Tensions in framings of geoengineering: Constitutive diversity and ambivalence

Nils Markusson

Climate Geoengineering Governance Working Paper Series: 003.

Published online 27 June 2013

Climate Geoengineering Governance (CCG)

Climate Geoengineering Governance (http://geoengineeringgovernanceresearch.org) is a research project which aims to provide a timely basis for the governance of geoengineering through robust research on the ethical, legal, social and political implications of a range of geoengineering approaches. It is funded by the Economic and Social Research Council (ESRC) and the Arts and Humanities Research Council (AHRC) - grant ES/J007730/1

CGG Working Papers

The CGG Working Paper series is designed to give a first public airing to a wide range of papers broadly related to the project's themes. Papers published in this series may be, but are not necessarily, early outputs from the project team; equally they may be from other authors, and reflect different perspectives and different issues from those directly pursued by the project itself. The aim is to promote vigorous and informed debate, in a spirit of pluralism.

What the working papers have in common is that they will all be at an early stage of development, prior to full publication. Comment and response, at any level of detail, is therefore doubly welcome. Please send all responses in the first instance to the authors themselves - each paper contains a correspondence address. We will be looking for opportunities to use the website or other project activities to give a wider airing to any dialogues and debates that develop around a paper or issue.

About the Author

Nils Markusson (N.Markusson@insis.ox.ac.uk) is a Research Fellow in the Climate Geoengineering Governance project at the Institute for Science, Innovation and Society (inSIS), University of Oxford. He previously worked as a research associate at Scottish Carbon Capture and Storage research centre at the University of Edinburgh. That work included contributing to several projects funded by the UK Energy Research Centre. Before his PhD on cleaner technology investments in the process industry, he worked as an innovation policy analyst and R&D funding programme manager at VINNOVA, a Swedish government agency working to develop the country's innovation capacity. In the CGG project, he is working on framing and forms of public consent.

Tensions in framings of geoengineering: Constitutive diversity and ambivalence

Nils Markusson

Institute for Science, Innovation and Society

University of Oxford

June 2013

Abstract

Framings of geoengineering are multiple and dynamic, and the discourse appears to have low coherence. How, then, can we analyse and understand its inherent tensions? The paper conceptualises framings as articulations of the geoengineering imaginary, and analyses diversity among articulations as well as ambivalence within them, as expressed by a selection of high-profile reports.

In many ways, the geoengineering discourse is open and fluid, but there are also some entrenched differences. The findings indicate attempts at performing two types of relationships. Firstly, the well-entrenched relations between geoengineering proponents and critics, as well as between the main geoengineering community and some of the most ardent proponents. Secondly, the ambivalent relationships of the geoengineering community with the wider society, the climate change mainstream and climate science. Many of the actors implied in the ambivalent articulations are so far silent, and the ambivalent framings are therefore to be seen as attempts at negotiating positions and relationships, rather than accomplishments.

The paper argues that the geoengineering imaginary is not just about a technical solution to a scientifically defined problem, or merely a political move to preserve carbon society, but also, and not least, 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. The analysis implies that geoengineering is not just a thing to be responded to and governed, but an opportunity for collective reflection on climate change, S&T and, ultimately, how we as a society chose our problems and solutions.

Theoretically, the paper 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.

1.Introduction

The imagined potential of climate geoengineering (or just geoengineering for short) technology has been attracting increasing attention and given rise to a growing number of academic publications as well as policy reports. We can trace the emergence of the geoengineering imaginary back to diverse origins including weather modification practice (Fleming 2006), emergency arguments in climate policy discourse (Hulme 2008) and scientific attempts at exploring the Earth system (NOVIM 2009).

Geoengineering is a controversial topic, characterised by heated argument as well as cold-shouldering and deliberate silences. It raises sensitive questions about the relation between it and established mitigation and adaptation options in climate policy. Geoengineering also re-opens political and academic controversies around the relationship between science and society, for example how much control science and policy can and should have over each other.

The ways in which geoengineering is defined and presented are diverse and dynamic (Scholte et al. 2013), and even incoherent. The shape of the geoengineering imaginary seems malleable, and indeed its fate wide open. This paper seeks to analyse how geoengineering is framed in public discourse, and in particular ask in what forms geoengineering framings may be stabilising. The paper analyses high-profile reports as articulations of the geoengineering imaginary, conjuring possible futures of climate, S&T and society. The reports construct framings of geoengineering as part of attempts at building support for, opposition to and re-shaping of the imaginary.

Given the fluidity and diversity of framings of geoengineering, this paper pays particular attention to tensions in the discourse on geoengineering. Tensions between reports are interpreted as diversity, and as the setting out of different viewpoints, the design of choice in framing and the digging of trenches between framing options. Tensions within specific reports are interpreted as ambivalence, the simultaneous belief in contradictory beliefs. Ambivalence, the paper argues, is indicative of

different agendas and actors coming together (Fischer and Forester 1993), as authors of a report, or through an expected author-audience relationship. Ambivalence, thus, indicates attempts at forging new connections and coalitions.

It is hoped that this analysis will tell us something about the meaning and wider significance – for climate change discourse, S&T and ultimately society – of the emergent geoengineering imaginary. Such insight may also have implications for if and how we chose to govern geoengineering.

2. The significance of frame diversity and ambivalence

Can we identify geoengineering framings, i.e. identify the forms in which discourse about geoengineering is stabilising as a coherent object (or not)? There is a small, but growing body of literature on geoengineering discourse, through such different but related lenses as frame effects of functions (Bellamy et al. 2012, Scholte et al. 2013), metaphors (Nerlich and Jaspal 2012, Luokkanen et al. 2013) and discursive strategies (Sikka 2012). A few findings recur across studies and over time. Notably, Nerlich and Jaspal (2012) identify emergency as a master argument, remaining stable as metaphors evolve, and the emergency frame is identified by most studies. Beyond that, the findings of this literature are rather divergent, producing lists of frames and metaphors that are not easily reconcilable. In part, this is likely down to the specificities of divergent methodological and conceptual approaches, but it may also suggest that geoengineering discourse is in fact characterised by tension and incoherence.

This paper argues that this is plausible and significant. It analyses such framing tension and incoherence not as an aberration or problem, but as constitutive of a process of (potential) stabilisation of a socio-technical imaginary, through discursive positioning. This strategic positioning attempts to forge new alliances as well as create new fault lines in the evolving and contested discursive geoengineering landscape, and operates not just through expression of coherent frames, but also, crucially, through frame diversity and ambivalence. Table 1 summarises the key concepts used in this paper, and they are elaborated below.

Entman (1993) defined framing as "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 for the item described". This paper operates with a slightly simplified definition focussing on combinations of problem definitions and proposed solutions. The analysis will identify frame dimensions – such as the relation between geoengineering and mitigation, or the relation between science and society – that the frames identified are oriented to, in multiple and divergent ways, as evidence of tension and incoherence in the discourse on geoengineering.

Table 1 Conceptual schema

	Communication	**Technology**	**Politics**	**Evidence**
Macro level objects	Discourse	Imaginary	Controversy	Corpus
Action	Framing	Articulation	Positioning	Reports
Micro level objects	Frames	Coherence, diversity, ambivalence	Alliances, trenches	Textual units in reports

The reports can be interpreted as articulations of a geoengineering imaginary. This socio-technical imaginary (Jasanoff and Kim 2009) is about visions of the future relationship between S&T, climate (nature) and society (Curvelho 2013). Articulations of the geoengineering imaginary are about what such visions may be possible and desirable or not, and used to mobilise and constrain action bearing on this relationship in the here and now. Jasanoff and Kim (2009: 120) define sociotechnical imaginaries as "collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects". The analysis presented here is less nation-specific, although it does focus on Anglo-Saxon countries, and more strongly focussed on design then fulfilment of policy. In this sense, what is analysed here could be called a proto-imaginary, yet to find its specific forms as and when reports shape national policy implementation, or indeed through more international forms and mechanisms.

Articulations of the geoengineering imaginary, through reports, draw on and express multiple frames. This study is designed to analyse the relations between frames, and especially on instances of incoherence and

tensions among frames. The analytic focus is thus shifted from the frames themselves to instances where they clash.

We may distinguish between incoherence and tensions as *diversity* amongst different articulations and as *ambivalence* within individual articulations. Diversity amongst different articulations is no surprise for a topic of any degree of controversiality that attracts the attention of a range of actors. Such diversity is an outcome of attempts at persuasion to particular viewpoints, attempts at designing the choices actors face and, at times, to digging deep trenches between divergent positions.

Ambivalence is here taken to mean incommensurable framings as part of single reports, single articulations of the geoengineering imaginary. Ambiguity in the texts here serves as evidence for ambivalence in the act of writing and publishing them. Again, ambivalence is here seen not as an aberration, or a mere absence of coherence and clarity, but as a constitutive property of a reconfiguration process in which the concept 'geoengineering' is constructed as a new assemblage of old concepts and narratives that may not fit together without problem (cf. Walker and Shove 2007). Ambivalence, this paper argues, serves to glue together disparate elements and actors. Ambivalence, then, is caused by groups of authors trying to seek agreement on a text, and express a coherent framing in spite of their differences (cf. Sarewitz 2011). Or, it may be the result of trying to pre-empt or entice responses from expected and imagined audiences. Either way, it is about forging and managing troublesome relationships.

Articulations of the geoengineering imaginary through reports can be interpreted as attempts at positioning the report authors, and their readerships, in the contested landscape of geoengineering discourse. Diversity amongst articulations shows the centripetal force of articulating divergent perspectives, whereas ambivalence in articulations indicates attempts at bridging across. Such bridges can be built amongst report authors or with intended audiences. The ambivalences identified in this study were interpreted as attempts at reaching particular audiences.

The building up of support for an imaginary like geoengineering means enrolling (Callon and Law 1982) more actors with their agendas. This can work if the imaginary has enough interpretative flexibility (Pinch and Bijker 1984), whilst also having enough coherence. This requires the building in of ambivalence, rather than purging it. So, if we are seeing ambivalence – alongside a degree of coherence – that is a sign that 'geoengineering' is alive and kicking, as a nexus for re-imagining the

relationship between S&T, climate and society. However, ambivalences are more apparent in times of change, as opposed to being comparatively routinized, taken-for-granted and adeptly smoothed over in more stable times. So, since they are apparent to us, there is change happening. And we may see this as an indication of geoengineering not being a mature and stable thing.

Finally, different combinations of diversity and ambivalence are possible. A tension can, for example, be characterised by strong diversity and no ambivalence, suggestive of a well-dug trench, with few attempts at bridging across, or cutting the cake in a radically different manner. Combinations of diversity and ambivalence can thus be indicative of different social dynamics in geoengineering discourse. Table 2 sets out the possible combinations (although in practice these stark dichotomies are likely to be less clear cut). Discourse without either diversity and ambivalence can be characterised as consensual. Discourse with both diversity and ambivalence would indicate a situation of lively disagreement, but openness to different viewpoints. Ambivalence without diversity would suggest shared contradictions, reflecting our collective experience of living in a world that poses dilemmas that are impossible to neatly resolve.

Table 2 Typology of combinations of discourse diversity and ambivalence

		Diversity	
		Yes	**No**
Ambivalence	**Yes**	Openness	Lived contradictions
	No	Entrenchment	Consensus

3.Close reading of high-profile reports

This paper thus sets out to analyse diversity among framings and ambivalences in specific articulations of the geoengineering imaginary, as attempted positionings in geoengineering discourse. In particular, the analysis focuses on the relation between geoengineering and:

- wider climate change discourse, because of the controversy it has caused with regard to climate policy making (ETC 2010), as well as
- wider debates about the role of S&T in society, and the social nature of S&T. The specific themes that guided the reading were: control, novelty and doability/feasibility.

One of the main manifestations of public discourse on geoengineering has been the production of a range of often cited, high profile reports. These were chosen as being 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.

The selection of documents was done with the aim to identify a limited corpus of authoritative documents that exemplify a wide range of perspectives on geoengineering. As a starting point, The Royal Society (2009) report on geoengineering was selected. Arguably, this report has gained a status as the key reference on geoengineering, in terms of its visibility and legitimacy. The document selection then proceeded to choose documents that contrasted with the Royal Society report. Firstly, the ETC (2010) 'GeoPiracy' report as a prominent case of critique against geoengineering. Secondly, the AMEG (2012) Strategic plan was chosen as an example of the strongest articulation of a pro position, and in particular of imminent deployment. These three documents cover a range of positions on a scale from pro to against. In addition, I also read documents from POST (2009) and CBD (2012). Whilst interesting, their perspectives are pretty much covered by Royal Society and ETC, respectively.

This is not to suggest that the diversity and nuance of positions on geoengineering can be reduced to a pro-anti dimension. To further probe the diversity of 'mainstream' geoengineering framings, a set of high profile reports presenting geoengineering and arguing for research support were added. This included a document from the Copenhagen Consensus Institute, (Bickel and Lane 2009) contributing another pro-leaning position from a very different point of view to the other documents, being based in economics rather than natural science. The NOVIM (2009) and Bipartisan Policy Centre – BPC (2012) reports were added, with especially the former adding useful detail on the relationship between science and engineering, and notions of novelty and doability. A report from GAO (2011) sets out the most explicit attempt to date at assessing the maturity of geoengineering technologies, which also gives a

rich material regarding doability/feasibility that contrasts with the Royal Society report in terms of its understanding of 'technology'.

Finally, and in order to address the sub-question of novelty, it was also useful to bolster the analysis by reading the historical work by Fleming (2006; 2010), which sets out a perspective of continuity between geoengineering and earlier plans to control weather and climate, which contrasts with the otherwise normal framing of geoengineering as novel.

The aim was not to find an exhaustive set of reports. It is debatable if that is at all possible, and it is certainly not doable within the scope of this study. Rather, the corpus is selected as a representative sample, and one that includes a wide range of perspectives, as well as reflects the starting points of this study. There is a strong focus on reports from Anglo-Saxon, English speaking countries, due to limitations in the researcher's language skills. This study does not look at change over time. For that, a larger corpus would be needed, which would allow a periodization with enough material for each period. Again, this exceeds what is doable with the practical limitations of this study.

The data collection proceeded through close reading of a selection of reports. The reading was done carefully, with plenty of time. Detailed notes were written up. The notes were coded, and short summaries of the main points and take home messages from each document were produced. The reading and coding were guided in part by pre-defined themes. The pre-defined themes were: the controversial relation of geoengineering to climate mitigation and adaptation, and its relation to society, summarised by the familiar science studies themes of control, feasibility and novelty. The themes served as search heuristics for what data to collect, alongside an attempt at being open to the framings and themes in the documents.

The reading and analysis sought to identify tensions between documents, as indications of variety and choice of framing. Seven tensions were identified. These tensions were analysed and written up as having elements of problem definition and problem solution (as a minimum definition of a 'frame'). Seven tensions were identified. These are listed in Table 3. For each tension, there are two positions labelled a and b (sometimes with further varieties). The two positions contrast strongly, reflecting a tension in a particular frame dimension. In practice, there are nuances and grey scales of course, but this analysis serves to analyse the diversity in geoengineering discourse. Below follow elaborations on each tension. Moreover, the reading and analysis also led to the identification

of instances of tensions in these frame dimensions within the individual documents. This serves to highlight the occurrence of ambivalence in articulations of geoengineering.

Finally, the analysis sought to assess the strength of the diversity and ambivalence. Strength was assessed using two criteria: 1) a specific ambivalence observed in several reports, or the evidence for a particular diversity collected from several reports, rather than just one report, and 2) whether the ambivalence and diversity observed was central to the arguments of the reports, or not. This enabled classification as cases of strong and weak (or no) ambivalence or diversity.

It should be noted that this study takes the reports as the objects of analysis, rather than the writing process behind them. The assumption made is that a report is produced through a process aiming to deliver a coherent statement that can speak for itself after publication. The reports constitute strategic actions that can be interpreted as particular articulations of the geoengineering imaginary, and as attempts at positioning the report and its authorship in the contested and evolving landscape of geoengineering discourse, forging alliances and digging trenches. The point of this study is to analyse what the reports say, in themselves, in the context of the evolving geoengineering discourse, about frames, articulations and positionings. It would be interesting to study the writing process, but that would answer different questions, about, for example, what alternative statements were contemplated but not published.

Table 3 Tensions among framings of geoengineering

	The problem is	The solution is
	The 'root cause' of climate change	
1a	* GHG concentrations in the atmosphere	* Designed GE cooling mechanisms (sinks and shields) offsetting the human-induced warming * [GE operations/industry balancing with fossil reliant energy system]
1b	* Carbon society	* Societal change, avoiding need for countermeasures
	Relationship of GE with mitigation	
2a	* Mitigation has failed * Mitigation will fail	* GE should complement mitigation * GE should replace mitigation
2b	* Talk of GE will undermine mitigation	* Moratorium on GE
	Science and governance	
3a	* There is not enough scientific knowledge to formulate policy (and save society)	* More research; let society respond
3b	* There is not enough policy to do research	* Governance first; science is political
	Novelty	
4a	* There is no body of research (nor technical precedent)	* Research, and only research, will yield the knowledge we need (and thus technology)
4b	* GE is a continuation of the pathological socio-technical trajectory of weather modification	* Stop them from doing it again
	* GE sustains the capitalist (northern, white, male) regime	* Mobilising resistance and instituting governance checks
	Doability - technology	
5a	* Emergency (and no tech problems)	* We're not deploying the kit
5b	* We don't understand Earth systems	* Modelling and monitoring
	Doability – socio-technical systems	
6a	* No one is doing geoengineering	* A void without obstacles to operate in
6b	* Same old institutions	* Act with care
	Agency (of states and corporations primarily)	
7a	* Multilateralism has failed	* A hero is needed
7b	* Some actor could get desperate * Some actor could get hubristic	* Global/multi-lateral consensus * Civil society involvement

4. Tensions in framings of geoengineering

#1 The root cause of climate change

This tension is between seeing the problem as mainly being about GHG concentrations out there in the atmosphere being too high (POST 2009) vs. seeing this as merely a symptom of the underlying problems of an unsustainable, carbon-addicted society (ETC 2010).

There is a notion of '*balancing'* ('offsetting' in POST 2009 and Bickel and Lane 2009; 'countering' in BPC 2012) in most reports, where the size of the effect of the intervention (the function of successful geoengineering) is intended to balance the extent of the problem out there in the Earth system. In the Royal Society report, GHG concentrations are 'the root cause', on which CDR techniques can work directly, whereas the management of solar radiation is said to offset the impact on global temperature of GHG concentrations (2010, p ix).

This can be compared to similar bookkeeping-inspired notions in mitigation, where mitigation in one part of the system is constructed as an offset of emissions elsewhere. In both cases there is a problem of commensuration, of deciding how things are to be deemed equal. For the case of geoengineering, is 1 Watt of shortwave solar radiation reflected equal to 1 Watt of longwave heat retained by the greenhouse gas effect? Is 1 tonne of carbon sequestered 'the same' as one tonne emitted at a different time, in a different place, by different actors? Should geoengineering interventions try to counter dynamic phenomena like climate emergencies, and thus seek to match also the time patterning of global warming (NOVIM 2009, p6)?

The balance of geoengineering also requires the establishment of a new set of practices and new industries that then needs to balance our existing GHG-emitting production and consumption practices and industry interests. The social structures of consumption and production have their own dynamics, path dependencies and politics. It is not obvious how one would govern a balance between geoengineering activities and the rest of

society.[1] These issues are not well explored in the corpus, reflecting a tendency in the literature to focus on scientific aspects of the geoengineering imaginary, as opposed to a broader socio-technical spectrum of aspects. (Cf. the perception of geoengineering as being established in a social void, as discussed below.)

There is some ambivalence in a few of the reports with regard to this balancing of the Earth system. The NOVIM (2009) discusses the limitations historic emissions have already made to the climate, and how this limits our ability to use historical climate records to assess the effects of interventions. The Royal Society (2009) report states that geoengineering would create a situation where we'd be designing a qualitatively new climate, without historic precedence. Both unintentional emissions and intentional intervention thus potentially undermine the scope for informed 'balancing' of the climate.

In contrast with the view of the problem as being 'out there' in the atmosphere, there is the view that the problem is a societal one, of sticking to unsustainable consumption and production practices (ETC 2010). ETC go so far as to say that geoengineering is best seen as a political strategy – as opposed to a technological solution – and backed by industrial interests and political conservatives. As the problem is in this way 'socialised', the problem of commensuration becomes less serious, and ultimately the distance between problem and solution disappears as the practices and social structures that cause emissions become the object of policy and change. (And then other, familiar and painful problems re-appear, like the need to reform consumption and production patterns.)

The corpus includes documents with very different positions along this dimension of the problem being 'out there' in the atmosphere or 'in here' in society. There is some ambivalence in the scope for 'balancing' where the impacts of human activity undermine our ability to balance and manage the climate. Through this ambivalence, human agency is brought back into perspectives predominantly framing the problem as being out there, in the atmosphere and oceans. All in all, however, there is weak ambivalence in this dimension.

[1] Fast geoengineering, like aerosol injection, faces a particular challenge of rapid steering, which suggests that it would only work if the weight and heft of the industry is limited, and that governance arrangements need to

#2 The relationship with mitigation

Geoengineering is framed as separate from, but at the same time constituted in relation to, mitigation. The relationships between the two are multiple, and in part contradictory.

At the most basic level, there is the tension between the belief that mitigation can deliver in the short to medium term – or not. If not, geoengineering becomes more attractive, as the only technology solution with any promise of helping us avoid dangerous impacts of climate change (assuming geoengineering risks are not bigger than the climate change risks). Mitigation policy is typically construed as globally, multi-laterally negotiated. There is a range of positions here with regard to timing, from mitigation policy already having failed (AMEG 2012) to it being doomed to fail in the relatively near future, or at least being very unlikely to deliver much (POST 2009).

In contrast with this, is the position that mitigation is necessary and may yet work. And that to talk of geoengineering now will undermine efforts to make mitigation (and adaptation) work, i.e. a version of the moral hazard argument (ETC 2010). As the taboo on talking about geoengineering has been broken, the solution is to institute a moratorium, preferably a total one including also research. Anything else just diverts attention from the societal change that needs to happen.[2]

There's a tension among pro-positions between replacing and complementing mitigation. This is related to time frames. In the most urgent and short-term focussed positions, mitigation has already failed and geoengineering must be made to work immediately (AMEG 2012). In less urgent positions, mitigation efforts may yet work if given more time. In this kind of scenario, geoengineering R&D should be carried out. Either in case of a future climate emergency, or as insurance if mitigation policy does not deliver on time, or to buy more time for policy making on mitigation (Royal Society 2010, Gardiner 2011).[3]

There is, however, also an ambivalence in these positions insofar that it is rarely made very clear why time will help, i.e. why mitigation policy will deliver in the future if it has not done so already, and why the derided global consensus is likely to be more feasible in the future. There may be an implicit reliance here on the apparent imperative of future climate

[2] Even ETC (2010) can accept some research, so don't quite live up to the extreme position described here.
[3] At least the latter two arguments suppose that geoengineering policy will be easier to forge than mitigation policy, which is contested.

emergencies triggering buy-in to mitigation. Or it might be mere window dressing, with references to future mitigation being made to make geoengineering more acceptable. Or possibly just a belief that policy making and/or technology development takes time. Either way, it seems clear that for those positions that do not advocate immediate geoengineering deployment, there is a somewhat uneasy reliance on future mitigation policy in spite of dismissing its achievements to date, in constructing arguments about future geoengineering deployment and current R&D.

There is also the position that geoengineering may be cheap and can be used to lower the cost of mitigation, by deferring mitigation efforts, which by means of discounting are thus made cheaper (Bickel and Lane 2009). The tension between geoengineering and mitigation deployment is here somewhat resolved since deferred deployment is expected to increase the attractiveness of mitigation as a policy option and thus make its future success seem more plausible and more clearly visible. The recommendation of supporting geoengineering R&D in the short term is however the same as in framings where the future of mitigation is more obscure.

There is clearly diversity in the corpus with regard to the relationship between geoengineering and mitigation. This is mainly well-rehearsed arguments about moral hazard (e.g. Hamilton 2011). The key ambivalence is about the fate of mitigation in scenarios with future geoengineering deployment. At the very least, this is a nod in the direction of the climate policy mainstream, and an attempt at linking in geoengineering with that mainstream. There is, however, broad agreement that mitigation and geoengineering are separate, and thus that there can be a choice between the two.

#3 Science and governance

This tension is about the relationship between scientific knowledge and governance/society. On the one hand, there are those arguing that sound policy is dependent on science, and since we don't know enough yet, we should hold off with the policy – especially any moratoriums or other very intrusive restrictions of scientific enquiry (Royal Society 2009, p37). Science works best when left to its own devices. What is needed is more research, and funding for it. Society can then react to the findings, in due course (NOVIM 2009, p vi).

On the other hand, there is the more socialised view that we need governance of science. Since research is here seen as a risky venture, there needs to be some checks and balances from the off. Until we have a system of governance, including of geoengineering research, we should not be funding the science (ETC 2010).

This 'risky science' position still assumes that geoengineering is basically about doing research. In contrast, and ambivalently, the ETC (2010) also challenge this assumption and state that geoengineering is primarily to be understood as a political move – as an enabler of sustained emissions and thus preserving the status quo of the carbon society. A subtler example of this same ambivalence is when the BPC (2012, p 20) discuss the need for a geoengineering research programme to be responsive to societal conditions and norms and thus to integrate a range of disciplines and kinds of expertise. The BPC then end the discussion with a 'back to basics' assertion that "the problem to be solved" should be the focus when organising the research, assuming that such a consensus could be established straight-forwardly, presumably envisioned to be done on the terms of natural science, thus effectively foreclosing much of the inter-disciplinary discussions and responsiveness previously promised. The ambivalence as the political nature of science is also reflected in discussions of engagement with publics. We can distinguish an instrumental position on early engagement and governance that aims at building legitimacy and avoiding protest, and a more integrated position that aims to modify scientific practice to reflect societal values (BPC 2012, Royal Society 2009).

A view of science as separate from the politics of society dominates, but how is this separation achieved? One technique is to envision linear stage models of geoengineering innovation. Typical examples see three stages: lab research, field tests and large scale deployment (NOVIM 2009, Royal Society 2009). One of the functions of this conceptualisation is to delineate a space for research that is hoped to be uncontroversial and apolitical, as it avoids the risks of experimentation with the climate system. This 'stage' creates a safe space for lab research (incl. modelling and the study of natural analogues), at the price of a limit to experimental work. Another function of the stage model is to imply a temporal sequence, where research happens before testing and deployment, thus relegating interaction with the broader array of actors that would have strong claims on having a stake in these activities to a later time (and making their expertise irrelevant in the interim).

The Royal Society report exemplifies another way in which science and society is kept apart. Here, it is claimed that the broad category of geoengineering is "unhelpful to technology assessment", (2009, p 47), which is a somewhat remarkable statement in a report with that label in the heading. The report goes on to argue instead for the CDR-SRM distinction as the right level for making generalisations about usefulness, risks among other things. However, the report is only partially organised around this distinction. Much of the detailed assessment is made at the level of specific technologies, and these assessments are limited to scientifically defined effectiveness, material risks and costs. Governance is treated in a different chapter, and at more aggregate levels – mainly the overall category of geoengineering, but also CDR-SRM, encapsulated-unencapsulated, etc. The result is that much of the discussion regarding governance issues like lock-in, indeterminacy, unilateral action etc. are kept separate from the natural science, and that politics, ethics, legal matters, etc. do no impinge on the facts about geoengineering technologies as asserted by scientists. This sets up a marked ambivalence between governance of science concerns and ungoverned science.

One of the consequences of the separation of science from society is the scope for playing down indeterminacy. The NOVIM report (2009 p2) acknowledges that the complexity of the climate system and biosphere[4] may be such that indeterminacy[5] is irreducible. But, they continue, given a potential for climate emergency, it is important to give policy makers the best technical information and judgement available. Silence in the face of insuperable indeterminacy is thusly ruled out, and scientists can with a good conscience focus on, and build their legitimacy around, what can be quantified and probabilistically risk-assessed. In Bickel and Lane (2009), the major importance of potentially dangerous and disruptive side-effects is acknowledged, but the lack of quantifiable knowledge about side-effects nevertheless means it has to be by-passed in the analysis of costs and effects, which is said to be of large important to decision-makers. The best possible knowledge isn't necessarily good enough, or even advisable, as a guide for action.

There is diversity with regard to whether science is seen as apolitical and cleanly separate from society or as an integral part of messy societal politics. The corpus studies shows strong ambivalence as to the

[4] And that does not take into account the social system they also set out to optimise and control (NOVIM 2009, p 37).

[5] The term used in the report is 'uncertainty', with the argument that it is perhaps irreducible due to the inherent complexity of the climate system and biosphere (NOVIM 2009, p2).

relationships between natural (incl. engineering and economics) and social sciences (and the humanities), between science and publics, between science and governments. What is at stake is the autonomy and independence of science and its ability to assert truths, and the need to be seen as legitimate and well-behaved, i.e. the social contract of science. These are familiar issues and not distinctive for geoengineering science, but they do serve to highlight the extent to which geoengineering discourse is constructed to foreground scientific research, as opposed to, say, entrepreneurial experiments or climate change policy making. Moreover, the ambivalences discussed indicate that society quickly leaks back in, and that geoengineering scientists see a need to appeal for societal legitimacy. This ambivalence is about the relationship between scientists and the rest of society.

#4 Novelty

There is a stark contrast between perspectives emphasising novelty and those emphasising continuity. The novelty position is constructed around claims that no one has proposed intentional modification on a global scale before and that we don't know how to do it (Royal Society 2009). Moreover, the novelty of geoengineering is constructed through an emphasis on scientific research as the origin of technology. The novelty of research explicitly about geoengineering (for many, but not all, of the specific technologies) is taken as evidence that the development of geoengineering technology is as yet only at the stage of research (Royal Society 2009, p xii). Linear stage models of innovation abound, as discussed above, here supporting the notion of research being 'upstream' of deployment, and playing down the scope for transfer of technology from other application contexts, the translation of scientific knowledge about the climate hitherto not labelled as 'geoengineering', and the scope for learning from immediate field tests since pre-field stage research per definition[6] needs to happen before field experiments.

The NOVIM (2009) report touches on the need to inventory the technical capabilities as well as the stock of scientific knowledge, but mainly in terms of climate monitoring and less so for the science needed for prediction of effects. This ambivalence serves to present prediction as

[6] Although not necessarily in practice. In fact, a linear process would have to be created through governance arrangements. In consequence, talk of stages implies the need for moratoria. Unless there is a moratorium on field research, there is no guarantee that field tests will not happen in parallel or before much of the research that could usefully be done beforehand.

more novel than monitoring and validation. There are a few other cracks in the research-novelty façade, where histories of on-going research emerge, e.g. ocean fertilisation (Royal Society 2009) or biomass CCS (BPC 2012), but no very strong ambivalences.

In contrast, there is a continuity position that observes that there is no scale distinction between weather and climate (the scientific distinction is about time, not scale) (Fleming 2006, p 17) and emphasises the history of previous plans for climate control and weather modification. The suggested continuities include hubristic scientific mind sets, emphasis on speculative, cutting edge science, etc. (Fleming 2010) as well as industrial and military interest and capabilities (ETC 2010).

In a version of the continuity position, the focus is shifted away from science to the wider capitalist regime, with its Northern, white and male dominated structures (ETC 2010). This regime, then, is assumed to have steered science and technology in ways that caused environmental problems, and will continue to do so with geoengineering unless stopped, or at least kept in check. Fleming (2010) is ambivalent on whether the hubristic mindset is part and parcel of science, or the result of distortions.

The ETC (2010) report is strongly ambivalent with regard to the continuity or novelty of geoengineering. On the one hand, it does strongly emphasise the continuity with weather modification practices and sees geoengineering as merely the latest instalment in the saga of capitalist use of science and technology. On the other hand, the report buys into science-based notions of novelty, and claims that geoengineering "technology itself is largely theoretical" (ETC 2010, p39) and that whilst it works "in principle" it will not work in practice. Statements about a linear progression from lab to commercialisation and calls for independent scientific scrutiny, sit uneasily next to discussions of the value of local knowledge and the need for common sense (ETC 2010).

The existence of divergent framings with regard to novelty or continuity is again about the relationship between science and society. Claims of novelty serve to portray geoengineering as being about science, rather than politics or technology development and deployment, and the preserve of scientists. The strongest ambivalence is in the critical framings of ETC and Fleming, suggesting that they are trying to have a dialogue with science, or at least are finding it hard to articulate geoengineering entirely independently of it. There is also some, weak ambivalence in the novelty framings.

#5 Technical doability

This tension operates around two very different notions of technology, with different assessments about whether geoengineering is doable or not in the short term. The doable position assumes that we know enough about impacts of climate change and of interventions in the climate to act. This perspective focuses instead on geoengineering as 'equipment', the equipment needed for delivery of the intervention. The technology for delivery is assessed to be relatively mature, with only few problems needing to be sorted out before deployment, and this is said to be possible to do quickly (AMEG 2012). The bigger challenge, instead, is to mobilise political support to act. The reason to downplay the uncertainty of effectiveness is for AMEG (2012) the current state of emergency which means we need to get on with deployment based on sufficient current indications of emergent emergency.

The opposite position sees our ability to assess the effects of intervention as too limited, and emphasises the risks of deployment. Geoengineering technology here is taken to include the re-designed Earth systems as hybrid nature-artefacts (cf. Galarraga and Szerszynski 2012). When assessing doability/feasibility/maturity, this perspective assesses the status of scientific knowledge needed for prediction (Royal Society 2009, ETC 2010) and monitoring (NOVIM 2009). Maturity, then, is about how well/badly we can predict the impacts of geoengineering interventions.

The reports diverge in terms of how doability is to be assessed. The Royal Society (2009) report deals almost exclusively with the status of scientific knowledge, rather than delivery mechanisms. The GAO (2011) report looks at both delivery and effect, but the distinction is rather implicit and both the two elements are not always covered. The NOVIM (2009) report gives the most complete account of delivery and understanding of impact.[7] The NOVIM report also distinguishes between prediction of impact and monitoring of outcomes (2009), and demarcates the former as the most scientific – as opposed to technical – and the one most in need of funding. The technology of monitoring (e.g. satellites) is not given an equivalent in the technology of prediction (e.g. modelling software). There is ambivalence here between framings as science and technology respectively in articulations of doability and viability.

[7] It should be noted that the NOVIM report is relatively strongly focussed on stratospheric sulphate injection, and that the problem of prediction of impact is rather larger here than for, say, biochar.

The reports, however, agree that geoengineering is viable 'in principle'. The Royal Society report says that geoengineering, whilst barely formed and having a lot of uncertainty, is "very likely to be technically possible" without explaining how this overall conclusion was reached (cf. statement in the report cited about the overall level of geoengineering not being very useful for technology assessment).

No report addresses very clearly the institutionalisation of knowledge needed for routine deployment, i.e. what sort of practice and institutional context could deliver routine predictions and monitoring of geoengineering interventions? How could black boxing (Latour 1987) of the processes between the intention to intervene and the effect be achieved? How can experiment be turned into taken-for-granted routine? The NOVIM (2009) report touches on the need for inventorying the stock of available science and engineering knowledge, dataset, equipment and networks, but the complex process of reconfiguring these into a functioning socio-technical system is not analysed, beyond a relatively basic linear model. Bickel and Lane (2009) do go into this in a bit more detail, and acknowledge the non-linearity of innovation processes, and the need to learn through iterations of deployment, and the role of research to solve problem emerging from deployment experience. As a consequence, they are rather less bullish about the scope for rapid development.

The issue of translating climate science into geoengineering science also brings up a question about why geoengineering science will deliver where climate science hasn't. Why will all the uncertainty go away now that we re-brand and re-focus the research as 'geoengineering'?

The diversity in positions on the topic of whether to intervene now, or after having figured out how it is supposed to work, is a well-known bone of contention (e.g. Hegerl and Solomon 2009). The – weak – ambivalence about how to assess and conceptualise viability among the less gung-ho positions tells a different story. Having first separated science out from the rest of society, and established its viability 'in principle', this divergence of ways of thinking about doability and viability is indicative of the need to translate idealised science back into more heterogeneous visions of technical practice. This ambivalence, then, is about the relationship between geoengineering science and (the rest of) climate science.

The main impression though, is of little interest in this issue and limited attempts at widening the scope from scientific practices. Bickel and Lane's

(2009) recognition of the time scales involved (and taken against the backdrop of the intervening now or later positions) suggests that this ambivalence is about time. The dominating absence of technical perspectives on prediction and monitoring serves to foreshorten the time horizon of geoengineering becoming viable, which underpins the urgency of its claims for support. Conversely, the presence of technical perspectives, then, speaks of a desire for a sustained process of interaction with the rest of the climate science community.

#6 Socio-technical doability

If the previous tension was between science and technology as artefact (or nature-artefact hybrids), we are here concerned with the technology as socio-technical ensemble, recognising that to work, it would have to involve actors, and specifically actors beyond scientists and engineers. Key questions then are: who will do what in the process of making geoengineering work and who will be affected.

There is an idea in the documents of *a 'void'*, in which geoengineering can be done, i.e. assumptions that no one is doing geoengineering (BPC 2011), and therefore there is an empty social space in which it could happen. This resonates with notions of science as a frontier and imagery of scientists as explorers boldly going where no one has gone before (cf. Bush 1946). Gardiner (2011) makes a related point, commenting on the Royal Society report's tendency to talk of 'humanity' rather than specific, differentiated actors.

This can be construed as an advantage, with claims that geoengineering would not have to compete directly with other activities, and that there is no need to persuade any incumbent actors to change their ways. Bickel and Lane (2009) provide the clearest articulation of the void vision. They argue that geoengineering will not compete with other technologies, and thus avoid much politicking amongst technical communities and wider sets of actors about what counts as a viable and desirable technology. This is geoengineering as a technical fix and an add-on to society, rather than something that happens in it.

The void notion also reinforces the view of science being separate from society. The process of building a global climate management bureaucracy presumably needed for routine deployment, as discussed

above, and its relation to the evolution of geoengineering science, is invisible.

The opposite view holds that we'd be facing the same old institutions: companies, governments, the military etc., and that geoengineering will mobilise actors in the energy, agriculture and other sectors, and/or is already driven by such interests (ETC 2010). Geoengineering is here a seamless continuation of existing capitalist structures, and business as usual.

The void perspective relates to the balance notion discussed above, which is dependent on a distinction between current society and geoengineering practice. Without a void, there can be no balancing of a new industry against existing society and its emissions. However, there is ambivalence in the presentation of the void, when industry is mentioned on the margins of the discourses, as having an interest in geoengineering, as being involved in experiments (Post 2009, Royal Society 2009), as being sources of required expertise (AMEG 2012) and as being potential suppliers of technology, services etc. (Bickel and Lane 2009). In the material, there are examples of geoengineering technologies that deliver co-benefits, e.g. BECCS systems delivering both electrical power and sequestration (Royal Society 2009) or photovoltaics that produce electricity *and* reflect energy back into the sky (the consultation responses to the Royal Society 2009 report). This sort of envisioned solution clearly implicates existing industries, and further challenges the notion of geoengineering as necessarily happening in a void.

The military is also mentioned, albeit in strictly cautionary ways, as potentially having an interest in geoengineering (Royal Society 2009, NOVIM 2009). The exception here is the "war room" rhetoric of AMEG (2012, p 13)[8], which invokes the military even if it does not explicitly invite their participation.

There is a clear divergence between framings here, with a strong contrast between the void and the business as usual perspectives. The ambivalence in the void position is about the need to balance the preservation of the image of science as free of political (other than climate policy) and commercial interests, with some acknowledgement of the expected need for support from such actors.

[8] AMEG (2012) are clear though that they don't want to see commercial interests involved in R&D funding.

#7 Collective agency, or not

All perspectives agree in their despair over what global, multi-lateral negotiations have so far been failing – more or less completely – to deliver on mitigation. Beyond that basic consensus it gets complicated. The most gung-ho positions call for heroic, top-down action to save the world (AMEG 2012). A less idealist position is to recognise the real-political scope for (research and) deployment through agreement by only a limited set of major powers (Bickle and Lane 2009).

These positions rely heavily on policy-making dominated by technical expertise (AMEG 2012, p16). Bickle and Lane (2009) explicitly contrast the transaction costs of politics, with the ability of self-interested and well-informed policy makers to avoid problems like premature deployment and damage caused by interrupted operations.

More cautious perspectives recognise a need for global agreements on governance of geoengineering. Not least to avoid the case of some actor (state or perhaps even organisation) going it alone, out of desperation or – perhaps less excusably – profit or military strategy (Royal Society 2009).

There is diversity in the corpus regarding the value and rationality of politics, as opposed to scientific expertise. Geoengineering is sometimes seen as a rational and consensual scientific-technical activity in the asocial void, in contrast with the irrational bickering of multi-lateral climate policy and the messy entanglements of decarbonising consumption and production.

A different flavour of the need for collective arrangements position sees the hubristic mind set of actors – not least scientists – as the problem (Fleming 2006), which need to be kept in check through the collective action of setting up a multi-lateral governance regime (ETC 2010). In contrast with this, are framings of early stage, pre-field research as less controversial.

As discussed above, there is ambivalence here, with regard to the value of messy engagements with publics and across disciplines. Fleming's (2006) account of hubristic science is further evidence of this ambivalence, as he is arguing both that hubris is inherent to science and that 'immodest' macro-engineering proposals are the result of misguidedness and a shallow understanding of the complexity of climate systems.

This ambivalence is about an engagement with science policy and especially a negotiation of the right to govern science. But the ambivalence is also about defending and challenging the role of scientific rationality as a basis for policy.

There is broad agreement that the role of society is to react to science: rein it in so as to contain risks, perhaps put moratoria in place to buy time or avoid irreducible risks or chose the 'best' options presented by science. There are no attempts at saying that society and policy should shape the nature of the technology and seek to bring forth good geoengineering.

5. Articulating positionings through diversity and ambivalence

There is clearly diversity among framings articulated in the different documents in the corpus. Table 4 summarises this. In some cases the pattern observed is one of quite clear demarcations - e.g. problem 'out there' or 'in here' and 'novelty' versus 'continuity', between primarily geoengineering researchers and ENGOs (the ETC). In other cases, there is more of a continuity of positions, notably in regard to the need to govern pre-field science.

We can discern several seemingly entrenched issues with strongly divergent positions. AMEG (2012) stands out for its stances on mitigation, the need for any scientific knowledge and – together with Bickel and Lane (2009) – the value of political rationality. On the issues around the 'root cause' of climate change and the 'novelty'/'continuity' of geoengineering, there is a stark different between ETC (2009) and other reports. The positions on 'socio-technical doability' are interesting. Here, both the most gung-ho proponents and the fiercest critics coincide in the need to discuss wider societal involvement in technology development. The results point towards the existence of a geoengineering mainstream, bounded by strong differences with both the most ardent critics as well the most strident proponents.

Table 4 Diversities

Frame dimension	Diversity	Dissenting voices
1. Root cause	Out there or in here?	ETC
2. Relationship with mitigation	Mitigation or geoengineering first?	AMEG
3. Science and governance	Science or governance first?	A wide range of positions
4. Novelty	New or old?	ETC, Fleming
5. Technical doability	Need for any scientific knowledge?	AMEG
6. Socio-technical doability	Emerges in void or embedded?	ETC, AMEG, Bickel and Lane
7. Collective agency	Is political rationality valuable?	AMEG, Bickel and Lane

There is also ambivalence in several of the dimensions analysed. Here, contradictory positions co-exist indicating coalitions of actors and combinations of interests and agendas. Such ambivalence might arise from coalitions of diverse authors seeking to agree on a text. Or, they could arise as the authors seek to enrol intended audiences. Table 5 gives an overview of the ambivalences found and their relative strength. The table also sets out the main relationships at stake, i.e. if an ambivalence is indicative of an attempt at forging a coalition between actors located close to the epicentre of geoengineering and others, then who is this other?

We have identified three main relationships that are being articulated and potentially re-negotiated through the ambivalent framings expressed in the corpus of reports. Firstly, there is ambivalence in the reports with regard to the role of geoengineering science in society. The relationship here is with the wider society, mediated in the first instance through science policy, but potentially through a much wider range of policies and strategies. This relationship turns on notions of the need for and forms of collective governance of research and development (the need for governance of deployment is both less controversial and more distant for most actors). Many of the questions raised are familiar from many other

areas of S&T: Can we trust scientists to self-regulate? What will the role of commercial, and even military, interests be? A perhaps more specific question is the demarcation between pre-field and field tests[9], although that may resonate with dynamics around for example field trials of GM crops.

Table 5 Ambivalences

Frame dimension	Ambivalence	Strength	Authors	Relationship partner
1. Root cause	Balancing or creating new climate	Weak	NOVIM, Royal Society	Climate change community
2. Relationship with mitigation	Why time might solve the tension, and the future of mitigation	Strong	All	Climate change community
3. Science and governance	Autonomy and legitimacy of science	Strong	All	Society
4. Novelty	Hard to dismiss	Weak	ETC, Fleming	Society
5. Technical doability	Need for scientific knowledge and applied climate science	Weak	Royal Society, NOVIM, GAO	Climate science
6. Socio-technical doability	Scope for transfer and relationship with industry (and military)	Strong	Royal Society, NOVIM, POST, AMEG, Bickel and Lane	Society
7. Collective agency	Role of science for policy	Strong	All	Society

[9] Cf. van Hemert, 2012, who found different competing scientific ideals re field experimentation in the area of ocean fertilisation

There is also an ambivalent relationship between the geoengineering actors and the wider climate change community. This ambivalence boils down to disagreement about the scope for adding geoengineering technologies to the climate policy mix and of the prospect of designing climates. There is so far a dearth of climate policy reports that include discussion of geoengineering, and the articulation of this ambivalence may change as the high-profile IPCC AR5, due out in 2014, alters this.

Finally, the results also suggest an ambivalent relationship with climate science. This relationship turns on the need and scope for turning climate science into an applied art, and ultimately a technological intervention.

With this overview of ambivalences in place, it is also possible to analyse what *combinations of diversity and ambivalence* tell us about the discursive politics of geoengineering. The reports agree, at least in broad terms, on the salience of climate change for policy, and the lack of progress with mitigation. Beyond that, there appears to not be much consensus, although this analysis has focussed on tensions, i.e. situations where the articulations of the geoengineering imaginary are diverse or ambivalent. Several of the tensions are characterised by both high diversity and high ambivalence, suggesting relatively open and fluid relationships.

Some of the tensions identified are characterised by high diversity and low ambivalence. This would suggest entrenched positions. Such tensions include 'the root cause is out there or in here' and 'novelty or continuity', which appears to be a well dug trench between geoengineering mainstream and ETC (which may represent some but not all wider environmental activist opinions). There are also trenches between the geoengineering mainstream and AMEG (potentially representing other emergency activist positions) on such issues as 'mitigation or geoengineering first' and 'the need for scientific knowledge before deployment'.

This analysis has found no clear instance of 'lived contradictions', i.e. articulations that are ambivalent but not diverse. This would be instances of several reports embodying the same ambivalence, where all the authors (together with their imagined audiences) are articulating the same contradictory, ambivalent positions. The closest to this is perhaps the relatively limited interest in technical doability and rather incoherent treatments of technology maturity. This contradiction is about the engineering in geoengineering, and the challenges of how to reconcile the uncertainties of climate science with the need for reliable and predictable

deployment. It is difficult to escape the impression that the current geoengineering discourse does not take technology very seriously, but is rather about scientific development.

Clearly some contributors in the discourse see geoengineering as primarily a technical solution to a problem, whereas for others it is primarily a political move to defend the interests of the winners of carbon society. The results of this study suggest that we can also see geoengineering as an attempt at demarcating and defending *a space for scientific research*. The boundaries of this space are contested in time (novelty), in relation to other fields of S&T (climate science, mitigation technologies) and in relation to other spheres of societal activity (industry, defence).

And, of course, the very need for such a space is contested too. Scholte et al. (2013) have compared framings of geoengineering with other technologies, and found that whilst there are many similarities, the – often critical – frames of geoengineering as a technical fix and as a response to emergency stand out as less typical. The analysis in this paper confirms the technical fix frame, whilst also showing that the 'void' notion it relies on is somewhat ambivalent. Not least when authors consider how to make geoengineering innovation happen in practice, society leaks back in.

The emergency framing is somewhat less prominent in the analysis above. It plays explicit and central roles in the advocacy of imminent action of AMEG (2012), in the slightly longer term strategy articulated by NOVIM (2009) and in the counter-advocacy of the ETC (2010). In some reports, like the Royal Society (2009) one, the potential for emergency is presented alongside other deployment scenarios. However, as discussed above, emergency also lurks in the background in the ambivalent tension between geoengineering and mitigation, as a potential explanation for why geoengineering proponents think mitigation will work better in the future. The emergency framing has not gone away, but it may have submerged to a degree.

Apart from a move to create a new scientific space, the geoengineering imaginary is also a part of a broader re-configuration process, potentially shifting the relationship between science, climate and society. Whilst it is not necessary to buy into the deterministic notion of the Anthropocene (Crutzen and Stoermer 2000), at the very least 'geoengineering' is about an attempt at turning climate science into an experimental art, at preparing to bringing our technical impulse to bear on our relationship

with nature at a global scale, and ultimately to change the way we relate to nature.

6.Ambivalence speaks volumes

This paper has identified tensions in articulations of the geoengineering imaginary, through close reading and analysis of a corpus of high-profile reports. The paper found diversity between reports, as well as ambivalence within reports. Diversity indicates a range of choices that can be made, as suggested and designed by the authors. Diversity thus represents multiple attempts at persuasion, in a contested discursive landscape. We here see ambivalence not as an aberration, or a mere absence of coherence and clarity, but as a constitutive property of a reconfiguration process in which the concept 'geoengineering' is constructed as a new assemblage of old concepts and narratives. Ambivalence, we argue, serves to glue together disparate elements, agendas and actors, or at least is used in attempts at 'gluing'.

The analysis has highlighted the role of diversity and ambivalence in the forging of new relationships between the geoengineering community and various actors, like the climate change mainstream, climate science and the wider society. Overall, the findings support a diagnosis of geoengineering discourse as being contested, with a mix of openness and attempts at bridging across positions, with carefully drawn battle lines and well-dug trenches.

It should be noted that large parts of society that have, or could have, a stake in geoengineering, are relatively silent or absent from geoengineering discourse. This is true for the military, many industrial sectors, many areas of policy, as well as island states vulnerable to climate change, religious groups and the labour movement. If the 'geoengineering' imaginary survives, we will certainly see more diversity and perhaps also ambivalence in the articulations of it.

Theoretically, this paper argues that ambivalence is central to analysis of the articulations of sociotechnical imaginaries. Moreover, analysis of ambivalence and diversity can help with the assessment of the relative openness or entrenchment of discourse, and the forms into which geoengineering framings are stabilising.

In the case of geoengineering discourse, the roles of both climate change and science & technology in society are at stake. Taking this ambivalence

seriously, we need to see 'geoengineering' not simply as an emergent technical solution to a well-defined problem, nor just as a defensive, political move aiming to sustain carbon society, but also as an opportunity for collective reflection, about climate change, about S&T and about how we as a society choose our problems and solutions (Walker and Shove 2007). In terms of governance implication, this suggests that we need to create and sustain a diverse conversation. Alongside, or even instead of, the politics and the R&D we might also be tempted to do.

A final note of reflection may be warranted. The analysis presented here is a socialised one, and as such has a closer kinship with the socialised the problem is 'in here' position, than the natural science one that tends to place the problem 'out there'. That said, it has been guided by a different set of questions and analytical perspectives and so offers a distinct contribution.

References

AMEG (2012) *AMEG Strategic Plan*. Arctic Methane Emergency Group. Available at: http://www.ameg.me/index.php/2-ameg/45-strategic-plan.

Bickel, J.E. and L. Lane (2009) *An Analysis of Climate Engineering as a Response to Climate Change,* Copenhagen Consensus on Climate. Available at: http://fixtheclimate.com/component-1/the-solutions-new-research/climate-engineering/.

BPC (2011) *Geoengineering: A national strategic plan for research on the potential effectiveness, feasibility, and consequences of climate remediation technologies*. The Bipartisan Policy Center's Task Force on Climate Remediation Research. Available at: http://bipartisanpolicy.org/library/report/task-force-climate-remediation-research.

Bush, V. (1946) *Endless horizons*. Public Affairs Press, Washington, D.C.

Callon, M. and J. Law (1982) On Interests and Their Transformation: Enrolment and Counter-Enrolment, *Social Studies of Science,* **12** (4): 615-625.

CBD (2012) *Impacts of climate-related geoengineering on biodiversity: Views and experiences of indigenous and local communities and stakeholders*. Convention on Biological Diversity, Subsidiary Body on Scientific, Technical and Technological Advice. Available at:

http://www.cbd.int/doc/meetings/sbstta/sbstta-16/information/sbstta-16-inf-30-en.pdf

Crutzen, P. and E. Stoermer (2000) The 'Anthropocene'. *Global Change Newsletter,* **41**: 17–18.

Curvelho, P. (2013) Questioning the Geoengineering Scientific Worldview. *The International Journal of Interdisciplinary Environmental Studies*, **7**.

ETC (2010) *Geopiracy: The case against geoengineering*. ETC Group. Available at: http://www.etcgroup.org/content/geopiracy-case-against-geoengineering.

Fischer, F. and J. Forester (1993) *The argumentative turn in policy analysis and planning*. Duke University Press, Durham, N.C.

Fleming, J.R. (2006) The pathological history of weather and climate modification: Three cycles of promise and hype, *Historical Studies in the Physical and Biological Sciences*, **37** (1) 3-25.

Fleming, J.R. (2010) *Fixing the sky: The checkered history of weather and climate control*, Columbia University Press, New York, US.

GAO (2011) *Climate engineering: Technical status, future directions, and potential responses*. United States Government Accountability Office. Available at: http://www.gao.gov/products/GAO-11-71.

Galarraga, M. and Szerszynski, B. (2012) Making climates: solar radiation management and the ethics of fabrication. In: Preston, C. (ed.) *Engineering the Climate: The Ethics of Solar Radiation Management*. Lanham, MD, U.S.: Lexington Books, pp. 221-235.

Gardiner (2011) Some Early Ethics of Geoengineering the Climate: A Commentary on the Values of the Royal Society Report. *Environmental Values,* **20**: 163–188.

Hamilton, C. (2011) Ethical Anxieties About Geoengineering: Moral hazard, slippery slope and playing God, *Paper presented to a conference of the Australian Academy of Science Canberra*, 27 September 2011.

Hegerl, G. and S. Solomon (2009) Risks of Climate Engineering. *Science,* **325**: 955-966.

Hulme, M. (2008) The conquering of climate: discourses of fear and their dissolution. *The Geographical Journal* **174** (1): 5-16.

Jasanoff, S. and S.-H. Kim (2009) Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea. *Minerva,* **47**: 119–146.

Latour, B. (1987) *Science in Action: How to Follow Scientists and Engineers Through Society*. Harvard University Press, Cambridge, Mass.

Luokkanen, M., S. Huttunen, et al. (2013) Geoengineering, news media and metaphors – framing the controversial. *Public Understanding of Science*.

Nerlich, B. and R. Jaspal (2012) Metaphors we die by? Geoengineering, metaphors, and the argument from catastrophe. *Metaphor and Symbol* **27** (2): 131-147.

NOVIM (2009) *Climate Engineering Responses to Climate Emergencies*, NOVIM. Available at: http://arxiv.org/pdf/0907.5140.

Pinch, T. and W. Bijker (1984) The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. *Social Studies of Science,* **14**: 399-441.

POST (2009) *Geo-engineering research*. postnote. London. 327. Parliamentary Office of Science and Technology. Available at: http://www.parliament.uk/documents/post/postpn327.pdf.

Royal Society (2009) *Geoengineering the climate: science, governance and uncertainty*. (Including responses to call for Evidence), London, The Royal Society. Available at: http://royalsociety.org/policy/publications/2009/geoengineering-climate/.

Sarewitz, D. (2011) The voice of science: Let's agree to disagree, *Nature*, **478**: 7.

Scholte, S., E. Vasileiadou and A.C. Petersen (2013): Opening up the societal debate on climate engineering: how newspaper frames are changing, *Journal of Integrative Environmental Sciences*.

van Hemert, M. (2012) Issues of scale and ignorance in geo-engineering: Controversies over experimentation in ocean fertilization. Presentation at 4S/EASST conference *Design and displacement – social studies of science and technology*, Copenhagen.

Walker, G. and E. Shove (2010) Ambivalence, Sustainability and the Governance of Socio-Technical Transitions, *Journal of Environmental Policy & Planning*, **9** (3-4): 213-225.