is to ensure that the benefits of the research are realized to inform civil society decision making, the associated challenges are well understood, and risks are kept small"(National Research Council 2015b: 10, 153). This statement manages public perceptions by framing the concept of geoengineering going forward as a process which would be controlled by civil society. Furthermore, the major element of uncertainty that is emphasized when actually focusing on the science is minimized in this framing, which indicates "challenges" *can be* "well understood" and that "risks" *can be* "kept small."

However, the abstract notion of public participation, while aiding in discursive claims to legitimacy, does not necessarily translate into an engaged democratic process (e.g., Stirling 2008; Brown and Michael 2002; Corner, Parkhill and Pidgeon 2011; Felt and Fochler 2010). Rather, what we see instead is an attempt to use the concept of public participation in a more subversive sense. "Public participation" carries connotations of democratic engagement of society and the notion of citizen oversight. The way the term is used in geoengineering reports, however, signals an intent to utilize public participation strategically in order to placate the public in regard to the pursuit of climate engineering endeavors. Similarly, the terms multilateralism and transparency are employed frequently in a manner relevant to perception management.

Public perception is treated as a challenge to the pursuit of geoengineering. According to the Royal Society:

> Public attitudes towards geoengineering, and public engagement in the development of individual methods proposed, will have a critical bearing on its future. Perception of the risks involved, levels of trust in those undertaking research or implementation, and the transparency of actions, purposes and vested interests, will determine the political feasibility of geoengineering. (Royal Society 2009: xii, cf. 56, 59)

In regard to CDR approaches, the NRC Committee states: “Public perception of the safety and effectiveness of geological sequestration will likely be a challenge until more projects are underway with an established safety record” (National Research Council 2015a: 67). However, the importance of public perception is even greater in regard to albedo modification.

In relation to both multilateralism and public perception is the idea of international perception of national actions:

> Moreover, international attitudes towards deployment of albedo modification strategies would have important implications for how any deploying nation or group of people is perceived. Action with even the best intentions can be perceived negatively if those intentions are not clear, and based on demonstrably credible research that supports that such actions would be overwhelmingly positive for humanity. Thus understanding the factors that affect perceptions, and the factors that affect social response to the outcomes of albedo-modification need to be extensively studied in order to strengthen—or at least minimize—the damage to international relationships prior to, during, and post any potential deployment. (National Research Council 2015b: 136)

Perception here is treated as an important factor in communications related to climate engineering actions. Managing perception is acknowledged as a legitimate goal in communication as indicated by this explicit and reflective statement. Considerations of public perspective management is explicit where there is discussion of ways in which the scientific community involved in geoengineering might for instance emphasize multiple benefit research to “minimize fears” or transparency and involvement of private contractors (rather than military) to “promote international buy-in and help minimize conspiracy theories” (National Research Council 2015b: 150, 209).

Reference to the importance of “transparency” is common in these reports. For example in the NRC *Reflecting Sunlight* report, the terms “transparency” or “transparent” are used in 22 instances. Certainly, transparency is important when dealing with the pursuit or even research of geoengineering. There are two potential functions of transparency. The first is so the public can provide checks against the progress of something that affects them; the other is the opposite: using an emphasis on transparency to minimize public concern. Due to explicit and conscious concern regarding ameliorating public concern, there is a risk that the latter could overshadow the former function (cf. Felt and Fochler 2010; Stirling 2008: 264, 267; Corner, Parkhill and Pidgeon 2011: 24).

Comparing Reports

There is a common flow to the discourse of geoengineering policy reports. The ideal type can be summarized as: (1) climate change is a pressing challenge; (2) the preferred option of mitigation and long-term emissions control has not been successful to date; (3) anyway, at this point immediate cessation of emissions would not prevent some of the risks of climate change due to the latency problem; (4) due to the risks of climate change caused by continued and latent greenhouse gasses, and especially because of the possibility of a "climate emergency," geoengineering should be considered in addition to mitigation and adaptation; (5) there is a broad range of geoengineering schemes that have been proposed as potential options to address effects of climate change; (6) these options all incur risks and costs of varying degrees, some are extremely problematic although others could have potential despite risks, costs and unknowns; (7) among those options, here is an evaluation based on current research that elevates some and critiques others; (8) with the conclusion that more research should be pursued, especially on those methods distinguished as better than alternative options. The NRC report is representative of this ideal type, with other geoengineering-focused reports including these topics with some degree of variation.

Each one of these segments in the structuration of policy reports is related to discursive themes discussed within this chapter. Items 1-4 are core to the background and premise of the reports. Item 5 represents the presentation and framing of the "range of options" as discussed here. Item 6 offshoots from this "range of options" framing toward elevating and legitimizing some options relative to others through comparison and utilizing the decoy effect framing, while item 7 addresses internal evaluation and the further elevation (or relative dismissal) of proposals based not only on comparison, but also the level of academic interest in the topic to date. Item 8 directs the overall emphasis on advancing research toward a more narrowed focus resulting from the consideration of items 6-7. The outcome is an argument couched in an implicit sense of inevitability to the prospect of geoengineering, elevating certain options, and promoting the pursuit of the necessary research and development to achieve these options, despite abundant caveats regarding the risk and novelty of geoengineering as well as emphasizing that geoengineering cannot substitute for emissions reductions

All the scientific policy reports strongly urge caution regarding the risks, uncertainties, and dangers of climate engineering. The National Research Council and Royal Society reports are clear that risks, uncertainties, and environmental impacts make the potential deployment of climate engineering, especially albedo modification, a serious and complex decision. However, they recommend advancing research and development of the technologies in case they "should ever be needed," with the argument that research would allow for informed decision making and that any deployment should be based on the most rigorous scientific assessment possible.

The IPCC treatment of albedo modification is the most strongly reluctant regarding the pursuit of albedo modification. The 2014 IPCC report provides direct statements regarding the risks. They assert: "If it were deployed, SRM would entail numerous uncertainties, side effects, risks and shortcomings" and that "SRM technologies raise questions about costs, risks, governance, and ethical implications of development and deployment" (IPCC 2014: 102). Whereas the other reports considered arrive at the conclusion that research should be pursued despite these risks and challenges due to the potential of rapid cooling unique to albedo modification, the IPCC report takes a notably more reserved and caveat-infused position on this potential: "SRM is untested, and is not included in any of the mitigation scenarios, but, if realisable, could to some degree offset global temperature rise and some of its effects. It could possibly provide rapid cooling in comparison to CO_2 mitigation" (IPCC 2014: 102).

The 2009 Royal Society report and the 2015 National Research Council reports share many similarities of style and substance, but the time gap in publication as well as differences of structure and scope make for some notable differences. Both reports aim to summarize and explain the current state of the field, drawing upon existing research and relevant publications. Many of the same actors participated in writing and advising on these reports and many of the same primary sources are relied upon. As such, there was not a pronounced change in general recommendations over the course of the six-year gap in publication. Both reports argue that nothing can replace mitigation and that there is no silver bullet to climate change among geoengineering proposals. However, both also argue forcefully for the pursuit of geoengineering research. Both highlight the risks of geoengineering techniques and particularly caution that albedo modification techniques are not ripe for deployment. However, they both also envision scenarios in which geoengineering strategies may be deemed useful. Indicating that geoengineering is not a substitution for mitigation and adaptation, the Royal Society states that geoengineering "should only be considered as part of a wider package of options for addressing climate change" (2009: 58). Similarly, the NRC makes frequent reference to what they call a "portfolio of climate responses," which would include mitigation, adaptation, CDR, and possibly albedo modification techniques (e.g., National Research Council 2015b: ix, 2, 8, 11, 32, 33, 35-6, 144, 146, 154-5).

Within this "wider package" or "portfolio of responses," there are some differences in the conclusions of these reports separated by time. The NRC report directly advocates for the pursuit of CDR while The Royal Society report advocated for continued research but not necessarily pursuit. The Royal Society recommendation that geoengineering "should only be considered as part of a wider package of options for addressing climate change" is followed by the statement that "CDR methods should be regarded as preferable to SRM methods as a way to augment continuing mitigation action in the long term" (Royal Society 2009: 58). In this way, The Royal Society argues that CDR techniques are preferable to SRM, but does not quite make an argument for their immediate pursuit. By contrast, the NRC Committee argues that CDR technologies are an integral component of the "portfolio of climate responses." They assert: "Even if CDR technologies never scale up to the point where they could remove a substantial fraction of current carbon emissions at an economically acceptable price, and even if it took many decades to develop even a modest capability, CDR technologies still have an important role to play" (National Research Council 2015a: 87).

Another notable change between the Royal Society and other earlier reports and that of the NRC report is the reconsideration of terminology. As noted, the NRC Committee rejected the terms "geoengineering," "climate engineering," as well as "albedo enhancement" and "solar radiation management." They instead use the terms "climate intervention" and "albedo modification." As argued here, such changes have influence beyond semantics since the terminology is integral in issue framing, so terms implying beneficial outcomes (as in "enhancement" or "management") or indicating unsubstantiated levels of human control (as in "engineering" or "management") can contribute to a potentially misleading framing of these topics. The future of discourse on this topic remains to be seen, but it is likely that these changes of terminology will be broadly adopted into the scientific and policy discourse.

Discussion and Conclusion

Within fields of emerging or contested technologies, discursive representation is paramount to public and political reception. Scientists within such fields, including GM, nanotechnologies and geoengineering, have increasingly recognized the importance of "public consent" (Healey 2014). Discursive strategies can help to present the technology to the public in a more understandable and accessible manner. Moreover, conventionalized discursive strategies can legitimize, rationalize, and bolster public acquiescence and political support of a technological pursuit as was seen in the case of nuclear policy during the Cold War. In like manner, discursive strategies can construct a sense of legitimacy around the pursuit of geoengineering and bolster public acceptance of geoengineering research. This chapter identifies and examines discursive strategies recurrent in geoengineering science policy reports, which contribute to normalizing the novel, reframing risks, and constructing notions of legitimacy through the privileged "voice of science" (Mukerji 1990), especially a "univocal" voice emanating from a highly respected scientific institution that carefully curates its own projection of legitimacy (Hilgartner 2000). Analysis of the two most influential geoengineering policy reports, published six years apart, reveals the persistence and, in some instances, deepening of these discursive strategies over time.

The NRC report follows the precedent of the Royal Society by prefacing their report with the caveat that geoengineering is not a substitute for traditional mitigation efforts and then proceeding with the central message being the need for additional research on geoengineering methods, including those methods of which they caution against deployment. As discussed elsewhere, the drive for advancing knowledge is both cultural and material. Within the scientific profession, there is a professional culture shaped by the core of the professional process: inquiry, curiosity, and experimentation. There are also material interests that naturally affect both organizations and individual scientists within the field. Such material interests for individuals can be pecuniary, in the form of grants, research funds, and merit-based pay. Quite often these material interests intersect with status enhancement as well. So for individuals who work on research directly or tangentially related to geoengineering, there are clear interests in advancing the support of related research and development. The effect with organizations is very similar. Organizations like the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), as well as National Laboratories and research universities with investment in this field, have a clear interest in the advancement, and related funding support, that would come with governmental policy in support of research related to geoengineering.

For the sake of organizational survival and growth, for organizations like NASA and NOAA, any premise for continuing, expanding and developing a new generation of instruments for observational monitoring, climatic and oceanic data collection, etc. enhances organizational security while supporting organizational missions. The goal of promoting this research, for example in albedo modification, is underscored by the layered argument in which the advancement of this research is argued for (1) its own sake (in case we need it), (2) for defensive purposes (in case someone else pursues it), and (3) with the underlying argument that much of the research can be defined as "multiple benefit research" that has other benefits that may come from it even if society is not interested in albedo modification. Combining these different strategies to argue for the pursuit of advancing albedo modification highlights that the goal is the advancement of this research as opposed to any one of these individual strands of argumentation.

Despite acknowledging risks of "moral hazard" and "lock-in," the drive for advancing scientific knowledge and capability is the dominating theme of these reports. The promotion of research is consistent for both CDR and albedo modification, even as the authors display marked reservations regarding deployment of the latter. The overarching promotion of geoengineering research is undergirded by a multi-pronged construction of legitimacy through discursive strategies, including the relative legitimation of actors and approaches, differentiating research from deployment, elevating particular methods through comparative evaluation, and normalizing and naturalizing geoengineering proposals. Together, these discursive strategies, recurrent in two seminal geoengineering policy reports, contribute to constructing a sense of legitimacy for the pursuit of geoengineering.

First, by establishing a hierarchy of legitimacy, especially through constructing the rogue as an unidentified other, notions of risk are reoriented from *what* to *who* and *how*. Within a field defined by risk, this reconceptualization affects perceptions about geoengineering and its trajectory. The NRC report especially implicates a legitimacy hierarchy of actors and approaches. Emphasizing the potential of unilateral pursuit is used to argue for the necessary legitimate pursuit of albedo modification by the United States in cooperation with other international actors. Like the nuclear analogy, the convention of establishing a delineation between legitimate and illegitimate actors upholds the internal logic of domestic pursuit of the technology.

Second, furthering the sense of relative legitimacy, certain geoengineering proposals are treated as more credible than others, highlighted through evaluation by comparison. The implication that certain geoengineering proposals are superior to others reorients evaluation from considering inherent desirability versus non-action (cf. Bellamy 2013; Bellamy *et al.* 2012). Moreover, different relative rankings emerge depending on which assessment criteria are privileged, including conceptions of effectiveness, cost, safety, and timeliness (cf. Stilgoe 2015: 117; Bellamy 2013: 2). Both benchmark reports warn against and yet utilize evaluation by comparison. While STS analyses examining earlier reports and appraisals have noted and cautioned against the trend of narrow “internal comparisons between geoengineering options” (Bellamy 2013: 927; see also Bellamy *et al.* 2012; Stilgoe 2015: 117), the current research shows that the NRC report not only continues the trend but deepens it. Moreover, it is argued here that evaluation by comparison not only serves to elevate particular proposals, but rather promotes geoengineering more broadly by reorienting questions of risk and feasibility to relative rather than absolute terms, discursively transforming negative language of risks and challenges to positive language of relative advantages and potential.

Third, the differentiation of research and deployment further constructs a paradigm of legitimate pursuit. The NRC report has deepened the discursive distinction between research and deployment, moving from the Royal Society's conception of research as preliminary to possible deployment toward a proactive decoupling of the concepts. The decoupling of research and deployment can be compared to the discursive convention during the Cold War of emphasizing nuclear amassment for the sake of deterrence not war (Mehan, Nathanson and Skelly 1990). When this discursive convention was "breached" during the Reagan administration, it invoked a public backlash against longstanding nuclear policy (Mehan, Nathanson and Skelly 1990: 134). In the case of geoengineering, since the public is much more open to research than deployment (Corner *et al.* 2013: 941), discussion of albedo modification deployment rather than research would be expected to increase public opposition to the technology, creating potential obstacles for both research and deployment. Proceeding toward research on albedo modification (but not deployment "at this time") is put forth by the NRC report as a more credible path than that of seeking deployment, even as the research advocated is the same that would be necessary for deployment.

Fourth, normalizing and naturalizing climate modification approaches through analogy contributes toward legitimating geoengineering. Science policy reports acknowledge that completely novel planetary conditions would be experienced if various geoengineering schemes were deployed. However, through analogy to natural processes or mundane environmental pollution, these novel schemes are normalized. An earlier study by Corner *et al*. found that naturalizing geoengineering proposals dispelled concerns among the public and thus cautioned against future geoengineering publications "describing particular geoengineering technologies as 'natural', or using direct analogies with natural processes." They argue that "Given the importance that participants attributed to the naturalness of the different technologies described, there is a need to ensure that technologies are not associated with the positive notion of 'naturalness' by analogy if, in fact, they are highly artificial" (Corner, Parkhill and Pidgeon 2011: 26). Yet, as demonstrated in this analysis, the 2015 NRC report continues and expands upon this precedent of normalizing novel geoengineering schemes through recurrent analogy to natural processes and commonplace experiences.

Together, these discursive strategies construct a sense of legitimacy around the pursuit of geoengineering research, especially as encapsulated within the Royal Society and NRC reports, which represent the intersection of science and policy, the line between description and prescription, what "is" known and what "ought" to be done (Stilgoe 2015: 105). They influence the reception of geoengineering concepts among policy makers and the public with material repercussions as future decisions are made on addressing the climate crisis. For instance, advancements in research of geoengineering resulted directly from the Royal Society's 2009 report. The UK government invested in geoengineering research, as promoted by the report, including grants to technical research and experimentation, such as the SPICE project. The impacts of the 2015 NRC report are still unfolding. At the time of writing, the tumultuous political climate in the United States creates uncertainty regarding both governmental support of science research overall as well as near-term commitment to mitigation as "Plan A," leaving a void of uncertainty around geoengineering as "Plan B." However, as shown here, the 2015 NRC report builds upon discursive practices also used in the Royal Society report that promote the advancement of geoengineering through constructing notions of legitimacy around particular avenues of pursuit and the field more broadly. The entrenchment and deepening of these discursive strategies contributes both to legitimating and mainstreaming the field of geoengineering.

Science is not insulated from broader social relations and does not operate autonomously from relations of governance, politics and public life (e.g., Nowotny, Scott and Gibbons 2001). Beyond acknowledging the importance of public acceptance of technological endeavors, STS scholars have emphasized the need for meaningful public deliberation and engagement with new technologies that go beyond instrumental dialogue in order to democratize technological decision making (e.g., Stirling 2014; Stirling 2008; Corner, Parkhill and Pidgeon 2011; Corner *et al.* 2013; Bellamy *et al.* 2013; Bellamy 2013; Fischer 2017; Brown and Michael 2002; Nowotny, Scott and Gibbons 2001). Geoengineering represents such a massive intervention in the Earth system that the need for democratic awareness and debate is at least as pressing as for any other emerging technology, while also particularly problematic (Szerszynski *et al.* 2013). Rob Bellamy argues that "different instrumental framings can serve to 'close down' on certain geoengineering proposals" and that "Geoengineering assessments should instead seek to 'open up' option and policy choice" (2013: 2; cf. Stirling 2008). In light of the subsequent 2015 NRC report, the present analysis demonstrates that this point remains relevant. While the reports themselves acknowledge the need for transparency, deliberation and debate, the most influential geoengineering science policy reports employ discursive strategies that establish prior control over the terms and boundaries of deliberation. This analysis of geoengineering policy reports especially illustrates how strategic discursive representation can promote the legitimization of climate engineering research.

Chapter Two, in part, includes material as it appears in “Constructing Legitimacy in Geoengineering Discourse: The Politics of Representation in Science Policy Literature.” 2018. *Science as* Culture. Forthcoming. Jacobson, Brynna. The dissertation author was the sole investigator and author of this paper.

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CHAPTER 3 — Geoengineering Presented to the Public: News Media, 1991 - 2016

Introduction

Geoengineering conceptions exist and are shaped and reshaped within the realm of "socio-technical imaginaries," the "collectively held and performed visions of desirable futures […] animated by shared understandings of forms of social life and social order attainable through and supportive of, advances in science and technology" (Jasanoff 2015: 19; cf. Bellamy *et al.* 2012; Stilgoe 2015: 7-10; Stilgoe 2016; Healey 2014; Markusson 2013: 4; Corner *et al.* 2013). While science policy reports represent the translation of geoengineering imaginaries into language assessable to political decision makers, news media bring these concepts to a broad audience (cf. Markusson 2013: 4). Opinions differ on how and to what extent the news media influence public opinion, but it is generally understood to have a role in encouraging consideration of presented topics or "agenda setting" (e.g., Cohen 1963; McCombs and Shaw 1972; McCombs 2014). Whether or not readers agree with the positions raised in a newspaper or magazine article, the act of reading engages them with the topic and introduces new topics to their purview. The press "may not be successful much of the time in telling people what to think, but it is stunningly successful in telling its readers what to think *about*" (Cohen 1963: 13; see also McCombs and Shaw 1972: 177).

Other scholarship suggests that media influence does, in fact, extend much deeper than bringing public awareness to a topic. While not necessarily "telling people what to think," discursive framing of a topic can guide how it is thought about. Within the realm of nascent technologies, imbued with ideas new to readers, the presentation and framing of their introduction may have significant effects on how these ideas are considered and thought about going forward. Consideration of “framing recognizes the ability of a text—or a media presentation—to define a situation, to define the issues, and to set the terms of a debate” (Tankard 2001). “To frame is to *select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation*. Typically frames diagnose, evaluate, and prescribe” (Entman 1993: 52, emphasis in original). In this way, media can shape public consideration through enumerating and framing the legitimate options available. In the case of climate change and geoengineering proposals as possible responses to it, framing can shape public discourse through defining the problem, presenting the scope of available options to address the problem, and differentiating these options as more or less legitimate areas of pursuit. Various discursive trends, strategies and conventions contribute to this presentation and filtering of possible actions. These include conceptual framing such as what analogies and metaphors are employed, substantive elements like who is quoted for expert explanation, and the scope of climate abatement or geoengineering proposals enumerated in describing the options available

Examining the presentation of geoengineering in news media is informative for understanding how it is presented to the public and, as a result, how the imaginary of geoengineering may manifest itself within the public’s conceptualization. The public can be expected to draw from news media to inform their perspectives on novel emergent technologies such as geoengineering, even as fundamental values and worldviews of individuals may shape their reading and interpretation. Presentation within news media includes a relaying of scientific rhetoric and discursive framings that originated within the scientific community, such as the statements of scientists or science policy reports, including those discussed in the previous chapter. In addition, based on broader journalistic structural and stylistic trends, news media also insert their own framings and presentation styles that affect how the concepts are portrayed. Both these elements affect how geoengineering is presented to the public. Since geoengineering currently exists mainly in the realm of imaginaries, which are articulated and shared (and in the process, reinforced or reshaped through their representation) through discursive portrayal (Stilgoe 2015: 7-10; Markusson 2013: 4), the link from media to the public is a necessary one for their manifestation within the public mind. Public acceptance or rejection of geoengineering proposals may influence whether they will transform from imaginaries into fully deployed realities.

Although the genre of news media is not the only manifestation of public discourse, it is a primary one that can introduce novel concepts and provide a proxy measure of public attention to such issues. News media articles collected online are examined here to understand the content, extent and fluctuation of geoengineering discussion in public discourse over time. Analysis of news media provides insights into the substance of that discourse, including how it is presented by experts called upon to inform the journalists' accounts and how the journalists frame the ideas for the broader public. As discussed, geoengineering as a concept requires translation from the models and imaginaries of scientists to the understanding of policy makers or the general public. Science policy reports, as examined in the previous chapter, are one crucial genre in this process of translation and presentation. Published articles by science reporters, journalists, and editorialists are another crucial step.

It is primarily through news media that the concepts of geoengineering, and various viewpoints in respect to it, are presented to the public. News media consolidate and package the current state of scientific discourse, including ideas, advancements and opinions. Even among the subset of the general public most interested in the topic, few will ever read the geoengineering reports by the Royal Society or the National Academy of Sciences, but they may read *The Guardian* or *The New York Times* science editors' articles discussing them or quoting the expert informants. As such, news media serve as a communication bridge between experts and the public. From there, social media and social interaction may internalize the concepts to recirculate and reformulate through peer-to-peer engagement. Public discourse at this level, in the case of a nascent field like geoengineering, however, is dependent upon initial introduction, which can generally be expected to occur through general audience media.

Moreover, news media also contribute to the process of constructing legitimacy as introduced in the previous chapter. This occurs both through relaying notions of legitimacy expressed from within the field and also through their own treatment of the topic resting on the legitimacy of the publishing source. For instance, as will be discussed, news media convey a narrative regarding the mainstreaming of geoengineering. The role of a prestigious publication like *The New York Times* indicating geoengineering's move to mainstream in essence contributes to its move toward mainstream. In selecting which scientific voices and narratives are brought from within the field and broadcasted to a public audience, news media contribute to reinforcing certain notions of legitimacy over others.

This chapter contributes toward a better understanding of the public discourse on geoengineering and its trajectory. Analysis to date on geoengineering's presentation in news media has been limited. An exception is an article by Matti Luokkanen, Suvi Huttunen and Mikael Hildén (2014), which analyzes metaphors used in relation to geoengineering as presented in *The New York Times* and *The Guardian* from 2006-2011. Their focus was specifically on metaphors as was that of Nerlich and Jaspal's (2012) study of trade literature.

While Luokkanen *et al*. (2014) considered geoengineering in news media, their study was limited to the two newspapers within a narrow time span. The present analysis expands the study of geoengineering discourse to a broader public domain encapsulated in the universe of English-language print news media through 2016. Drawing upon this expanded corpus of news media, it also opens up the discourse analysis to consider additional discursive trends (beyond metaphors), framing mechanisms, and substantive questions such as the sources of expertise called upon in discussing the subject.

Luokkanen *et al*. aptly assert that "as an object of public debate geoengineering is still in an early stage. It is therefore of interest to explore how it enters public knowledge and how it is presented to this audience" (2014: 967). As discussed in the previous chapter, the nature of geoengineering as an emergent technology makes the discourse around it especially pertinent both in terms of how it is presented by experts to others and how it is presented to the public. Similarly, Luokkanen *et al*. point out:

> For a wider public audience these complex issues are new (Ipsos-MORI, 2010; Mercer et al., 2011). Because of this novelty, the terminology and conceptualization are important in influencing the basic understanding of the issue. The novelty of concepts, proposed actions and the possibilities that are inherent in the techniques, are relevant factors for a media study. (2014: 967)

This observation remains relevant and motivates the current study, which expands upon and deepens the examination of geoengineering in general audience publications.

Method

The focus of this qualitative analysis is on articles from English-language mainstream news sources, based in the United States and United Kingdom. In their study, Luokkanen *et al*. selected *The New York Times* and *The Guardian* for their "extensive coverage" of geoengineering and also because "they are elite newspapers influencing other media and public debates" (Luokkanen, Huttunen and Hildén 2014: 969). For these same reasons, these two newspapers are also well represented in the corpus of the present research.[7] However, this research was structured to include a broader range of news sources, both print and online, that present mainstream journalistic reporting and analytical editorials.

Google News was searched for articles from any news source using relevant terms, geoengineering, geo-engineering, climate engineering. Search was repeated numerous times over the research period. Also during this period, other relevant articles brought to attention were included. Additionally, specific news sources were searched using their own search systems to maximize the number of relevant articles under consideration. These specific news sites were chosen from respected mainstream news sources that represented a spectrum of science-specific and general audience reporting. They included *The New York Times*, *The Scientific American*, *The Guardian*, *The Economist*, and *Newsweek Magazine*.

[7] *The Guardian* was consistently the highest producer of geoengineering related articles from 2008-2016, at least among the broad range of newspapers included in the LexisNexis search engine.

Table 3.1: Distribution of news sources for articles analyzed within corpus

News Source	# Articles
The New York Times	18
Newsweek	13
Slate	8
The Guardian	7
Washington Post	5
The Economist	4
Scientific American	4
Associated Press	2
BBC	2
Inverse	2
Live Science	2
Marketplace	2
Nature	2
The Atlantic	2
The San Jose Mercury News	1
The New Yorker	1
National Geographic	1
CNN	1
Other Print magazines (i.e., The Nation, New Scientist)	2
Other online news sites (i.e., Ars Technica, Grist, Climate Wire, Weather Channel, GreenBiz)	6
University news sites (i.e., Berkeley News, Brown Political Review, Yale Environment 360)	4
Other sources, combined	5
N=94	

Articles substantially relevant to geoengineering were reviewed carefully through close reading. The qualitative coding software, Nvivo, was used to demarcate and track relevant themes, subjects, actors, and linguistic or discursive practices throughout the corpus. In total, 94 unique geoengineering-focused articles were reviewed and analyzed. (See Table 3.1 for a listing of the news sources from which articles analyzed within the corpus originated.) An additional 25 articles focusing on climate change or related topics were also reviewed to add perspective on relevant themes and framing practices. Articles from all dates through 2016 were considered. The majority of articles were published between 2006-2016, with one outlier from 1991. This distribution reflects the publication trends on the topic, which began to garner public attention in 2006 with a significant increase starting in 2009, as will be discussed. The search process did not guarantee inclusion of all relevant articles, however no articles relevant to the topic were excluded, such that the resulting corpus of articles is meant to be extensive, inclusive and representative, although certainly not exhaustive, of the universe of possible geoengineering articles in mainstream news reporting.

To complement this qualitative analysis and further show trends over time, a LexisNexis search was also created and used to track the total number of geoengineering-related news articles per year in the broad array of English-language international newspapers included in the LexisNexis news database. For this purpose, a list of search terms was developed and refined to maximize relevant results with minimal false positives.[8] This research stage allowed for a discussion of the quantitative presence of news media articles on geoengineering. The purpose of this component of the research is primarily to show change over time, so the exact numbers are not the key takeaway, but rather repeating the search for each year for all English language news articles discussing geoengineering in the LexisNexis database allows for a useful representation of the presence of geoengineering discussion within the genre. This approach also facilitated examination of other trends such as who is most cited

[8] Search terms, of which variations were tested and the list optimized to maximize relevant results and minimize false positive results, were: Climate OR warming AND geoengineer! OR geo-engineer! OR climate engineer! OR solar radiation management OR albedo enhancement OR albedo modification OR carbon dioxide removal AND NOT Senergy OR Seismic.

throughout this extensive array of English-language news, complementing the qualitative analysis that considers these issues in depth.[9]

Shifting Sentiment and Move to Mainstream

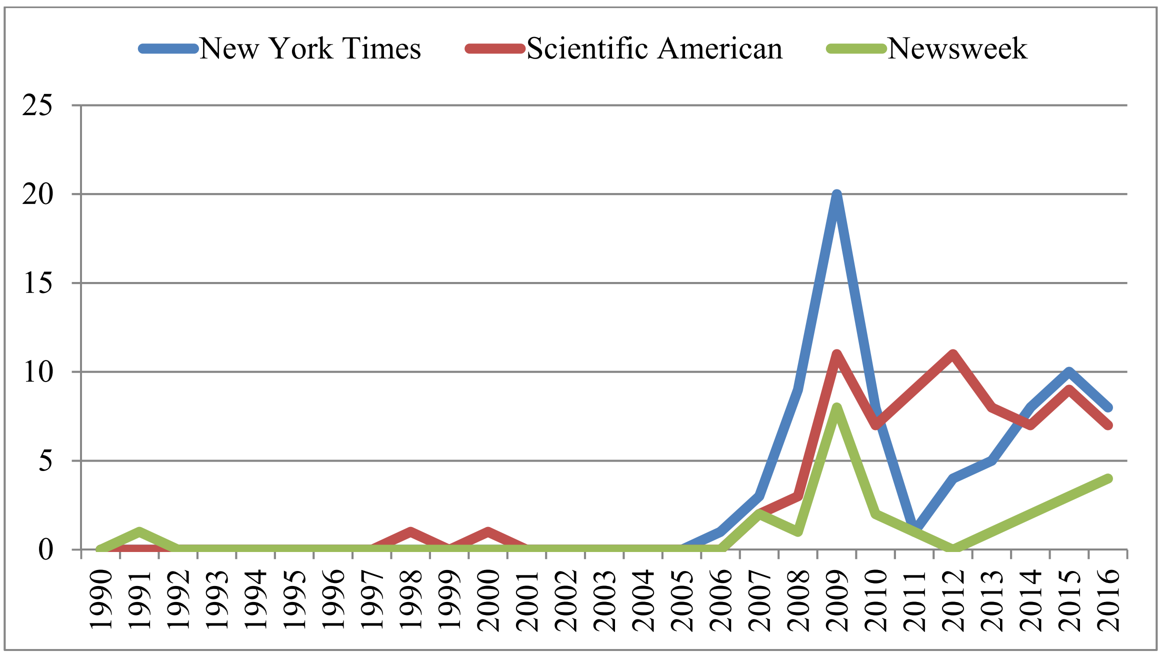
Geoengineering emerged as a theme in popular media in the mid-2000s, with 2009 marking a significant shift in its increased attention. Using *The New York Times* as an example, this mainstream newspaper's first article on geoengineering was published in 2006, followed by three articles in 2007 (in addition to at least three op-eds or letters to the editor), nine articles in 2008, 20 in 2009, eight in 2010, one in 2011, four in 2012, five in 2013, eight in 2014, ten in 2015, and eight in 2016 (see Graph 3.1).[10] For *The New York Times*, geoengineering articles clearly spiked in 2009. Similarly, the weekly news magazine *Newsweek*, published a single article on geoengineering in 1991 and then turned to the subject again starting in 2007 with two articles, followed by one in 2008, and with a spike of eight in 2009 before returning to four or less for subsequent years through 2016. Looking at a non-specialist audience publication focused on science, the *Scientific American* discussed proposals that fit with the Carbon Dioxide Removal (CDR) geoengineering category in individual articles in 1998 and 2000, then

[9] The qualitative analysis was the primary methodology and guided the complementary quantitative component, which served to confirm that the trends seen within the qualitatively analyzed corpus of geoengineering-focused articles were consistent with the broader universe of English-language newspaper articles that discuss geoengineering. For example, for each of the individuals cited to or discussed regularly within the studied corpus, a LexisNexis search was conducted to track their presence in the much broader selection of news articles in the database.

[10] These figures are based on searching for "geoengineering" on the individual publications' websites and then qualitatively assessing which articles include relevant discussion of geoengineering as the term relates to the present topic.

in 2007 two *Scientific American* articles discussed geoengineering, three articles focused on geoengineering in 2008, eleven in 2009, seven in 2010, nine in 2011, eleven in 2012, eight in 2013, seven in 2014, nine in 2015 and seven in 2016. For the *Scientific American*, 2009 also represented the first dramatic rise in attention to geoengineering, with attention in this publication remaining fairly sustained subsequent years. (See Graph 3.1 for a visual representation of these data.)

Graph 3.1: News articles substantially discussing geoengineering for three periodicals by year

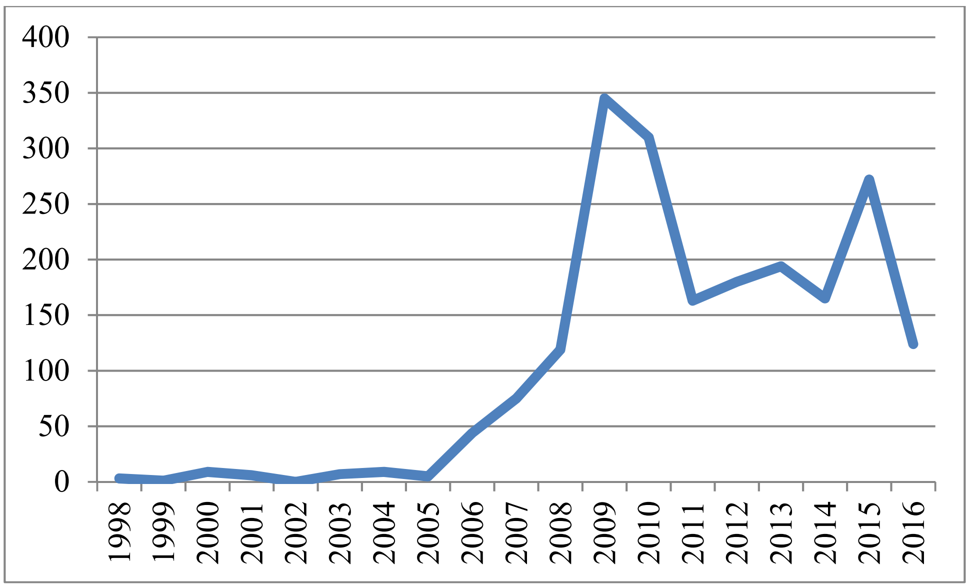


A similar pattern can be seen in international aggregate news sources. To capture this, Graph 3.2 shows by year the total English-language newspaper articles that reference geoengineering from all news sources within the LexisNexis database.[11] Again, the year 2009 shows a dramatic peak with 345 newspaper articles referencing geoengineering. There is a

[11] Data based on searching the LexisNexis database by year with a search list optimized to capture relevant articles while minimizing false positives. The figures are based on the resulting search results, refined to newspapers only and controlled for high similarity.

secondary peak in 2015 with 272 relevant articles. These two years that show spikes in media attention to geoengineering correspond with the publication of important document within the field, respectively of the 2009 UK Royal Society report on geoengineering and the 2015 publication by the US National Research Council of the National Academy of Sciences.

Graph 3.2: Combined English-language newspaper articles that discuss geoengineering by year, from the LexisNexis database



In terms of the geoengineering field itself, there are certain core publications that have influenced, legitimated, and shone light on the discourse of geoengineering. The three most pivotal are a 2006 article by Nobel laureate Paul Crutzen encouraging consideration of albedo modification, the 2009 Royal Society Report, and the 2015 National Research Council (NRC) report. These publications have influenced the public discourse on geoengineering and the number of news articles by year reflect the release of these seminal documents. Attention to geoengineering within news media began to increase in 2006, coinciding with the publication of Crutzen's seminal article, the significance of which will be discussed in detail below. News coverage of geoengineering peaks in 2009, which is also the publication year for the Royal Society report, and experiences another spike in 2015, the year of the NRC report (see Graph

3.2). As discussed in the previous chapter, these two reports have been the preeminent benchmark science policy reports related to geoengineering and their treatment of the subject has contributed to increasing a sense of legitimacy and mainstreaming of geoengineering, which is also reflected in related news media discourse as will be discussed.

Within popular media, 2009 represents both a spike in the attention given to geoengineering as reflected in the number of geoengineering articles and also the transition point of perceiving geoengineering's move from the fringe toward the mainstream. Looking at use of the word itself, "fringe" appears explicitly within the corpus of articles in the years of 2009 and 2010. In 2009 "fringe" is still used in the present tense and in 2010 usage is split between present and past tense. For example, David Victor *et al*. write in 2009 that "Geoengineering continues to be considered a fringe topic" (Victor *et al.* 2009). Relatedly a *New York Times* article attributes to David Victor the perspective that geoengineering "needs to be brought in from the mad-scientist fringe" (Lohr 2009). In March of 2010, *The Economist* writes that "Modern climate scientists […] usually see geoengineering research as niche, if not fringe, stuff" (2010b). However, by December of 2010, "fringe" becomes a past tense descriptor as stated by an Associated Press journalist reporting from the Cancun climate talks: "Just a few years ago, geoengineering was regarded as a fringe idea, a science-fiction playground for imaginative scientists and engineers" (Hanley 2010).

By contrast, in the years after 2010, the term "fringe" largely disappears from the discourse. It is entirely absent from the corpus of news articles reviewed here from 2011 forward. From this point forward, a common theme in popular media literature is the shifting sentiment surrounding geoengineering, particularly its move toward mainstream consideration. This discursive trend includes three elements which may be integrated or stand alone: (1)

emphasizing geoengineering's move from the fringes of science toward mainstream consideration, (2) pointing to certain scientific publications of esteemed individuals, especially Paul Crutzen, or scientific societies, especially the Royal Society and the NRC, as indication of the move toward mainstream, and (3) connecting the increasingly mainstream consideration of geoengineering to the increasingly notable effects of climate change and the problematic state of mitigation efforts.

General audience articles on geoengineering often include these multiple elements of discussing the shift toward mainstream consideration. For example, this selection from a 2014 article in *The New York Times* encapsulates the three themes considered here:

> Once considered the stuff of wild-eyed fantasies, such ideas for countering climate change — known as geoengineering solutions, because they intentionally manipulate nature — are now being discussed seriously by scientists. The National Academy of Sciences is expected to issue a report on geoengineering later this year.
>
> That does not mean that such measures, which are considered controversial across the political spectrum, are likely to be adopted anytime soon. But the effects of climate change may become so severe that geoengineering solutions could attract even more serious consideration. (Fountain 2014)

The first sentence of this quotation emphasizes the perception of the fringe origins of geoengineering with the evocative phrase "Once considered the stuff of wild-eyed fantasies" and how such markedly offbeat origins have shifted now to "being discussed seriously by scientists" (Fountain 2014). The unmodified word "scientists" implies legitimate and mainstream scientists, unless otherwise indicated by descriptors. The word 'scientists' is a carrier of legitimacy especially due to its position in the sentence in contrast and opposition to "wild-eyed fantasies." The legitimacy of the consideration by scientists is further emphasized by reference to the report underway at the time by the respected and undeniably scientific mainstream National Academy of Sciences. Finally, the author states that, despite the controversy over such methods, "the effects of climate change may become so severe that geoengineering solutions could attract even more serious consideration" implicitly recognizing the insufficiency of mitigation efforts to date, which sets the premise for mainstream consideration of geoengineering (Fountain 2014). These three themes encapsulate the sense of shifting sentiment on geoengineering as portrayed in general audience publications and will be considered individually below.

(1) Articulating fringe origins and the move toward mainstream

Consistently from 2010 through 2016, popular media articles on geoengineering emphasize its move from the fringes of science toward the mainstream. According to a 2010 article addressing the emergence of geoengineering as a potential consideration at the Cancun international climate talks: "'The taboo is broken,' Paul Crutzen, a Nobel Prize-winning atmospheric scientist, told The Associated Press. Whatever the doubts, 'we are amazingly farther up the road on geoengineering,' Crutzen, who wrote a 2006 scientific article that sparked interest in geoengineering, said" (Hanley 2010). The notion that there once was a "taboo" regarding the open discussion of geoengineering, which has subsequently been broken, is a recurring theme in popular discourse on geoengineering, reflecting a perspective articulated among geoengineering advocates. As will be discussed in greater detail, the article cited in the quotation above, written by Nobel laureate chemist Paul Crutzen and published in the journal *Climate Change*, is consistently identified as a critical factor in breaking the "taboo" on open discussion of geoengineering. As such, it has become a core element in the dominant narrative around the progression of geoengineering, which is conveyed and reinforced within news media.

Similar to the idea of a taboo that has been removed, is the theme of fringe science versus mainstream science, and the significant shift of geoengineering from the former to the latter category in both practice and perception. In an article examining a scientist's advocacy for using olivine, a mineral that absorbs carbon dioxide, as a form of CDR, the geochemist is quoted as saying: "When I started, I was a nutty professor," Dr. Schuiling said. But when he gives a talk nowadays, "the first question after I finish is, 'Why don't we do it?'" (Fountain 2014). In this instance, there is clear indication of a shift in perception among his audience, as the individual professor experienced different reactions to his consistent message on his CDR proposal, which transitioned from a response of dismissal to one of serious consideration.

The perspective presented in news media that geoengineering has shifted to mainstream consideration reflects the sources interviewed by newspapers. One reporter cites David Victor as saying: "Most analysts who examined the options closely had concluded that it would be reckless to mess with the planet. […] That is changing" (cited in Fischer 2009). The taboo narrative as well as the related, although somewhat contradictory, fringe-to-mainstream narrative have become entrenched in geoengineering discourse.[12] Geoengineering advocates have variously promoted both narratives.

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[12] While the fringe origins of geoengineering has been a prevalent narrative within geoengineering discourse, its premise is dependent upon where the starting point in the timeline of geoengineering's intellectual history is set. As discussed in the introduction chapter, the origins of the concept of geoengineering in response to climate change go back to the 1965 Report of the Environmental Pollution Panel of the President's Science Advisory Committee. Again the concept surfaces in the 1993 NRC report, as will be discussed in this chapter. This presumably leaves the period of time from the 1993 NRC report through 2006 when the "taboo" was "broken" by Crutzen's article as the dark ages for geoengineering. The fringe origins narrative is seemingly dependent then on setting the origins of consideration in this period. Furthermore, although they serve similar purposes in emphasizing the move to mainstream, there is some contradiction between the fringe narrative and the taboo narrative. The taboo narrative implies that mainstream scientists were silenced in regard to

As the "taboo" has lifted since 2006, experts and proponents have emerged willing to discuss geoengineering. Frequent interviewees include core members of the geoengineering community. Science journalist Eli Kintisch in his book *Hack the Planet* (2010: 8) coined the term "Geoclique," which subsequently Clive Hamilton expanded upon in his book *Earthmasters* to refer to the "constituency for geoengineering […] developing around a network of individuals with personal, institutional and financial links" (Hamilton 2013a). Hamilton specifies: "At the centre of the network is a pair of North American scientists actively engaged in geoengineering research –David Keith and Ken Caldeira" who "have been dominant voices in virtually every inquiry into or report on geoengineering" (Hamilton 2013a). The present research reaffirms that Keith and Caldeira continue to be "dominant voices" and not only within the geoengineering community but as the voices communicating it to the public through citation in news reports and editorials.[13]

David Keith in particular is disproportionately cited compared to other experts within the field. For at least ten years, Keith was consistently the most cited scientist, by far, within public discourse in regard to geoengineering. Within the sample of articles studied here that are substantially focused on geoengineering, 28% cite to David Keith (see Table 3.2). Over 5.4% of articles with any reference to geoengineering cite to David Keith in the years 2007-2016 (see Table 3.3). The next most cited individual, Ken Caldeira, is cited in 16% of the sample and 4%

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geoengineering, while the fringe narrative obfuscates the relationship of mainstream scientists with geoengineering until the point at which it is considered to have moved mainstream.

[13] Keith and Caldeira are also among the expert witnesses called upon to testify before Congress on the topic of geoengineering, as will be discussed in the next chapter. Tangentially, it is an interesting twist upon their concept of the "geoclique" that both Eli Kintisch and Clive Hamilton themselves are now among some of the individuals most cited in geoengineering public discourse (see Table 3.2).

of the broader 10-year period sample from LexisNexis. For comparison, the chair of the National Academy of Sciences / National Research Council Committee on Geoengineering, Marcia McNutt, garnered reference in 5.4% of the sampled articles and 0.8% of articles referencing geoengineering within the ten-year period in the LexisNexis database. (Incidentally, Marcia McNutt is the most frequently cited woman in the field, followed by Jane Long formerly of Lawrence Livermore National Laboratory, who receives references in 0.4% of the articles within the ten-year period).

Table 3.2: Most frequently cited or referenced individuals in geoengineering-focused articles

Person	**# articles referencing**	**% articles referencing**
David Keith	26	27.7%
Ken Caldeira	15	16.0%
Alan Robock	11	11.7%
Paul Crutzen	11	11.7%
Oliver Morton	8	8.5%
Raymond Pierrehumbert	8	8.5%
Clive Hamilton	7	7.4%
John Latham	7	7.4%
David Victor	6	6.4%
Jane Long	5	5.3%
Marcia McNutt	5	5.3%
Edward Teller	5	5.3%
Hugh Hunt	4	4.3%
Eli Kintisch	4	4.3%
Stephen Salter	4	4.3%
Victor Smetacek	3	3.2%
Note: Based on Sample of articles focused specifically on geoengineering. N=94		

Among the frequently cited individuals, Bjørn Lomborg stands out in the fourth position behind David Keith, Ken Caldeira and Paul Crutzen in Table 3.3, showing percentage of articles citing to these individuals among those discussing geoengineering in the LexisNexis database. Lomborg proclaimed himself “The Skeptical Environmentalist,” with his 2001 book of this title. He has been a controversial figure in relation to climate change as he has gone against the grain of overwhelming consensus on the need to pursue mitigation to address anthropogenic climate change. He is known as a global warming skeptic (Weisenthal 2009), acknowledging existence of anthropogenic climate change but downplaying its risks and urgency to act. For example, he openly campaigned against the Kyoto Protocol (Dasgupta 2007). In terms of geoengineering, Lomborg is emblematic of climate skeptic turned geoengineering advocate. This category also includes organizations such as American right-wing think tanks like The American Enterprise Institute, The Climate Response Fund and the Climate Institute (Sikka 2012: 163-4). Lomborg also stands out as the most cited non-scientist on the list, which is particularly striking given what a controversial figure he is. (See Table 3 for demarcation by category of which of the frequently cited individuals are scientists, engineers, or social scientists.) As will be discussed further, controversy is a recurrent theme emphasized by news media and inclusion of controversial figures contribute to this.

Table 3.3 includes three columns of values, two five-year periods and the aggregate ten-year period of 2007-2016. This differentiation gives a sense of which individuals remain consistently influential in news media over the ten-year period and those whose voices in public discourse increased or decreased during this time. For instance, David Keith is consistently prominent. He is the most cited individual in connection to geoengineering within public discourse in the last ten years by any measure. By contrast, Marcia McNutt had no public exposure as measured by newspaper citations from 2007 through 2011, but later (in 2015) came to be cited relatively frequently due to her role as chair of the NRC Committee responsible for the pivotal 2015 geoengineering report. Other individuals such as Bjørn

Lomborg, Stephen Salter, John Latham and Hugh Hunt received fewer citations in 2012-2016 relative to their representation in public discourse the previous five years.

Table 3.3: Most frequently cited or referenced individuals in articles discussing geoengineering, 2007-2016 and 2012-2016 compared, and total 2007-2016

	2007-2011	**2012-2016**	**2007-2016**
David Keith*	5.2%	5.7%	5.4%
Ken Caldeira*	4.7%	3.2%	4.0%
Paul Crutzen*	4.9%	1.9%	3.5%
Bjørn Lomborg^	4.4%	2.2%	3.4%
Alan Robock*	1.8%	2.5%	2.1%
Clive Hamilton^	0.5%	3.0%	1.7%
Stephen Salter**	2.8%	0.4%	1.6%
John Latham*	1.9%	0.6%	1.3%
Marcia McNutt*	0.0%	1.7%	0.8%
Raymond Pierrehumbert*	0.3%	1.3%	0.8%
Hugh Hunt**	1.2%	0.1%	0.7%
Eli Kintisch^	0.7%	0.5%	0.6%
Victor Smetacek*	0.7%	0.5%	0.6%
David Victor^	0.8%	0.2%	0.5%
Jane Long**	0.3%	0.5%	0.4%

Note: Based on Sample of articles referencing geoengineering from LexisNexis database (controlled for high similarity), 2007-2011 (N=1,012), 2012-2016 (N=935), and 2007-2016 (N=1,947)
*= Scientist (e.g., climatologist, physicist, atmospheric scientist)
**= Engineer
^ = Social scientist (e.g., political scientist, ethicist, journalist)

(2) Using scientific publications as indication of move to mainstream

Geoengineering was included as one possible consideration in the National Research Council (NRC) 1993 publication "Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base." This inclusion did not garner much attention compared to the subsequent publications focused on geoengineering. However, at the time, science journalist Sharon Begley honed in on the significance of the NRC's treatment of geoengineering, foreshadowing many themes that would be seen more than two decades later when the NRC reexamined geoengineering in its extensive 2015 report on the subject. After emphasizing the "zaniness that has kept [geoengineering proposals] out of the scientific mainstream" she points to the inclusion of geoengineering in what was the forthcoming 1993 NRC report as indication of its move toward the scientific center:

> But now these schemes may be ready for their day in the sun. In a soon-to-be-released report, the National Research Council (NRC)--the operating arm of the prestigious National Academy of Sciences--endorses further study of geoengineering, granting the field a legitimacy it has so far lacked. Although the panel does not support even pilot programs, it calls geoengineering "technically feasible in terms of cooling effects and costs" and says it has "the potential to affect greenhouse warming on a substantial scale." (Begley 1991)

As it turned out, the schemes were not quite yet "ready for their day in the sun" and after the 1993 publication, there was a significant gap during which geoengineering did not receive mainstream scientific attention. In fact, it is often said that geoengineering became a taboo subject during this time period as not to interfere with the scientific community's emphasis on emissions abatement in response to climate change. This changed in the early 2000s. Publications from esteemed scientists, such as Paul Crutzen's seminal 2006 article breaking the "taboo" on advocating pursuit of albedo modification, and reports from esteemed scientific organizations, notably the Royal Society's 2009 report and the NRC's 2015 report, have served as indication of geoengineering's move to the mainstream as interpreted by popular media. These publications have significantly influenced the trajectory and discourse of geoengineering both within the relevant scientific communities and also externally, bridging the technical fields and public discourse around them.

In the *Scientific American*, Douglas Fischer explains the significance of Crutzen's article breaking the taboo on openly discussing to possibility of albedo modification:

> For years […] it was taboo [to discuss geoengineering] on the fear that, if climate control was seen as a viable option, pressure on world leaders to reduce

> emissions might ease […] That changed in 2006 with the publication of a seminal essay in the journal *Climatic Change* by Nobel laureate Paul Crutzen, emeritus professor at the Institute for Marine and Atmospheric Systems at Utrecht University in the Netherlands. (Fischer 2009)

Crutzen's article was groundbreaking as an open endorsement of geoengineering pursuit by a prominent scientist, notably a Nobel laureate with all the legitimacy that title entails, in a mainstream scientific journal that had previously, like others of its ilk, steered clear of geoengineering. As reported in a contemporaneous *New York Times* article, the publication of Crutzen's piece was not taken lightly, but rather imbued with controversy, characterized as a "bitter dispute" (Broad 2006). After significant negotiation, Crutzen's paper was ultimately published as part of a "compromise" in which a number of commentaries on the topic of geoengineering, from multiple perspectives, were included in the same issue presumably to provide a balance of perspectives and offset the impacts of Crutzen's argument (Broad 2006).

Despite this compromise, it is clearly Crutzen's piece that has had the most lasting influence in subsequent years on geoengineering discourse within relevant scientific communities and among the public. It is frequently referenced as a critical point in breaking the "taboo" on geoengineering. For example, a book review of contemporary publications on geoengineering credits Crutzen for the turning point in geoengineering consideration: "In 2006, depressed by the lack of progress on emissions, Paul Crutzen, an atmospheric researcher, broke a long-standing taboo among climate scientists by publicly pointing out that if humans have the power to heat the planet, then they also have the power to cool it down again" (*The Economist* staff 2013). A *Slate* article on the who's who of geoengineering describes Paul Crutzen as follows: "Crutzen, a Nobel Prize-winning atmospheric chemist, helped legitimize scientific conversations about geoengineering with his 2006 paper about seeding the atmosphere with sulfur to reflect sunlight back into space" (Brogan 2016). These examples, as well as the

Fischer (2009) citation above, credit the Crutzen article with breaking the "taboo" on mainstream geoengineering discussion and notably point to its role in legitimizing the field.

More than simply breaking the taboo, Crutzen's article marks an important transition point in the legitimacy of the field. It paved the way for other mainstream publications on geoengineering and influenced the subsequent publication of scientific reports that have added a new layer of perceived legitimacy to the field of geoengineering. In the introduction chapter to the National Research Council (NRC) report, the most extensive scientific report on geoengineering to date, the sub-section entitled "Motivation for researching albedo modification" explicitly cites to Crutzen's article in its explanation, stating: "Crutzen (2006) raised the question of whether humanity might want to develop the capability to intentionally modifying Earth's albedo to a greater degree and offset a larger amount of forcing" (National Research Council 2015b: 31).

Subsequent to Crutzen's 2006 article, the Royal Society's 2009 *Geoengineering the Climate* report and the NRC 2015 *Climate Intervention* two-volume report have both marked significant advances in the attention to and perceived legitimacy of geoengineering as a concept. The very existence of these reports, *irrespective of content*, has contributed to a sense of increased legitimacy for the field of geoengineering as can be seen in journalistic accounts. Before the National Academy report was even published, its pending publication was referenced as evidence of geoengineering's move toward mainstream. Joel Achenbach writes in *The Washington Post* the week before the report's release: "That an institution as lofty as the National Academy of Sciences would take seriously an idea as dramatic as geoengineering is a sign of how little progress has been achieved in efforts to mitigate climate change" (Achenbach 2015). In earlier anticipation of the report's release, *The New York Times* article by Henry

Fountain, previously quoted, indicates that there has been a clear and dramatic move from the fringe – ("stuff of wild-eyed fantasies") to the mainstream ("now being discussed seriously by scientists") with the evidence of seriousness and legitimacy clenched simply with the fact that the National Academy of Sciences has taken on the issue for review (Fountain 2014).

An editorial examining geoengineering in *The Guardian* states: "It's tempting too to dismiss ideas like pumping sulphate particles into the atmosphere or making clouds whiter as some sort of surrealist science fiction. But beyond the curiosity lies actions being countenanced and discussed by some of the world's leading scientific institutions" (Readfearn 2014). This article includes a subsection entitled "Geoengineering on the table" (Readfearn 2014). Among the facts given to support the notion that geoengineering is now being taken seriously (in other words, "on the table"), the author points to the Royal Society's report, the IPCC 2014 report that addresses geoengineering, and the National Academies report, which was forthcoming at the time:

> The Royal Society – the world's oldest scientific institution – released a report in 2009, also reviewing various geoengineering technologies. […]
>
> The latest major United Nations Intergovernmental Panel on Climate Change also addressed the geoengineering issue in several chapters of its latest report. […]
>
> Towards the end of this year, the US National Academy of Sciences will be publishing a major report on the "technical feasibility" of some geoengineering techniques. (Readfearn 2014)

While this editorial takes a critical approach on geoengineering, the role of these organizations in considering it is used as evidence of the seriousness of the field. The inherent prestige and credibility of these institutions is taken *prima facie* to show that the mere consideration and discussion of the topic as a serious strategy among these organizations indicates that geoengineering has shifted to mainstream consideration and is now "on the table" (Readfearn 2014).

As discussed in the introduction chapter, what climate solutions are even considered as options "on the table" has been a significant factor in climate politics to date. Steven Lukes (2005) theorized that power can be understood as three dimensional: the power to achieve a desired outcome, the power to include or exclude an option from consideration, and the power to exclude an option even from consciousness. In terms of climate change politics, the second dimension of power, "confining the scope of decision-making to only those issues that do not seriously challenge their subjective interests," has been employed by the American conservative movement to the effect of obstructing meaningful climate mitigation policy (McCright and Dunlap 2010: 106; see also Lukes 2005). Geoengineering being ascribed as now "on the table" is a new development in these climate politics. It is signaled by the scientific community in statements and especially through science policy reports as indicated by the quoted selection above. The notion that geoengineering is now an option within the scope of consideration is also reinforced through public discourse as seen in the case of news media. Of course, the serious consideration of geoengineering within the mainstream scientific community is inextricably intertwined with the context of climactic trends and perpetually challenged mitigation politics. As will be discussed presently, this comes through in news media.

<u>(3) Emphasizing failure of mitigation to explain geoengineering's move toward mainstream</u>

A prevalent framing in news media articles about geoengineering, especially within editorials, is emphasizing the poor state of mitigation efforts to explain geoengineering's move toward mainstream. An op-ed in *The New York Times* by Joe Nocera (2015) is a clear example of this framing, which involves a flow of three steps: (1) emissions controls are identified as the best answer to confronting climate change, (2) their failure to date is acknowledged, and so (3) it is argued that geoengineering must be considered. In Nocera's editorial it went like this:

> What's the best way to reduce the chances of climate change wreaking havoc on Earth? […] The most obvious answer — one we've known for years now — is to reduce the amount of carbon dioxide we're pumping into the atmosphere. […] Despite this knowledge, however, few policies have been put in place to spur any of that. […] So maybe we need to start thinking about coming at the climate-change problem from a different direction. Instead of hoping that humans will start reducing their carbon use, maybe it's time to at least consider using technology to keep climate change at bay. (Nocera 2015)

The imperative of geoengineering is framed as a direct result of failed or insufficient mitigation efforts.

The framing is sometimes more concise. Brad Plumer writes for *The Washington Post*: "Many of the world's nations show few signs of cutting their greenhouse gas emissions anytime soon. That's why, in recent years, more and more climate scientists have been pondering the concept of 'geoengineering' as a way to slow the pace of global warming" (Plumer 2014). Here, the problem is identified as emissions and the failure of cutting emissions is used to explain the shift toward mainstream scientific consideration of geoengineering.

A 2009 article published in *Scientific American* opens with the premise that insufficient mitigation efforts have opened the door to geoengineering proposals, stating: "Failure to make difficult choices to cut greenhouse gas emissions exposes humanity to an increasingly dire set of climate scenarios. But there is a way to buy time: Geoengineering" (Fischer 2009). The author then discusses the controversial nature of geoengineering and the range of geoengineering options, all of which "have major drawbacks" (Fischer 2009). The article concludes nonetheless that, despite the controversy and drawbacks, "the concept is gaining more traction as politicians, confronted with the ugly reality of trying to wean economies off fossil fuels, cast about for a strategy that will work if climate changes quickly or in nasty ways" (Fischer 2009). Fischer quotes David Victor in saying that "Most analysts who examined the options closely had concluded that it would be reckless to mess with the planet […] That is changing." This changing sentiment on considering geoengineering is explained as having transitioned from being characterized as recklessness due to risks of moral hazard threatening abatement efforts to the point of mainstream consideration largely due to the emerging consequences of climate change in the face of insufficient mitigation efforts. As Fischer asserts:

> It's changing, in large part, because the chances of any sort of international agreement on radical emissions cuts are plummeting even as scientists find evidence that these emissions have the potential to destabilize the Earth's climate to a degree unforeseen in human history.
>
> If those predictions come true, scientists fear any hand-wringing over the consequences of planet-wide mitigation will pale in comparison to the inconsolable pleas of populations facing rising seas, searing dust storms and savage famines, scientists warn. (Fischer 2009)

The implication is that, despite the taboo on geoengineering, insufficient mitigation efforts have paved the way for geoengineering proposals to garner more serious attention.

Drawing upon influential voices in geoengineering discourse, Michael Specter demonstrates the logic used by research advocates in propelling geoengineering progress. He quotes David Keith as saying: "There will be no easy victories, but at some point we are going to have to take the facts seriously" (Keith quoted in Specter 2012). Citing Crutzen, Specter goes on to explain:

> Although the I.P.C.C., along with scores of other scientific bodies, has declared that the warming of the earth is unequivocal, few countries have demonstrated the political will required to act […] With each passing year, goals become exponentially harder to reach, and global reductions along the lines suggested by the I.P.C.C. seem more like a "pious wish," to use the words of the Dutch chemist Paul Crutzen. (Specter 2012)

To clinch the argument, he then turns to Lord Rees:

> "Most nations now recognize the need to shift to a low-carbon economy, and nothing should divert us from the main priority of reducing global greenhouse gas emissions," Lord Rees of Ludlow wrote in his 2009 forward to a highly influential report on geoengineering released by the Royal Society, Britain's national academy of sciences. "But if such reductions achieve too little, too late, there will surely be pressure to consider a 'plan B'—to seek ways to counteract climatic effects of green-house gas emissions." (Specter 2012)

Again, the implication of this course of argument is that geoengineering must be taken seriously as an option to address climate change as a direct result of mitigation not being taken seriously by policy makers.

Discussion of geoengineering at the 2010 Cancun climate talks marked an important moment in the mainstreaming of geoengineering discourse. Reporting from the talks, one journalist states: "Like the warming atmosphere above, a once-taboo idea hangs over the slow, frustrating U.N. talks to curb climate change: the idea to tinker with the atmosphere or the planet itself, pollute the skies to ward off the sun, fill the oceans with gas-eating plankton, do whatever it takes" (Hanley 2010). This observation couples the increasingly notable effects of climate change with the newfound openness to broach geoengineering as a serious option rather than focusing climate negotiations solely on abatement.

The taboo narrative is premised on two concerns regarding consideration of geoengineering: the moral hazard concerns that pursuit of geoengineering may reduce greenhouse gas abatement efforts, as discussed in the introduction chapter, and the direct risks and potential for incalculable ecological harm that could result from geoengineering deployment. Sharon Begley, who has written a number of articles on geoengineering for *Newsweek*, showcases the point that geoengineering is increasingly considered *despite its serious risks*. In one article, she draws upon a publication entitled "20 Reasons Why

Geoengineering May Be a Bad Idea" published in the *Bulletin of the Atomic Scientists* by Alan Robock, a wary geoengineering researcher often quoted for expert commentary (see Tables 3.2 and 3.3):

> After decades spent studying volcanoes, Alan Robock can list 20 reasons why humans should not try to play God with the world's climate by [deploying albedo modification with stratospheric sulfuric aerosols, which […] might counter the global warming caused by carbon dioxide and other greenhouse gases […] But that's not all sulfates do […]
>
> The particles also deplete the planet's ozone layer, which is just starting to repair itself now that ozone-shredding chemicals are banned. They cause acid rain, too. And by cooling large land masses like Asia and Africa, the heat-reflecting particles reduce the temperature difference between them and the already-cooler oceans, which could stifle the monsoons that millions of people depend on for agriculture. Because the particles block direct sunlight more than diffuse rays, they also alter the balance of radiation reaching Earth's surface, with unknown consequences for plants that can be kind of finicky about the kind of sunlight they need.
>
> And yet […] In a sign of how dangerous global warming is starting to look and of how pitiful the world's efforts to control greenhouse gases are, even Robock—list and all—hedges his bets. Geo-engineering, allows the Rutgers University meteorologist, "might be held in reserve for an emergency." (Begley 2007)

This lengthy quote paints a stark contrast between the serious risks associated with Stratospheric Aerosol Albedo Modification and the fact that even some of the scientists most aware of these risks, and deeply concerned about them, still see plan B pursuit as necessary. The Plan B in-case-of-climatic-emergency framing of geoengineering is a central strand of narrative throughout geoengineering discourse, including in scientific publications, science-policy reports and statements, as well as popular media (cf. Bellamy 2013: 1; Bellamy *et al.* 2012: 605, 609; Nerlich and Jaspal 2012: 142; Corner, Parkhill and Pidgeon 2011: 13; Corner *et al.* 2013: 945). The narrative is premised on the idea that there is some critical (although currently undefined) tipping point at which the dangers of climate change may be determined to outweigh the dangers of geoengineering. Begley's juxtaposition of the dangers of geoengineering enumerated by Robock paired with his reluctant position that it may prove necessary anyway highlights the seriousness of unmitigated climate change by showcasing the extreme risks of geoengineering solutions being considered to address it.

After the Paris international climate summit in 2015, considered to be the most successful summit to date, geoengineering again emerged within popular discourse as a potential outcome of that summit, which officially only focused on mitigation as have all other UN climate talks to date. An editorial by a legal scholar asserts that the Paris accord "establishes an aspiration goal of holding climate change to 1.5°C, with a firmer goal of holding the global temperature decrease 'well below' 2°C. As a practical matter, the 1.5°C goal almost certainly would require geoengineering, such as injecting aerosols into the stratosphere or solar mirrors" (Farber 2015). Similarly, an article in *Slate* points to pursuit of geoengineering as an underlying risk to post-Paris climate dynamics, despite the lofty emission goals set and the absence of geoengineering from the official discourse of the summit: "The historic agreement forged in Paris among 195 countries in December holds the promise of triggering a global shift to combat climate change—and harbors a hidden warning" in regard to the possibility of geoengineering (Venkataraman 2016). The author asserts that while "the Paris accord is a triumph of diplomacy", its "success in heading off the worst climate disruptions hinges on whether countries fulfill the pledges each made leading up to the Paris talks and make bolder ones this decade" (Venkataraman 2016). However:

> The United States faces strong internal pressure to keep burning fossil fuels, reflected in our divisive politics; other nations—especially island nations like Tuvalu and Kiribati—face strong pressure to keep the planet cooler at any cost. The seas are already rising. The mood is ripe for private-sector companies or individual nations to seek drastic ways to change the climate, either to avoid the cuts agreed to in Paris or to hedge their bets in case of political failure. Yet absent from the Paris agreement and absent from U.S. political discourse is any robust discussion of what could be a growing threat, especially after the

> November presidential election: that countries, people, or businesses will take it upon themselves to directly cool the planet. (Venkataraman 2016)

This line of speculation culminates with the simple factual statement: "Experiments in geoengineering have already been tried" (Venkataraman 2016). Given the material manifestations of climate change and differing national interests, the indication is that unilateral geoengineering is an underlying risk should the spirit of Paris fall short of realizing bold abatement efforts. This editorial expressing concern regarding the possibility of geoengineering adopts a form of the climate emergency narrative, premising the risk of geoengineering, especially done unilaterally (another prevalent theme in geoengineering discourse as discussed in the previous chapter), on the failure of the global community to adopt sufficient carbon abatement measures leading individual entities to subjectively determine that the emergency or catastrophe threshold has been reached such as to justify geoengineering deployment.

Even with the relative success of the Paris Summit, its contextual position as one in a long line of historically failed agreement efforts provides an opening arguments to advance geoengineering due to failure of achieving meaningful mitigation policy.

> As negotiators at the climate talks underway here spar over what to do about adding more CO_2 to the air, geoengineering becomes more and more attractive to those with this tinkerer's bent […]
>
> The incredibly slow progress in combating climate change worldwide—the Paris talks are the 21st attempt to reach international agreements in the past 25 years—raises the appeal of the seemingly quick fix of seeding the sky. I remember attending a panel on geoengineering with Morton back in the heady days before the 2009 United Nations Climate Change Conference negotiations in Copenhagen. As Morton and his fellow panelists pointed out, with little hope to cut pollution, artificial volcanoes or a fleet of aircraft spewing out sulfur might prove not just enticing but necessary. (Biello 2015)

The tone and flow of narrative in this selection is illustrative of a theme within public discourse on geoengineering that indicates a sense of inevitability arising from the failure of mitigation negotiations. The public or political acceptance of inevitability, of course, can have material effects in the trajectory of the field. An entrenched sense of inevitability is akin to the social psychology concept of a "self-fulfilling prophecy" that "itself produces the requisite conditions for the occurrence of the expected event" (Watzlawick 2011 [1984]: 393).

As discussed in this section, public discourse around geoengineering has included a narrative emphasizing a move toward mainstream from the realm of so-called fringe science in conjunction with a lifting of a taboo within mainstream science. The move toward mainstream, however, does not come without controversy. As will be discussed in the following section, the discursive theme of emphasizing controversy arises with the theme of geoengineering's mainstreaming. Once geoengineering is treated as a mainstream consideration within popular discourse, a space is opened up for portraying the competing notions of legitimacy between and among advocates and critics.

Focus on Controversy

In contrast to science policy reports, as discussed in the previous chapter, popular media presentations on geoengineering often highlight controversy. This is not surprising, given that controversy provides for an engaging literary effect to interest readers. Furthermore, as customary in journalism, there is a tendency to present two sides of a story. For geoengineering, that means there is a presentation of controversy between proponents and critics both within and beyond the scientific community. To illustrate the common theme of controversy in regard to geoengineering, Table 4 contains a representative selection of passages from various articles that put explicit emphasis on controversy regarding geoengineering. As displayed in these numerous quotations, the words "controversy" or "controversial" are consistently used to describe the field of geoengineering and specific geoengineering proposals in both American and British media.

Table 3.4: Emphasizing controversy: Exemplary quotations and news sources

Quotation	**Source**
"Few issues arouse as much controversy in environmental circles these days as geoengineering 'technical fixes' to tackle climate change, by sucking carbon dioxide from the air or by reducing the amount of sunlight hitting the Earth." (Black 2012b)	*BBC News*, Science & Environment section
"The field of implementing technical climate fixes, or geo-engineering, is full of controversy, and even those involved in researching the issue see it as a last ditch option, a lot less desirable than constraining greenhouse gas emissions […] Adding to the controversy is that some of the techniques proposed could do more harm than good." (Black 2012a)	*BBC News*, Science & Environment section
"[…] such ideas for countering climate change […] are now being discussed seriously by scientists […] That does not mean that such measures, which are considered controversial across the political spectrum, are likely to be adopted anytime soon." (Fountain 2014)	*The New York Times*, Environment section
"Engineering the planet's weather and climate is a highly controversial idea." (Coghlan 2014)	*New Scientist*
"Some are arguing the best way to address climate change is to use the controversial practice of geoengineering." (Goodman 2013)	*Democracy Now!* Transcript of interview with Clive Hamilton
"What all of these schemes have in common, however, is controversy." (Pappas 2013)	*LiveScience*, Tech section
"Hacking the planet's climate through geoengineering, though controversial and 'an utter political nightmare', would buy time to develop cleaner sources of energy, the astronomer royal Lord Rees will say in a speech to the annual British Science Festival." (Jha 2013)	*The Guardian*, Science section
"The second option, called solar radiation management, is far more controversial." (Fountain 2015)	*The New York Times*, Science section

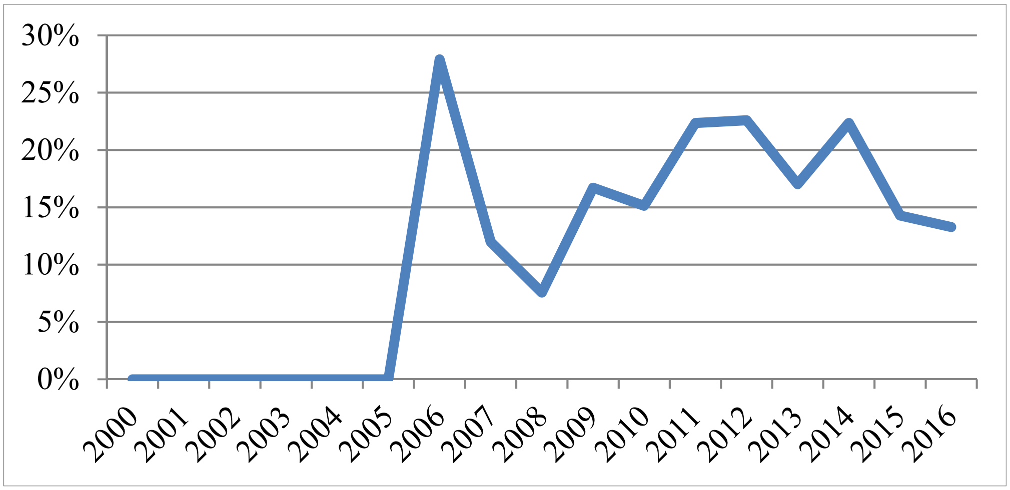
Table 3.4: Emphasizing controversy: Exemplary quotations and news sources (continued)

Quotation	**Source**
"Scientists are so concerned about global warming that they're now calling for tests to find ways to cool the planet – the first step toward exploration of a highly controversial field that sounds like science fiction." (Krieger 2015)	*San Jose Mercury*, Environment & Science section
"Here's a word guaranteed to start an argument among scientists and environmental activists: geoengineering. The word covers a variety of hypothetical technological fixes for the problem of climate change." (Achenbach 2015)	*The Washington Post*, Health & Science section
"To say that geo-engineering is controversial is an understatement." (*The Economist* staff 2013)	*The Economist*, Books & Arts section, book review of *Earthmasters* by Clive Hamilton and *A Case for Climate Engineering* by David Keith
"Like genetic engineering was in the 1970s, the very idea of geoengineering is controversial." (*The Economist* staff 2010b)	*The Economist*, Science & Technology section
"Climate engineering evokes very disparate and strong reactions." (Long 2015)	*Nature*, book review of *The Planet Remade* by Oliver Morton (review by geoengineering researcher Jane Long)

As discussed in the previous section, one of the narratives common around geoengineering is its fringe origins and subsequent move toward mainstream. As seen in these examples (Table 3.4), which are clustered largely around 2012-2015, the explicit highlighting of "controversy" arises within the studied corpus after "fringe" has become a past-tense descriptor, in a sense taking its place in the storyline of interpersonal intrigue. This suggests that controversy becomes a core component of the geoengineering narrative only after it becomes sufficiently mainstream to warrant contention between competing notions of legitimacy.

However, to better understand when the theme of “controversy” entered the public narrative in news reports on geoengineering, the LexisNexis search engine was again used to compare the analyzed corpus with a wider selection of English-language news. Among articles discussing geoengineering in the LexisNexis database, from 1995 through 2005, none used the words “controversy” or “controversial.” This changed with a dramatic spike to 26% of geoengineering-relevant articles in the database using one of these terms in 2006. From 2007 through 2016, 16% of articles with any discussion of geoengineering in the LexisNexis database use a form of the word controversy, with some variation by year (see Graph 3.3). This indicates that “controversy” became a common theme within public discourse on geoengineering starting in 2006, the year of Paul Crutzen’s influential article, which has been ascribed as breaking the “taboo” on discussing geoengineering and driving the concept into mainstream consideration. Moreover, the spike from 0% to 26% suggests the concept did not enter the discourse gradually, but arose suddenly as a new discursive theme that became quickly established.

Graph 3.3: Percentage of news articles discussing geoengineering that mention controversy, by year (based on English-language news articles included in LexisNexis database)



Once controversy becomes part of the common narrative, it is taken for granted and spoken of in bold and absolute terms. As seen in the examples in Table 3.4, controversy is spoken of as an essential component of the technology: geoengineering "is" controversial (as opposed to being "considered" controversial or any other mitigating terminology). Furthermore, not only is this controversy essential, but extreme, as demonstrated by these and other quotes in Table 3.4: "Few issues arouse as much controversy" as geoengineering (Black 2012b); "To say that geo-engineering is controversial is an understatement" (*The Economist* staff 2013).

Once controversy is established as a discursive theme, there are various ways to go about detailing it, particularly in terms of framing the sides of the debate. To say there are only two sides of the geoengineering debate would be a gross simplification. A better conceptualization would be a spectrum of viewpoints ranging from strong advocates of geoengineering technologies through strong critics. The middle range of the spectrum would include a broad variety of positions including CDR advocates opposed to albedo modification, research proponents reluctant about deployment, and those with ambiguous positions due to concern that the technology is dangerous paired with concern that it may nonetheless be necessary. However, within news media, a two-sided debate is often implied through referencing proponents and critics in a point-counterpoint style. Depending on the vantage point of the writer, and this is stronger in editorial-style articles than news-style articles, the "sides" of the debate might be characterized very differently.

In setting up the sides of the debate, an interesting word choice is used by some journalists to describe opponents of geoengineering. While the term "skeptics" in relation of climate issues has a longstanding meaning of those who dismiss or attempt to problematize science regarding climate change, within geoengineering discourse the term has been appropriated to refer to those concerned about the prospects of geoengineering. This usage means that geoengineering "skeptics" quite often include environmentalists who believe in, and are very concerned about, climate change. Contrastingly, as will discussed further, some of the strongest advocates for geoengineering are erstwhile climate skeptics (see Hamilton 2013c).

Presenting Geoengineering as a Mitigation Alternative

Tangentially related to the emphasis on controversy as well as the trend of presenting "two sides" of a debate on geoengineering is the theme of mischaracterizing geoengineering as an alternative to mitigation. Despite frequent reiteration from the scientific community, including proponents, that geoengineering is perhaps a supplement or a stop-gap but not an alternative to reducing emissions, this subtlety is often lost in the presentation of geoengineering through popular media.

Science policy reports, as discussed in the previous chapter, as well as scientist advocates of geoengineering are explicit that geoengineering, particularly albedo modification, is not an alternative to emissions abatement. Rather, geoengineering is commonly presented by experts in three manners: (1) a supplement to mitigation, (2) a stop-gap measure to buy time for sufficient emissions reductions to be instated and become effective, especially in light of relevant latency issues, and/or (3) a Plan B in the case of climate emergency due to insufficient mitigation. The importance of emissions abatement is consistently and clearly emphasized.

For example, the National Academies report states at the outset: "There is no substitute for dramatic reductions in the emissions of CO_2 and other greenhouse gases to mitigate the negative consequences of climate change, and concurrently to reduce ocean acidification" (National Research Council 2015a: 2). The Committee's "Recommendation 1" is: "Efforts to address climate change should continue to focus most heavily on mitigating greenhouse gas emissions in combination with adapting to the impacts of climate change because these approaches do not present poorly defined and poorly quantified risks and are at a greater state of technological readiness" (National Research Council 2015a: 3). In the context of albedo modification, it is emphasized: "The less CO_2 that humans release to the atmosphere, the lower the environmental risk from the associated climate change and the lower the risk from any albedo modification that might be deployed as part of the strategy for addressing climate change. It is widely recognized that the possibility of intervening in climate by albedo modification does not reduce the importance of efforts to reduce CO_2 emissions" (National Research Council 2015b: 36). Elsewhere: "albedo modification is no substitute for mitigation. Hence, in order to avoid serious longer-term problems, any future decision to embark on aerosol injection should be paired with efforts to mitigate greenhouse gas emissions, remove carbon dioxide from the atmosphere, or both" (National Research Council 2015b: 145). Similarly, the Royal Society report explicates: "Geoengineering methods are not a substitute for climate change mitigation, and should only be considered as part of a wider package of options for addressing climate change" (Royal Society 2009: 58). Both of these key geoengineering science policy reports clearly point to geoengineering as a potential supplement to mitigation and not a replacement or alternative to mitigation.

Among scientist advocates, the message tends to be the same. David Keith is one of the most vociferous and oft-quoted proponents of geoengineering from within the expert scientific community (see Tables 3.2 and 3.3). He unabashedly advocates for consideration of solar geoengineering, and not just as a Plan B like many frame it, but rather he asserts: "Early use of solar geoengineering" should be considered to save certain ecosystems and slow carbon cycle feedbacks (Keith 2016). Despite being a strong proponent of albedo modification, Keith clearly states that "it is not a substitute for cutting emissions—it is a supplement" (Keith 2016). What he advocates is "A combination of cutting emissions and solar geoengineering" to stave off dramatic effects of climate change (Keith 2016).

Other scientist proponents of albedo modification make similar caveats. For example, space scientist Russell Bewick, who has researched possible strategies of space-based geoengineering, is quoted in a *LiveScience* article as stating: "I would like to make it clear that I would never suggest geoengineering in place of reducing our carbon emissions" (Choi 2012). Bewick goes on to specify his take on the temporal dynamic in regard to a particular space-based albedo modification scheme: "We can buy time to find a lasting solution to combat Earth's climate change. The dust cloud is not a permanent cure, but it could offset the effects of climate change for a given time to allow slow-acting measures like carbon capture to take effect" (in Choi 2012).

Advocates from other disciplines also specify their position that geoengineering is not a substitute for addressing emissions. Oliver Morton, a journalist who has extensively covered geoengineering and written a book on the subject, argues on its behalf as a serious climate solution, but he also clarifies, as quoted here: "I do not in any way see geoengineering as an alternative to a program of emissions reduction" (Morton 2015). Martin Bunzl, a philosopher engaged with geoengineering, also frames it as a strategy that would be taken in conjunction with emissions abatement: "We have to decarbonize. We can decarbonize with the option to geoengineer, or we can decarbonize without the option" (in Fischer 2009).

In these ways, Keith, Bewick, Morton and Bunzl represent a particular strand of temporal treatment regarding the consideration of geoengineering: "early use" to prevent certain ecological effects of climate change (Keith 2016) and to "buy time" (Choi 2012; Fischer 2009; cf. Morton 2015) to "decarbonize the economy" (Fischer 2009). Another common narrative strand treats solar geoengineering as a plan B on reserve "in case needed." Geoengineering researcher Hugh Hunt's perspective fits with this emergency scenario strand of the narrative: "You'd only consider doing it if it was a real emergency and there was no other solution […] But I do worry we're getting close to that situation" (in Pappas 2013). Both of these temporally disparate arguments in favor of pursuing albedo modification have in common the caveat that geoengineering does not replace the need for mitigation.

One of the reasons that discussion of geoengineering is often, and has historically, been minimized in climate discourse is the same reason that experts on the topic so frequently reemphasize that geoengineering would constitute a supplement rather than an alternative to mitigation: concerns of moral hazard. As mentioned in the introduction chapter, moral hazard is "a term derived from insurance, and arises where a newly-insured party is more inclined to undertake risky behaviour than previously because compensation is available" (Royal Society 2009: 37). In the case of geoengineering, the concern is that a strategy that seems to present an alternative to mitigation would reduce the tenuous political and social motivation to address the emissions which are the cause of climate change. However, beyond concern of minimizing this risk of moral hazard, as presented in the range of examples above, among mainstream experts on geoengineering there is by and large consensus that geoengineering, especially albedo modification, independent of emissions abatement, would not be advisable or desirable even if feasible. In the words of the NRC report: "The Committee considers it to be irrational and irresponsible to implement sustained albedo modification without also pursuing emissions mitigation, carbon dioxide removal, or both" (National Research Council 2015b: 147).

Despite the insistence of scientists with expertise in the field that geoengineering would be a supplement, a stop-gap, or a Plan B to mitigation, writers addressing geoengineering in popular media at times miss this point and can contribute to the false understanding that geoengineering may present an alternative to emissions abatement. For example, an article in *The Economist* states: "Geoengineering is an umbrella term for large-scale actions intended to combat the climate-changing effects of greenhouse-gas emissions without actually curbing those emissions" (*The Economist* staff 2010b). While this definition of geoengineering does not necessary preclude the possibility that emission abatement may proceed simultaneously, it implies that geoengineering may constitute an alternative to "actually curbing" emissions. The article goes on to set up a dichotomy between those who favor mitigation and those who favor geoengineering: "Most of those who fear climate change would prefer to stop it by reducing greenhouse-gas emissions. Geoengineers argue that this may prove insufficient and that ways of tinkering directly with the atmosphere and the oceans need to be studied" (*The Economist* staff 2010b). By constructing a dichotomy between traditional mitigation-seekers and "geoengineers," there is a false implication that those the article refers to as "geoengineers" are not also strongly in favor of mitigation. As discussed above, even strong proponents of geoengineering solutions usually see them as a supplement, stop-gap, or plan B to emissions abatement.

A *Newsweek* article in response to the failed Copenhagen Climate Summit, presents geoengineering as an alternative to addressing emissions:

> There will be no climate treaty to emerge from the conference in Copenhagen this month, global leaders now concede. But there may be alternative ways to help combat global warming. Various methods of geo-engineering employ unorthodox means to cool the planet. Advocates say that some of these proposals could be implemented quickly and cheaply. One concept is known as stratospheric aerosol insertion. (Ellison 2009)

In this selection, the phrasing "to help combat global warming" leaves room for some ambiguity in the degree to which geoengineering stands alone or not. While this ambiguity is left to stand in the article, what is more striking in the framing is the construction of a juxtaposition between geoengineering and mitigation. The author explicitly uses the word "alternative" in relation to geoengineering set in juxtaposition to a climate treaty, which is implicitly tantamount to saying emissions mitigation.

Treating geoengineering as an alternative to mitigation is often a subtle or indirect implication as opposed to an explicit contention. For example, a *Newsweek* article demonstrates the tendency to imply that geoengineering is an alternative to mitigation through comparison:

> It sounded like a panacea for climate change: "geo-engineering" the atmosphere to block some sunlight and counter global warming […] a quick fix to stabilize or even reverse the heating of the planet. It would head off worsening heat

> waves, droughts, and rising sea levels. The estimated price is right, too. A 2009 analysis found that geo-engineering would cost only $2 billion or so a year, chump change compared with converting from CO_2-producing coal, oil, and natural gas to wind, solar, nuclear, and biofuels. (Begley 2011)

By characterizing geoengineering as a "panacea" and a "quick fix," the author implicitly juxtaposes it against the arduous efforts involved in reducing emissions. Moreover, by comparing the price of albedo modification strategies to the cost of transforming energy systems, the author implicates that the two would be competing solutions as opposed to coexisting or supplemental as scientists tend to present albedo modification. Another *Newsweek* article similarly implies albedo modification as an alternative to mitigation through cost comparison: "A judicious application of sulfur dioxide to the upper atmosphere […] would have an almost immediate impact on temperature. And it would cost a thousand times less than even the most optimistic scenarios for cutting emissions" (Guterl 2009). Particularly with albedo modification, for which cost is relatively low compared to mitigation, it is common for journalists and editorialists to indicate it would be a cheaper alternative. This provides the audience with the false sense of competing options.

Even authors who elsewhere recognize that geoengineering is not a substitute, make statements that imply otherwise. In the opening paragraph of Karl Mathiessen's (2015) article in *The Guardian*, entitled "Is geoengineering a bad idea?" he critically states: "It is considered by many to be the ultimate admission of our failure to curb carbon emissions – a tech-fix that excuses continued carbon gluttony in the industrialised world." While elsewhere he notes the NRC position against geoengineering as a stand-alone strategy, he implies in the characterization of "a tech-fix that excuses continued carbon gluttony" that geoengineering is presented as an alternative to mitigation.

Similarly, Guterl's (2009) *Newsweek* article repeats his point twice about how geoengineering might be a practical solution, partially because it would "cost a thousand times less" than emissions cuts, positioning it as an alternative to emissions cuts. Near the end of his article, Guterl discusses the political risk of moral hazard, again based on the evaluative factor of differential costs: "Success in lowering temperatures—or even the knowledge that scientists had the means to do so—might decrease the political will to make costly emissions cuts" (Guterl 2009). This moral hazard framing again juxtaposes costs as if there were as economic calculation to be made. Moreover, it implies the potential of geoengineering standing in the place of emissions reductions or threatening emission cuts through its very consideration. However, in this discussion, he does ultimately clarify that "Not even the most zealous advocate of geo-engineering argues for using it in lieu of cutting and capturing carbon" (Guterl 2009).

Certainly there are some who consciously present geoengineering as an alternative to emission abatement. They tend to represent vested interests like the oil and gas industry or conservative think tanks with fringe positions. For example, Bjørn Lomborg, a political scientist and the self-titled "Skeptical Environmentalist" who thrives on controversy, as mentioned, has inserted himself in geoengineering discourse with arguments that geoengineering may be a better solution than mitigation. Lomborg represents the community of climate-skeptics turned geoengineering advocates. As Clive Hamilton wrote in *The New York Times*, "Engineering the climate is intuitively appealing to a powerful strand of Western technological thought that sees no ethical or other obstacle to total domination of nature. And that is why some conservative think tanks that have for years denied or downplayed the science of climate change suddenly support geoengineering, the solution to a problem they once said did not exist" (Hamilton 2013c). Tina Sikka's analysis of conservative think tank discourse discusses how advocates from these communities "construct geoengineering research and practice as necessary, commonsensical and natural" (Sikka 2012: 166). This community stands apart from the mainstream scientific community concerned with climate, including geoengineering advocates within it.

Within popular media, however, some of the most forceful geoengineering advocates, like social scientist David Victor, indicate a viewpoint that geoengineering may be an alternative to emissions abatement despite providing acknowledgment of the mainstream emphasis on emission controls. In an influential *Foreign Affairs* article promoting geoengineering, Victor, *et al*. state:

> Most cost estimates for such geoengineering strategies are preliminary and unreliable. However, there is general agreement that the strategies are cheap; the total expense of the most cost-effective options would amount to perhaps as little as a few billion dollars, just one percent (or less) of the cost of dramatically cutting emissions. (Victor *et al.* 2009)

Comparing the cost of albedo modification proposals to the cost of "dramatically cutting emissions" implies an either-or relationship between those two strategies for addressing climate change as opposed to a supplementary or complementary relationship.

These authors, who are among the strongest advocates of geoengineering, close the article by stating:

> The best and safest strategy for reversing climate change is to halt this buildup of greenhouse gases, but this solution will take time, and it involves myriad practical and political difficulties. Meanwhile, the dangers are mounting. In a few decades, the option of geoengineering could look less ugly for some countries than unchecked changes in the climate. Nor is it impossible that later in the century the planet will experience a climatic disaster that puts ecosystems and human prosperity at risk. It is time to take geoengineering out of the closet—to better control the risk of unilateral action and also to know the costs and consequences of its use so that the nations of the world can collectively

> decide whether to raise the shield if they think the planet needs it. (Victor *et al.* 2009)

The statement that "The best and safest strategy for reversing climate change is to halt this buildup of greenhouse gases" at first seems consistent with the scientific consensus emphasizing the importance of emissions abatement. Likewise, the next phrase of the sentence regarding the emissions solution taking time, appears consistent with the common argument among geoengineering proponents within the scientific community who argue that albedo modification may be a useful or necessary option to pursue in conjunction with emissions abatement, generally as a stop-gap measure to buy time while emissions are dramatically reduced. However, the final phrase of this sentence, that "it involves myriad practical and political difficulties" paired with the subsequent sentences reorients the message. The authors imply that the "myriad of practical and political difficulties" challenging emissions mitigation efforts would not be mirrored in the political challenges also inherent in the pursuit of albedo modification. They fail to acknowledge that replacing this political-consensus defying strategy with geoengineering may repeat the same international and domestic challenges in a new realm.

In presentation to the public by news media through both editorialist and journalistic accounts, a sense of ambiguity is relayed in regard to the relationship between geoengineering and emissions abatement. Within the corpus, there is some recognition of the caveats raised by scientists that albedo modification would not replace the need for abatement. However, this point is often obscured by discursive moves that imply an either-or relationship, such as juxtaposition of geoengineering and mitigation as distinct choices or through the comparison of costs/effort that indicate geoengineering as a cheaper/easier option thereby implying the two would not coexist. The treatment of geoengineering within popular media as the other side of mitigation in a dichotomous relationship may be an extension of the journalistic tendency to portray two sides of an issue. The resulting tensions contribute toward reshaping the public narratives around the geoengineering socio-technical imaginary of what is possible, acceptable and desirable.

The Decoy Effect in Presenting Geoengineering "Options"

One discursive theme particularly common in popular media covering geoengineering is one that can be characterized as a geoengineering options decoy effect. This engaging discursive technique presents descriptions of the range of options among geoengineering proposals, initially including more extreme, controversial or absurd proposals before progressing to discussion of comparatively moderate options. There are two primary effects of the use of decoy options, the first simply being literary intrigue to engage readers on the topic of geoengineering. The second is the potential to influence readers in their perspectives on geoengineering. These decoy options are geoengineering proposals not being seriously advocated, but rather easily dismissed in favor of more popular proposals actually under consideration. By inclusion of more extreme and easily contestable decoy options in the presentation of geoengineering schemes, other options can be framed as more reasonable or benign by comparison. Contrary to the assumptions of many utility theories, which assume that "irrelevant alternative" or decoy choices do not affect the outcome of rational decision making, decoys can have a significant effect in choice selection (Soltani, De Martino and Camerer 2012). Hence, the common use of decoy options in geoengineering literature can contribute to normalizing, legitimizing or otherwise reorienting the audience's thinking about particular geoengineering proposals, whether incidentally or intentionally on the part of the authors.

Within popular literature, the use of decoy or straw man options in discussion of geoengineering often appears as a literary technique to build intrigue in the story. Among geoengineering literature written for a general audience there is a tendency to choose particularly extreme options, emphasizing their enormity or even absurdity. For instance, in one article, the editors of *Scientific American* introduce the range of geoengineering options by stating: “Scientists and engineers have proposed various approaches besides iron fertilization, such as hazing the skies with sulfates to mimic the cooling effects of a volcanic eruption or even launching a fleet of mirrors to deflect sunlight away from the planet” (Board of Editors 2015). The language of the last option, prefixed with the word “even” and with the enormity of the undertaking characterized by the description of “a fleet,” makes clear that this option is not necessarily being presented as a serious consideration, but rather a decoy option that has the effect of increasing the scope of presented options, potentially making other options come across as more tenable than they would alone.

Another geoengineering article in the *Scientific American* presents the range of options in this way:

> Some ideas are the stuff of science fiction: 15 trillion mirrors positioned in orbit to shield the planet from the sun’s rays; a fleet of blimps 20 kilometers up feeding a constant stream of sulfur into the stratosphere; a navy of robot-controlled ships prowling the world’s oceans, spraying seawater skyward to generate reflective clouds.
>
> Others are more mundane: Plant trees to soak up carbon dioxide or paint roofs white to reflect sunlight. Most are unproven. All have major drawbacks. None offset ocean acidification. (Fischer 2009)

This presentation provides the two extremes of the range of options: those up-played in regard to their extremity or absurdity and those presented as “mundane,” which include the least novel and lowest risk options. Framing the range of options with such a widespread spectrum of risk and novelty, from the “stuff of science fiction” through the “mundane,” has the discursive effect of acknowledging and discrediting the reader’s potential starting position of assuming the absurdity of geoengineering overall. It is emphasized that while some geoengineering schemes are on the absurd end, the spectrum contains a wide array of options, including relatively lower risk and lower novelty proposals. Compared to “a navy of robot-controlled ships prowling the world’s oceans,” painting roofs white seems particularly tame.

The prevalence of including decoy or straw man options among articles in popular media representing a wide range of positions and publishers, is highlighted by the disproportionate presentation of space mirrors as a potential albedo modification option. The geoengineering proposal of space mirrors is generally dismissed from serious consideration due to prohibitive costs. Moreover, there is no significant advocacy within the field for pursuit of this option. Yet, out of the corpus of 94 news articles analyzed, 25 articles include space mirrors or space reflection as one of the explicit geoengineering options presented. Incidentally, 25 articles also present marine cloud brightening (MCB) as a potential option. Notably marine cloud brightening is consistently considered among experts and proponents to be among the two most viable albedo modification strategies (National Research Council 2015b: 39, 113; Bellamy *et al.* 2012: 602), while space reflection is consistently dismissed as overly expensive and impractical for serious consideration (National Research Council 2015b: 104; Bellamy *et al.* 2012: 602; Royal Society 2009: 32-33). Yet, within the corpus, an equal number of popular media articles list these two options in presenting the range of geoengineering options available for consideration.

Space reflection is a popular scheme for reference, particularly in general audience literature, precisely because it is considered intrinsically extreme or absurd. Recurrently the idea of space mirrors is explicitly linked to the common analogy comparing geoengineering to science fiction: “some proposals, like launching a cloud of mirrors into space to deflect some of the sun’s heat, sound like science fiction” (Hamilton 2013c); “the stuff of science fiction: 15 trillion mirrors positioned in orbit” (Fischer 2009); “[schemes] range from the benign […] through to the science fiction, like putting a cloud of mirrors in space to deflect some sunlight” (Hamilton 2013b). In other instances the extremity or absurdity of the space mirrors proposal is highlighted by particular wording such as the word “even” as in “proposals *even* include…” This is seen in the *Scientific American* editorial list of geoengineering options ending with “even launching a fleet of mirrors to deflect sunlight away from the planet” (Board of Editors 2015) and in a *Slate* editorial critical of albedo modification, which states: “solar geoengineering seeks to reduce the amount of sunlight that warms the Earth at the surface, troposphere, upper atmosphere, or even space level” (Jospe 2016). One editorial presents examples of geoengineering options as follows:

> Geoengineering comprises technologies designed to counteract human-caused climate change: towering “carbon scrubbers” that would suck carbon dioxide from the atmosphere; the injection of iron pellets into the ocean to stimulate growth of carbon consuming phytoplankton blooms; or — my personal favorite— deploying zillions of mirror-coated nanotechnology flying saucers to form a stratospheric solar reflector. (Kahan 2015)

The absurdity of the solar reflection option is up-played with the language emphasizing the technological novelty (“nanotechnology flying saucers”) and enormity of the effort (using the word “zillions” rather than a specific number range). While presented as absurd, this option is made to stand out, with the first-person aside “—my personal favorite—” used to draw particular attention to it.

One article, while itself subject to the trend, identifies a reason for the disproportionate representation of the space mirror option among the range of options: “From a technological standpoint, the flashiest geoengineering scheme is space-based" (Pappas 2013). After then describing the basic technical process of the space reflection concept, the article goes on to say "However, space-based schemes are the least likely to be implemented" due to their vast impracticalities as identified by experts (Pappas 2013). The emphasis on space-based schemes is explicitly recognized due to their being technologically flashy even though they are then dismissed as infeasible within reasonable time-periods. This article, like others in the popular media geoengineering genre, focuses largely on setting up a range of options of geoengineering proposals, making them seem engaging and interesting, while also emphasizing controversy. It quotes primary scientists in each option area presented. Ultimately it elevates the options that are most commonly advanced among the range of options. Presenting the more extreme and "flashiest" options like space reflection frames the subsequent presentation of "less dramatic, and more feasible" options such as stratospheric aerosols and marine cloud brightening, contextualizing their challenges as relatively surmountable (Pappas 2013).

For proponents of particular geoengineering proposals, the presentation of a range of options broadened by inclusion of more extreme or controversial ideas, makes the favored options seem more reasonable by comparison through the implicit suggestion that these are relatively moderate or realistic. Embodied within public audience literature, journalists present the sense of honing in on options most favored by advocates within the geoengineering community. This is demonstrated in the *Scientific American* article in which the extreme "stuff of science fiction" is juxtaposed to the "more mundane," and ultimately the discussion is funneled down to focus on "[t]he most favored option today [which] is the injection of sunlight-reflecting sulfur particles high into the atmosphere" (Fischer 2009).

Often journalists explicitly convey the preferred proposals of geoengineering advocates. In a review of *The Planet Remade*, science journalist Oliver Morton's book advocating geoengineering, another science journalist Thomas Sumner writes in *Science News Magazine*:

> The book lays out the typical laundry list of geoengineering proposals, from extracting carbon dioxide from the air to deploying giant Earth-orbiting space mirrors. But Morton has a clear favorite. A variety of airborne particles reflect sunlight like tiny disco balls. A fleet of high-flying planes could spray these aerosols into the stratosphere and thicken the sun-dimming veil that surrounds Earth. (Sumner 2015)

Similarly, in describing a speech on geoengineering by Lord Rees, Alok Jha writes:

> Geoengineering involves deliberate planet-scale interventions to counteract global warming. Techniques suggested include placing mirrors in space that reflect sunlight away from the Earth and fertilising the oceans with iron to encourage the growth of algae that can soak up atmospheric carbon dioxide. Other options include Rees's preference – to seed clouds in the upper layer of the Earth's atmosphere to bounce some of the sun's energy back into space. (Jha 2013)

These examples demonstrate the flow from decoy options to presenting the options being explicitly advocated by proponents.

A more subtle version of this trend of honing in on a preferred option can be seen in the influential *Foreign Affairs* article advocating for more serious consideration and pursuit of albedo modification, written by geoengineering proponents David G. Victor, M. Granger Morgan, Jay Apt, John Steinbruner, and Katharine Ricke. They introduce the range of albedo modification options as such:

> Most schemes that would alter the earth's albedo envision putting reflective particles into the upper atmosphere, much as volcanoes do already. Such schemes offer quick impacts with relatively little effort. For example, just one kilogram of sulfur well placed in the stratosphere would roughly offset the warming effect of several hundred thousand kilograms of carbon dioxide. Other schemes include seeding bright reflective clouds by blowing seawater or other substances into the lower atmosphere. Substantial reductions of global warming are also possible to achieve by converting dark places that absorb lots of sunlight to lighter shades—for example, by replacing dark forests with more

> reflective grasslands. (Engineered plants might be designed for the task.) More ambitious projects could include launching a huge cloud of thin refracting discs into a special space orbit that parks the discs between the sun and the earth in order to bend just a bit of sunlight away before it hits the planet. (Victor *et al.* 2009: 68)

Their range of options begins with their most favored proposal, stratospheric aerosols, and then goes on to list a number of other options of various levels of feasibility or practicality. These authors, who are proponents of albedo modification pursuit, positively frame the range of options presented. For instance, they use the positive term "ambitious" to characterize the space reflection category of albedo modification as contrasted from the many authors who emphasize its absurdity or novelty rather than its ambitiousness. While they do not explicitly dismiss any of the albedo modification options presented, they use the range of options to hone in on their favored method, making clear that the alternatives are less feasible and practical than their preferred option. Immediately after this list, they emphasize this point by returning to the relative advantages of stratospheric aerosols: "So far, launching reflective materials into the upper stratosphere seems to be the easiest and most cost-effective option" followed by a more detailed discussion of the topic (Victor *et al.* 2009). This is an example of presenting a range of options, including decoys, to suggest a sense of internal evaluation between options that ultimately advances the favored choice being promoted.

Even for authors more cautious or concerned about the prospect of geoengineering, the discursive trend of presenting a range of options broadened by decoys may have the effect of normalizing other options. For instance, Clive Hamilton an Australian public intellectual who has written extensively on geoengineering, employs the decoy effect despite his tendency to lean toward caution and concern regarding geoengineering technology. In a *New York Times* Op Ed, Hamilton writes: "While some proposals, like launching a cloud of mirrors into space to deflect some of the sun's heat, sound like science fiction, the more serious schemes require no insurmountable technical feats" (2013c). This is a quintessential presentation of a decoy option, emphasizing the absurdity of space mirrors through use of the science fiction analogy, prior to opening the discussion of "more serious schemes" and their advantages. Yet, the article is not representative of a geoengineering proponent position, but rather a concerned perspective in which Hamilton emphasizes the risks and uncertainties of geoengineering along with the potential mismatch of the "solution" to the cause of the climate crisis. Furthermore, in his book on geoengineering, Hamilton includes an even more extreme decoy option than space reflection in his presentation of the range of geoengineering proposals: the "novel scheme to counter global warming" published in "the esteemed journal *Climatic Change*" that suggested "the effects of global warming could be countered by increasing the radius of the Earth's orbit around the Sun" (Hamilton 2013a: 3; referencing Jain 1993). These examples point to how the use of decoy options has become entrenched into geoengineering literature to the point where this discursive tool, which proponents may employ toward normalizing their favored geoengineering approaches, is also commonplace among authors with a neutral or critical stance on geoengineering.

Analogies and Metaphors

Metaphors and analogies affect the interpretation, shaping and reconstructing the geoengineering socio-technical imaginary. George Lakoff and Mark Johnson argue broadly in *Metaphors We Live By* that "most of our normal conceptual system is metaphorically structured; that is, most concepts are partially understood in terms of other concepts" (Lakoff and Johnson 1980: 56). Metaphors are particularly important for shaping conceptualizations of emerging technologies, which are subject to “interpretive flexibility,” and as such can “play an important role in the general framing of geoengineering”(Luokkanen, Huttunen and Hildén 2014: 978). As discussed, within scholarship analyzing geoengineering discourse, there are a few studies to date focused on metaphors.

Nerlich and Jaspal (2012) examined metaphors within trade literature from 1988-2010. In the case of the industry trade literature genre, metaphors primarily served the purpose of promoting or positively framing geoengineering. The three “conceptual master metaphors they identify” are: the planet is a body, the planet is a machine, and the planet is a patient/addict (Nerlich and Jaspal 2012: 131, 135). From there, they identify other discourse metaphors related to these concepts. In their study, the metaphors used in geoengineering discourse were found to promote geoengineering and to frame geoengineering as a necessary option to have available (e.g., within the metaphor of earth as patient, geoengineering is likened to chemotherapy, citing David Keith to say no one wants it, but we want it available if needed) as well as feasible and doable (e.g., within the metaphor of earth as machine, comparing geoengineering proposals to how one would fix a car gives sense of “easy” or “routine” feasibility) (Nerlich and Jaspal 2012: 137-9). Like other authors (e.g., Bellamy *et al.* 2013), they argue that “The geoengineering metaphors and arguments found in this corpus therefore seem to be closing down debates about geoengineering and, in the process, debates about climate change mitigation, rather than opening them up […] This rhetoric limits social and ethical reflection on the issue of geoengineering by implicitly establishing the boundaries of ‘legitimate’ debate” (Nerlich and Jaspal 2012: 142-3).

Luokkanen, Huttunen and Hildén (2014) analyzed metaphors used in relation to geoengineering as presented through *The New York Times* and *The Guardian* from 2006-2011.

In general audience news media, metaphors can be used in support or opposition to advancing the technology (Luokkanen, Huttunen and Hildén 2014: 978). The main metaphors identified within Luokkanen *et al*.'s corpus of study are: (1) war and fight ("acting on climate change is like fighting a war," which is "commonly used in describing geoengineering neutrally"); (2) controllability ("geoengineering is like preparing for the future with insurance," with metaphors of controllability "mainly used to support further studies of geoengineering"); (3) mechanisms ("earth is like a machine and interventions on earth are like interventions in a machine's mechanism," which is often used in arguments against geoengineering); (4) health and illness ("the earth is like a living organism and geoengineering actions are like medical actions," which is often used in arguments against geoengineering) (Luokkanen, Huttunen and Hildén 2014: 973-7).

The corpus of articles reviewed in this study complements and builds upon these previous analyses of metaphor in relation to geoengineering. Because geoengineering is based upon hypothetical scenarios and therefore abstract to a general audience, metaphors and analogies are potent tools for explanation and framing. Like the articles by Nerlich and Jaspal (2012) and Luokkanen *et al*. (2014), the present study illuminates the common usage of mechanical and medical analogies.

A frequent analogy within surveyed news articles compares implementing albedo modification to setting a global "thermostat." Nerlich and Jaspal's study of trade literature considered the mechanistic metaphor as supporting arguments for pursuing geoengineering through presenting the earth as a machine that can be "fixed or repaired" (2012: 137). By contrast, Luokkanen *et al*. found mechanistic metaphors in newspaper articles to often be used in arguments against geoengineering (Luokkanen, Huttunen and Hildén 2014: 975). The present research on news media is consistent with this latter finding. Over half (ten of 17 or 59%) of the articles studied here that employed the thermostat metaphor, used it to raise the question of "who gets to set the thermostat" in the case that albedo modification is deployed, emphasizing the problematic global political challenges to agreeing upon a course for geoengineering. For example: "which country's hand gets to rest on the global thermostat?" (Jones 2016). Speaking about the high barrier of challenges to instituting geoengineering, *New York Times* environmental journalist Andrew Revkin writes that among the barriers, "The main one is diplomatic, not technological. Who sets the thermostat?" (Revkin 2015). Emphasizing the potential for international conflict, one journalist writes: "there may be disputes over the 'right' temperature, setting off what's been dubbed 'the Thermostat Wars' -- if Indonesia wants cooling to avoid sea level rise and Russia wants warming to increase agricultural production, for instance" (Krieger 2015). Douglas Fischer also raises the "central question: Who sets the thermostat?" (Fischer 2009). He cites to Ken Caldeira in describing the risks: "'My biggest fear is that we're getting into the controls of the planet,' said Calgary's Keith, 'where one part of the world wants to run the planet different than another. […] If one tweaks the knob a different way than another - or adds one knob atop another - it could be a real disaster'" (Fischer 2009). As these examples illustrate, while the thermostat metaphor implies a sense of easiness, it is often employed in an ironic manner that points to the political difficulties that are inextricable from the technical feasibility.

Both the studies by Nerlich and Jaspal (2012) and Luokkanen *et al*. (2014) included discussion of medical metaphors, in which planet Earth is discursively treated as a living organism needing healing or protection from bodily harm, or mechanical metaphors in which the Earth is treated as a machine that can be fixed. The present corpus of news articles is consistent in including similar medical and mechanical metaphors. These include medical metaphors comparing albedo modification to “chemotherapy for the planet” (Nocera 2015; see also Specter 2012). One notable factor is how certain metaphors are introduced or perpetuated within the discourse.

In the case of some of the medical analogies, certain influential individuals are often cited. The chemotherapy metaphor has been attributed to various elite academics involved in geoengineering research, including Hugh Hunt of Cambridge University (see Specter 2012) as well as Gernot Wagner (see Nocera 2015) and David Keith (Nerlich and Jaspal 2012: 139; Howell 2010) of Harvard University. Ken Caldeira, climate scientist at the Carnegie Institution for Science at Stanford University, is quoted as referring to geoengineering as “kind of a symptomatic relief […] I’m thinking like morphine for the cancer patient” (Carr 2015). David Keith, the most oft-cited scientist in the field, has also imparted mechanical metaphors toward the normalization of geoengineering. Keith is quoted in one *Washington Post* article as saying: “A muffler is a technological fix for the fact that the internal combustion engine is very noisy, and people don’t have a problem with mufflers” (Achenbach 2015).

Journalists and editorialists also contribute to these metaphors. For example, an article in *The Economist* (2010a) includes an extended medical analogy: “Cooling might take the edge off the peak of a planetary fever, or perhaps buy time as emissions cuts begin to have the desired effects. But hazing is a complementary medicine, not an alternative one.” Michael Specter writes in *The New Yorker*: “Many people see geoengineering as a false solution to an existential crisis— akin to encouraging a heart-attack patient to avoid exercise and continue to gobble fatty food while simply doubling his dose of Lipitor” (Specter 2012). While the medical and mechanical analogies attributed to geoengineering researchers listed above tend to use the metaphors to indicate legitimacy (e.g., likened to chemotherapy for a cancer patient or a muffler for a car), those by journalists include presentation ranging from positive or neutral ("complementary medicine") to a negative or critical tone (as exemplified in Spector's Lipitor analogy).

In addition to these sorts of metaphors, there is also a trend of analogizing geoengineering to other technologies. These analogies are distinct from the types of metaphors previously discussed. As opposed to being morphine or chemotherapy in a metaphorical sense, geoengineering is directly compared to existing technologies. In the case of an influential article written by geoengineering advocates, analogies to other technologies are used to diminish the sense of novelty and the grand extent of global risk of the proposed research and pursuit of geoengineering. This is seen in the *Foreign Affairs* article entitled "The Geoengineering Option" (2009) by David G. Victor, M. Granger Morgan, Jay Apt, and John Steinbruner, and Katharine Ricke. They write:

> Assessing and managing the risks of geoengineering may not require radically different approaches from those used for other seemingly risky endeavors, such as genetic engineering (research on which was paused in the 1970s as scientists worked out useful regulatory systems), the construction and use of high-energy particle accelerators (which a few physicists suggest could create black holes that might swallow the earth), and the development of nanotechnology (which some worry could unleash self-replicating nanomachines that could reduce the world to 'gray goo'). The option of eliminating risk altogether does not exist. Countries have kept smallpox samples on hand, along with samples of many other diseases, such as the Ebola and Marburg viruses, despite the danger of their inadvertent release. All of these are potentially dangerous endeavors that governments, with scientific support, have been able to manage for the greater good. (Victor *et al.* 2009: 75-76)

Victor *et al.* choose analogies that had initially provoked deep concerns, but which were largely dismissed after further development. Analogizing to contested technologies, which have experienced a trajectory of normalization, while pointing to the most extreme characterizations of risk (straw man arguments regarding “black holes” and “gray goo”) that have been presumably discredited, helps the authors make a case to dismiss and trivialize concerns regarding albedo modification. This example is, of course, on the advocacy side of the spectrum of public discourse on geoengineering.

News articles more broadly employ comparison to other contested technologies such as nuclear technology and genetic engineering. For example, nuclear technology can be used toward positive, neutral or negative effects in analogizing, and hence framing, geoengineering. In arguing that the risks of geoengineering can be contained through scientific norms, Victor *et al*. point toward the nuclear precedent as a positive analogy: “Scientists could be influential in creating these norms, just as nuclear scientists framed the options on nuclear testing and influenced pivotal governments during the Cold War” (Victor *et al.* 2009: 74). Employing a neutral nuclear analogy, Daniel Cressey in *Nature* quotes “Shobita Parthasarathy, a public-policy researcher at the University of Michigan, Ann Arbor, [who] says that the field urgently needs to agree on detailed rules for IP […] One possible solution, she says, is to develop a unique system for handling geoengineering patents, akin to the way that atomic-energy patents are controlled in the United States” (Cressey 2012). (While the analogy itself is neutrally employed, such comparison to existing technologies may contribute to a normalizing effect in the overall framing of geoengineering.) Employing the nuclear analogy as a negative framing, an article in *Slate* posed the argument and leading question: “We need global norms that take into account the uncertainty and serious risks that solar radiation management could pose. [...] If early experiments epically fail, will they be counterproductive to the technology over the long term, like the nuclear meltdown in Three Mile Island?” (Venkataraman 2016). As these examples demonstrate, the nuclear analogy has been used toward positive, neutral and negative framings of geoengineering.

Similarly, analogy to genetic engineering is employed toward various framings. As an example of a positive framing promoting consideration of geoengineering, Andrew Revkin writes for *The New York Times* environmental opinion pages: “Walling off this arena makes as little sense as talking about feeding some nine billion people on a still-biodiverse planet without technology, including genetic engineering” (Revkin 2016). In this way, he dismisses arguments that would *prima facie* write off either of these controversial technologies As was seen with the nuclear analogy, analogizing geoengineering to genetic engineering is also used neutrally to discuss the formation of norms as a potential safeguard: “A recent global summit on gene editing technologies hosted by national scientific councils from the United States, the United Kingdom, and China could provide a model for how policymakers, ethicists, scientists, and the public can set boundaries on the use of technologies with unknown and intergenerational consequences” (Venkataraman 2016). An article in *The Economist* (2010b) is premised on an extended analogy to genetic engineering to discuss the importance and possibility of regulation of the technology. Again, using these analogies as precedents for possible regulation, norms, and safeguards can help to normalize and diminish the sense of risks involved with novel emerging technologies.

Both metaphors and analogies are important tools for framing the presentation of the nascent concepts of geoengineering to the public. As seen in the examples presented here, individual metaphors or analogies can be used toward constructing positive, neutral or negative framing. The wider corpus of articles examined here reaffirmed some of the findings of earlier studies, such as the application of medical and mechanical metaphors, while expanding upon these findings, and introducing the importance of direct analogies in contributing to various framings and potential normalization of proposed geoengineering technologies.

Media Treatment of the National Research Council Geoengineering Report

As discussed in the previous chapter, science policy reports allow experts in an emerging field to encapsulate current thinking within the field and express it to policy makers and the public. It is through news media, however, that the content within scientific reports primarily gets translated and repackaged for public consumption. The 2015 two-volume *Climate Intervention* report by the National Research Council (NRC) of the National Academy of Sciences is the most substantial science policy report focused on geoengineering to date. This makes it an appropriate case study for examining how news media interact with science policy reports.

Within the corpus of 94 geoengineering news articles studied in detail here, 25 articles discuss the 2015 NRC *Climate Intervention* report. Of these, seven speak of the report in anticipation before its release, six are specifically focused on discussion of the report upon the release of the prepublication copy in February 2015, and another 12 articles reference or discuss the report following its release. The selection of articles discussing the NRC report are from *The New York Times*, *The Guardian*, *The Nation*, *Slate*, *The Washington Post*, *Scientific American*, *Ars Technica*, *The San Jose Mercury*, and *National Geographic*.

This selection of articles is a microcosm of some of the themes considered in this chapter. As discussed, the mere existence of these reports contributes to the idea of increased legitimacy of the field. Through direct and implicit language, the fact that such a respected institution as the National Academy of Sciences has undertaken study of geoengineering is used to indicate a move toward mainstream legitimacy of the field. On the other hand, the theme of controversy also emerges in the discussion of the report. Journalists tend to cite individuals with strong feelings on the reports, providing a window into some internal controversy. This section considers questions like how the report is characterized, what elements of the report are considered, which experts are most cited in articles discussing the NRC report, and how the primary recommendations given in the report are relayed by journalists and editorialists for consumption by the public.

To begin, how much of the NRC report is actually considered by authors when writing news articles in regard to it? It is generally understood that the summary is the most influential section of a policy report since many readers may rely heavily or exclusively on the summary. This certainly appears to be accurate in regard to journalists' discussion of the NRC *Climate Intervention* report. Within the selection of articles, the entirety of direct quotes and paraphrasing from the report can be attributed to the "Summary" or "Preface" sections. There are certainly practical reasons for why journalism in response to the report would limit specific references to the summary sections. First, the news articles that are the most focused on the report are those that were published the week of its release. One would not expect the writers to have had the opportunity to read the report volumes in their entirety, as the two volumes together exceed 346 pages of dense scientific and technical content. Second, the news articles that discuss the report later in 2015 or 2016 also rely upon the summary sections, but since these articles are not focused primarily on the NRC report, specific discussion of the report in these articles tends to be less in-depth. In either case, for practical purposes, it seems that it is from the "Preface" and "Summary" sections that reporters and editorialists draw to discuss the report's content. This fact underscores the argument in the previous chapter that the content and framing (what is said and how it is said) in the summary sections of science policy reports is particularly salient for how the content and take-away points of the reports are considered and interpreted.

Moreover, the report-originated quotations tend to be sparse and short in most general-audience articles. Within the studied corpus, only six of the 18 articles that discuss the NRC report after its release include direct quotations from the report itself. Other sources relied upon to discuss the report contents include the National Academy press release and press briefing, members of the research committee, reviewers of the report, unaffiliated scientists, social scientists and other journalists. Indicating a breadth of sources, 28 different individuals are cited within the news articles analyzed here that discuss the report following its release. Most of these people are cited in only one article each, meaning there is a diverse array of expertise and opinions relied upon to complement content drawn from the report. Within the corpus of articles discussing the report, the most oft-quoted person is NRC committee member Raymond Pierrehumbert who is quoted in five separate articles. For comparison, Marcia McNutt, the chair of the Committee on Geoengineering Climate which was responsible for authoring the report, is quoted by three separate articles. Of the 28 individuals cited, nine were members of the committee responsible for the report and seven of these were each quoted by only one news article in the selection. Individuals acknowledged in the NRC report as reviewers were also cited: climatologist Alan Robock (3 articles), David Keith (3 articles) and Clive Hamilton (2 articles). Unaffiliated science journalist, Eli Kintisch, and climate politics author, Naomi Klein, were each cited multiple times as well. This means there was a broad spectrum of possible opinions and interpretations to color discussion of the report.

To assess whether the citation trends within this qualitative study match broader patterns, the LexisNexis news search engine was again used to investigate the extent to which these and other individuals were cited by all English-language news articles within the database. There were numerous individuals cited in news articles that discuss the release of the report, but certain voices emerge as frequently evoked in news media while others remain absent or sparse. Table 3.5 shows the percentage of articles that reference or cite relevant individuals among geoengineering-related articles that discuss the NRC report the month of its release within the LexisNexis database. All of the individuals listed in Table 3.5 were also cited within the corpus of articles analyzed in-depth qualitatively, however with some variation in the listing order.

Table 3.5: Most cited individuals within news articles discussing NRC report in February 2015, the month of its initial release

Marcia McNutt **	33%
Alan Robock *	33%
Raymond Pierrehumbert **	22%
David Keith *	19%
Clive Hamilton *	19%
Ken Caldeira **	14%
Waleed Abdalati **	14%
Naomi Klein ^	8%
Eli Kintisch ^	6%

Note: Based on newspaper articles within the LexisNexis database of English-language news articles for February 2015 that include geoengineering terms plus “National Academy of Sciences” or “National Research Council”, controlled for high similarity. There were 36 such articles. The values reported here are the percentage of these articles that cited to or referenced each individual.
** = Committee member; *=Report Reviewer; ^ Unaffiliated

Of the sixteen members of the Committee, eight members are cited by any newspapers in the database and only five of these members in multiple articles. Frequent reference to

Marcia McNutt would be expected as she was chair of the committee responsible for the report. Other than McNutt, Raymond Pierrehumbert is the most cited member of the Committee. He is a unique Committee member, being outspoken in his criticism of geoengineering and also providing a sharp commentary on the collaborative process of developing the report, to the point of questioning its coherence. An article in *The Washington Post* emphasized controversy regarding geoengineering and cited Pierrehumbert toward this end:

> "It will come as no surprise that there were very, very vigorous discussions by people on the committee who had very different viewpoints," said committee member and University of Chicago climate scientist Ray Pierrehumbert. "Once the report is out, it'll be a free-for-all in figuring out what the report actually means." (Achenbach 2015)

Similarly, in the Opinion pages of *The New York Times*, Andrew C. Revkin writes:

> I loved what the climate scientist Raymond Pierrehumbert had to say in *Slate* yesterday. His views are particularly notable not only because he was one of the report's authors but also because of his unbridled language in describing the process and his conclusions:
>
> The nearly two years' worth of reading and animated discussions that went into this study have convinced me more than ever that the idea of "fixing" the climate by hacking the Earth's reflection of sunlight is wildly, utterly, howlingly barking mad. In fact, though the report is couched in language more nuanced than what I myself would prefer, there is really nothing in it that is inconsistent with my earlier appraisals. (Revkin 2015)

As indicated here, Pierrehumbert both proactively voiced his thoughts upon the publication of the report, including posting in *Slate*, and also forthrightly, at times colorfully, articulated concerns and critiques to be quoted by journalists. He uniquely embodied being a member of the committee that was responsible for the geoengineering report, while remaining consistent in his outspoken critique of geoengineering proposals.

Of the ten individuals acknowledged as reviewers of the report, four of them are cited within the LexisNexis English-language newspapers results. David Victor is cited once, while Alan Robock, David Keith and Clive Hamilton are cited in multiple articles. David Keith is the most cited person in geoengineering, so it is not surprising that he is oft-cited in articles that also discuss geoengineering's definitive report. Within public discourse of geoengineering, Keith seems to ensure that his voice is frequently heard. Oft-cited by journalists, he seems to make himself available for comment and he is also author of editorials (one of which will be discussed below) and a general-audience book advocating for geoengineering (*A Case for Climate Engineering*, 2013). Clive Hamilton has also been a consistent voice in geoengineering commentary and is author of an influential book on the subject, *Earthmasters*. Climate scientist, Alan Robock, has been a longtime critic of geoengineering and published in 2008 an influential article in the *Bulletin of the Atomic Scientists*, entitled "20 reasons why geoengineering may be a bad idea" (Robock 2008).

Alan Robock took on a specific role in his correspondence with journalists in respect to the NRC report, acting as a sort of whistle blower in regard to the role of the United States Central Intelligence Agency (CIA) in partially funding the report and showing interest in details of albedo modification. This is a primary focus of the majority of articles citing Robock in regard to the NRC reports. An article in *The Guardian* revolves around this issue:

> Alan Robock, a climate scientist at Rutgers University in New Jersey, has called on secretive government agencies to be open about their interest in radical work that explores how to alter the world's climate. […] "The CIA was a major funder of the National Academies report so that makes me really worried who is going to be in control," [Robock] said. […] Robock said he became suspicious about the intelligence agencies' involvement in climate change science after receiving a call from two men who claimed to be CIA consultants three years ago. "They said: 'We are working for the CIA and we'd like to know if some other country was controlling our climate, would we be able to detect it?' I think they were also thinking in the back of their minds: 'If we wanted to control somebody else's climate could they detect it?'" (Sample 2015)

A number of news articles around the time of the NRC report release quote Robock in disclosing the role of the CIA in funding the report (at least 11 articles published in February

2015) and also details of the phone call and his concerns regarding CIA interest in geoengineering endeavors (at least 5 articles published in February 2015). Citing to Robock, like Pierrehumbert, advances characterization of controversy. These scientists provide voices of opposition and critique within the field to counter advocating voices, such as David Keith and others, so often included.

A number of unaffiliated individuals were asked to provide commentary in various news articles, some more than others. Eli Kintisch showed up in multiple instances in the corpus analyzed and in the database results. Kintisch has been a consistent voice providing commentary on the field of geoengineering, authoring one of the most influential general audience books on the subject, *Hack the Planet*, and providing nuanced critique of geoengineering proposals and possibilities. Karl Mathiesen writes in *The Guardian*: "science writer Eli Kintisch called geoengineering 'a bad idea whose time has come'(Mathiesen 2015). Naomi Klein is evoked as geoengineering critic, having devoted a book chapter to the subject (*This Changes Everything*, 2014) and otherwise being outspoken in her critique. She is an example of a figure who is sometimes evoked merely as a personality representing critics, without necessarily being quoted directly. Extending the metaphor of voices of geoengineering, she becomes a face but not a voice in such articles.

Overall, the news reporting on the NRC report mostly accurately presents the Committee's primary recommendations. Within the corpus, all six of the articles primarily concerned with the report at its time of publication, in addition to several subsequent articles, accurately relay the Committee's emphasis on the importance of continued mitigation and adaptation efforts.[14] For example, Andrew Revkin writes in *The New York Times*: "The panels' overarching bottom line is straightforward: 'There is no substitute for dramatic reductions in the emissions of CO_2 and other greenhouse gases to mitigate the negative consequences of climate change, and concurrently to reduce ocean acidification'" (Revkin 2015). Craig Welch writes in *National Geographic*: "Committee members were blunt in their first recommendation: The world should focus first and foremost on curbing fossil fuel emissions rather than on any kind of geoengineering" (Welch 2015). Karl Mathiesen writes in *The Guardian*: "A report released on Tuesday by the US National Academies of Sciences (NAS) said tinkering with the global climate now would be 'irrational and irresponsible' and climate change can only be avoided by cutting emissions" (Mathiesen 2015).

All of the articles focused on the report's release also accurately conveyed the overarching recommendation for increased research into geoengineering, as did a number of others. Mathiesen goes on to say that, despite the caveats, "the influential group of 16 scientists who authored the report urged policy makers to commit to further research into some geoengineering techniques"(Mathiesen 2015). Lisa Krieger writes: "The council recommended a research agenda for how to offset our release of billions of tons of carbon dioxide a year caused by the burning of fossil fuels" (Krieger 2015). Dan Kahan writes: "Last week the National Academy of Sciences made headlines by calling for stepped-up research into geoengineering" (Kahan 2015).

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[14] The Committee's first recommendation was: "Efforts to address climate change should continue to focus most heavily on mitigating greenhouse gas emissions in combination with adapting to the impacts of climate change because these approaches do not present poorly defined and poorly quantified risks and are at a greater state of technological readiness" (National Research Council 2015, 3).

The details and meaning of the research agenda vary between different articles' framings, but the majority that discussed the recommendations in detail recognized the Committee's differentiation of CDR and albedo modification. Newspaper articles varied on whether they discussed the Committee's positions regarding pursuit of CDR and/or albedo modification in detail. One or the other were commonly absent in later articles that were not specifically focused on the report.

There is room for ambiguity and differing interpretations regarding some of the report's recommendations, especially in regard to albedo modification. Nils Markusson, in his analysis of tensions in geoengineering reports, indicates there are tensions in regard to the framings of geoengineering within and between relevant reports (Markusson 2013: 4). Diversity between documents results from differing opinions and "attempts at persuasion to particular viewpoints" while ambivalence within documents "is caused by groups of authors trying to seek agreement on a text, and express a coherent framing in spite of their differences [or as] the result of trying to pre-empt or entice responses from expected and imagined audiences" (Markusson 2013: 7).

Some of this ambivalence can be seen in regard the NRC report's recommendations regarding albedo modification. The Committee's "Recommendation 3" is that "Albedo modification at scales sufficient to alter climate should not be deployed at this time," while "Recommendation 4" is that "an albedo modification research program be developed and implemented that emphasizes multiple benefit research that also furthers basic understanding of the climate system and its human dimensions" (National Research Council 2015b: 148, 152). Within the same *New York Times* article discussing the report, two scientists are quoted providing very different interpretations of the Committee's recommendations regarding albedo modification:

> David Keith, a researcher at Harvard University who reviewed the reports before they were released, said in an interview, "I think it's terrific that they made a stronger call than I expected for research, including field research." Along with other researchers, Dr. Keith has proposed a field experiment to test the effect of sulfate chemicals on atmospheric ozone. […] Dr. Keith agreed, adding that he hoped the new reports would "break the logjam" and "give program managers the confidence they need to begin funding."
>
> […]
>
> Raymond Pierrehumbert, a geophysicist at the University of Chicago and a member of the panel, said in an interview that while he thought that a research program that allowed outdoor experiments was potentially dangerous, "the report allows for enough flexibility in the process to follow that it could be decided that we shouldn't have a program that goes beyond modeling." (Fountain 2015)

These two individuals quoted, of course, represent very different positions in regard to the appropriate trajectory for albedo modification. Pierrehumbert, in the quotation above, speaks to this idea of ambivalence, which he characterizes as "flexibility."

Nevertheless, most of the news articles picked up on the NRC's reluctance and very caveated position regarding albedo modification. All but one of the articles that discussed this issue in any detail pointed to concerns and caveats couching recommendations regarding albedo modification. David Biello characterizes the research recommendation as saying "we should study up on climate interventions but focus the majority of efforts on thinning the blanket of CO_2" (Biello 2015). Scott Johnson says: "When the National Academy of Sciences report on geoengineering, released last week, looked at techniques to reflect some sunlight away from the Earth to counteract anthropogenic warming, the result wasn't exactly a glowing appraisal" (Johnson 2015). Andrew Revkin points to the report's consideration of "geoengineering prospects and concerns — the concerns mainly being about adding sun-blocking particles to the atmosphere" (Revkin 2015). Referring to the report summary, Joe Nocera states:

> The reports concluded that, while "climate intervention is no substitute for reductions in carbon dioxide emissions," the politics around carbon reduction have been so fractious that the day could well come when geoengineering was needed as part of a "portfolio" of responses to global warming. It urged further study for both methods, and, in particular, called for the establishment of a research program to examine the possible risks of solar radiation management. (Nocera 2015)

In regard to relaying the Committee's caveated position on proceeding with albedo modification research, the one exception within the corpus studied was an editorial by none other than David Keith. While other editorialists as well as journalists acknowledged the reservations the Committee signaled regarding albedo modification, Keith's framing is singular. His editorial entitled "Why We Should Research Solar Geoengineering Now" was not specifically focused on the NRC report, but it does engage with the report and claims that the NRC 2015 report, along with previous consideration by the National Academy, legitimizes and promotes field studies of albedo modification:

> Because the warming impact of carbon is more or less forever, all that we can achieve this century by cutting emissions is to stop making the problem worse. Solar geoengineering allows a more optimistic outcome. In combination with technologies to remove carbon that is already in the atmosphere, it would allow humanity to aim to restore the preindustrial climate over two human lifetimes.
>
> Despite this promise, there is little organized research on solar geoengineering. The U.S. National Academy of Sciences highlighted the potential of solar geoengineering in 1982. It delved deeper in 1990 and again in January 2015, when it recommended a broad research program and suggested that small-scale outdoor experiments could yield valuable knowledge. (Keith 2016)

Here, Keith disproportionately emphasizes a recommendation of field experiments as a takeaway from the NRC report. In the report, the Committee makes an unqualified recommendation to advance CDR research. However, its discussion around albedo modification research leaves open whether outdoor experimentation is recommended. As Pierrehumbert suggests, the reports leave room "that it could be decided that we shouldn't have a program that goes beyond modeling" (cited in Fountain 2015). Keith's editorial article lists only “small-scale outdoor experiments” for “solar geoengineering” in detailing the Committee’s recommendation for “a broad research program,” implying a mandate on outdoor experimentation from the report, which is a contestable interpretation of the Committee’s research recommendations.

As a microcosm of broader geoengineering public discourse, news articles engaging with the NRC science policy report simultaneously portray various tensions. The consideration of geoengineering prospects by preeminent research academies is used to indicate increasing legitimation of the field. At the same time, however, a sense of controversy among scientists and others within the field is emphasized in news media. Which voices receive outlet in news media is part of this, with individuals representing strong opposing positions often invoked for citations and references. Moreover, the risks and, at times, outlandishness of geoengineering proposals are highlighted. Finally, interpretation and presentation are closely linked to how writers frame relevant content, as can be seen in how various authors present the highlights and recommendations of the NRC report.

In his study of high profile geoengineering reports, Nils Markusson argues “that ambivalence, together with diversity, is key to the analysis of socio-technical imaginaries, and indicative of attempts at forging new relationships around the geoengineering imaginary” (Markusson 2013: 4). News media in repackaging viewpoints on geoengineering for public consumption, provide an extra layer of potential ambivalence and diversity of considering the geoengineering imaginary. Through their presentation, news media reinforce and legitimize certain geoengineering narratives but can also reshape them in the process. In grappling with some of the nuance and ambiguities involved on reporting on an nascent, evolving, and contested field that exists largely in theory as opposed to material manifestations, new strands of “ambivalence” or “diversity” emerge in regard to the socio-technical imagination of geoengineering.

Conclusion

Through in-depth analysis of a broad corpus of news media, this study contributes a further depth of understanding to public discourse of geoengineering as understood through the core artifact of written media treatment of the topic. News articles have both represented and articulated increased attention and interest in geoengineering, particularly in the ten-year period of 2006-2016. The move of geoengineering consideration from “fringe” to mainstream, coinciding with key documents within the field itself (particularly Crutzen’s 2006 article, the Royal Society’s 2009 report, and the NRC’s 2015 report), is paralleled by the news coverage of it.

As discussed, news media presentation of geoengineering includes a filtering through of scientific rhetoric and discursive framings that originated within the scientific community, such as from the statements of scientists or science policy reports. In addition to curating and repackaging scientific discursive framings and narratives for public consumption, journalistic media also insert their own framings and presentation styles that affect how the concepts are portrayed. As discussed in this chapter, the trends seen in journalistic articles on geoengineering include, for example, an emphasis on controversy as well as directing attention to “decoy” geoengineering proposals. While driven, in part, by substance (i.e., geoengineering *is* controversial), the ways in which these framings and presentation styles are used, reflect broader trends in journalism, such as the tendency to present two sides of a debate, emphasizing points of contention, or the journalistic intrigue that comes from emphasizing the more sensational elements of a technological field. Through both the particular relaying of scientific discursive framings as well as through journalistic framings and styles inherent to the genre, the ways in which general audience media present geoengineering affect the public discourse on the topic, including how the concepts are introduced to new audiences.

As this chapter has shown, there exist multiple tensions within the public coverage of geoengineering. First, news media emphasize both the purported legitimation of the field while at the same time highlighting a sense of controversy within and surrounding it. In this coverage, certain voices are more influential than others, as seen in journalistic trends favoring citation of particular geoengineering experts and commentators. General audience discourse in news media also highlight the extreme inherent risks and, at times, absurdities, of proposed technologies. Some of these extreme options act as decoy proposals within an implied range of options that facilitate honing in on more favored proposals. While, on the one hand, emphasizing absurdity and risk of geoengineering proposals, on the other hand, media often indicate that the failure of mitigation is paving the way for geoengineering. Moreover, while generally recognizing the importance of continued mitigation efforts, as articulated by climate experts including geoengineering advocates, popular media can falsely imply geoengineering exists as a mitigation alternative.

In addition to these original findings, this research expands upon existing understandings of how metaphors can be used toward various framings in geoengineering discourse. While reaffirming some findings of other studies, the present discursive study both expands upon and deepens the scope of analysis through contextual consideration of such metaphors in a broad corpus. Furthermore, the element of analogies to existing technologies is appended to the conceptualization of metaphors in geoengineering discourse.

News media publications of geoengineering, of course, encompass a broad range of voices, vantage points, opinions, framings, and highlighted facts. Notwithstanding the challenges of assimilating the disparate themes inherent in such a wide range of reporting and editorializing on the topic, through in-depth discourse analysis of a broad range of articles within the universe of geoengineering-focused news articles, this study has aimed to contribute toward better illuminating the ways in which this potentially world-changing technology is presented to the public.

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CHAPTER 4 — Geoengineering in the Political Sphere: Congressional Hearings, 2009 - 2017

Introduction to U.S. Congressional Hearings on Geoengineering

The United States House of Representatives includes 20 standing committees, and numerous sub-committees therein. Each committee "considers bills and issues and recommends measures for consideration by the House" (United States House of Representatives 2017). Among their activities, committees "frequently hold hearings to receive testimony from individuals not on the committee" (Office of the Clerk 2018). According to the U.S. Government Publishing Office (1999), the purpose of congressional hearings is "to obtain information and opinions on proposed legislation, conduct an investigation, or evaluate/oversee the activities of a government department or the implementation of a Federal law. In addition, hearings may also be purely exploratory in nature, providing testimony and data about topics of current interest."

The United States Congress held four hearings on the topic of geoengineering between November 2009 and November 2017. These hearings were before the U.S. House of Representatives Committee on Science and Technology, later reconstituted as the Committee on Science, Space, and Technology, as well as constituent subcommittees on Energy and Environment (see Table 4.1). Each hearing considered a specific aspect of geoengineering. The first hearing in November of 2009 was entitled: "Geoengineering: Assessing the Implications of Large-Scale Climate Intervention." The second hearing occurred in February of 2010 and was entitled: "Geoengineering II: The Scientific Basis and Engineering Challenges." The third hearing occurred soon thereafter, in March of 2010, and was entitled: "Geoengineering III: Domestic and International Research Governance." After a significant time-gap, the fourth hearing occurred in November of 2017, entitled "Geoengineering: Innovation, Research, and

Technology." See Table 4.1 for an overview of some relevant details relating to the four geoengineering hearings. These four hearings make up the corpus of material for the analysis in this chapter.

Table 4.1: Overview of U.S. House of Representatives hearings on the subject of geoengineering

Hearing Title	Date	Convening body	Presiding Chair	# Witnesses	# Members
Geoengineering: Assessing the Implications of Large-Scale Climate Intervention	Nov. 5, 2009	Committee on Science and Technology	Bart Gordon (D-TN)	5	11
Geoengineering II: The Scientific Basis and Engineering Challenges	Feb. 4, 2010	Subcommittee on Energy and Environment (of the Committee on Science and Technology)	Brian Baird (D-WA)	4	3
Geoengineering III: Domestic and International Research Governance	Mar. 18, 2010	Committee on Science and Technology	Bart Gordon (D-TN)	5	4
Geoengineering: Innovation, Research, and Technology	Nov. 8, 2017	Subcommittee on Environment and Subcommittee on Energy (both of the Committee on Science, Space, and Technology)	Andy Biggs (R-AZ)	4	11

Video recordings of all four hearings were carefully reviewed along with relevant written materials. The hearing videos, uploaded by Congress, are available for viewing through YouTube. (Last accessed April 7, 2018.) The official record for the first three hearings includes transcripts of hearing testimony as well as written statements and other documents submitted for the public record. At the time of writing, the written record for the November 2017 geoengineering hearing had not been released, although select written materials were available, such as the hearing charter and written statements by the witnesses. Page numbers are included in citations of quotes drawn from the written material of the official record, including transcripts of hearing testimony, but obviously not for quotations transcribed directly from the video recordings. The research process included close readings of the written materials and viewings of the hearing videos, transcribing select sections of the fourth hearing, memoing for all hearings, tracking themes, topics and actors within written materials using Nvivo, and creating spreadsheets to track data of relevant attributes and positions stated for all witnesses and participating committee members at the four hearings.

The panels for the four hearings were comprised of four or five testifying witnesses with experience in various aspects of geoengineering research. Each of these panels included two to four witnesses from academic institutions in addition to one or two affiliated with either a national laboratory or a think tank. The March 2010 hearing supplemented this witness pattern with one representative from the Government Accountability Office (GAO) and the unique inclusion of a member of Parliament from the House of Commons in the United Kingdom, as there was a joint inquiry on geoengineering between the counterpart science committees in the U.S. House of Representatives and the U.K. House of Commons. Table 4.2 provides a detailed list of panelists. In terms of committee member participation, as seen in Table 4.1, the first and the fourth hearings each included statements or questions from eleven congressional representatives, while the second and third hearings were sparsely attended and included statements and questions from three and four congressional representatives respectively.

External factors beyond the scope of the Committee influence the attendance, course and progression of these events. As Hugh Mehan pointed out in his study of “social structure and power as an interactional process” within schools, “circumstances which originate outside the institution [“distal circumstances”] interact with circumstances which originate within it [“proximal circumstances”] to influence the course of interaction and the work of the formal organization” (Mehan 1987: 291, 293). Such distal and proximal circumstances also affected the proceedings and interactions studied within these congressional hearings. As will be discussed further, political disagreements external or tangential to the specific subject matter of the hearings influenced the interactions within the geoengineering hearings. Furthermore, completely separate policy issues that overlapped temporally with these congressional hearings affected the proceedings, competing for time and attention of members of Congress. Particularly, votes and political debates taking place within the House on other topical matters affected attendance and performance at the geoengineering hearings.[15]

When votes were scheduled to occur in the House of Representatives, the hearings were, of necessity, more rushed so that the members could leave to cast their votes. The Committee Chair’s time management of the hearing proceedings was clearly affected by the voting schedule. For example, partway through the first hearing (Congressional Hearing 2009a), Chairman Gordon declared: “I am going to be a little more strict because we are going to votes, unfortunately, in a few minutes” to which congressional member Ehlers replied: “It is so amazing how the clock runs so much faster when it is my time.” At the second hearing (Congressional Hearing 2010a), because of timing of votes conflicting with the timing of the hearing, the witnesses were introduced and some statements were made before the hearing was

[15] For instance, the first three hearings occurred during a critical period related to the major congressional issue of the time, healthcare reform. The first House Committee on Science and Technology hearing on the topic of geoengineering occurred the week that the House was debating and voting on the Affordable Care Act (ACA). The third hearing occurred the week that Congress was voting to reconcile the House and Senate versions of the ACA.

officially called to order, with opening verbal statements foregone (written statements were submitted into the record). An hour recess was held in the middle for votes.

The third hearing (Congressional Hearing 2010b) was also affected by votes, with the witnesses being warned multiple times that imminent voting may necessitate a recess or conclusion of the hearing. During witness questioning, Chairman Gordon's questions were affected by this external time constraint. Chairman Gordon asked the panel their thoughts on "what agency or agencies would be the appropriate vehicles for this type of research" (Congressional Hearing 2010b). However, after one panel member responded to this question, Chairman Gordon interjected to say: "We are being called for votes, so let me just ask, I would assume everyone concurs with that, unless you have a suggestion of something specific. Otherwise, is there anyone that has anything else?" (Congressional Hearing 2010b). As it turned out, the other three members of the panel did all want to respond to the original question regarding agencies and were allowed to make brief statements, after which Chairman Gordon ended the hearing, stating: "As I said, we, our votes are on their way right now, so let me thank all of our witnesses for being here…" (Congressional Hearing 2010b). As demonstrated here, external factors and constraints affected the course of the hearing and in this example limited a discussion that may have continued had there been additional time.

This set of four hearings provides an opportunity to examine discourse in interaction, including the presentation and reception of geoengineering narratives and framing between two categories of elite actors, scientists and congressional representatives. The witnesses, mostly scientists with significant experience researching geoengineering concepts, provide testimony. The congressional committee members receive the same testimony differently with clear divisions of interpretation between Committee members, especially along party lines, but with some variance and change over time. Consistent with the trends found within other genres of social discourse on geoengineering, the increasing mainstreaming over time of geoengineering as a serious consideration is observable within the progression of these four congressional hearings that occur over an eight-year period. Of course, this setting of policy-makers considering geoengineering not only reflects views on the topic, but is intended, as per the purpose of congressional hearings, to affect the trajectory of policy on it.

Premises Articulated for Geoengineering and the Congressional Hearings

As discussed in the previous chapters of this dissertation, as well as in other studies (e.g., Bellamy 2013; Corner, Parkhill and Pidgeon 2011; Nerlich and Jaspal 2012), two central framings within geoengineering discourse are the emergency/catastrophe framing and the insufficiency of mitigation framing. These two framings were clearly identifiable within the charter for the first geoengineering hearing, which articulated the premise for both the hearing and for geoengineering as a possible response to climate change (Congressional Hearing 2009a). For example, the charter stated: "many in the international climate community hold that even the most aggressive achievable emissions reductions targets will not result in the avoidance of adverse impacts of climate change and ocean acidification" (Congressional Hearing 2009a: 4). It continued on to say: "Further complicating these projections is the possibility of non-linear, 'runaway' environmental reactions to climate change. Two such reactions that would amount to climate emergencies are rapidly melting sea ice and sudden thawing of Arctic permafrost" (Congressional Hearing 2009a). Thus, per the charter: "It is for these reasons that geoengineering activities are considered by some climate experts and policymakers to be [a] potential 'emergency tool' in a much broader long-term and slower acting global program of climate change mitigation and adaptation strategies" (Congressional Hearing 2009a). In this way, the premise of geoengineering and of the hearings on it were thus defined by the common narratives of insufficient mitigation and climate "emergency."

The initial hearing charter also engaged with the notion that geoengineering has recently moved toward mainstream consideration. The charter stated: "Scientific hypotheses resembling geoengineering were published as early as the mid 20th century, but serious consideration of the topic has only begun in the last few years" (Congressional Hearing 2009a: 4). This assertion of geoengineering now being subject "serious consideration" presents it as an appropriate topic for the committee's consideration, which in itself signifies a step in the direction of mainstreaming. Moreover, a list of respected mainstream organizations that have given attention to the idea of geoengineering is used as evidence of its move from obscurity to mainstream consideration. This list, underscoring legitimate ("serious") consideration of geoengineering, includes the National Academy of Sciences, the Intergovernmental Panel on Climate Change, the U.S. Department of Energy, NASA, DARPA, the NSF, and the Royal Society (Congressional Hearing 2009a: 4-5). In this way, there is a circular process snowballing the assertion that geoengineering is now mainstream based upon the elite institutions examining it, as each new institution points to those before it to justify the seriousness of the topic. Following these hearings, the House Committee on Science and Technology itself could be added to this list of elite institutions indicating legitimacy of geoengineering through their engagement with the topic.

In addition to introducing geoengineering concepts and explaining the premises for their consideration, the hearing charter background section explored various risks and challenges that would be involved with potential geoengineering. It drew significantly on the Royal Society report, which, as discussed, was the definitive geoengineering report to date in 2009. Like the science policy reports, this initial charter advocated research but raised caveats regarding deployment. It drew comparisons to nuclear weapons testing and the history of weather modification attempts as “Analogous Government Initiatives” characterized by significant risks and uncertainties, stating these technologies “display a number of similarities to geoengineering, including the difficulties of levying cost-benefit analyses of their impacts, uncertain ecological impacts, an unknown geographic scope of impact, and potential intra- and intergovernmental liability issues” (Congressional Hearing 2009a: 9). The nuclear testing and weather modification analogies were used as examples of precedential government initiatives that constitute domestic technological programs with international repercussions “incurred without international consent” (Congressional Hearing 2009a: 9).

In Chairman Bart Gordon’s opening statement at this first hearing, he specified that his decision to hold the hearing did not indicate “an endorsement of any geoengineering activity” but said that the topic “requires very careful consideration” as a potential “stopgap” measure or response to “a climate emergency” (Gordon, Congressional Hearing 2009a: 11-12). Chairman Gordon stated: “We must get ahead of geoengineering before it gets ahead of us, or worse, before we find ourselves in a climate emergency with inadequate information as to the full range of options” (Gordon, Congressional Hearing 2009a: 12). As exemplified in Chairman Gordon’s statement, at these hearings, consistent with other genres of geoengineering discourse discussed in the previous chapters, the catastrophe/emergency framing and the stop-gap/buy-time framing are two primary narratives used in support of geoengineering research and consideration. However, like science policy reports, he also emphasized that “nothing should stop us from pursuing aggressive long-term domestic and global strategies for achieving deep reductions in greenhouse gas emissions” (Congressional Hearing 2009a: 11-12). For the most part, this set the tone for the Democrat Committee members' discussion of geoengineering, which evolved somewhat over time but without ever losing this core duality of open but cautious consideration of geoengineering paired with a reiteration of the primacy of mitigation. As will be discussed, it is also closely aligned with the core messages of the witnesses who provide testimony at the four hearings. In contrast, the Republican position on geoengineering, as will be shown, makes a more dramatic transition over time.

An interplay of structural elements, external factors, and specific performances of politicians and witnesses, the four congressional hearings on geoengineering varied in content, tone, and participation, but all within the confines of certain institutionalized expectations. Despite the broad range of participation by Committee members, varying from three to 11 participating members, the formal elements of congressional hearings were steadfastly observed, with members invariably stating "Thank you, Mr. Chairman" as they began their timed five-minute periods for opening statements or (ostensibly) to ask questions of the witnesses or to formally request certain documents be included in the official record.

Other elements of the hearings, including partisan performances, were less formal, although no less entrenched. The Democratic members of the Committee reiterated at each hearing the existence of anthropogenic climate change and the primacy of mitigation and adaptation in addressing it. Certain Republicans displayed an opposing performance, questioning the importance or relevance of anthropogenic climate change, while others in the latest hearing adopted a strategy of decoupling geoengineering from climate change to minimize the cognitive dissonance of a certain enthusiasm for solar geoengineering irrespective of the party position on climate change. Within the structure of the hearings, politicians tried to claim the framing and representation of the issues being discussed. In the example of the most recent geoengineering hearing (November 2017), each Democrat reiterated the importance of prioritizing mitigation and adaptation, while (often reluctantly) accepting the premise of geoengineering research. In contrast, at this hearing, each Republican tried to distance their support of geoengineering technology from the problem of climate change it is meant to address, with no Republicans referencing mitigation or adaptation.

In articulating the purpose of the hearing, Committee Chairman Andy Biggs' opening statement to the fourth hearing in November 2017 explicitly specified: "The purpose of this hearing is to discuss the viability of geoengineering… the hearing is not a platform to further the debate about climate change; we've had lots of that this session" (Congressional Hearing 2017b). Since geoengineering is intricately related to climate change, it would not be expected that the two could be separated. Yet, during this hearing, Biggs and his fellow Republican members noticeably avoided the topic of "climate change," with most Republicans avoiding the concept and term entirely or obfuscating the concept when it could not be avoided. For example, Randy Weber, a Texas Republican and the chair of the Energy Subcommittee, enthused over the "bright" prospect of geoengineering while obfuscating its relationship to climate change. In his opening remarks to this hearing, he paused for a moment before clearly enunciating a demarcation between the topics of geoengineering and climate change:

> *If we put aside the debates about climate change,* we can support innovations in science that create a better prospect for future generations. The federal government should prioritize *this* kind of basic research, so we can not only understand the science of geoengineering, but hopefully partner with the private sector to develop technology to mitigate changes in climate. When the government supports basic research, everyone has the opportunity to access the fundamental knowledge that can lead to the development of future technologies. The future is bright for geoengineering. (Congressional Hearing 2017, italics based on verbal emphasis)

Within this statement, two conflicting elements coexist: advocacy for pursuit of geoengineering alongside a dismissal of the relevance of climate change upon which geoengineering is premised.

Weber suggests that geoengineering may be an area of political agreement under the condition that it is separated from climate change. By stating, “If we put aside the debates about climate change,” Weber proposed decoupling of geoengineering from climate change while at the same time perpetuating the partisan argument that there are “debates” regarding the existence of climate change (Congressional Hearing 2017b).

By contrast, the ranking Democratic member of the Committee at this hearing, Suzanne Bonamici of Oregon, couched her opening statements in terms of the importance of addressing climate change, emphasizing that mitigation and adaptation must be the first avenues irrespective of geoengineering: “Even with geoengineering, our first and primary actions to address climate change must be mitigation and adaptation strategies” (Congressional Hearing 2017b). Bonamici, like other Democrats on the Committee, reiterated the existence of anthropogenic climate change: “Our climate is changing and the warming trends observed over the last 100 years are primarily caused by human activities, specifically the emission of greenhouse gases. In fact, this is one of the most prominent findings in the Climate Science Special Report [Fourth National Climate Assessment, a government report released November 2017, shortly before this hearing occurred]. This report unequivocally lays out the need to reduce carbon dioxide emissions to prevent long term warming and short term climate change” (Congressional Hearing 2017b). This reiteration of basic facts of anthropogenic climate change is recurrent among Democrats on the committee.

Also at the fourth hearing, Marc Veasey, a Democrat from Texas, made the seemingly unequivocal statement in his opening remarks that: “Despite the numerous claims, geoengineering is not the answer to 150 years of polluting our planet at an unsustainable rate […] we have to get our priorities straight and mitigation and adaption must be part of the top priorities" (Congressional Hearing 2017b). Yet, despite this position, he came around to the pursuit of geoengineering, stating: "The long-term nature of this challenge [climate change] is the reason we need to investigate every possible solution in addition to implementing mitigation and adaptation strategies" (Congressional Hearing 2017b).

Jerry McNerney, Democrat from California, has been one of the strongest supporters of congressional consideration of geoengineering. McNerney advocated for holding the November 2017 hearing and subsequently, in December 2017, introduced a bill in support of geoengineering research to Congress. His bill, H.R. 4586, the Geoengineering Research Evaluation Act, "would provide for a federal commitment to the creation of a geoengineering research agenda and an assessment of the potential risks of geoengineering practices" (McNerney 2017).

Within the hearing, like his Democratic colleagues, McNerney reiterated facts of anthropogenic climate change: "Climate change is happening and the effects are accelerating faster than the scientific models predict… meanwhile carbon concentration in the atmosphere is continuing to increase" (Congressional Hearing 2017b). Also like his colleagues, McNerney reiterated the importance of mitigation and adaptation: "no matter what, it is absolutely critical to reduce carbon emissions and prepare for the changes coming" (Congressional Hearing 2017b).

In addition to reiterating the importance of mitigation and adaptation, McNerney also employed a very clear use of the catastrophe framing in support of research toward geoengineering (Congressional Hearing 2017b). In articulating his reasoning regarding geoengineering, McNerney implicitly referenced the challenge of latency in regard to greenhouse gases (GHGs), which includes the lag-time between GHG emissions and climatic effects from them and the fact that GHGs persist in the atmosphere for long time periods. He stated: "we are committed to significant change. The unknown is how much change we are committed to and how fast it will take place. It is not known if we are committed to truly catastrophic change with the current policies or not." He then laid out geoengineering as a tool for addressing potentially catastrophic climatic changes: "the changes we are committed to may be so strong that we need to know what can be done to prevent utter catastrophe" (Congressional Hearing 2017b).

Similarly, at an earlier hearing, Brian Baird, Democrat from Washington, combined the narratives of the primacy of emissions abatement with catastrophe and Plan B framing. Baird stated "Without question, our first priority is to reduce the production of global greenhouse gas emissions. However, as I said, if such reductions achieve too little, too late, there may be a need to consider a plan B" (Congressional Hearing 2010a).

Democrats within the Committee, reflecting the role of their Party more broadly in government and consistent with the Democratic Party's 2016 platform, took on the role of vigilant reiteration of the reality and significance of climate change and promoting mitigation and adaptation policy. Despite a reluctance among Democrats to show enthusiasm for geoengineering, the internal logic of their position on climate change and the evident frustration expressed by some members regarding the failure to enact meaningful mitigation policy, allowed an opening for the notion succinctly put by Marc Veasey, as mentioned above, that "we need to investigate every possible solution in addition to implementing mitigation and adaptation strategies" (Congressional Hearing 2017b) Perhaps more surprising is the recent embracing of geoengineering by those Republicans who simultaneously dispute the importance of climate change. Yet this follows a trend of other erstwhile climate change deniers becoming geoengineering advocates (Hamilton 2013: 76-7, 85, 98-9, 129). To reconcile the paradox requires a redefining of geoengineering.

The official records for the first and third hearings characterized geoengineering as "the deliberate large-scale modification of the earth's climate systems for the purposes of counteracting climate change" (Congressional Hearing 2009a; Congressional Hearing 2010b). At the fourth hearing, Suzanne Bonamici, the ranking Democrat on the Committee, defined geoengineering as follows: "Geoengineering is a set of climate interventions that aim to manipulate our climate, to either remove greenhouse gases from the atmosphere or reduce the amount of sunlight absorbed by the Earth" (Congressional Hearing 2017b). She then proceeded to contextualize it in relation to other climate change policy options: "Now some may argue that geoengineering is a way to use technology to bypass important mitigation and adaptation strategies that address the impacts of climate change, but even with geoengineering, our first and primary actions to address climate change must be mitigation and adaptation strategies" (Bonamici, Congressional Hearing 2017b). By contrast, Chairman Andy Biggs, a Republican from Arizona, stated: "In its simplest terms, geoengineering is the concept of using scientific understanding to alter the atmosphere in a way that produces positive outcomes and results" (Congressional Hearing 2017b). In this way, he defined geoengineering without reference to climate change. This redefining of geoengineering allowed for Biggs and other Republican members of the committee to support geoengineering without acknowledging or accepting climate change.

This constituted a remarkable shift from the earlier hearings on geoengineering to the most recent one. The first three hearings each included at least one Republican Committee member rejecting geoengineering in absolute terms, in relationship to the rejection of climate change. The fourth hearing in November 2017, however, despite having a high degree of participation with as many Republicans speaking as at any of the hearings, included no statements of absolute rejection of the pursuit of geoengineering. This change is facilitated by recasting geoengineering to be defined without reference to climate change. It also portrays a manifestation of the trajectory of geoengineering toward mainstream consideration as has occurred in the eight-year period between the first and fourth hearings.

Forms of Skepticism Enacted at Geoengineering Hearings

In the first three hearings, Republican rejection of climate change science and geoengineering technologies were exhibited by way of two distinct styles. Dana Rohrabacher, a Republican from California, represented one extreme style of rhetorical expression, characterized by adversarial statements and hostile questioning of the witnesses. At each of the first two hearings, Rohrabacher enacted a sort of script that he and his colleagues indicated had come to be expected of him at climate related hearings. The repetition of a script is suggested by the way in which Rohrabacher opened his allotted speaking time at the first of the geoengineering hearings: “Thank you very much, Mr. Chairman, and no hearing like this would be fulfilled without my adding a list at this point of 100 top scientists from around the world who are very skeptical of the very fact that global warming exists at all, but I would like to submit that for the record at this time” (Congressional Hearing 2009a). By stating that “no hearing would be fulfilled without” his introducing skepticism regarding the existence of climate change, Rohrabacher suggested that he regarded this as his primary role within such proceedings.

After submitting his list, he went on to question geoengineering based upon his questioning of climate science:

> There you go. Let me just note that there is ample reason for us to question whether or not things that are being suggested today are really needed because there is reason to question whether there is global warming, considering the fact that it has gotten—it is not gotten warmer for the last nine years, and the Arctic

> polar cap is now refreezing for the last two years. But that argument isn't what today's hearing is about, so I will just make sure that that is on the record and in people's minds when looking at some of these suggestions. (Congressional Hearing 2009a)

Rohrabacher's treatment of climate change follows the pattern, identified by Oreskes and Conway (2010), of sowing doubt regarding climate change through indicating a continuance of debate over its existence and questioning climate science especially through emphasizing the existence of (normal) scientific uncertainty, as discussed in Chapter One of this dissertation. At each of the hearings attended by Rohrabacher, this form of contesting the veracity of climate change and submitting the list of climate skeptics, was followed by adversarial interactions with the witnesses, in which he focused on problematizing the existence of climate change and mitigation concepts.

During the first hearing, the witnesses seemed taken aback by the line of questioning and attempted neutral responses steering the discussion back to the topic of geoengineering. Early in his questioning during this first hearing, Rohrabacher reacted negatively when Alan Robock corrected an inaccurate statement that Rohrabacher had made. This led to hostile questioning from the Representative and a response from Robock in which he attempted to answer the questions based on scientific knowledge and practical considerations despite the shift from information-gathering toward antagonistic questioning:

> Mr. ROHRABACHER: Let me ask about some of the specific suggestions. I… understand at 9/11 when they grounded all the airplanes that it actually increased the temperature of the planet, is that right? And thus——
>
> Dr. ROBOCK: Excuse me, that is not correct.
>
> Mr. ROHRABACHER: It is not correct?
>
> Dr. ROBOCK: There was one study that showed that without clouds from contrails that the diurnal cycle of temperature went up, that the daily temperature went up, the nighttime temperature went down, but that was later disproven. It

> was shown that was just part of natural weather variabilities. So that wasn't a very—
>
> Mr. ROHRABACHER: Let me note that every time it doesn't fit into the global warming theory, it becomes natural variability but when it does fit in, it becomes proof that there is global warming. Let me ask you this. That really wasn't then? Does anyone else have another opinion of vapor trails, by the way? So we have learned today that we really just have—and am I misreading you by suggesting that you, too, are part of the group that believes in global warming that would like to restrict air travel or try to find ways of eliminating frequent flyer miles? We know you don't want us to eat steak now. Are we also not going to be able to fly on airplanes?
>
> Dr. ROBOCK: Airplanes are one of the sources of emissions. If they use biodiesel and it recycles the fuel, then it wouldn't be part of the problem. But indeed, if we—we can do some emissions of CO_2. We don't have to—these mobile transportation sources are very hard to retrofit on airplanes. With cars, you can, of course, generate electricity with wind and solar, but airplanes, we still have to keep flying and we can live with a little bit of CO_2 emission if we deal with other sources. (Congressional Hearing 2009a)

This interaction began with Rohrabacher starting down a line of argumentation, which seemed to be aimed at challenging the concept of albedo modification. This challenge was based upon the notion that planes being grounded in response to the events of 9/11 led to increased temperature rather than decreasing it. If it were true that temperatures increased in response to the anomalous reduction in contrail emissions in the stratosphere, it would seem to challenge the premise of proposed forms of albedo modification, particularly stratospheric aerosols. However, before Representative Rohrabacher was able to articulate his argument, Dr. Robock interjected to clarify the scientific findings that he presumed were being used to inform Rohrabacher's claims and to indicate that these findings, and hence the premise of Rohrabacher's line of argumentation, had since been debunked, based on further scientific research. Drawing upon Stephen Toulmin's (1958) schema for analyzing argumentation, Robock challenged Rohrabacher's "claims" through problematizing his "grounds" for "warranting" those claims.

Being waylaid from his argument, Rohrabacher turned back to his original argument disputing climate change, despite having just indicated that he would move on from this line of argumentation because “that argument isn’t what today’s hearing is about” (Congressional Hearing 2009a). He, however, did return to it in the form of ad hominem attacks upon the panelist, with an accusatory tone when stating, “you, too, are part of the group that believes in global warming that would like to restrict air travel.” While Alan Robock certainly believes in climate change and in the need to reduce carbon emissions, the tone and context of the communication was one of accusation. Following this, the representative ended with a seemingly rhetorical question (“Are we also not going to be able to fly on airplanes?”), which Robock forbearingly answered as if the question were genuinely of the information-gathering variety, referring to which modes of transportation are practical for decarbonization and conceding that air travel may be an exception to emissions abatement (Congressional Hearing 2009a).

In this interaction, after being thwarted from one line of argumentation, rather than pursuing rebuttal, Rohrabacher turned to questioning the legitimacy of climate scientists as a premise for questioning their authority. The representative suggested that Robock and other climate scientists are arbitrary in use of evidence and in distinguishing between natural weather variability and climate change. Following this statement, Rohrabacher proceeded to suggest that Robock is part of a group campaigning against air travel, although he did not articulate any particular grounds to warrant the claim. In these ways, Rohrabacher’s rhetorical strategy seemed aimed at discrediting and denying Robock’s neutrality and objectivity by implying some sort of ulterior motive underlying the climate scientist’s statements on climate trends and the importance of mitigation. This constituted a direct challenge not only to Robock’s statements but to his integrity as a witness and as a professional scientist. Robock answered in a measured way, stating facts and not directly responding to the discrediting attack on his professional authority and integrity. Rather, he maintained a professional tone, giving scientifically-grounded, fact-based responses to the ostensible questions asked. Through projecting the demeanor of an impartial and unflappable scientist, Robock implicitly reasserted his credibility of scientific authority in response to its being rhetorically challenged by Representative Rohrabacher.

At the same hearing, following this exchange with Robock, there was a similar interaction between Representative Rohrabacher and Ken Caldeira. As discussed in the previous chapter, climate scientist Ken Caldeira is a prominent and oft-cited geoengineering researcher. Rohrabacher's interaction with Caldeira again exemplifies the congressional member's approach to disputing the relevance of anthropogenic climate change from multiple angles and returning to the issue of his disapproval of actual or perceived suggestions that lifestyle changes may be necessary:

> Mr. ROHRABACHER: […] there are those who have realized—in the past there have been many times when that CO_2 content was enormously greater, wasn't that right? And during that time period there were lots of animals, like dinosaurs and lots of things growing, and the world seemed to be doing pretty good.
>
> Dr. CALDEIRA: CO_2 concentrations were high in the past, and the biosphere flourished. And even if we disagree about what the threats are from climate change, and I think we do, that, you know, I don't think my house is going to burn down, but I buy fire insurance. And——
>
> Mr. ROHRABACHER: But you don't tell your neighbor that he can't have steak or visit his kids in an airliner, and that is the point.
>
> Dr. CALDEIRA: I don't——

Internally inconsistent with another claim, which he made at both this first hearing as well as the second hearing that the "tiny, miniscule amount" of CO_2 in the atmosphere may not have "anything to do with the changes in the climate" (Congressional Hearing 2010a), here Representative Rohrabacher referenced the age of the dinosaurs presumably to argue that higher

CO_2 may not be a bad thing, but rather beneficial. When Caldeira tried to redirect the dialogue back to geoengineering with the house insurance statement, Rohrabacher pivoted that analogy back to his contention regarding climate change mitigation, couched in second-person language ("you don't tell your neighbor that he can't have steak or visit his kids in an airliner"). The dialogue, diverted toward this question of lifestyle changes, continued like this:

> Mr. ROHRABACHER: There are going to be changes. People have to understand, there are going to be huge changes in our lifestyle——
>
> Dr. CALDEIRA: I don't——
>
> Mr. ROHRABACHER: —if this nonsense is accepted.
>
> Dr. CALDEIRA: I don't believe we are going to solve this problem by asking people to behave differently.
>
> Mr. ROHRABACHER: Okay.
>
> Dr. CALDEIRA: I think we are going to solve it by improving the systems that surround us. But to get back to my point, even if we don't believe that climate change will damage us, we have to say there is some risk. So then we have to say, well, how much should we invest to try to mitigate that risk.
>
> Mr. ROHRABACHER: We are broke right now, and the bottom line is that we have very little to invest in theories that may or may not be correct, and we also have a lot of indication, just the fact that you are using the word climate change is a difference than what was used 10 years ago which was global warming. And most of us realize that is because people now are trying to hedge their bets so they can have these controls, whatever way the temperature goes.
>
> Dr. CALDEIRA: No, I don't think that is true. You know——
>
> Chairman GORDON: Time.
>
> Mr. ROHRABACHER: Thank you very much.
>
> Chairman GORDON: Speaking of dinosaurs, the time for Mr. Rohrabacher has run out, and we will need to proceed to——
>
> Mr. ROHRABACHER: Thank you, Mr. Chairman. (Congressional Hearing 2009a)

In this interaction, Representative Rohrabacher repetitively interrupted the expert witness and used antagonistic language to dispute climate change, referring to it as “nonsense” and “theories that may or may not be correct” (Congressional Hearing 2009a). Moreover, this language is emblematic of the climate denial strategies introduced in Chapter One, including sowing doubt regarding the veracity of climate change itself (see Oreskes and Conway 2010).

The designation of climate change as “theory” (let alone “nonsense”) rather than “fact” is an important rhetorical move in making political space for alternative theories. It mirrors the rhetoric of anti-evolution creationism or “creation science” which insists that evolution is “only a theory” and therefore creationism should also be taught in science classes. In response to this line of argumentation, Stephen Jay Gould eloquently articulated: “evolution *is* a theory. It is also a fact. And facts and theories are different things, not rungs in a hierarchy of increasing certainty. Facts are the world’s data. Theories are structures of ideas that explain and interpret facts. Facts do not go away when scientists debate rival theories to explain them” (Gould 1981). Likewise, understanding and attempting to forecast the complex, multivariate interactive processes involved with climate change involves theories employing factual data. Climate scientists model various scenarios that may play out more or less accurately, but, in either case, the imperfections and uncertainties involved in modeling do not undermine the validity of the facts on which they are based. However, this denialist argument instantiated by Rohrabacher is based upon discrediting climate change on this basis.

Furthermore, Rohrabacher’s statements implied that proponents of climate mitigation policies employ deception (i.e., by changing terminology) to “hedge their bets” toward an end goal of emissions controls, although he did not articulate what interests he believed would underlie pursuit of emissions controls apart from climate mitigation (Congressional Hearing

2009a). The emission controls that he spoke of directly are those that fall into the category of lifestyle changes. In his interactions with both Robock and Caldeira, Rohrabacher rhetorically accused them of having an agenda to require some form of lifestyle changes, with the implication that this would be a suspect position to hold. In each of these two interactions, the respective scientists were speaking generally of climate science or the potential role of geoengineering, when the congressional representative insinuated that they had a personal agenda to change people's lifestyles. While Robock conceded that lifestyle components were one element of GHG mitigation (in discussion of reducing beef consumption), Caldeira indicated that he considered systems as more important than lifestyles for mitigation. In either case, these interactions demonstrate Representative Rohrabacher's multi-faceted argumentative approach toward challenging the existence of climate change through employing various rhetorical and discursive strategies, including calling into question climate science itself as well as the authority and objectivity of the climate scientist witnesses by implying they have a hidden agenda.

In both of these interactions, congressional member Rohrabacher made clear that one of his primary contentions with climate change was that addressing climate change would affect "our lifestyle," such as meat consumption and air travel (Congressional Hearing 2009a). Whereas during the later 2017 hearing prominent Republicans known for disputing climate change embraced SRM as an option for bypassing lifestyle changes relevant to emissions abatement, Rohrabacher's 2009 position was demonstrative of absolute climate change denial with internal consistency in its translation to dismissing geoengineering *prima facie*.

During the second hearing, the witnesses seemed more prepared for Rohrabacher's style of questioning and pushed back, disputing each of the representative's arguments, until Rohrabacher himself ended the discussion by stating that his time was up. Emphasizing the repetitive nature of Rohrabacher's performance, the response of the witnesses was commented upon by both the Democratic Subcommittee Chair and the Republican ranking member. Chairman Baird, Democrat from Washington, commented: "I thank the gentlemen for their responses and want to commend you. Some of the arguments that Mr. Rohrabacher has made have been offered previously to panels of climate scientists without response, and I commend you for the response" (Congressional Hearing 2010a). Republican ranking member from South Carolina, Bob Inglis, also commented: "I am with Chairman Baird, I thank you for answering the question because quite often those questions do go— or those assertions go unchallenged and so very cogent explanation there" (Congressional Hearing 2010a).

These comments speak to Rohrabacher's performance, with the elements repeated in both of the first two geoengineering hearings but with different results in interaction with the witness panel, being a common and expected pattern. While Rohrabacher did not attend the subsequent two geoengineering hearings, at other hearings relevant to climate, including one later in the same congressional session entitled "Monitoring, Measurement, and Verification of Greenhouse Gas Emissions," Rohrabacher also enacted the rhetoric of climate skepticism and submitted to the official record a (different) list of scientists "who are in disagreement with the theory that greenhouse gases are" causing global warming (Congressional Hearing 2009b). In a hearing on "Science of Capture and Storage" in 2014, Rohrabacher again indicated that the premise of climate change was subject of ongoing "debate" and explicitly stated his position that "the concept of global warming is fraudulent and it has not been proven" (Science of Capture and Storage: Understanding EPA's Carbon Rules 2014).

The geoengineering hearings were called for the purpose of information-gathering and the panelists were requested to testify as expert witnesses. Of the 24 unique representatives that spoke during the four hearings, only two took an antagonistic approach with the witnesses: Dana Rohrabacher, at the first and second hearings as discussed, and Adrian Smith at the first hearing. Adrian Smith, Republican of Nebraska spent his speaking time at the first geoengineering hearing hostilely asking the witnesses, who were all invited panelists due to their expertise on geoengineering, about whether they think beef, a major industry in Smith's district for which he is a strong proponent, is bad for the environment. Rohrabacher and Smith were anomalous in their interactions with the panelists in which they rhetorically challenged the credibility of the witnesses. By contrast, the other 22 representatives, including those who are resistant to climate change policy or critical of geoengineering, adhered to a standard of polite decorum and, in particular, treated the panelists with statements of respect, recognizing them as expert witnesses presenting on invitation from the Committee.

Ralph Hall, ranking Republican member from Texas, embodied this latter approach in contrast to the style of Rohrabacher and Smith. Like Rohrabacher, Hall is a so-called climate change skeptic. His opening statement at the first hearing encapsulated this position, drawing upon the common denial narrative that suggests a sense of uncertainty and inconclusiveness: "As many of my colleagues will agree, the debate about climate change is far from over, and I am sure that you have conducted and participated in that and came to the conclusion that the fact that there are still many, many opinions as to the causes, the effects and the potential solutions demonstrates how much uncertainty there is out there and how crucial it is for our Nation to continue to search for answers" (Hall, Congressional Hearing 2009a). However, while Hall was critical of geoengineering and climate change remediation, he spoke politely to the witnesses and Committee Chairman, despite some jovial jest with the latter.

At the first hearing on geoengineering, Hall highlighted the outlandishness of geoengineering proposals with an opaque analogy to Alfred Hitchcock's *The Birds* being adapted to "flying elephants" (Congressional Hearing 2009a). Hall then closed his opening remarks with an apparent joke, saying with a smile, "I would yield back to my Chairman, James Bond, and I thank you very much for letting me talk" to which Chairman Gordon said, "Well, Professor Shepherd [panelist from UK], welcome to America" and both the congressional members laughed at the interchange (Congressional Hearing 2009a). The banter between Chairman Bart Gordon and ranking member Ralph Hall seemed to counteract tension in the partisan posturing for controlling the parameters of debate. For example, Hall's use of self-deprecation regarding his lack of understanding geoengineering concepts provided a form of diffusion for tensions over substantive matters. At one point in the first hearing, Chairman Gordon was recommending the Royal Society Report as an informative source on geoengineering. He joked: "I was thinking about giving Mr. Hall the two-page summary, but I didn't want to overwhelm him…" to which Hall replied "You would have had to read it to me" (Congressional Hearing 2009a). Humor between these two committee members was used to smooth over a significant ideological and policy gap in respect to the issue of climate change and, at these hearings, the possibility of geoengineering.

This humor, however, was intermixed with statements professing respect, which tempered the dynamic. On the occasion of the third hearing on geoengineering, Hall stated the following as his opening remarks:

> Thank you, Mr. Chairman, and but for my respect for you, I would have a lot longer opening remark here, but I would just say that I believe this is the third hearing our committee has held on geoengineering. As I have expressed on previous occasions, I have significant reservations about pursuing this line of research. With that, in the interest of time and courtesy to our very distinguished guest, I will just put this [written statement] in the record. (Congressional Hearing 2010b)

Hall's expression of "reservations" regarding the pursuit of geoengineering research referred to his position as a climate change skeptic. In the same hearing, when questioning Hon. Phil Willis, a member of U.K. Parliament serving for the first time ever as a witness in a US Congressional Science and Technology Committee hearing, Hall stated: "I am not terribly enthusiastic about this, but I am excited about your appearance here and the Chairman's vision" (Congressional Hearing 2010b).

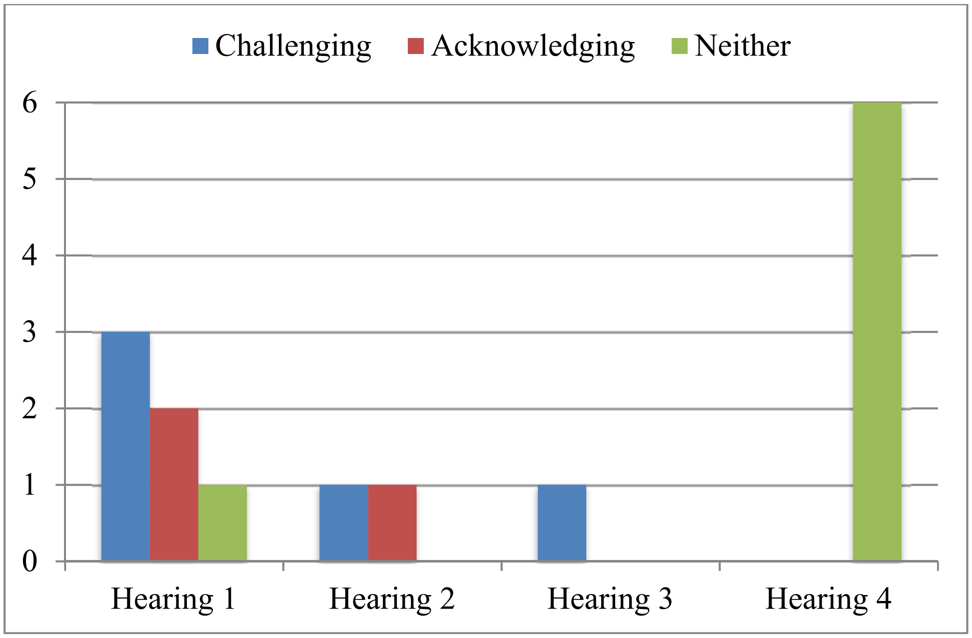
Ralph Hall and Dana Rohrabacher represent two extremes of approach in addressing climate change and geoengineering from a climate skeptic perspective. What they have in common is that their position on climate change informs their position on geoengineering. Because climate change is not a problem by their estimation, pursuing geoengineering as a potential solution to climate change is not a good use of government resources in their view. This position was recurrent in the first three hearings on geoengineering, which occurred in 2009 and 2010. However, between the third hearing in March of 2010 and the fourth hearing in November 2017, a shift occurred in which geoengineering became embraced by Republican politicians known as climate skeptics.

At the fourth hearing, several prominent climate change deniers emerged as the most enthusiastic proponents of geoengineering, as so vividly portrayed in Randy Weber's (R-TX) declaration that "The future is bright for geoengineering!" (Congressional Hearing 2017b). As mentioned, in the fourth hearing, all the participating Republican members either avoided discussion of climate change or made active efforts to decouple geoengineering from climate change. Among this group of Republican politicians, the interest is in albedo modification (solar radiation management, SRM, is the term most used), with no mention of carbon dioxide removal (CDR), fitting with a worldview unconcerned with greenhouse gases. The result is newfound

Republican support for geoengineering, providing a contingent of political support for it within Congress. This increased political support for geoengineering paralleled the other social moves, discussed elsewhere in this dissertation, of geoengineering moving from the margins of scientific discussion into mainstream consideration, but is unique in the element of discursively decoupling geoengineering from climate change.

While only Republicans questioned the existence of climate change, political party was not determinative of individual Committee members' positions on climate change. During the first three hearings, four of the seven participating Republican representatives acknowledged the existence and importance of climate change. Only three of the seven challenged the existence of climate change. These three were vociferous on the issue, however, and two of the three participated in multiple hearings such that five of nine incidents of Republican participation included challenging the existence of climate change, serving to magnify that "side" of the "debate." As discussed, at the fourth hearing, there was a shift in which the Republicans separated the issues of geoengineering and climate change. In contrast to the previous hearings, none of the six Republicans participating in the fourth hearing acknowledged climate change as an important issue, even as several of them showed great enthusiasm for geoengineering technologies.

Graph 4.1: Republican committee members' positions on climate change based on their statements at the four geoengineering hearings



Graph 4.1 provides a visual representation of the participating Republican committee members' positions on climate change as expressed at the four geoengineering hearings. While the second and third hearings were more sparsely attended, it is clear that over the course of the first three hearings there is a split in the Republican approach to climate change as a subject. Comparing the first and fourth hearings, which included an equal number of Republican participants, reveals the stark difference over time, from one Republican out of six at the first hearing remaining ambiguous on the subject of climate change to six out of six at the fourth hearing.

Only Republican positions are presented in Graph 4.1 because variance is only found among the Republican participants. One hundred percent of Democrat participants at the four hearings acknowledged the importance of climate change as an issue for governance. The change over time in the distribution of Republican positions contrasts with the Democrat members' consistent reiteration of the primacy of emissions abatement paired with willingness to consider, or at least learn more about, geoengineering proposals. As the discussion became increasingly specific over time, there was an eventual stabilization among the Democrat contingent around a position generally supportive of pursuing CDR and cautiously researching SRM, which was akin to the recommendations of the panelists.

At the first three hearings, the majority of aggregated unique Republican participants acknowledged climate change as an issue for governance. At the first hearing, one Republican, Brian Bilbray of California, articulated the politics around climate change in terms that instantiate Ingolfur Blühdorn's sociological concepts of "simulative politics" and the "politics of unsustainability" (Blühdorn 2000; 2011; 2007; Blühdorn and Welsh 2007) as discussed elsewhere in this dissertation. Representative Bilbray stated:

> I have come to the conclusion that we need to talk about mitigation of the crisis because we are not going to avoid it. There is not the political will to do what it takes. There is not even the political will to make it legal in the United States to do what it takes to avoid climate change because I believe strongly that we have got to have the ability to produce energy that doesn't emit greenhouse gases so we can shut down all those facilities that do, and there is not the political will to do with that what we did with the interstate freeway system where the government went out and sited, did the planning, did the things so we can shut down the coal producing and the emissions and all that other stuff. We are not willing to do that. We are just willing to talk about how terrible it is. (Bilbray, Congressional Hearing 2009a)

Bilbray's discussion of the lack of political will to "do what it takes" to address climate change through emissions abatement mirrors Blühdorn's language describing simulative politics: "despite their vociferous critique of *merely symbolic politics* and their declaratory resolve to take effective action, late-modern societies have neither the will nor the ability to *get serious*" (Blühdorn 2007: 253, emphasis in original).

In response to ongoing resistance from a subset of the Republican Party obstructing climate mitigation policy, Representative Baird, a Democrat from Washington, stated at the third hearing in March of 2010:

> I think there is an urgent need for a constructive dialogue with my friends on the other side of the aisle on this, because we spend an inordinate amount of time here, on this committee, unfortunately, debating whether or not this is real, as if the outcome of our debate will somehow impact what happens in the real world. By that, I mean, as if climate change is going to be stopped if we declare it is not happening. But I think the adverse consequences that you [panelists] are describing, the profound geopolitical, national security, economic disruption if you get your bet wrong, really has to be discussed. […] Because if we just say well, we are not going to do anything, because climate change is a hoax, as is sometimes said by colleagues, that hoax can have some darn serious consequences if it is not a hoax. (Baird, Congressional Hearing 2010b)

As it turned out, however, in subsequent years, moderate Republicans supporting climate policy, including Representative Bilbray quoted above regarding the lack of political will, disappeared from the House Science and Technology Committee. By 2013, climate change denial became the majority view on the committee (Lavelle and Hasemyer 2017). This compositional shift of the committee is one component of the discursive trends observed over the eight years of geoengineering hearings. Other components may include increasing awareness of climate change among politicians and their constituents at odds with a political investment and entrenchment of climate change denial, paired with a growing awareness, understanding and mainstreaming of geoengineering concepts and related economic interests. In any case, geoengineering's increased popularity (or mainstreaming) within Congress was paired with its becoming rhetorically detached from climate change as denialists became the majority on the Science, Space, and Technology Committee.

A Shift in Political Consideration of Geoengineering

During the course of the four hearings over eight years, with the first three clustered from November 2009 through March 2010 and the fourth in November of 2017, there have been some points of political consistency and some points of notable change over time. In 2009, there was little understanding on the parts of many of the congressional representatives about the topic, as demonstrated through questioning and statements. The witnesses spoke most about SRM as a topic and much discussion of geoengineering was at a vague level. Only one committee member at the first hearing, Suzanne Kosmas (Democrat of Florida), took an explicit position in favor of pursuing geoengineering. By 2017, most of the congressional representatives seemed to have some understanding of the concepts. Witnesses and representatives spoke individually about each SRM and CDR more specifically. At the fourth hearing, eight out of 11 participating committee members indicated favorability toward pursuit or research of some form of geoengineering.

In 2009, Republicans spent appreciable time disputing the existence of climate change and questioning the relevance of the topic of geoengineering given the "uncertainty" and "debate" about climate change. By 2017, while the Republicans still problematized or dismissed climate change, they nevertheless embraced SRM as a useful technology for climate control. While witnesses continued to stress the importance of mitigation and continued to advocate *de minimus* research, including climate models and cautious consideration of small-scale lab and field experiments, some Republicans indicated interest in actively pursuing SRM at a level beyond witness recommendation.

The most enthusiastic proponents of SRM at this fourth hearing were the two Republicans from Texas: Randy Weber and Lamar Smith, Chair of the Science, Space, and Technology Committee as of January 2013. Both of these congressional representatives from Texas have been vocal in climate change denial, including within committee hearings (Mervis 2014), and have close ties to the oil and gas industries. For example, oil and gas interests have made up the largest aggregate contributors to Lamar Smith over his career, contributing over $772,000 to his campaigns from 1989 through 2018 (The Center for Responsive Politics 2018;

Lavelle and Hasemyer 2017). Incidentally, the fossil fuel industry has also been the greatest contributor to members of the House Science Committee overall since 2006 (Lavelle and Hasemyer 2017). Moreover, as mentioned, during the time period between 2006 through 2013, the composition of the committee also changed with attrition of moderate Republicans who "accepted climate science" and "supported some climate action" (Lavelle and Hasemyer 2017). This compositional transformation of the committee accounts for some of the changes seen between the 2009/2010 and 2017 geoengineering hearings, especially the support of some Republicans for climate policy in the early hearings which was absent in 2017. However, the decoupling of climate change from geoengineering and the avoidance of climate change from the Republican discourse during the fourth geoengineering hearing extends beyond these changes.

It would have been plausible to expect the shift toward climate denial of the Republican contingent on the committee to result in more discussion of climate denial as exhibited by Dana Rohrabacher and Ralph Hall during the earlier hearings, but this was not the case. Rather, the 2017 geoengineering hearing was unique in the Republican contingent of the committee generally using one of two approaches, either avoiding the topic of climate change altogether or obfuscating anthropogenic climate change without directly contending with it while dismissing its relevance from the discussion of geoengineering. Lamar Smith, the chairman of the committee, came the closest to acknowledging the relevance of climate change. He stated:

> As the climate continues to change, geoengineering could become a tool to curb resulting impacts. Instead of forcing unworkable and costly government mandates on the American people, we should look to technology and innovation to lead the way to address climate change. Geoengineering should be considered when discussing technological advances to protect the environment and geoengineering should not be ignored before we have an opportunity to discover its potential. (Smith, Congressional Hearing 2017b)

This statement does refer to a changing climate in relation to the potential for geoengineering, but in a singular manner. It opens with the premise that "the climate continues to change," which, while it could be interpreted to be referring to climate change in the common meaning, leaves open the interpretation of the climate denial argument that the climate has always changed irrespective of people and greenhouse gas emissions. The second sentence, which criticizes government regulation of emissions, is the heart of Lamar Smith's position on climate change and also gets the closest to engaging with the concept of anthropogenic climate change in the form of disputing emissions reductions as Plan A, rather arguing that geoengineering might supplant the global community's Plan A. (This position is in stark contrast to the abundant caveats from geoengineering researchers, including the panelists at these hearings, that solar geoengineering could not replace emissions reductions and should not be considered as an alternative). In the final sentence of the selection, geoengineering becomes recast as a technology to "protect the environment" (Smith, Congressional Hearing 2017b).

By contrast to the more marked change in the discourse of Republican committee members, the positions of Democrat members remained fairly consistent, however with a gradual increase in favorability toward geoengineering research. Throughout the four hearings, Democrats reiterated the importance of mitigation and affirmed the existence of anthropogenic climate change. By the third hearing, the Democratic members indicated overall favorability to supporting geoengineering research. At the fourth hearing, Democratic members indicated favorability to pursuing CDR and researching SRM. The Democrats' positions on geoengineering research and the related framing and characterization of geoengineering tended to more closely parallel that of the witness panels, which largely emphasized the continued importance of emission reduction, discussed the role of CDR contributing to this, and provided caveats regarding risks of SRM, but nevertheless encouraged research into SRM as a potential consideration in terms of a "Plan B," as will be discussed.

Within his opening statement at the first hearing in November of 2009, Chairman Gordon framed geoengineering and articulated the premise of hearings on the topic in the following manner:

> Geoengineering carries with it a tremendous range of uncertainties, ethical and political concerns, and the potential for catastrophic environmental side-effects. But we are faced with the stark reality that the climate is changing, and the onset of impacts may outpace the world's political and economic ability to avoid them. Therefore, we should accept the possibility that certain climate engineering proposals may merit consideration and, as a starting point, review research and development as appropriate. At its best geoengineering might only buy us some time. But if we want to know the answers we have to begin to ask the tough questions. Today we begin what I believe will be a long conversation. (Gordon, Congressional Hearing 2009a)

This framing of geoengineering is reminiscent of content and tone found in the Royal Society report (2009) as well as the later National Academy report (National Research Council). Later in the hearing, Chairman Gordon referred to the Royal Society report in its capacity, at the time, as geoengineering's primary document for those trying to understand the concepts. Gordon stated: "I would really advise that anyone that has an interest in this issue to review the Royal Society's report. It is very good" (Gordon, Congressional Hearing 2009a). This speaks to the significance of science policy reports in influencing policy makers and their understandings of scientific and technological concepts. Chairman Gordon's opening remarks, clearly influenced by his reading of the Royal Society report, are also exemplary of the trend seen throughout the four hearings of Democrats largely matching their discourse on geoengineering with the terms, narratives and framings of scientific experts, including those serving on the witness panels, some of whom were also involved in the writing of the key science policy reports on geoengineering.

Witness Testimony

Table 4.2 lists the panelists who participated as expert witnesses at the four geoengineering hearings. Panelists were mostly scientists involved with geoengineering research. As mentioned, each panel was comprised of two to four witnesses from academic institutions in addition to one or two affiliated with either a national laboratory or a think tank.[16] The March 2010 hearing also including one representative from GAO and MP Phil Willis.

[16] The two think tanks represented at these hearings were the conservative American Enterprise Institute (AEI) and the Niskanen Center, often characterized in terms of libertarian values.

Table 4.2: Witnesses to congressional geoengineering hearings

Witness	Position	Affiliation (at time)
Geoengineering: Assessing the Implications of Large-Scale Climate Intervention, November 5, 2009		
Dr. Ken Caldeira	Professor of Environmental Science	The Carnegie Institution of Washington
Professor John Shepherd	Professional Research Fellow in Earth System Science	National Oceanography Centre
Mr. Lee Lane	Co-Director, American Enterprise Institute Geoengineering Project	American Enterprise Institute (AEI)
Dr. Alan Robock	Professor, Department of Environmental Sciences	Rutgers University
Dr. James Fleming	Professor and Director, Science, Technology and Society Program	Colby College
Geoengineering II: The Scientific Basis and Engineering Challenges, February 4, 2010		
Dr. David Keith	Research Chair in Energy and the Environment	University of Calgary
Dr. Philip Rasch	Climate Scientist	Pacific Northwest National Laboratory
Dr. Klaus Lackner	Geophysicist, Earth & Environmental Engineering	Columbia University
Dr. Robert Jackson	Chair of Global Environmental Change	Duke University
Geoengineering III: Domestic and International Research Governance, March 18, 2010		
Hon. Phil Willis, MP	Chairman, Science and Technology Committee	United Kingdom House of Commons
Dr. Frank Rusco	Director of Natural Resources and Environment	Government Accountability Office (GAO)
Dr. Granger Morgan	Professor, Department of Engineering and Public Policy	Carnegie Mellon University
Dr. Jane Long	Geotechnical engineer	Lawrence Livermore National Laboratory
Dr. Scott Barrett	Professor of Natural Resource Economics	Columbia University
Geoengineering: Innovation, Research, and Technology, November 8, 2017		
Dr. Phil Rasch	Climate Scientist	Pacific Northwest National Lab
Dr. Joseph Majkut	Director of Climate Policy	Niskanen Center
Dr. Douglas MacMartin	Senior Research Associate	Cornell University
Ms. Kelly Wanser	Principal Director, Marine Cloud Brightening Project	University of Washington

While a shift can be observed in the treatment of geoengineering by members of Congress, the panels of expert witnesses remain, for the most part, consistent in their discussions of geoengineering over time. At the fourth hearing, one witness, Douglas MacMartin, made the statement: "I think one of the striking things about this panel is actually how broad our agreement is likely to be on almost all of the issues" (Congressional Hearing 2017b). This assertion holds generally true across the 18 instances of witness testimony over four hearings,[17] with a few exceptions. Overall, the panelists showed broad agreement in terms of both advocating for geoengineering research and also expressing the importance of mitigation irrespective of geoengineering. In regard to the latter, all but two witnesses articulated the importance of traditional mitigation in their written and/or oral testimony and all but three placed strong emphasis on the importance of emission abatement irrespective of geoengineering pursuit.

The two primary exceptions to the tendency of witnesses to reiterate the importance of abatement were Lee Lane of the conservative think tank, American Enterprise Institute, and geophysicist Klaus Lackner of Columbia University. Lee Lane promoted pursuit of SRM as a top research priority and generally avoided the topic of emissions abatement. However, while answering a question he did concede that he did not "believe that we can go on emitting greenhouse gases at ever-increasing rates" and "eventually controls are going to be essential," but that "conditions are not in place yet" (Congressional Hearing 2009a). Lackner emphasized the importance of achieving a "carbon neutral energy economy" (Congressional Hearing 2010a). His testimony was unique, however, in his expressed belief that CDR could be relied upon to

[17] Philip Rasch, a climate scientist at Pacific Northwest National Laboratory, served as a witness at two separate hearings (the second and the fourth). In total, there were 17 unique witnesses, and 18 instances of witness testimony, including Rasch's two appearances.

achieve carbon neutrality without necessarily converting from a carbon-intensive energy economy. Kelly Wanser, the Principal Director of the Marine Cloud Brightening Project, speaking at the fourth hearing, displayed a position between these outliers and the otherwise consistent reiteration of the importance of mitigation among the other 14 unique witnesses. Wanser mentioned mitigation as one component that should be used along with other strategies in a portfolio of responses to climate change, but she did not emphasize the importance of mitigation to the same extent as did most witnesses (Congressional Hearing 2017b).

Apart from these few exceptions, among the four panels of witnesses, the most common treatment of mitigation was unwavering reiteration of its primacy. Exemplifying this position, Ken Caldeira stated simply: “Climate change poses a real risk to Americans. The surest way to reduce this risk is to reduce emissions of greenhouse gases, such as carbon dioxide” (Congressional Hearing 2009a). Alan Robock in his testimony made explicit his agreement with Caldeira, stating: “First I would like to agree with Ken Caldeira, that global warming is a serious problem and that mitigation, reduction of emissions, should be our primary response. We also need to do adaptation and learn to live with some of the climate change which is going to happen no matter what” (Congressional Hearing 2009a). Robert Jackson opens his testimony on geoengineering by stating the importance of emission reductions: “Let me begin by stating that a wealth of evidence already shows our climate is changing and is a threat to people and organisms. As a scientist and citizen of our great Nation, I urge you to act quickly to reduce greenhouse gas emissions” (Congressional Hearing 2010a).

Moreover, witnesses emphasized the primacy of mitigation *irrespective* of geoengineering. Robert Jackson’s written testimony expanded on his call to emissions reductions with the caveat: “The safest, cheapest, and most prudent way to slow climate change is to reduce greenhouse-gas emissions soon. No approach—geoengineering or otherwise—should lead us from that path" (Jackson written statement, Congressional Hearing 2010a). Alan Robock stated: "I would just like to say that we can't hold geoengineering as a solution and allow that to reduce our push toward mitigation. It is never going to be a complete solution. We may need it in the event of an emergency, but let us not stop mitigation and wait and see if geoengineering would work. That is not the right strategy" (Congressional Hearing 2009a). Summarizing many of these shared sentiments, John Shepherd, the lead author of the Royal Society Report, stated:

> Since time is short, I would like to move directly to summarize the key messages of our study and first among these is that geoengineering is not a magic bullet. None of the methods that have been proposed provide an easy or immediate solution to the problems of climate change. There is a great deal of uncertainty about various aspects of virtually all the schemes that are being discussed. So at present, this technology, in whatever form it takes, is not an alternative to emissions reductions which remain the safest and most predictable method of moderating climate change, and in our view cutting global emissions of greenhouse gases must remain our highest priority. (Shepherd, Congressional Hearing 2009a)

Through these various statements, the panelists expressed at the hearings, similar to the science policy reports to which some of them have contributed, that geoengineering is not a replacement for mitigation. Ken Caldeira put this point candidly when he stated, immediately after expressing the promising potential of SRM, that "Nobody thinks these approaches will perfectly offset the effects of carbon dioxide" (Congressional Hearing 2009a). Similarly, at the fourth hearing, Douglas MacMartin articulated: "It is important to stress at the outset that solar geoengineering cannot be a substitute for cutting emissions for several reasons. This conclusion has been reached by every assessment of the this technology, including by the National Academies in 2015" (Congressional Hearing 2017b).

David Keith, as discussed in the previous chapter, is one of the most prolific advocates of SRM pursuit with the bold position that SRM should not necessarily be reserved as a distant Plan

B (e.g., see Keith 2013: 172-3; Keith 2016). He insisted, however, that this position on solar geoengineering in no way diminishes his emphasis on the importance and urgency of emissions reductions. He stated: "We must make deep cuts in global emissions if we are going to manage the risks of climate change. Emissions reductions are necessary, but they are not necessarily sufficient" (Keith, Congressional Hearing 2010a). Keith's written statement emphasized that geoengineering and emissions abatement are not mutually exclusive: "Responsible management of climate risks requires sharp emissions cuts and clear-eyed research and assessment of SRM capability. The two are not in opposition. We are currently doing neither; action is urgently needed on both" (Keith written statement, Congressional Hearing 2010a). Similarly, Morgan Granger, a proponent of SRM pursuit discussed in the previous chapter regarding his co-authored editorial promoting SRM, included in his testimony a statement consistent with the panelists' collective emphasis on mitigation: "I want to emphasize that I am not arguing that the U.S. or anybody else should engage in SRM. The U.S. and other large emitting countries need to get much more serious about reducing emissions and lowering the concentration of atmospheric carbon dioxide. I believe that can be done at an affordable cost" (Granger, Congressional Hearing 2010b).

In addition to the emphasis on the importance of addressing emissions irrespective of geoengineering, the witnesses also engaged with several other narratives common to geoengineering discourse, including the idea of geoengineering as a "last resort" or "Plan B" and the related framing of geoengineering as a potential tool to address a climate catastrophe or emergency. Numerous scientists characterized geoengineering as "a last resort." Philip Rasch wrote: "Geoengineering should be viewed as a choice of last resort[.] It is much safer for the planet to reduce greenhouse gas emissions. Geoengineering would be a gamble" (Rasch written statement, Congressional Hearing 2010a). Jackson closed his testimony saying: “In conclusion, although emitting less carbon dioxide and other greenhouse gases should remain our first priority […] We need to get geoengineering right as a tool of last resort” (Congressional Hearing 2010a). Phil Willis stated: “this is an issue of last resort and must not, in fact, deflect us from our major task of making sure that we put less CO_2 into the air, and where it is there, that we look, in fact, to sequestrate it” (Congressional Hearing 2010b).

Of the 18 witness instances, 13 employed catastrophe framing that is common in regard to geoengineering. Catastrophe framing is a variant of “Plan B” framing in which geoengineering is treated as a tool that needs to be available in case of a climate emergency (cf. Nerlich and Jaspal 2012; Corner, Parkhill and Pidgeon 2011: 13). Alan Robock, who, as discussed in the previous chapter, is known for being particularly candid in his concerns regarding geoengineering, stated at the first hearing on the subject: “Using geoengineering should only be in the event of a planetary emergency and only for a temporary period of time, and it is not a solution to global warming” (Congressional Hearing 2009a). In this way, Robock engaged the common stopgap and climate emergency framings but used these framings as a caveat, not an imperative. Also at the first hearing, John Shepherd, lead author of the Royal Society report, stated: “in our view, this is not a technology which is ready for deployment in the immediate future. It is, however, a technology that may be useful at some point in the future if we find that we have need of it” (Congressional Hearing 2009a). In addition to this implicit use of catastrophe, or climate emergency, framing, Shepherd later refers to geoengineering as a Plan B: “What we need is research on a small portfolio of promising techniques of both major types in order that our Plan B will be well prepared, should we ever need it” (Congressional Hearing 2009a).

For the third hearing, Jane Long of Lawrence Livermore Laboratory presented the catastrophe framing premise within her written statement: “In this future, if climate sensitivity (the magnitude of temperature change resulting from a doubling of CO_2 concentrations in the atmosphere) turns out to be larger than we hope or mitigation proceeds too slowly, we cannot rule out the possibility that climate change will come upon us faster and harder than we—or the ecosystems we depend on—can manage” (Long written statement, Congressional Hearing 2010b). Phil Willis, the U.K. minister who spoke at the third hearing, provided another “Plan B” framing closely related to the catastrophe framing given by Robock, Long, and others: “If the climate warms dangerously, and we can’t fix the problem by reducing carbon emissions or adapting to the changing climate, geoengineering might be our only chance” (Willis, Congressional Hearing 2010b). This framing of geoengineering as being in reserve in case of a climate emergency is consistent with that in the major science policy reports, as discussed previously.

As may be expected due to the selection criteria for expert witnesses, all panelists promoted the need for geoengineering research with one possible exception. The promotion for research was consistent with the policy recommendations of science policy reports including the Royal Society’s report and the National Research Council’s report. Individual witnesses provided their own visions of how research might be best promoted and coordinated, but every witness promoted research. Ken Caldeira aptly articulated at the first geoengineering hearing: “while the panel disagrees about maybe the scale and scope of what a research program should be, I think it is indicative that the entire panel asserts the need for a research program” (Congressional Hearing 2009a). This observation generally holds throughout the four panels.

The one exception was science historian James Fleming, who was the lone social scientist included among the witness panels. He encouraged research on human dimensions related to the pursuit of geoengineering, but did not take an explicit position on geoengineering research itself, presumably as it falls outside his area of expertise (Congressional Hearing 2009a). The historian did, however, include a number of past examples of human hubris in relation to trying to control weather or climate, as well as the fallacies and risks involved. He cautioned learning from history's lessons. While not offering specific recommendations, Fleming indicated that mitigation is necessary and displayed reluctance regarding geoengineering, implying it may be a foolhardy endeavor. Fleming ended his testimony by saying:

> People have said that climate control is not a good idea. Harry Wexler, head of research at the Weather Bureau, said this in 1962, and just two years ago, Bert Bolin, the first chair of the IPCC, wrote that the political implications of geoengineering are largely impossible to assess and it is not a viable solution because in most cases, it is an illusion to assume that all possible changes can be foreseen. Climate change is simple. We should do the right thing. Climate is complex. It involves oceans and atmospheres, ice sheets and now monsoons, so studying the human dimension is essential. We need the interdisciplinary, international and intergenerational emphasis. (Fleming, Congressional Hearing 2009a)

In context, the otherwise vague statement that "We should do the right thing" implies mitigation through emission reductions and "Climate is complex" is a warning in regard to hubristic ventures attempting climate control (Fleming, Congressional Hearing 2009a). However, he does not explicate an opposition to technical research, only gives warning and indicates that any research that does occur should include "interdisciplinary, international and intergenerational emphasis" (Fleming, Congressional Hearing 2009a).

The other 17 instances of witness testimony included some degree of promoting geoengineering research, within a broad range of opinions of what research should be pursued and in what ways. For instance, Alan Robock, who consistently voices cautions in regard to SRM, specified that in terms of albedo modification, the only research he recommends is climate models and no field tests. He stated: "I would like to urge you to support a research program into the climatic response with climate models, into the technology to see if it is possible to develop different systems so that you can make an informed decision in the future" (Robock, Congressional Hearing 2009a). However, while encouraging research in the form of climate models, he was very clear in his position against field testing, arguing: "If we wanted to do experimentation, it is not possible to do just a small-scale test […] so we would really have to put a lot of material in for a substantial period of time to see whether we are having an effect. And that would essentially be doing geoengineering itself. You can't do it on a small scale […] it is problematic whether we could actually ever do an experiment in the stratosphere without actually doing geoengineering" (Robock, Congressional Hearing 2009a).

In contrast, during the same hearing, Ken Caldeira indicated that there are "small-scale field studies that could be done short of something that affects climate" (Congressional Hearing 2009a). Along these lines, at the second hearing, David Keith argued in his written statement: "Field tests will be needed, such as experiments generating and tracking stratospheric aerosols to block sunlight and dispersing sea-salt aerosols to brighten marine clouds" (Keith, written statement, Congressional Hearing 2010a). Keith further averred: "Although risk of climate emergencies may motivate SRM research, it would be reckless to conduct the first large-scale SRM tests in an emergency. Instead, experiments should expand gradually to scales big enough to produce barely detectable climate effects and reveal unexpected problems, yet small enough to limit resultant risks" (Keith, written statement, Congressional Hearing 2010a). In this way, Keith embraced the climate emergency framing, but recommended a gradual and preemptive implementation of geoengineering.

Philip Rasch took a position somewhere between that of Robock and that of Caldeira and

Keith. Like Caldeira and Keith, Rasch indicated that his vision of a research program would include a fieldwork component:

> Lab and fieldwork are critical to assure a thorough understanding of the fundamental physical process important to climate and that computer models are reasonably accurate in representing that process. I think it is critical to distinguish between "small scale field studies" where we might introduce some particles into the atmosphere over such a small scale that they would have negligible climate impact, and "full scale deployment" where we expect to actually have a climate impact. *Field studies might try to induce a deliberate change to some feature of the earth system at a level with a negligible impact on the climate, but the change would allow us to detect a response in a component important to climate*. (Rasch, written statement , Congressional Hearing 2010a: 154, italics in original)

However, like Robock, Rasch problematized the distinction between research and deployment and the difficulty of achieving meaningful field results without crossing over the line toward deployment. Rasch noted that there "will be substantial difficulties in evaluating this geoengineering strategy without full deployment. This makes it difficult to improve our understanding slowly and carefully using field experiments that do not change the Earth's climate" (Rasch, written statement, Congressional Hearing 2010a: 157). He went on to add nuance to this argument in terms of the challenges involved with field tests, concluding with an articulation of the resulting conundrum:

> So we are caught between rock and a hard place. Too small a field test, and it won't reveal all the subtleties of the way the aerosols will behave at full deployment. A bigger field test to identify the way the aerosols will behave when they are concentrated will have an effect on the planet's climate (like Pinatubo did), albeit for only a year or two. I have not seen a suggestion on how to avoid this issue. (Rasch, written statement, Congressional Hearing 2010a: 157)

Rasch's statement on this matter exemplifies the internal tension regarding recommending field tests but with extensive caveats regarding the thin, even elusive, line between research and deployment.

Granger Morgan was more sanguine regarding the possibility of drawing lines to differentiate various levels of experimentation. In fact, he proposed doing just that. He included in his testimony at the third hearing, diagrams that conceptualize the distinction of experimentation of a *de minimus* standard that he proposed should be exempt from additional oversight and governance apart from “transparent public announcement and informal coordination within the scientific community” (Morgan, slides, Congressional Hearing 2010b). For example, one of his slides shows a diagram in which “X, Y, and Z define the limits of an allowed zone. They refer, respectively, to the upper bounds on the amount of radiative forcing that an experiment might impose, the duration of that forcing, and the possible impacts on ozone depletion” (Morgan, Congressional Hearing 2010b). However, the values of X, Y, and Z, as well as “what forms of international agreement and enforcement, if any, would be most appropriate, and what scientific input would they require” was left as an open question (Morgan, Congressional Hearing 2010b).

These various positions on the pursuit of field experimentation underscore the variety of opinions held within the community of geoengineering researchers. It speaks to a tension in regard to the potential for knowledge-building through field tests, the risks that would be involved with field tests, and the nebulous border between experimentation and deployment. This tension can be seen embodied in an individual scientist’s reasoning, as demonstrated in Rasch’s statement cited above, or in diversity of competing opinions on this topic among the members of geoengineering research community, the so-called “geo-clique” (see discussion in the previous chapter and Hamilton 2013; Kintisch 2010). Nils Markusson argues “that the geoengineering imaginary is […] about the creation of a new scientific space for the conversion of climate science into applied, experimental technology, and that the boundaries and the very desirability of this space are contested” (Markusson 2013: 3). The points of consensus and the points of disagreement or tension demonstrated by the panelists within these hearings provides a window into the variously solidifying and contested boundaries of the space.

Markusson's (2013) research notes the ambivalence that manifests in geoengineering reports authored by a collective process. The variance between the witnesses giving testimony at these hearings speaks to this issue of diversity and resulting ambivalence in some of the co-authored articulations of the geoengineering imaginary. The data within the corpus of discourse being considered here complements Markusson's (2013) findings, since the witnesses at these hearings are exemplary of the cross-section of authors participating in collectively authored geoengineering reports. For example, of the 17 unique individuals who gave testimony at the congressional hearings, seven were involved in the writing or review of either the 2009 Royal Society report or the 2015 National Research Council report, the two most important geoengineering science policy reports, which were discussed at length in Chapter Two. The examples discussed above regarding the range of opinions on field experimentation, were all drawn from this subset of seven witnesses who were also involved in the science policy reports. Hence, these individual articulations of the geoengineering imaginary and the envisioning of what a geoengineering research program would include provide a nuanced perspective into the diverse range of positions that become encapsulated within influential geoengineering reports and summations.

Other points of disagreement emerge in terms of the consideration of deployment and the economic arguments drawn upon by advocates to promote solar geoengineering as a relatively inexpensive venture. For example, at the first geoengineering hearing, Alan Robock, one of the most precautionary geoengineering researchers, raised doubts or questions to some of the statements of other panelists. For instance, in his testimony, Ken Caldeira had drawn upon a narrative common in geoengineering discourse, asserting: "Preliminary research suggests that we could rapidly and relatively cheaply put tiny particles high in the stratosphere and that this would cause the earth to cool quickly" (Congressional Hearing 2009a: 16). Then Lee Lane of AEI pushed this narrative further, making the argument in his testimony that SRM would be a low cost investment with high potential benefit (Congressional Hearing 2009a: 33).

During his testimony, Robock raised questions regarding the assumed cheapness and ease of execution of SRM: "Ken [Caldeira] said it would be easy and cheap, but there is no demonstration of that. It might not be that expensive, but such equipment just doesn't exist today" (Congressional Hearing 2009a: 44). He also critiqued the economic analysis cited by Lee Lane, saying: "I disagree with the economic analysis because they just ignored many of the risks and didn't even count what the possible dangers might be" (Robock, Congressional Hearing 2009a: 45). However, Robock was in agreement with the central argument of advocating research. He continued: "But I agree with everybody that we need a research program so that we can quantify each of these [risks and dangers] so policymakers can tell if—is there a Plan B in your pocket, or is it empty? We really need to know that, and we don't know the answer to that yet" (Robock, Congressional Hearing 2009a: 45). While the promotion of research is entirely consistent with the other panelists, Robock's framing of the Plan B narrative was more cautious than its typical use. He advocated research to establish *whether* there is a Plan B as opposed to preparing Plan B for readiness.

Moreover, Robock was the most consistent witness in returning the discussion to the issue of risks, as opposed to simply mentioning risks and then pivoting toward other issues of interest. For example, as discussed in Chapter Two, volcanoes are frequently used as an analogue for stratospheric aerosol albedo modification. This analogue was brought up a number of times at the hearings both in oral statements and in the written record. Ken Caldeira, for instance, spoke in positive terms about how the idea of SRM is demonstrated through the natural experiment of large volcanic eruptions, explaining that SRM methods "seek to reduce the amount of climate change by reflecting some of the sun's warming rays back to space. We know this basically works because volcanoes have cooled the earth in this way" (Congressional Hearing 2009a: 16). Several other witnesses employed the volcanic analogy in a similar manner.

Later in the hearing, during the question period, Chairman Gordon had asked an unrelated question, but before answering the question, Robock returned to the volcano analogy to express the reverse side of the natural experiment: "First of all, I would like to mention that although the Pinatubo volcanic eruption cooled the planet, it also produced drought in Asia and Africa. It destroyed ozone, and it reduced solar radiation generation from direct solar radiation by 30 percent in those technologies that were developing. So it is a lesson of efficacy but also of problems" (Congressional Hearing 2009a). After making this statement, he returned to the question asked. Robock's consistent role in reiterating the level of risk involved in solar geoengineering highlights the ease at which these novel technologies can become normalized in common discourse on geoengineering in the absence of someone so vigilantly returning to the risks. This is despite the fact that the far-reaching nature of geoengineering risks are broadly agreed upon within the geoengineering research community. However, as discussed elsewhere, risks are often mentioned before discussion is pivoted toward technical questions or else treated as footnotes, sometimes quite literally, as discussed in Chapter Two regarding the volcano analogy's treatment in the NRC report.

These examples highlight variance of opinions between panelists on topics such as field experimentation, the estimated costs of SRM, and degree of confidence in the feasibility of a

Plan B. Despite the differing positions on these topics as well as on the specific details on how to best fund and coordinate research, the panels displayed consistent promotion of the importance of geoengineering research for both SRM and CDR. As Ken Caldeira noted, variance among witnesses on envisioning the details of a research program, highlights the consistency of the shared sentiment that there should be some form of research program (Congressional Hearing 2009a). The need to support research in some form or another received unanimous consensus among witnesses speaking at the four geoengineering hearings. Furthermore, with the exception of the few anomalies discussed earlier in this section, there was broad agreement on the urgency and primacy of mitigation and the related point that geoengineering cannot replace mitigation.

Situating Geoengineering Hearings in Context

Congressional hearings provide a platform for reenacting recurrent political arguments of differing levels of relevance to a topic. For example, within the geoengineering hearings, there is spillover of the partisan contention regarding climate change, which has also received its own hearings within the same Committee on Science, Space, and Technology. This includes Republicans reiterating "uncertainty" regarding climate change and implying the science is still a matter of "debate" while Democrats reiterate the existence of anthropogenic climate change and the urgency of mitigation and adaptation. The hearings further included Republican recitations of narratives regarding economic competition, national debt, and economic responsibility, which influenced their engagement with climate change and geoengineering, based on ideology that prioritizes economic over environmental concerns.

As mentioned in Chapter One, Aaron McCright and Riley Dunlap's (2010) research points to the ways in which the American conservative movement has managed the boundaries of climate policy. Moreover, the climate skepticism movement that is related to this continues to cultivate the sense that there is an ongoing debate about the existence of anthropogenic climate change. The congressional hearings on climate change from recent years, especially since the committee transitioned to being majority skeptic, reaffirm this trend as demonstrated by the witness lists that have been designed to simulate debate within the formal structure of congressional hearings that are ostensibly meant to provide information to guide policy making. For example on March 27, 2017, the House Committee on Science, Space, and Technology held a hearing entitled "Climate Science: Assumptions, Policy Implications, and the Scientific Method," which included four panelists: three (Judith Curry, John Christy, and Roger Pielke Jr.) who dispute scientific consensus on climate change and one (Michael Mann) to represent the majority view on climate change. Similarly, an earlier hearing of the Subcommittee on Environment on March 6, 2013 called "Policy Relevant Climate Issues in Context" included three panelists: two who have been vocal in disputing climate change consensus (Judith Curry and Bjørn Lomborg, the self-labeled "skeptical environmentalist" discussed in the previous chapter) and one (William Chameides) who has been vocal on the dangers and risks of climate change. In these instances, the Committee on Science and the Subcommittee on Environment designed the climate change hearings to provide a performance of debate on climate change, a literal manifestation of the political contention that debate continues. The witness panels of these climate change hearings, moreover, were constituted by a majority of panelists presenting the minority views disputing climate change and only one scientist at each hearing to present the mainstream perspective.

The geoengineering hearings provide an additional venue for performance of political posturing, presentation and interaction with climate change and proposed policy approaches.

Within the geoengineering hearings, a sub-set of Republican representatives reassert the narrative that the science of climate change is not settled, but rather subject to an active debate. However, geoengineering complexifies the dynamic, by offering a "solution" that is acceptable to conservative interests and this same sub-set of Republican representatives, even while they continue to deny the relevance of the problem it addresses. This became evident at the fourth of the geoengineering hearings when Texan Republican representatives, known for positions against climate mitigation policy, came to enthusiastically embrace solar geoengineering as a favorable alternative to mitigation, or "regulation" as Chairman Smith refers to it (Congressional Hearing 2017b). Projecting albedo modification as an alternative to mitigation was in clear contrast to the core message from the four sets of panelists with few exceptions: that geoengineering should be researched, but that it is not a magic bullet, there is a primary need to reduce emissions, and that geoengineering is not an alternative to emissions reductions (Congressional Hearing 2009a; Congressional Hearing 2010a; Congressional Hearing 2010b; Congressional Hearing 2017b).

Members of both political parties recurrently reiterated their party's position on climate change and then pivoted the discussion in such a way that by the final two hearings on geoengineering, a majority of members of both parties ultimately express some level of support for pursuing geoengineering research and some degree of possible implementation. This is seen among the Democrat members' reiteration of the urgency and primacy of mitigation and adaptation, but with discursive flexibility that leaves room for the consideration of geoengineering as an additional strategy. As discussed, the Republican committee members employed the discursive technique of decoupling climate change and geoengineering to facilitate the simultaneous support of otherwise contradictory positions, dismissing climate change and embracing solar geoengineering.

At the earlier hearings, members from both parties expressed concern about the lack of political will to match the urgency of climate change. Eight years later, climate policy remains an issue of speculation and the arguments that geoengineering may be necessary should mitigation efforts be insufficient have become increasingly pertinent. However, geoengineering would involve its own social and political challenges and risks in addition to environmental risks. Jane Long's written testimony for the third geoengineering hearing spoke directly to this. She wrote: "As we consider geoengineering, we have to recognize that society has not been able to quickly or easily respond to the climate change challenge. Consequently, the geoengineering option isn't just a matter of developing new science and technologies. It is also a matter of developing new social and political capacities and skills" (Jane Long, written statement, Congressional Hearing 2010b). Yet, as expressed by nearly every witness within the four panels, geoengineering cannot replace mitigation. Geoengineering, then, presents an additional layer of political performance and maneuvering, a forum for the "politics of representation" (Mehan 2000; Mehan and Wills 1988) within an arena characterized by the "politics of unsustainability" (Blühdorn 2011; Blühdorn and Welsh 2007). While geoengineering cannot replace mitigation and comes with its own environmental, social, and political challenges, it provides another avenue for continued "debate" that further facilitates prolongating the status quo as climate mitigation policy decisions are delayed. Meanwhile, the stakes and risks involved continue to escalate, reshaping the environmental and political landscape in which eventual decisions will be made.

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CHAPTER 5 — Connections, Conclusions, and Reflections on Reflexivity

Interactional Effects, Interconnections, and Complexities

Geoengineering is controversial for a number of reasons, including its novelty, the magnitude of its risk, the challenges of governance involved, the regional disparity of potential effects, and concerns regarding moral hazard, meaning that its very consideration could impede emission reduction efforts (e.g., Hulme 2014; Szerszynski *et al.* 2013; Stilgoe 2016; Fischer 2017: 84-85). The implementation of geoengineering projects would bring about new risks and uncertainties inherent in the pursuit of such real-world experiments (e.g., Huesemann and Huesemann 2011; Beck 2009; Harris 2013; Hamilton 2013; Parkinson 2010; Macnaghten and Szerszynski 2013; Szerszynski *et al.* 2013; Stilgoe 2016). Nevertheless, geoengineering is being mainstreamed as a topic of consideration within scientific communities, politics, and the public.

The three genres of discourse considered in this dissertation all contribute to and reinforce each other on reflecting and advancing the mainstreaming of geoengineering. Science policy reports, especially the Royal Society and National Research Council (NRC) reports, represent a critical juncture in the trajectory of geoengineering. They are used as evidence by journalists of the mainstreaming of geoengineering within the scientific community and they have also been relied upon as a premise for government hearings. The very existence of the reports furthers mainstreaming. Moreover, discursive conventions within them help to normalize novel geoengineering proposals and legitimize geoengineering research. News media, in the process of reporting upon the developments related to geoengineering, have reinforced the narrative of its move from “fringe” to mainstream and have themselves brought increased public attention to geoengineering since 2006. Congressional hearings held between 2009 and 2016 reflect the mainstreamed political consideration of geoengineering, with Congressional representatives from both major political parties demonstrating increasing receptivity over time to the idea of geoengineering, although for different reasons. As illustrated in the three empirical chapters of this dissertation, among scientists, even strong proponents of geoengineering solutions usually see them as a supplement, stop-gap, or plan B to emissions abatement. Nevertheless, as geoengineering increasingly mainstreams, there exists a risk that Plan B encroaches upon Plan A, especially as politicians embrace the technical solutions divorced from climate change as their raison d'être.

Geoengineering represents a radical departure from previous risks and the potential for a new existential crisis, novel in its global scale and the intentionality of the process. Despite its novelty and globality, the paradigm of governance is based upon existing structures and assumptions. It is assumed policy would facilitate and guide behavior of market economies in responsibly pursuing CDR as it becomes cost effective to do so in place of traditional mitigation. The assumption of market-based policies and decisions weighed by costs places geoengineering largely under the control of the market. Yet, deployment at scale of CDR and/or albedo modification would require international cooperation and planning at a level at least equal to that which the international community has failed so far to reach in regard to meaningful mitigation through emission reduction measures. Moreover, the potential implementation of geoengineering does not supersede the need for international cooperation on emissions reductions; rather it adds a new level of necessary cooperation, rife with similar political challenges. The discourses that guide geoengineering's development are characterized by knowledge-seeking and faith in technological advancement within the scientific professional sphere and the politics of unsustainability within the political sphere. The counter-pressure is provided by the discourses and actions associated with environmentalism and radical life politics.

The research in this dissertation informs and engages with three levels of consideration regarding geoengineering's trajectory and its implications. First, in terms of social theory, the current resurgence of attention placed on geoengineering represents a retreat toward the mentality of simple modernity, as contrasted to the reflexivity emblematic of high modernity as seen in the environmental movement (e.g., Giddens 1990; 1994). It represents a new layer to the "politics of unsustainability" (i.e., Blühdorn 2000; 2007; 2011; Blühdorn and Welsh 2007). However, while Blühdorn argues that we have entered an era of "post-ecologism," this research finds the move from ecologism to be more complex and dynamic with a persisting tension between simultaneous forces of ecological reflexivity and instrumentality. These tensions can be seen in the big-picture debates around climate change and geoengineering, but also embodied in the ambiguity of policy reports and individual actors who, for example, advocate for geoengineering research, while remaining reluctant about its use and reiterating the primacy of mitigation. Moreover, environmental social movements, which have been engaged and active over the same time-period that geoengineering has been mainstreaming, remain the vanguard of reflexivity in the realm of climate politics, as will be discussed further.

Second, organizational dynamics as well as political-economic structures and conditions affect the trajectory of geoengineering. There are clear economic incentives among certain interests to promote geoengineering (Gunderson, Petersen and Stuart 2018; c.f. Long and Scott 2013). There are also push factors embedded within institutional and professional cultures (c.f. Long and Scott 2013). As the "inhabited institutions" concept within organizational sociology has elucidated, dynamics within organizations are complex and agentic individuals within them “possess varied, and sometimes crosscutting logics of action […] on a continuum of almost purely universalistic to almost purely institutional” and “these actors are idiosyncratically endowed with interests” (Binder 2007: 567-8). Applied to geoengineering, it is clear that particular components of professional culture among scientists and their drive for organizational survival and success influence the scientific community’s treatment of geoengineering.

Most scientists engaged with geoengineering premise their position on underlying concerns regarding the seriousness of the threat of climate change and the corollary objective to maximize potential climate response options. The professional culture of research scientists also tends to promote the furthering of scientific knowledge as intrinsically valuable (cf. Stilgoe 2015: 16). The humanistic concern regarding climate change as well as the professional culture valuing scientific progress would constitute the more universal side of the continuum while the other end includes interests regarding agency, departmental, and personal research funding and prestige. A diverse array of individuals from a diverse array of institutions are active in shaping the trajectory of geoengineering. Actors include engineers, physicists, climatologists and ecologists as well as investors, social scientists, bureaucrats, and politicians from organizations that include for-profit corporations, academic research institutions, and government agencies. Cross-cutting interests, tendencies and concerns, interact in affecting individual and organizational positions that influence the future of geoengineering.

Third, as empirically examined in this dissertation, discursive trends, both strategic and incidental, significantly influence the reception and consideration of geoengineering as a potential response to climate change. In particular, in the genres of science policy reports and general audience journalism, certain discursive trends contribute to the construction of legitimacy in relation to the field of geoengineering notwithstanding an explicit emphasis on its novelty and risks. Within the political sphere, different ideologically-informed framings compete for legitimacy. As discussed, the staging and framing of an emerging technology like geoengineering affects its reception and political support, while also reflecting values, interests and concerns of the speakers.

Interactions between these social, cultural, and institutional influences as well as the related forms of discursive presentation are multi-directional. The politics of unsustainability and the corresponding move away from ecologism influence the incentive structures at the political-economic level, which in turn influences the discourse. From the other direction, the discursive trends support the institutional structures that are advancing geoengineering and reinforce or enact the politics of unsustainability.

Some individuals straddle the lines of interests, roles, and underlying ideology. For example, as discussed in this dissertation, David Keith is emblematic of being involved with nearly every aspect of geoengineering in various roles and within organizations of differing types and purposes, while prolifically contributing to the discourse of geoengineering. Keith is the most cited proponent of geoengineering within popular literature (see Chapter Three), has served as a member of the Royal Society working group that penned the influential 2009 report and also served as a reviewer of the National Research Council's 2015 report (see Chapter Two), and has testified before Congress as an expert geoengineering witness (see Chapter Four). In terms of professional roles, Keith is a professor that runs a research group on solar geoengineering at Harvard, but he is also an entrepreneur, having founded Carbon Engineering, a for-profit corporation pursuing industrial level CDR projects. Keith defines himself both as an "environmentalist," stating "Wilderness has shaped my life," as well as "a tinkerer and technophile" (Keith 2013: xiii-xiv). Keith embodies the ambiguity and complexity of advocating for the hubristic techno-fix of instrumental control over nature, while practicing a personal version of ecological reflexivity, which he articulates in the preface of his manifesto on geoengineering (Keith 2013: ix-xix).

Other influential actors involved in geoengineering also exemplify the complexities, tensions, and ambiguities involved in geoengineering. For instance, in contrast to Keith's enthusiastic advocacy, climate scientist and geoengineering researcher Alan Robock has been particularly outspoken in his concerns and reluctance about geoengineering (as discussed in Chapters Three and Four). He authored the article "20 Reasons Why Geoengineering May Be a Bad Idea" (Robock 2008). He acted as a whistle blower on the CIA's interest in geoengineering (Sample 2015). He unequivocally told members of Congress that mitigation was paramount to addressing climate change:

> global warming is a serious problem and […] mitigation, reduction of emissions, should be our primary response. We also need to do adaptation and learn to live with some of the climate change which is going to happen no matter what. […] we can't hold geoengineering as a solution and allow that to reduce our push toward mitigation. It is never going to be a complete solution. We may need it in the event of an emergency, but let us not stop mitigation and wait and see if geoengineering would work. That is not the right strategy. (Congressional Hearing 2009: 43, 87)

With his strong reservations on geoengineering, Robock's reluctant support for geoengineering research speaks to the nuance and ambiguities ingrained in geoengineering discourse, especially situated within the context of climate change politics. As mentioned in Chapter Three, science journalist Sharon Begley wrote in *Newsweek* magazine: "In a sign of how dangerous global warming is starting to look and of how pitiful the world's efforts to control greenhouse gases are, even Robock—list [of 20 reasons geoengineering may be a bad idea] and all—hedges his bets" with geoengineering. (Begley 2007)

Climate change is characterized by non-linear unfolding of new risks, complicated by tipping points and feedback effects. The idea of a tipping point is that there is some threshold at which the climate system transitions significantly, and perhaps irreversibly, out of the existing equilibrium and toward a new one (see Lenton 2011). There is debate as to exactly what these tipping points may include and whether some may have been reached (e.g., see Revkin 2009; Levitan 2013). Feedback effects include environmental changes that result from climate change that, in turn, exacerbate climate change. For example, when ice sheets in the arctic melt due to the warming effects of climate change, and then that melting changes the composition more in favor of water (which absorbs heat) than ice (which reflects heat), causing the warming in the arctic region to proceed significantly faster than previous rates. These factors related to climate change are fitting analogies for geoengineering, which is proposed as an approach to address that climate change. Within the social world, there are tipping points and feedback cycles as well.

In regard to the establishment of legitimacy around the pursuit of geoengineering, one key tipping point with resultant feedback effects can be characterized around the upswell of geoengineering attention following Paul Crutzen's article (2006) in the journal *Climatic Change*, which advocated for consideration of albedo enhancement with stratospheric aerosols as a possible strategy to mitigate effects of climate change. This seminal article demonstrates the interconnections and interactions between scientific, political and popular discourse on geoengineering, as well as the profound influence one discursive contribution can make. As discussed in Chapter Three, it was following this article's publication that news media began covering geoengineering to an appreciable degree. However, not only did Crutzen's article indicate a move toward legitimacy for geoengineering spectators, but it inspired climate scientists to take geoengineering seriously. For example, Dr. Phillip Rasch, a climate scientist within the US National Laboratories who has become an influential geoengineering researcher, states during the November 2017 congressional hearing on geoengineering that the Crutzen article "is what brought me into the field" (Congressional Hearing 2017). Moreover, the National Academy cites to Crutzen's article as motivation for its examination of geoengineering in the NRC report (National Research Council 2015b: 31).

As also discussed in Chapter Three, there was contention regarding the publication of Crutzen's article promoting consideration of albedo modification, with the concern that it would be "irresponsible" to promote geoengineering as a possible response to climate change (Mark Lawrence, cited in Broad 2006). The compromise was reached in which Crutzen's editorial was published alongside counterargument editorials. As it turned out, however, Crutzen's article did have a disproportionate effect to those counterarguments, with geoengineering gaining attention, prominence, and legitimacy as a result of it. Tracing the discourse of geoengineering from within scientific, popular and political discourse, a snowballing effect of legitimacy becomes apparent. Crutzen's article inspired new scientists to turn their attention to geoengineering. These scientists contributed to the National Academy's influential NRC report. News media point to both the Crutzen article itself and the NRC report as indicating the mainstream legitimacy of geoengineering. Congress calls upon these scientists to provide testimony at hearings aimed at informing legislative policy on geoengineering. And so it goes.

Changing the Political Debate

The notion that geoengineering could serve as a "hedge" or "Plan B" to confronting climate change realigns the parameters of political debate with the idea that there are a variety of potential responses to climate change. Increasing scientific attention to geoengineering also fragments scientific resources, risks diluting the sense of near consensus regarding the need for emission reductions, and opens up new scientific and technical uncertainties which can be exploited by political interests hostile to emission reductions. Clive Hamilton argues that in the 1990s, geoengineering proposals were regarded as a "distraction from the real task of reducing emissions" and that "almost all climate scientists took the view that the availability of an alternative to cutting emissions, even if manifestly inferior, would prove so alluring to political leaders that it would further undermine" emission reductions (2013: 14-15).

The Solar Radiation Management Governance Initiative report notes the potential for climate engineering research to present "moral hazard" in which the perception of protection "against the potential consequences of climate change" may make people or governments "less likely to take the actions necessary to reduce greenhouse gas emissions" (2011: 20). The NRC Committee recognizes this risk of moral hazard, but contends that we have reached the point where "the severity of the potential risks from climate change appears to outweigh the potential risks from the moral hazard" in regard to geoengineering (National Research Council 2015b: 8).[18] Among the general public, Phil Macnaghten and Bronislaw Szerszynski found: "Even though solar radiation management may be presented in good faith as 'Plan B' ('Plan A' being continued effort at climate mitigation), there was a shared concern across the [focus] groups that its very availability as a technological option would weaken the commitment to climate mitigation – the well-known 'moral hazard' argument, that today's 'Plan B' would become

[18] The Royal Society, by contrast, indicates a level of uncertainty in regard to the moral hazard concern, speculating that rather than simply decreasing motivation for mitigation, "it is possible that geoengineering actions could galvanise people into demanding more effective mitigation action" and therefore calls for additional research into the risk of moral hazard as related to geoengineering (2009: 39).

tomorrow's 'Plan A'" (Macnaghten and Szerszynski 2013: 470).

Hence, mere consideration of geoengineering is perceived by some "as indirect permission to abandon serious efforts to cut emissions" (Specter 2012: 100). However, even among scientists working directly on geoengineering schemes, there is a strong reluctance toward the prospect of actually implementing geoengineering. Hugh Hunt who leads the Cambridge team of the Stratospheric Particle Injection for Climate Engineering (SPICE) project is quoted as saying "the last thing I would ever want is for the project I have been working on to be implemented […] If we have to use these tools, it means something on this planet has gone seriously wrong" (quoted in Specter 2012: 98). As with many technical reports on climate engineering, the influential Royal Society (2009) and NRC (2015a; 2015b) reports are laden with caveats and identified uncertainties within its analysis of possible geoengineering options. It is expressed that "Geoengineering of the Earth's climate is very likely to be technically possible. However, the technology to do so is barely formed, and there are major uncertainties regarding its effectiveness, costs, and environmental impacts" (Royal Society 2009: ix). The NRC report bluntly indicates: "There is significant potential for unanticipated, unmanageable, and regrettable consequences in multiple human dimensions from albedo modification at climate altering scales, including political, social, legal, economic, and ethical dimensions" (National Research Council 2015b: 148). While arguing that geoengineering is a necessary "Plan B," Lord Rees of the Royal Society, admits "Geoengineering would be an utter political nightmare" and that there "could be unintended side-effects" (as quoted in Jha 2013). The notion of a political nightmare is telling since one of the bases for geoengineering is to circumvent the initial political failure of agreeing to meaningful international carbon reductions and standards. In this way, the techno-fix does not manage to solve the political problems inherent in addressing a global environmental catastrophe.

The idea of a "Plan B" by definition implies that it is a back-up option, rather than a primary strategy. However, despite overwhelming scientific evidence and broad international acknowledgment that there is first and foremost a need to cut greenhouse gas emissions, the argument for a Plan B becomes stronger with each passing year as rising carbon emissions continue mostly unabated (see Specter 2012: 100; Rees 2009: v; National Research Council 2015b: ix). In his overview of the American political response to climate change, Paul Harris explains how the response of several presidential administrations[19] "to global warming was to call for more scientific research, which some interpreted as simply a recipe for pushing any requirement for US action well into the future" (2013: 67). Calls to research geoengineering as a Plan B perpetuate this precedent of pushing meaningful climate mitigation policy further into the future as hope lingers for a technological solution. In the case of geoengineering research, pushing out the time horizon increases the likelihood of this Plan B eventually being implemented. The NRC report argues that, while they advise against deployment of albedo modification "at this time," research toward understanding and developing the technology should be pursued in case the point comes that such technology would be "useful" (National Research Council 2015b: e.g., 7-8, 49-54, 121).

Controlling discourses of the "future" has been noted as an important strategy in presenting and enhancing legitimacy in regard to contested or emerging technologies (Welsh 2000: 6; Selin 2007; Brown and Michael 2003). Ian Welsh notes that "Big science projects […] typically have very long lead times which almost inevitably involve considerable areas of

[19] In context, he was specifically referring to the Reagan and George H.W. Bush administrations.

uncertainty […] The future invoked within such discourse typically emphasises positive collective outcomes for 'mankind' in the face of current uncertainties and doubts" (Welsh 2000: 6). Nik Brown and Mike Michael identify the framing of "temporal representations of change and the future" and also note the "metaphor of the 'breakthrough'" as a "pervasive discursive method for organizing narratives about science" (Brown and Michael 2003: 7-8). This sort of positive framing of the technology's development can be seen in geoengineering discourse (as mentioned in Chapter Two). In regard to geoengineering, the future is also invoked in another sense, as characterized by the "Plan B" and "climate emergency" framings, which project a future in need of saving.

Discourse around climate change has included a technocratic and techno-enthusiast component. The movement of geoengineering from the margins toward the center of climate change debate reflects this element. As Clive Hamilton states: "It is into the yawning gap between the urgent response scientists say is needed and the timid measures governments are willing to take that geoengineering has stepped" (Hamilton 2013: ix). Despite the monumental risks involved, geoengineering resonates with a culture that is exuberant about technology solving the world's problems, even and especially those caused by technology in the first place (Blühdorn and Welsh 2007; Huesemann and Huesemann 2011). The idea of a technological fix to climate change is appealing to the general public and particularly "climate engineering is intuitively appealing to a powerful strand of Western technological thinking and conservative politicking that sees no ethical or other obstacle to total domination of the planet" (Hamilton 2013: 18). Geoengineering as a techno-fix to climate change is the most obvious manifestation of a social and political retreat from reflexivity back toward the technological faith and economic dogmas of simple modernity, characterized by "an instrumental approach to nature, faith in technological progress and abstract systems of expertise, and the exclusion of ambivalence and uncertainty" (Thorpe and Jacobson 2013: 100; Giddens 1994: 5-7, 80-87).

The prospect of geoengineering as a potential technological solution offers a new strategy to repress the ontological insecurity that accompanies concerns of unmitigated climate change. Clive Hamilton contends: "Everyone is looking for an easy way out" and the "technofix of geoengineering [offers] a third way out" after the coping strategies of denialism and optimism (2013: 107). However, geoengineering itself poses new global risks that present similar issues of ontological insecurity and existential crisis, literally a crisis of existence, to replace – or join – that related to the dangers of climate change itself. This sentiment can be seen in Phil Macnaghten and Bronislaw Szerszynski's focus group data in which subjects expressed fears of being part of a real world global experiment with the potential to "destroy the Earth" (2013: 470).

Ian Welsh (2007) argues that technologies are promoted by scientific social movements and those that come to prevail have compatibility with social zeitgeist. However, publics are not homogenous and reception of technologies are not straightforward. In his case study, he argues that the public has always been ambivalent about nuclear technology, with varying levels of quiescence within the broader public, but always a presence of opposition and resistance (Welsh 2000). The same appears to be the case with geoengineering technology. David Keith, geoengineering advocate *par excellence*, commented in his testimony to Congress: "It is a healthy sign that a common first response to geoengineering is revulsion. It suggests we have learned something from past instances of techno-optimism and subsequent failures" (Congressional Hearing 2009). Geoengineering enthusiast that he is, he then goes on to argue that "we must not over-interpret past experience" and that climate policy must include "sharp emissions cuts and clear-eyed research on SRM linked with the development of shared tools for managing it" (Keith statement at Congressional Hearing Congressional Hearing 2009). However, irrespective of his conclusions, he points to this tendency of a recoiling response to the prospect of geoengineering, which makes room for the potential of countervailing forces to resist technocratic determinism.

Geoengineering and the Economy

Within the climate science community and policy arena, proposals for advancing climate engineering research and experiments are generally framed very explicitly as *not* an alternative to emission reductions. For example, the Royal Society report clearly states that "The safest and most predictable method of moderating climate change is to take early and effective action to reduce emissions of greenhouse gases. No geoengineering method can provide an easy or readily acceptable alternative solution to the problem of climate change" (Royal Society 2009: ix). The National Research Council contends: "There is no substitute for dramatic reductions in the emissions of CO_2 and other greenhouse gases to mitigate the negative consequences of climate change, and concurrently to reduce ocean acidification" (National Research Council 2015b: 2). In his forward to the Royal Society report, Lord Rees frames this premise by stating "nothing should divert us from the main priority of reducing global greenhouse gas emissions. But if such reductions achieve too little, too late, there will surely be pressure to consider a 'plan B'—to seek ways to counteract the climatic effects of greenhouse gas emissions by 'geoengineering'" (Rees 2009: v). According to the Royal Society's conclusions: "The global failure to make sufficient progress on mitigation of climate change is largely due to social and political inertia, and this must be overcome if dangerous climate change is to be avoided. If this proves not to be possible, geoengineering methods may provide a useful complement to mitigation and adaptation if they can be shown to be safe and cost effective" (Royal Society 2009: 57). The NRC supports this idea that geoengineering would complement, not supersede, mitigation. They refer to a "portfolio of climate responses" which could include mitigation, CDR and, perhaps, albedo modification (National Research Council 2015b: ix, 146). In the case of the latter, they emphasize:

> The less CO_2 that humans release to the atmosphere, the lower the environmental risk from the associated climate change and the lower the risk from any albedo modification that might be deployed as part of the strategy for addressing climate change. It is widely recognized that the possibility of intervening in climate by albedo modification does not reduce the importance of efforts to reduce CO_2 emissions. (National Research Council 2015b: 36)

In any of the scenarios, then, whether or not geoengineering is integrated within the "portfolio of responses," mitigation remains essential.

By contrast, for some financially interested parties, promoting geoengineering is a back-up to peddling skepticism as opposed to a good faith back-up for failures of timely emissions reductions. For instance, the oil and gas industry has been a major contributor to promoting climate change "skepticism" and, more recently, geoengineering. Claire Parkinson explains that in recent years, "climate skeptics and friends of the fossil fuel industry have […] discovered geoengineering" (2010: 15). For instance, ExxonMobil and some of its executives have been instrumental in the American Enterprise Institute, which has long worked "to deny the scientific consensus on climate change" and which now runs "one of the few funded policy centers on geoengineering" (Parkinson 2010: 15). As mentioned in Chapter Four, one witness at the first congressional hearing on geoengineering was the co-director of AEI's Geoengineering Project, who was unique in his enthusiastic promotion of albedo modification and notably minimal discussion of mitigation. Exxon has also directly recruited engineers who, "ensconced in Exxon" have become influential on geoengineering, even influencing "'independent' reports into geoengineering, such as the 2007 NASA report on solar radiation management" (Hamilton 2013: 78). Geoengineering in this instance constitutes a different kind of Plan B. Rather than the Plan B of trying to mitigate the potential extremes of climate change, for those deeply invested in the carbon-intensive energy economy, geoengineering is a Plan B—a back-up to the first strategic plan of climate change denial—to resist or defer the advancement of emission reductions.

It is not just oil and gas interests who are opposed to cutting emissions. Carbon emissions are built into the worldwide industrial system of production. Constant growth is central to the global economic system and is necessary to avert economic crises within the system of competitive capitalism (Harvey 2010; Harman 2010). As mentioned in Chapter One, the modern economic system has been characterized by environmental sociologists as "the treadmill of production," in which production drives the growth of the global economy as well as the corresponding environmental effects (Gould, Pellow and Schnaiberg 2008). The treadmill of production theory emphasizes technology and production as the critical variables in explaining environmental impact starting in the third quarter of the twentieth century (Gould, Pellow and Schnaiberg 2008: 19). They propose that "[c]ontrary to classical and neoclassical economic theories that posit that consumer preferences determine the contour of markets, consumer behavior is consciously being shaped by industry" (Gould, Pellow and Schnaiberg 2008: 21).

Climate and geoengineering science policy reports tend to obliquely allude to this challenge, of industry and vested interests' influence over the market and climate politics. For example, the National Research Council report notes that "Mitigation, although technologically feasible, has been difficult to achieve for political, economic, and social reasons that may persist well into the future" (2015b: 146). Similarly, the IPCC states that while there exist "multiple mitigation pathways that are likely to limit warming to below 2°C relative to preindustrial levels […] Implementing [the necessary GHG emission] reductions poses substantial technological, economic, social, and institutional challenges" (IPCC 2014: 90).

There have been significant advances in alternative energies in recent years. However, overcoming technical challenges to mitigation does not have a corollary effect in regard to economic, social and institutional challenges. In fact, it appears that such technical advancements in energy alternatives may create further incentives for entrenched interests to resist the threat of transformation of the energy system. For instance, climate advocate, former Vice President Al Gore, argues that in response to both solar and wind power becoming increasingly affordable, "utilities are fighting back […] by using their wealth and the entrenched political power they have built up over the past century" (2014: 87). Finding a techno-fix that might advert some or all pressures for carbon emission reductions would thus be a utopian reconciliation for the present capitalist fossil fuel-dominated economy and the environmental crisis we face from global climate change.

Not only does geoengineering promote the general political agenda of economic growth and the interests of the entrenched energy economy (cf. Gunderson, Petersen and Stuart 2018), but furthermore, various reports have linked advocates of geoengineering to specific financial interests. For example, Hamilton notes that a number of the expert scientists and policy influencers in regard to geoengineering are holders of related patents (Hamilton 2013: 17, 75-84, 173; c.f. Lukacs, Goldenberg and Vaughan 2013). Investors in private geoengineering ventures include oil tycoons such as "Murray Edwards, a Canadian oil billionaire with perhaps the largest financial stake in developing Alberta's tar sands" (Hamilton 2013: 74; cf. Vidal 2018). Such industry investors might be expected to have a double-interest in the success of geoengineering as a techno-fix to climate change, especially if it can dampen calls for emission curtailment while making a profit in and of itself. However, one of the most important investors in geoengineering is not an oil but a silicone billionaire. Bill Gates is “the world’s leading financial supporter of geoengineering research” (Hamilton 2013: 74).

The ability of powerful individuals and organizations to disproportionately influence the future of geoengineering is a recurring concern among proponents, critics and commentators alike (e.g., National Research Council 2015b: ix, 9, 32, 33, 107, 122; Royal Society 2009: 39-40; Victor 2011: 196-7; IPCC 2014: 102). In contrast to the potential of life politics as a transformative and multilateral response to the climate crisis, geoengineering detracts from this democratic turn, regressing toward a renewed threat of oligopoly in climate politics. The concept of geoengineering serves powerful political and economic interests by deflecting urgency in emissions reductions, facilitating the notion that growth may continue within the carbon-intensive energy economy, and by creating of a new market for high-tech, high-cost technological research and development.

In a recent article, Ryan Gunderson, Brian Peterson and Diana Stuart argue that geoengineering, particularly the most favored form of solar geoengineering, stratospheric aerosol injection, “supports economic priorities (and powerful financial actors), protects an inherently ecologically harmful social formation, and relegates the fundamental social-structural changes needed to actually address climate change” (2018: 14). Since “emissions reductions, unlike geoengineering, are expensive, rely more on social-structural than technical changes, and are at odds with the current system (i.e., the current social system may be structurally incapable of significantly reducing emissions),” they “predict that geoengineering strategies, no matter how risky, will increasingly be considered principal means to combat climate change, perhaps even as alternatives to emissions reductions" (Gunderson, Petersen and Stuart 2018: 14). The mainstreaming trends identified and analyzed in this dissertation tend to reinforce the basis of this prediction. However, the potential of countervailing social forces to pose a challenge to this direction remains an open question. The opposite of geoengineering as an instrumental, technological response to climate change is not merely the absence of geoengineering. Rather it is the revitalization of life politics and environmental social movements.

The Counter Move of Environmentalism

Reflecting upon the emergence of the so-called self-regulating market following the Industrial Revolution and the social dislocation caused by it, Karl Polanyi wrote in 1944: "human society would have been annihilated but for protective counter-moves which blunted the action of this self-destructive mechanism" (Polanyi [1944] 2001: 79.) According to Polanyi, social history of the 19th Century is that of a double movement: the development and expansion of markets but also the protective measures to check the market's impact on what he calls the "fictitious commodities" of land, labor and money. It can be surmised that without these counter moves, the perils of the market would have been more devastating. Likewise, the modern environmental movement, has served as a critical countervailing force in the era of advanced industrial society, endeavoring to protect social and environmental values put in jeopardy by economic values.

Modern environmentalist movements and environmental thought emerged in the mid-twentieth century, arguably coalescing in the space between the 1962 publication of Rachel Carson's groundbreaking book, *Silent Spring*, and the first Earth Day in 1970. This emergent environmentalism linked scientific knowledge with new social values and political mobilization.

Scholarship on New Social Movements traced a shift in activism from traditional grievances, especially economic, to more cultural and social aims, which included the ecological movement (e.g., Habermas 1981). These movements, and forms of consciousness, posed a fundamental challenge to the modern view of economic growth and technological progress as goods in themselves.

The significance of environmentalism as a challenge to simple modernity was recognized sociologically by Anthony Giddens and centrally informed his conception of reflexive modernization (Beck, Giddens and Lash 1994; Giddens 2009; Giddens 1990; Giddens 1994). Other scholars of reflexive modernization, including world risk scholar Ulrich Beck (eg., Beck 1997 [1993]; Beck 1992) as well as proponents of ecological modernization theory (e.g., Mol and Spaargaren 2000; Mol 2000), have also pointed to the significance of environmentalism in regard to reflexive modernization, as it encapsulates two key factors of reflexivity: impact science and social movements (McCright and Dunlap 2010: 103-104). For Giddens (e.g., 1990; 1994), environmentalism was a form of "life politics" that reopened the existential question of "how should we live?" This existential question, Giddens argued, had been closed down by modernity's compulsive drive toward economic growth and its one-dimensional focus on the technological control of nature (Giddens 1994: 10-11; Thorpe and Jacobson 2013: 104).

The rise of life politics, characterizing high modernity, meant that modernity's suppression of existential dilemmas would give way to new forms of reflexivity (Giddens 1990: 38-45; 1994: 7, 13, 42, 86, 90, 111; Thorpe and Jacobson 2013: 104-5, 108). However, Giddens also recognized that life politics came into contradiction with the dominant institutions of the capitalist state, which were not geared toward dealing with the kinds of reflexive questions regarding quality of life. Hence, he suggested that high modernity would require a new "double democratization," at the local and global levels (Giddens 1998: 70-8). The subsequent failure of global capitalism to achieve such institutional transformation is evident in the stagnation of efforts to negotiate international treaties or implement meaningful material practices that would produce carbon emission reductions necessary to control climate change, suggestive of the concept of the "politics of unsustainability" and society's shift toward "post-ecologism" (Blühdorn and Welsh 2007; Blühdorn 2000; 2011).

While climate politics generally, and geoengineering specifically, have been illustrative of both the "politics of unsustainability" and the retreat from reflexivity, the broad trends of top-down influence guiding this trajectory are not immune to fissures to the paradigm of unsustainability from below, in the form of a return to life politics at the grassroots level. Recent grassroots activism representing radical ecologism, antithetical to post-ecologism, involve a number of local and international campaigns, efforts and actions. Specific examples include 350.org's international divestment campaign that has successfully encouraged individual and institutional investors to pull money out of fossil fuel industries, with "total value of institutions" that have divested surpassing $6 trillion according to the organization (Fossil Free 2018); "kayaktivists" in Seattle practicing civil disobedience to obstruct Shell's deep-sea oil rig on its way to arctic drilling (Keim and Macalister 2015); and various oil pipeline battles, such as that around the Keystone XL pipeline that became a focus of climate activism (Avery 2013), as well as members of numerous Native American tribes and environmentalists blocking construction of the Dakota Access Pipeline at Standing Rock (Heim 2016), or the Kalamath tribe in Oregon in their own, currently unfolding, pipeline battle (Gentry and Marris 2018). Climate action movements represent a rekindling of the social reflexivity that poses a challenge to the hegemony of a "post-ecologist" paradigm.

While, for the most part, states have remained the key official actors in climate politics despite the limitations of state-based climate diplomacy (Harris 2013), broad grassroots environmental movements have served as the vanguard of life politics relevant to climate change and have been responsible for nudging governments forward on what progress has occurred on climate policy. The role of movements in climate politics, and their potential to affect norms and mores relevant to climate change mitigation, is an important component of international climate politics. International climate negotiations have historically been challenged by the lack of appropriate institutional arrangements (Harris 2013; Victor 2011). However, where formal institutions are missing, informal institutions such as standards of behavior, norms and cultural values, are critically important (North 1990). To date, the existing achievements on climate mitigation efforts have largely been led by civil society movements (cf. Urry 2011: 111, 114). If we are to avoid the "Plan B" of geoengineering in response to climate change, environmental social movements will continue to be a big part of driving change in terms of policy and social mores. Social movements help fill the vacuum created by the failure of formal international institutions to adequately regulate carbon consumption behavior.

Frank Fischer (2017) argues for local democratization, in the form of participatory governance, as an essential ingredient to climate mitigation. Relatedly, Andrew Stirling (2014) argues that to achieve sustainable solutions to the climate crisis, as well as other related environmental and social problems, the focus must be on *transformation* as opposed to merely *transitions.* Transformation arises from the public and involves "social and technological innovations driven by diversely incommensurable knowledges, challenging incumbent structures" while transition, the more typical form of political progress, results from efforts of incumbent political and economic elites guiding favorable policy "often driven by technological innovation, managed under orderly control, by incumbent structures according to tightly-disciplined frameworks for knowledge" (Stirling 2014: 1). This concept is relevant to the understanding of life politics as encompassing a plurality of values and practices that contribute toward cultural and material transformation. Stirling contends that geoengineering constitutes a "regressive" response to climate change "in the sense of being aligned with entrenched existing concentrations of power extending out from the energy sector" as opposed to a "progressive" transformation toward sustainable practices (Stirling 2014: 15).

Life politics, social movements, and participatory governance drive the potential for such progressive transformation. This is the reverse of the technocratic approach of geoengineering. More than any other manifestation of life politics, environmentalism is necessarily *life* politics in a literal and biological sense. Life politics cannot just be concerned with the cultural question of how should we live, but it must also encompass the material question of how can we live sustainably. In respect to environmentalism, then, life politics must change our relationship to the material world. Since modern society's primary relationship to the material world is intricately bound by systems of production and consumption, environmental life politics require reevaluation and transformation of these systems in a direction more compatible with the ecological systems with which they must necessarily interface and impact. Elsewise, in the context of climate change, the framing of geoengineering as a "Plan B" in case mitigation is "insufficient" becomes a discursive holding pattern until such time that the self-fulfilling prophesy triggers an enactment of this crisis script, which has become so embedded in the narratives explaining the legitimate role of geoengineering in society.

Concluding Summations on Geoengineering Discourse

This dissertation has examined the discourse of geoengineering, with a focus on science policy reports, news media, and congressional hearings. These are three important genres with the ability to influence the trajectory of geoengineering's social and political acceptance as well as the substantive practices related to it, including the course of research and potential development of proposed technologies. Science policy reports on geoengineering from elite scientific societies have both reflected and promoted the mainstreaming of geoengineering. Discursive strategies within such reports construct legitimacy and contribute to the mainstreaming of geoengineering within scientific, political and public discourse. News coverage of geoengineering has increased since 2006, coinciding with important publications from the scientific community, with scientific publications used to indicate the mainstreaming of geoengineering as well as offering topical insight. Recurrent narratives within popular media also contribute to the mainstreaming of geoengineering through presenting its trajectory as moving from fringe origins to serious consideration. Over the course of four congressional hearings on the subject, geoengineering has increasingly garnered political support from both major political parties in the United States, but for different reasons and with different interpretations of the role it might play in climate policy. This dissertation has also demonstrated the role of certain geoengineering researchers and advocates in influencing the deliberation and presentation of geoengineering within science publications, popular media, and policy discourse. These three genres reinforce one another in reflecting and advancing the mainstreaming of geoengineering.

Geoengineering discourse is comparable to that of other emerging technologies in that framings, narratives and discursive strategies compete for influencing the terms of deliberation and future prospects of the technology's development. Geoengineering is distinct from other emerging technologies, however, in both its scope of possibilities and premise. In terms of possibilities, as previously mentioned, even proponents concede the global risks of dramatically changing or even extinguishing life on Earth. In terms of premise, geoengineering is envisioned as a possible response to climate change, itself imbued with global existential risks (Beck 2009; Thorpe and Jacobson 2013). While proponents of biotechnologies or nanotechnologies, for instance, identify potential for their research to address global problems, these are qualitatively and quantitatively distinct from climate change. The magnitude of climate change and its worst-case scenarios create a context in which otherwise outlandish or inconceivable geoengineering proposals have become mainstreamed, garnering serious consideration by scientists and governments. As illustrated in this analysis of geoengineering, consideration of the inconceivable is further aided by controlling the representation of this technology through discourse.

Chapter Five, in part, includes material as it appears in "Constructing Legitimacy in Geoengineering Discourse: The Politics of Representation in Science Policy Literature." 2018. *Science as* Culture. Forthcoming. Jacobson, Brynna. The dissertation author was the sole investigator and author of this paper.

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