The Global Governance of Climate Engineering – Draft of a Research Agenda

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Abstract

This paper outlines the research agenda of a multidisciplinary project “The Global Governance of Climate Engineering”, a topic which has garnered increasing public attention. The political science component of the project at Heidelberg University seeks to answer if, when and to which extent governments will use climate engineering as a substitute for or alternative to CO_2-mitigation efforts to stabilize the earth’s climate. Geo- or climate engineering refers to the deliberate large-scale alteration of the climate system by technological means. While geo-engineering (GE) does not provide an alternative to carbon emission reduction yet, some GE techniques promise to mitigate the negative effects of climate change in the short term. At the same time, these techniques involve considerable risks of hidden long-term costs, thereby upsetting existing cost-benefit calculations and raising serious questions of intra- and intergenerational justice. In the first part of this paper, we sketch out the assumptions of the project, identify sociological risk analysis and IR social construction as our analytical framework, and present the case study design on risk cultures and GE policies of three EU member states. In addition, we summarize insights from the natural sciences regarding the technological feasibility and potential risks of GE technologies. The second part addresses the governance aspect – the public-private interaction, both in discourse and policies – as well as the expected contribution of the project to the scholarship on science and politics, risk analysis, and the actorness of the EU in environmental policy.

1. Introduction

International climate negotiations once again ended in a deadlock in December 2009: At the UN Climate Conference in Copenhagen, states failed to adopt a legally-binding agreement on greenhouse gas (GHG) emission targets. According to the IPCC (2007), anthropogenic climate change will have a detrimental impact on mankind by way of the steady increase of global average air and ocean temperatures. In the absence of effective mitigation and adaptation strategies to prevent climate change, GE technologies have a growing appeal. Thus, as a global undertaking of highest complexity and uncertainty, concepts on engineering the climate will be one of the most challenging issues for policy-makers in a medium term perspective. At present, no political or legal regulatory framework is in place to guide research in and the potential deployment of these technologies (Blackstock/Long 2010). Despite expanding activities in the natural sciences, the question of manipulating the earth's climate system has received only limited attention from International Relations (IR) scholars.

This paper outlines the research agenda of the interdisciplinary project "The Global Governance of Climate Engineering" at the University of Heidelberg[1]. The project focuses on exploring risks, benefits and limitations of GE technologies. Although the idea of engineering the climate in itself is technical and the scientific debate is predominantly shaped by natural scientists, the consequences of altering the climate system raise serious social, political, legal and ethical questions (Ott 2010; Kraemer

[1] The interdisciplinary project "The Global Governance of Climate Engineering" was initiated in 2009 by the Marsilius-Kolleg at the University of Heidelberg. The Marsilius-Kolleg was established as a Centre for Advanced Study to promote interdisciplinary dialogue and research. It is part of the so-called excellence initiative, launched by the federal and state governments in Germany (www.marsilius-kolleg.uni-heidelberg.de).

2010, Robock et al. 2010; Virgoe 2009; Victor et al. 2009; Barrett 2007; Jamieson 1996; Bodansky 1996).

To address these implications, the research project embraces a transdisciplinary perspective ranging from humanities to social and natural sciences. Researchers from different disciplines - physics, economics, law, philosophy, geography, political sciences, and psychology - develop a more comprehensive understanding of GE. By linking IR to other sciences, insights into the distribution of risks and benefits, international models of governance and political guidelines for decision-makers are envisaged.

Our IR project sets out with the assumption that GE poses long-term policy challenges to both national and global governance institutions. Such challenges will occupy at least one human generation, include substantial uncertainty over time and engender public good problems (Hovi et al. 2009: 20). In this sense, GE measures can be regarded as risks in terms of uncertainties about involved agents, unintended consequences and potential losses. GE is one of numerous other significant risk issues (e.g., genetically modified crops, disposal and storage of radioactive waste or technical catastrophes) modern industrial societies face. As such, it also raises a host of questions about the roles scientists play in rationalizing the cost/benefit considerations in modern societies (Drori et al. 2003; Pielke 2007). Therefore, the term risk and the roles scientists play in addressing them occupy a central position in our research project and this paper.

We seek to incorporate both constructivist approaches and sociological theories on risk research in our approach. In the wake of the “cultural turn”, many constructivists and sociologists argue that social and cultural factors shape the relevant dimensions of risks and the way these are assessed, communicated and perceived (van

Zwanenberg/Millstone 2000; Jasanoff 1987; Douglas/Wildavksy 1982; Beck 2008). Conversely, we argue that the response to risks depends on the respective risk culture that explains how, why and to what extent uncertainties turn into risks and risks are accepted or rejected and acted upon by societies.

Indeed, this perspective challenges the traditional roles scientists have played in the policy-making process. We posit that under conditions of uncertainty, which can be defined as the "character of a decision in which agents cannot anticipate the outcome of a decision and cannot assign probabilities to that outcome" (Beckert 1996: 840), scientists may hold a variety of different roles in the process of the societal construction of uncertainty and risks. Whereas rationalistic and cognitivistic theories conceive uncertainty as incomplete information (ignorance) or misinterpreted information (confusion), a sociological understanding of uncertainty implies indeterminacy, i.e. a lack of concrete values and norms that determine "appropriate behavior" and the respective cost-benefit calculations (Rathbun 2007). Hence, we suggest that scientists, depending on the role they play, do not merely provide information to counter ignorance, but they may "frame issues" so that it resonates with other socially constructed norms and identities (Finnemore/Sikkink 1998). In sum, variance in the roles scientist take on in public discourse, they do influence risk policy choices of goals, strategies and instruments and decision makers may use science (and the respective) scientists strategically to legitimate policies, thereby upsetting established patterns of inclusion and exclusion between science and politics (Hellmann 2008; Pielke 2007). In this paper, we discuss (and reflect upon) the role of science within the GE-debate, asking if scientists should use self-restraint, keeping knowledge confidential, to influence the structure and dynamic of (democratic) public discourse on GE.

In particular, this paper emphasizes the influence of risk cultures, knowledge, and institutional settings on policy-based risk-management in EU member states, and the impact on EU environmental actorness in the field of GE technologies. The project asks whether the Union will keep up with its leading role in tackling climate change by fostering a common position on GE risk management and its respective consequences. We assume that the current EU capability as an actor in international climate policy points to governance qualities that may help to overcome the protracted long-term policy challenges of GE. Moreover, we argue that variance in risk cultures of member states already fostered the EU's leadership position in international mitigation efforts during the past decade. Thus, arguably, the EU offers the best case for our analysis as it is supposed to be one of the pioneering actors in GE politics.

The project examines the positions of three member states (Netherlands, United Kingdom (UK) and Germany) with respect to different risk cultures and their constitutive influence on the perception of risks and benefits. First, we seek to analyze how risk-benefit perceptions of different GE technologies vary and evolve over time and across actors in the respective domestic discourse (discourse formation on risk). Secondly, we will examine whether and to what degree such differences result in demands for the implementation of a regulating governance structure under the EU's environmental policy framework (patterns of delegation).

This paper proceeds as follows: The first section outlines the core assumptions and questions adopted by the research project. The second section then frames the potential role of GE against the backdrop of international climate negotiations and international efforts to reduce carbon emissions (mitigation). Section 3 discusses several GE technologies and current research projects. The section explicitly addresses the feasibility of different GE options with regard to technological viability, probable detrimental effects, and likely distributional disparities. The fifth section sketches our research design, referring to our constructivist approach on risk culture, knowledge and the role of discourses. The final section discusses our contribution to the public policy debate and points out three scenarios for the potential management and deployment of GE technologies

2. Assumptions and Research Questions

We start from following core assumptions. First, if, at all, GE will be (primarily) state-based and thus elected decision-makers will be important and responsible actors. Currently, the GE debate maintains elusive and proceeds at an early stage, involving only a small scientific community (Wiertz 2009: 40; Victor et al. 2009). The question of whether to engineer the climate or not has barely reached the level of government policies (Blackstock/Long 2010). Instead of political actors, at this stage transnational networks of scientists are the key drivers of the debate. We hold that this may change (even dramatically) as GE becomes more attractive to political decision-makers as a “climate emergency” strategy (Blackstock et al. 2009). Thus, in the project we seek to identify “discursive tipping points”, around which established discourse patterns (the relative salience of arguments and dominance of speakers) change and allow for substantial policy reversion, e.g. research, laboratory-, field testing or implementation.

Secondly, we assume that the EU may play a key role in research on, legal regulation, and eventual implementation of engineering measures. Due to the EU’s institutional structure, the European Commission has proved to be a powerful policy entrepreneur in environmental politics and has fostered technological innovation in the past. Exercising its policy initiation function, the Commission is prone to push for the exploration of GE. At this time, it promotes a research program on the Implications and Risks of Engineering Solar Radiation to limit Climate Change (IMPLICC), and makes sustained efforts in the research and deployment of Carbon Capture and Storage technologies (CCS). Also, in 2009, the European Parliament and the Council proposed a directive on the capture and geological storage of carbon dioxide (EU Parliament 2009). The directive is part of a growing number of legislative acts under the integrated package of climate and energy policy which was adopted in 2008 to reduce GHG emissions by 20% in 2020.

Thirdly, the EU has become the central avenue for Germany and other member states in the area of environmental politics. First, the EU has pledged to play a leading role in the international climate change negotiations (Bretherton/Vogler 2006, Oberthür/Kelly 2008; Schmidt 2008; Lindenthal 2009). EU leadership not only shaped the Union's strong support for the UN Framework Convention on Climate Change, but also directs various domestic action. In 2005 the EU implemented the Emissions Trading Scheme (ETS), to reduce CO_2 emission and realize parts of the Kyoto target in a cost-effective way (Convery 2009: 407). Implementing the world's first international carbon market also shows the Union's proactive role in climate policy (Bretherton/Vogler 2006). Secondly, the EU took on a leading position throughout the Kyoto negotiations, despite differences between its member states. Through tactical cohesion, the Union aggregated "a range of different national requirements into a common policy" (Vogler 1999: 41), implementing a solidarity mechanism (or EU "bubble"), that allows for distributional justice by addressing respective economic and environmental concerns.

A fourth assumption concerns the role that scientific knowledge plays in policy-making. We hold that political debates are shaped and framed by knowledge discourses. The way in which scientists interpret and respond to explicit uncertainties influences societies and political decision-makers alike, because they constitute risks by implicitly or explicitly attaching norms and values to their cost-benefit analysis. We thus posit that scientist may act as important speakers (referred to as “privileged story-tellers” by Milliken 1999: 236) in societal discourses that may exert “socializing pressure” because of their “expert status” and trust in the respective judgment.

Finally, we assume that GE may dramatically shift the risk-benefit calculations of concerned societies as some technologies promise short-term solutions to avoid the negative impact of climate change. It is important to note that substituting GE for CO_2 mitigation may be a cost-effective strategy, but only if these technologies pose a negligible (climate) or manageable risk.

In this sense, GE creates a classical “moral hazard”[2] problem: First, states are able to prepare, develop and deploy engineering measures unilaterally since some of the technologies are both inexpensive and highly effective (Teller et al. 2003; Barrett 2007), thereby avoiding collective actions problems and cost-intensive investments in mitigation or adaptation efforts (Kraemer 2010). Secondly, GE methods promise to a varying degree to quickly stabilize negative effects and obfuscate negative long-term consequences (Bial et al. 2001; Barrett 2007), thus they may induce risk-prone behavior as common in moral-hazard situations.

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[2] The term “moral hazard” derives from insurances and refers to the “tendency for the insurance against loss to reduce incentives to minimize the cost of loss” (Baker 1996). In other words, GE may provide an insurance against losses that are caused by negative climate change.

Based on these assumptions, we seek to ask the following research questions:

- How and in what way are GE technologies salient in scientific, public and political discourses?
- How and to what extent are risk cultures of member states influencing the process of political decision-making within the EU?
- What is the "tipping point" at which governments decide to fund, test and deploy engineering measures as a substitute for or alternative to CO_2-mitigation efforts?
- Which technologies will be used?
- Which model of international coordination or governance can guide research activities on and full-scale deployment of GE technologies?

3. The Technology

The term "geo-engineering" or "climate engineering" can be defined as „the deliberate manipulation of the earth system to manage the climatic consequences of human population and economic expansion" (Schneider 2001: 417). Proposals to engineer the earth's climate system appeared consistently throughout history[3]. Early studies on weather modification date back to the ideas of the American meteorologist James Pollard Espy in the year 1830 (Royal Society 2009). However, the term "geo-engineering" was used for the first time by Cesare Marchetti (1977) in the 1970s and expanded by the Russian climatologist Mikhail Budyko (1977) for "the purpose of counteracting inadvertent climate modification" (quoted in Schneider 1996: 293). Further research on climate and weather modification was conducted throughout the 1990s (National Academy of Sciences 1992). Today, mitigation and adaptation measures are central to the international political debate, no state or private actor has thus far declared a GE policy (Virgoe 2009; Victor et al. 2009).

[3] For a detailed history of GE see Keith (2000) and Schneider (1996).

Two sets of GE measures can be distinguished: First, “Solar Radiation Management” (SRM) aims to reduce the absorbed solar radiation to produce a cooling effect on earth. This can be achieved either by reducing incoming short wave solar radiation, or by deflecting sunlight and/or increasing the reflectivity (albedo) of the earth. Secondly, concepts of “Carbon Dioxide Removal” (CDR) are under discussion, aiming to reduce the amount of carbon dioxide in the atmosphere. Each of the proposed methods differs with regard to costs, effectiveness and uncertainty about unintended side-effects (potentially producing relative winners and losers). Most importantly, some of the proposed methods only treat one of the symptoms of climate change (global warming), but do not address its causes. As a consequence, GE does not lead the way toward a low-carbon society and thus allows industrial and emerging economies, which continue to be based on fossil fuel and the emission of CO_2 in the foreseeable future, to continue past consumption patterns (Victor/Morse 2009).

Solar Radiation Management (SRM)

Shielding solar radiation includes a variety of concepts ranging from the idea of whiten surfaces - on land or ocean - to space-based reflectors (“sunshades in space”). Moreover, whitening clouds (e.g., marine cloud whitening) to reflect sunlight back in space are under consideration. Although SRM measures are imperfect in terms of uncertainty and risks, they affect the climate system in an “almost instantaneous manner” (Moreno-Cruz/Keith 2009: 3).

Stratospheric Aerosols: One of the most controversially discussed ideas among SRM-technologies is Paul Crutzen`s proposal to dramatically increase the amount of sulfate aerosols in the stratosphere (Crutzen 2006). The idea goes back to an observation made after the eruption of Mount Pinatubo in 1991: For two years, the global surface temperature sank by about 0.4℃. Cri tics argue that such a large-scale experiment would have negative consequences. First, after ceasing to emit aerosols into the stratosphere, the climate will move back to the original state of GHG concentration, warming up the planet rapidly within a few years (Robock et al. 2009; Bengtsson 2006). Secondly, stratospheric GE could cause droughts, sustained ocean acidification from CO_2, ozone depletion, human error and negative environmental impacts (Robock et al. 2009). Although inserting sulfate aerosols is highly uncertain in terms of safety, unintended side-effects and regional and global ramifications, it will have immediate effects on the climate system.

Surface albedo approaches: In contrast, concepts such as white roof tiles in urban areas, increase the reflectivity to sunlight (albedo) of the earth's surface, thereby cooling the planet. Enhancing the reflectivity of the earth's albedo by brightening surfaces is considered relatively inexpensive, but most experts agree that it will have only little impact on overall earth temperatures. As for the timeframe, the Royal Society (2009: 25) estimates that it would take several decades to change the color of enough roofs, pavements and roads in the world to achieve a significant effect.

Sun-shields in space: Another approach involves elements in space to reflect and/or deflect the solar radiation. Due to the "huge logistical demands" (ibid, 32), this approach is questionable. Similarly to the idea of sulfate aerosols in the stratosphere, the operation of space-reflectors cannot be stopped without producing disastrous consequences. However, one advantage of space-based methods is that the climate system would respond quickly within a few years (Caldeira/Matthews 2007). But developing and deploying sun-shields would not only take several decades, it would also produce high costs initially (Royal Society 2009: 33).

Cloud albedo enhancement: Finally, schemes of albedo enhancement aim to whiten clouds over the ocean to decrease earth temperature. This could be achieved by modifying the reflectivity of clouds spraying seawater in the atmosphere by ship (Salter et al. 2008). Some scientists state that the best place to implement albedo enhancement by whitening clouds are the West coasts of North and South America and the West coast of Africa (Latham et al. 2008). Although feasibility, effectiveness and costs are still uncertain, research in cloud albedo enhancement is expanding. In Russia, first field experiments on studying solar radiation attenuation have been conducted in the surface atmospheric layers (Izrael et al. 2009).

Carbon Dioxide Removal (CDR)

In contrast, CDR methods show effects significantly slower and need to be implemented for a long period of time to reduce the risk of negative climate change impacts. These methods to remove CO_2 from the atmosphere involve a variety of land- and ocean-based measures. In this paper, only concepts which are technically feasible now are considered: ocean fertilization, land-use management and afforestation, biochar or biomass-related methods and carbon sequestration. Some experts argue carbon sequestration is not a GE measure (see Royal Society 2009) and should be considered apart from the idea of influencing earth's climate system. The concept of CCS requires the capture of CO_2 at the source, whereas GE methods (e.g., ocean fertilization) aim to remove gases that are already in the atmosphere. For this reason, CCS is mostly mentioned separately from CDR and SRM methods. Due to the fact that CCS is already recognized by policy-makers and the public, we will include this technology in the paper. Moreover, we argue that the initial deployment of CCS triggers a "technical spillover" because it is close to other GE carbon sequestration methods such as capturing CO_2 directly from the atmospheric air. To the extent that CCS is working effectively it will also raise demands for increasing deployment of other techniques as some actors take advantages from it ("political spillover”). For instance, Saudi Arabia shows growing interest in CCS whilst highlighting the importance of oil for global energy production. Saudi Arabia declared CCS as "the most promising and effective win-win technology for combating greenhouse gas emissions” and supports the incorporation in the Clean Development Mechanism (CDM) of the Kyoto Protocol (IISD 2006; UN 2007).

Carbon Capture and Storage: The technology refers to a process of capturing CO_2 from industry- and energy-related sources. Afterwards, the carbon is transported and stored it in a suitable underground reservoir (e.g. in geological formations). Although CCS is considered crucial for keeping the release of CO_2 under control, it has to date not been implemented on a large-scale level.[4] Environmental groups are concerned that the safety of CO_2 storage cannot be assured yet (ETC 2009; Greenpeace 2008). Moreover, critics argue that CCS might reduce efforts to replace fossil fuel-based energy production. However, capture and storage technologies are currently considered to be technically feasible (Gibbins/Chalmers 2008: 4317). Besides political actors and environmental groups, other vested interests are involved. In particular, multinational oil and gas companies (e.g., ExxonMobil, Shell, Total) have a strong interest in carbon sequestration.

The EU has come to advocate CCS technologies in its larger energy and climate strategy. In March 2007, leaders of EU member states agreed to a proposal by the Commission to support the construction of up to 12 large-scale CCS demonstration plants by 2015 (EurActive 2010). They further agreed that by 2020, all new coal-fired plants should include CCS technology and existing plants should be subsequently retrofitted. According to the President of the Commission, the EU has “to continue to

[4] The International Energy Agency (IEA) proposes a "virtual decarbonisation of the power sector" by 2050 and supports CCS as one of the ways of achieving this alongside other alternative energy resources (IEA 2008).

be able to exploit fossil fuels as a key source of energy for decades to come, […], so we need to make CCS the norm for new power plants" (Barroso 2008). The Commission also launched a European Technology Platform for "Zero Emission Fossil Fuel Power Plants" (ZEP) which aims to develop EU fossil fuel plants without CO_2 emissions by 2020. On the international level, the COACH (Cooperation Action within CCS China-EU) project aims to establish a broad cooperation between China and the EU. In January 2008, the Commission published community guidelines on state aid for environmental protection, allowing member states to adopt CCS "as important projects of common European interest" (EU Commission 2008).

Ocean fertilization: These measures aim to increase the rate of CO_2 absorption of oceans by manipulating its carbon cycle. Therefore, CO_2 "is fixed from surface waters by photosynthesisers by microscopic plants" (Royal Society 2009: 16). To stimulate the bloom of these plants, oceans are fertilized with iron or similar effective substances. Like any other CDR method, ocean fertilization is associated with different risks. Inserting iron in the ocean bares unintended ecological side-effects on the marine ecosystem and might even produce "dead zones" (ibid, 18) in the ocean. However, iron fertilization is one of the best explored technologies. Besides scientific institutions, many private actors, such as the Ocean Nourishment Corporation or Climos, are exploring processes of manipulating the ocean carbon cycle. In 2009 the Indo-German iron fertilization experiment LOHAFEX in the Southern Ocean triggered an intense and critical debate in the public. Ocean fertilization is regarded as a very cost-effective technology, even though risks and uncertainties exist to a significant extent.

Biochar and biomass-related concepts: Bio-char is defined as readily available bio-mass (wood, stalks from grain crops, vine cutting) reduced to carbon in a low oxygen atmosphere through the process of pyrolysis (European Biochar 2008). According to the Royal Society (2009: 48), Biochar scores high in safety and affordability but could create two serious problems: First, it may cause land use conflicts similar to the debate on biofuel (e.g., food versus growth of biomass). Secondly, long-term effects on soils are not sufficiently explored yet (ibid, 13).

In sum, substantial differences between measures of SRM and CDR have been pointed out. Concepts of SRM such as stratospheric aerosols serve as “rapid palliative responses” (Blackstock et al. 2009: 3) to global climate emergencies, but cannot reduce the amount of CO_2 already in the atmosphere. In contrast, measures of CDR remove CO_2 from the air, but they may well take several decades to impact upon the earth climate successfully (Royal Society 2009). Some CDR measures (e.g., ocean fertilization, biochar, afforestation) as well as SRM concepts (e.g. white roofs) are technologically feasible. Others, such as injecting aerosols into the stratosphere, involve high uncertainties and make near-term deployment risky (Blackstock et al. 2009: 3). Taking the listed consequences seriously, in our view means that neither SRM nor CDR measures are ready for large-scale experiments yet. Most of them are barely explored and hold considerable risks.

Because engineering the climate constitutes a potentially irreversible “large scale experiment” (Barrett 2007: 48) more research in GE is required. At the moment, only little public funding is provided to reduce uncertainty by further research. Hence, demands on research funding had been discussed by the Science and Technology Committee of the UK Parliament and the U.S. Congress. Against this background, the report of the Royal Society (2009) created a “window of opportunity”, opening the debate on GE not only to the scientific community, but also to the public.

4. The Politics of Climate Abatement, Adaption and Engineering

The Kyoto Protocol imposes obligations on its ratifying nations to reduce the concentration of GHGs in the atmosphere according to the principle of “common but differentiated responsibilities”. Making the initial move, Annex I countries committed to reduce their emissions by an average of 5.2% from a 1990 baseline by 2008 to 2012 (Bretherton/Vogler 2006: 3). Yet, the lack of a binding agreement to replace the expiring protocol clearly demonstrates the deep disagreements between the parties to the UNFCCC. Although the UN still plays a key role in providing the international framework for negotiations on climate change, collective action-problems between its members turned out to hamper commitments (Helm 2008; Harris 2007).

As a result, the recent Copenhagen Accord fell far short of the goal to impose collectively negotiated targets for emission reductions (Egenhofer/Georgiev 2009: 2). It states that deep cuts in global emissions are required and that countries should ensure action to prevent global temperatures rising more than 2℃ above nineteenth-century pre-industrial levels. The accord neither mentions long-term targets for 2050, nor does it require generally binding reduction schedules. Conflicts arose mainly over the concept of common but differentiated responsibility. These pitted rapidly developing economies (e.g., India or China) against industrialized countries (e.g., the U.S. and member states of the EU), which are responsible for the majority of historical CO_2 emissions. China and India refused to sign commitments to contribute to reduce global warming up to 50 percent by 2050. In contrast, those countries most vulnerable to the negative impacts of climate change, such as the group of small island states, pushed for limiting the temperature increase to 1,5℃. Hampered by a domestic debate over a climate bill, the U.S. also failed to put forward new reduction targets (Wagner/Machnowski 2009). In sum, tensions between developing and industrialized countries precluded the introduction of new agreements. Arguably, previous mitigation strategies will not effectively avoid a critical level of climate change.

The growing appeal of GE technologies

As a long-term and high-impact policy problem, climate change poses a serious environmental challenge when establishing distributional fairness on living conditions both within and between generations (Goes et al. 2010). Even if states could settle for a very ambitious mitigation and adaption scheme in the foreseeable future, the risk of disastrous effects of global warming would still be very high (Matthews et al. 2009). This is so, because the impact of carbon emissions made in past centuries and those that will have to be made in the immediate future is persistent and increasing (inertia problem). More specifically, given that the GHG emission impact is assumed to increase nonlinerary, if not quadratically and keeping in mind the uncertainty about the slow-response of some elements of the atmosphere, it is plausible to suggest that this inertia creates a high risk potential (Moreno-Kruz/Keith 2009: 3).

Changes in life style, especially in energy consumption patterns, towards a decarbonized society and economy may mitigate the (exponential) increase of risks of catastrophic climate events (Holdren 2006). But these measure are unlikely to keep CO_2 concentration in the atmosphere at the level of 450 parts per million, the commonly held ceiling above which the risk of dangerous climate change becomes very high (Keith 2009: 1654). As a consequence, GE technologies that do promise to reduce climate risks emanating from the CO_2 driven global warming, although they may never deliver on that promise, have a growing attractiveness for societies and policy makers (Cicerone 2006).

GE technologies differ considerably in their effect on the persistence of the CO_2 induced risks of dramatic global warming events. They also may be distinguished according to their technological viability, their probable detrimental effects and distributional disparities. These diverse characteristics raise a host of important governance issues when the implementation of these technologies is considered: first, if GE technologies are pursued in earnest (research, field testing, large scale introduction, feed-back), who will govern this technology, who will control the climate to what degree? Secondly, if GE proves a viable technological option, will that reduce the motivation to pursue mitigation and adjustment? If so, GE may change nature so irreversibly that important long-term ethical questions appear about responsibility and fairness among the parties concerned. Thirdly, GE touches upon the relation between science and politics, because scientific knowledge plays an important role in constituting risk assessments, cost-benefit analysis and tipping points, including climate emergency situations (Lenton et al. 2008). This, of course, raised important questions about who and what is represented in the "risk discourse on geo-engineering" (Liverman 2009).

On balance, techniques to increase the Earth's reflectivity appear to pose small to medium technological challenges with marginal costs, when calculated relative to the costs inflicted by unhindered global warming. However, at this stage SRMs are considered to entail considerable risks and unintended consequences, including an increase in ocean acidification, ozone depletion and unforeseen changes in atmospheric circulation (Robock 2008: 15; Goes et al. 2010). In addition, these technologies do not reduce the risks from the CO_2 already disseminated in the atmosphere. For example, CCS, which is considered by some experts as a "light form" of GE, captures CO_2 from industrial production with high CO_2 emissions, e.g.

energy production and may involve even less hidden risks than other SRMs. But CCS will limit only that part of the CO_2 risk that emerges from ongoing CO_2 emissions. It cannot eliminate the risk posed by emissions taken and persistent in the atmosphere.

The techniques that promise to counter the risk of CO_2 already in the air, are the most expansive and technological challenging (Keith 2000; Lampitt et al. 2008; Keith 2009). These CDR techniques try to trap CO_2 from the air in soils, fluids or biomass (see above). At this time, these technologies are the only ones that promise to remediate the existing human impact on the carbon cycle, most prominently, global warming. But, except for CCS which appears to be viable at reasonable costs, these methods may not be ready for another generation and they may never work cost-effective (Herzog 2003). In addition, recent studies show considerable variance in the public responses vis-à-vis CCS, suggesting that public support can be earned only slowly but must not be taken for granted (Alphen et al. 2007; Sharp et al. 2009; von Goerne 2009).

In nuce, solar radiation management appears to be doable, relatively cheap but with a high potential for creating troublesome incentives and that may create risky trade-offs between CO_2 mitigation and SRM application (see above section on moral hazard). In contrast, carbon cycle engineering is viewed by some experts as expansive and ripe with technological problems while promising high returns with much less unintended consequences at a later stage.

Thus, the incentive structure appear to privilege a high risk strategy based on SRM techniques, because “SRM solutions” allow for early and effective responses by national decision-makers to a “climate emergency situation” (Lawrence 2006) while obfuscating the follow-on costs and probable unintended consequences of their application. In addition, the probable hazardous environmental effects of SRM are magnified by their impact on global governance: SRMs do not require cooperation by various parties, but they require very careful calibration because of their strong distributional effects (e.g. on precipitation). This high “leverage effect” (unilateral applicability/strong distributional effect) sets the stage for conflict between the implementing and the aggrieved parties (Robock et al. 2009).

5. Research Design

The analytical goal of our project is to identify and describe emerging discourse structures in European states and their influence on policy-based risk assessments. We assume that member states vary in their commitment to promote research in GE technologies because of their different risk cultures, institutional settings and knowledge debates on the domestic level (Bulkeley 2005; 2001). This assumption derives from two observations: First, states have already demonstrated diverging attitudes towards climate change and accordingly pursued different mitigation and adaptation measures. Secondly, these attitudes are also reflected in the debate on GE. For instance, there is a more vivid debate over engineering the climate in the UK and the Netherlands, whereas less attention is paid to the issue in Germany and other European states.

The Netherlands, Germany and the UK

The debate on engineering measures has not reached the level of EU-politics, but is evolving continuously within some member states. Therefore, our case studies focus on the level of states, examining the Netherlands, the UK and Germany. We selected these member states for three reasons: First, they provide a most-similar cases design, as they are all liberal democracies and modern industrialized societies with a comparable level of socio-economic development, techno-scientific affinity and competence. Secondly, the sector of environmental politics is firmly rooted in their political systems, public opinion is incorporated in the decision-making process and all are members of the UN and other international organizations. Thirdly, the Netherlands and the UK are among the most vulnerable European countries to climate change.

In the Netherlands, 60 percent of the population lives in the 25 percent of the country which are below the sea level (Pettenger 2007: 51). Surrounded by water to the North, East and West coast, the Netherlands are extremely vulnerable to the predicted rise of sea levels (ibid, 51). This is often cited as one of the main reasons for the country's strong engagement in climate change policy and leading role in tackling global warming on an international scale. In 2007, the Netherlands Environmental Assessment Agency (PBL) published a report in which the agency advises to promote an international program on accessing "emergency policy options", including research, demonstration and deployment of GE technologies (PBL 2007). Recently, the PBL held a side event on extreme mitigation and adaptation measures at the CoP 15 meeting, again including the option of GE.

Germany also is one of the driving forces behind the EU's integrated climate and energy policy, advocating stronger measures to address climate change (Weidner/Mez 2008). Domestic pressures determined by the emergence of green parties during the 1980s led to sustained efforts in international climate negotiations. In particular, during the period of Angela Merkel's presidency of the G8 and the EU council, Germany insisted on setting binding targets for the reduction of greenhouse gases and the expansion of renewable energies. Against this background, policies were adopted to promote new energy resources, notably solar and wind energy.

CCS-technologies remain under discussion, although the German parliament has not yet decided on the geological storage of carbon dioxide. Germany's engagement in the development of new energy technologies as an alternative to nuclear energy and its affinity to science-based technology make a growing interest in GE-research activities plausible.

In the UK, climate change and sea level rise are as well issues of unique importance. Besides the threat of coastal flooding, the European Environmental Agency (EEA) predicts an increase in winter precipitation, river flow northward movement of freshwater species and higher risks for fish stocks in Northwestern Europe and in the European seas (EEA 2008). In 2008 the UK Parliament held a hearing on GE and since the Royal Society Report was published, a debate over the public funding of GE research has been waged. The British Innovation, Universities, Science and Skills Committee recently stated that "geo-engineering technologies should be evaluated as part of a portfolio of responses to climate change, alongside mainstream mitigation and adaptation efforts" (UK Parliament 2009).

If the EU aims to govern effectively in fields of climate-modifying technologies, cooperative relations between its member states need to be established. We argue that variance in risk culture of member states will influence their respective willingness to delegate GE competences to the EU. Hence, this project analyzes the coherence and compatibility of different risk cultures and the resulting willingness to delegate climate engineering policies.

Thus far, the scholarly literature on risk culture emerged from sociology (Douglas Wildavsky 1982; Rayner 1987; Schwarz/Thompson 1990), focusing on the identification of specific group-prototypes within a society (e.g., entrepreneurial, egalitarian or bureaucratic). In contrast, assuming that risk cultures are less constant over time and actors, we focus on discourse formations, the way in which arguments on GE risks are framed, tied to norms and values of the respective societies and used to legitimate behavior with (high) distributional consequences. Methodologically, discourses bridge the gap between perceived risks within a society and its capacity and willingness to act.

Our approach to risk culture

Indeed, issues of risk and uncertainty have played a key and arguably growing role in the development of humanity. According to Beck's (2008) influential "risk society" thesis, risks always occur as side-effects of modern industrial societies and are responsible for their transformation over time. As such, complex technological development cannot be addressed by statistical-probabilistic risk assessments only, because they involve large scale societal effects. Risks, thus, call for an interdisciplinary research approach which addresses the variation in the nature and construction of risk by a wide spectrum of societal actors and scientific disciplines (Renn 2008, Taylor-Gooby/Zinn 2007).

We start from the assumption that climate change poses a typical risk as it involves scientific and social complexity, deep forms of ambiguity and uncertainty, temporal and spatial inequalities as well as governance dilemmas (McLean et al 2009; Bulkeley 2001; Pidgeon/Butler 2009). Against this background risk culture is crucial among other variables explaining actor's attitudes towards GE technologies in the wider context of climate change. In our view Beck's idea on the creation of risks by the dynamics of reflexive modernization only offers a starting assumption for our exploration. As such, Beck's "risk hypothesis" does not offer a systematic and analytic explanation of why and how distinct definitions or concepts of risks come to dominate and shape political action (Bulkeley 2001: 430).

This paper suggests an approach focusing on the nexus between risk and culture. It posits that the way risks are perceived and presented is to a significant extent based on social and cultural values[5]. The cultural understanding of risk focuses on the meaning that different actors assign to it. Cultural theories argue that public values and social concerns do clearly influence the way that risks are handled within a society (Johnson/Covello 1987: 3; Rathbun 2007). Individuals, groups or communities decide - depending on their social (material and immaterial) background - if GE projects are risky or not. According to the assumptions of the anthropologist Mary Douglas, each society has its own repertory of risks that are believed to be worthy of concern (Douglas/Wildavksy 1982: 14).

Constructivism and Risk Culture

Many constructivists argue that culture can be understood as both a causal or constitutive concept to explain/understand behavior in international relations (Katzenstein 1996, Lapid/Katrochwil 1996, Weldes 1999, Ulbert 1997). This is based on the claim that state behavior is not determined (solely) by materially forces, i.e. power, but also by immaterial forces, i.e. intersubjective understandings such as norms, values, cultures (Wendt 2007). In this vein, social constructivism may be merged with sociological risk culture research which emphasizes "the social contextualization of risk" (van Zwanenberg/Millstone 2000: 259).

Hypothesis

Against this background, the research project is based on three working hypotheses: First, elements of risk culture can be detected in domestic discourses between the dominant actors in science, politics and the public. A discourse can be defined as "a

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[5] We do not question that risks are part of the real world as negative impacts (e.g., technical catastrophes or environmental pollution) cause real damages and losses. But the concepts to predict the probability of such occurrences are constructed (Rohrmann/Renn 2000).

specific ensemble of ideas, concepts and categorizations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer 1995: 44). Accordingly, elements of risk culture can be found in discourse formations, explaining why and by what process some framings of risk issues come to be seen as relevant and reliable. Secondly, the variance of risk cultures influences the perception of risks, thereby, either supporting or inhibiting the development of GE politics. Depending on the understandings of the "self" and the "other", risks indicate what is considered as a potential danger to central norms and values of a society. Thirdly, the extent of compatibility of member states' risk cultures shapes the content and degree of EU actorness. The following paragraph briefly outlines how risk cultures may be operationalized. Discourse analysis serves as an instrument to indentify risk culture elements within the debates.

How to conceptualize risk culture?

Following Daase (2007), risk can be defined "as the probability of a future loss or damage that can be influenced by current action". In contrast, a threat appears when states perceive an actor (agent), which holds an adversarial intention (intention) and possesses the means to inflict considerable damage (capability). In the absence of one or more of these elements – actor, intention or capability – a threat turns into a risk as a result of uncertainty (Daase 2002). Drawing on the three components we prepared a first-cut set of analytical questions to identify shared attitudes on risks in the respective discourses.

First, we ask which actors and institutions hold a dominant role in the GE debate (responsibility and legitimacy). How are their strategies and proposals judged by other actors (trust)? Secondly, considering capabilities, we examine how the probability of potential losses in the future is perceived and how risks of GE concepts are assessed (likelihood of losses). How do actors decide if a risk is acceptable or not (acceptability)? Thirdly, we locate intention within the wider context of climate change, asking how the negative impacts of global warming are perceived (severity of current and future impacts of global climate change). How are the results of climate negotiations perceived and interpreted?

As Bulkeley (2001: 443) states, “argumentative struggles” may emerge between policy-network, involving states and non-state actors, but also within those networks. These debates will be dissected from published material and interviews, public speeches, conferences etc. First, we focus on the scientific debate, analyzing scientific papers (e.g., journal articles, working papers or technical reports). Secondly, we include political discourses, which can be found in parliamentary debates and hearings, laws, political speeches or policy communications. Thirdly, we consider the media and the public opinion as crucial elements, taking press articles, editorials and scientific publications in magazines into account.

At this point, we detect that risk assessments concerning GE do not follow party lines. Therefore, we seek to identify so-called discourse formations that share arguments. In addition, using tools and concepts of discourse analysis such as story lines, frames, rhetorical methods or types of narration, we intend to identify overlaps or conflicts between discourses as well as dominant structures and norm entrepreneurs. We concentrate on debates starting in the year 2009, after the Royal Society initiated a broader discussion. We then follow the discourses in the UK, Germany and the Netherlands for three years, analyzing how they differ and evolve across time and actors. Moreover, we seek to reveal how and to what extent these discourses influence each other.

6. The Global Governance of GE

The intricate complexity of the earth system, the inertia and pervasiveness of unintended consequences of GE technologies as well as the well-documented tendency of experts to overestimate their expertise (Jamieson 1988; Jasanoff 1987) suggest that (at this stage) the level of reliability of predictions is low and the risk of harmful and irreversible decision making is high. The "Global Governance of Climate Engineering"[6] is further complicated by two additional factors: first, there exists no comprehensive legal framework (national or international) today, that may help regulate some or all governance issues (research, control, participatory discourse) of GE; Secondly, GE promises to preserve the current CO_2 fixated consumerist lifestyle. It thus sets the stage for conflict between those that may perceive the current mitigation efforts as a threat to their interests – energy producers, industrialists (e.g. car and aircraft companies) as well as motorists etc. – and groups and individuals that do not (or do not yet) heavily rely on a high CO_2 footprint (least developed countries, environmentalists etc.).

The introduction of GE technologies, starting with research, will thus create a new set of "winners and looser", if only because already climate change itself spreads the costs and benefits of global warming differentially: allowing for gains by access to resources and shipping routes in the Arctic sea and high-latitude farming, initiating costs by changes in atmospheric circulation (e.g. droughts, hurricans) or rising sea

[6] Global governance can be defined alongside three criteria: structure, actor and process. First, structure implies that the concept of global governance is not limited to the international scale as local, national and regional levels are included ("multilevel governance"). Secondly, not only different state but also private actors (e.g. multinational corporations, networks of scientists or intergovernmental organizations) are involved. Thirdly, process refers to a variety of political cooperation such as hegemonic, international or transnational governance. For instance, the model of transnational governance includes public-private and private-private partnerships (Behrens/Reichwein 2007).

levels, with serious, sometimes irreversible consequences for the livelihood of the concerned.

The risks of geo-engineering thus include judgements on the desirability of future states of the world made by a great variety of nations and people. These judgments on the risks of GE are prone to vary substantially between countries as the different responses to the mitigation scheme in the Kyoto protocol indicate. In terms of discourse structure, two ideal-type positions on “climate justice” may be distinguished at this point: a position in which the overall wealth (measured in economic output and acceptable climatic conditions) is increased while the distribution of each is unequal and a position where greater equality is the preferred state although this may imply less overall wealth (Jamieson 1996: 328).

7. Contribution to research on GE politics

Theoretically speaking, the debate on GE is a debate on the constitutive and regulatory effects knowledge created, among others, by natural and social scientists and political decision-making. We contend that scientists that advocate intensified GE research may ultimately „reconstitute the political world“ by enabling elected officials to choose between imposing further CO_2 mitigation demands on their electorate or employing GE technologies that diffuse and shift adaption costs to other regions or generations. By diminishing the reliance on joint CO_2 mitigation efforts, „scientifically viable geo-engineering techniques“, would thus open up the political room for uni- or plurilateral maneuver (MacCracken 2006).

Those who oppose GE as a „cost-efficient method“ on which a strategy after the failure of mitigation efforts can be build question the claim that costs and benefits are calculated precisely or fairly. Drawing on analogies to the failure of governments to establish a sustainable concept for nuclear waste disposal in a democratic society, they fear that the „true costs of geo-engineering“ will be obfuscated, i.e. spread over time and various geographical areas so that diffuse politicization will lead to a „fairness gap“ (e.g Ott 2010). Legally speaking, a whole set of questions about allocating responsibility and determining liability may arise (Davies 2009: 5).

Some supporters of GE acknowledge the desirability in theory to act multilaterally. However, they also note the limited willingness to engage in serious inter-governmental negotiations of northern industrialized countries and the limited capacity of southern developing societies to come up with a communal cost-benefit calculation. Hence, the threat persists and increases that GE will create knowledge about the probable „winners and losers of geo-engineering“, thereby further reducing the chances for a fair and politically viable solution.

Contribution to risk sociology, political science and public discourse

As a long-term policy problem GE poses a critical challenge to scientific theories that are based on causal rather than constitutive reasoning. Risks, defined as the probability of a future loss or damage that can be influenced by current action, are thus inherently generical. They include, by definition, the impossibility to assign reliable quantitative values to the various „probable states of the world in the future“ (Daase 2002).

At this time, we simply do not know enough about the risks of GE. By finding out, however, scientists, both natural and social, „constitute these risks“ in the sense that their scientific risk-assessments may become „accepted knowledge through scientific discourse”. In contrast to earlier studies on „epistemic communities“ and „advocacy coalitions“ which assumed strong motives by scientists about their preferred future state of the world, the proposed research project propagates a „reflexive risk sociology“ which does not posit fixed preferences as such. We envision all kinds of “scientific normative entrepreneurs” in the GE debate which engage to varying degrees in the “strategic construction” of identities and interests, using norms (pro/con) to define what should be considered as appropriate state behavior towards GE.

We use Robert Pielke’s conceptualization of the different roles a scientist can take on when engaging in policy advice. Pielke specifies four ideal-type roles: the pure scientist, which focuses on research with absolutely no consideration for its use or utility, and thus in its purest form has no direct connection with decision-makers; the “issue advocate”, who focuses on the implications or research for a particular political agenda, and thus aligns himself with a group seeking to advance its interest through engaging with decision-makers; the “science arbiter”, who seeks to stay removed from explicit considerations of policies but acknowledges that policy makers have questions and want judgments by experts; and the “honest broker”, who engages in decision making by clarifying and seeking to expand the scope of choice available to policy-makers. The honest broker actively seeks to integrate scientific knowledge with stakeholders concerns in the form of possible courses of action (Pielke 2007:15-18).

In addition to the variation in roles scientists, we posit that the (democratic) political process in which GE is considered must be taken into account. Interests by stakeholders will be represented differently in the political system under review. Scientists may therefore have doubts about sharing their knowledge at this may impact upon the discourse in a unforeseen or unwanted way. As D. Keith and several others have noted recently, to date only a small community of GE researchers and government officials is engaged in the GE debate. For a long time – until 2006 – most scientists treated GE as a taboo „too afraid to tell the children“, i.e. their democratic populace. This position, of course, rightly or wrongly, implied that democratic societies are either ill-prepared to rationally discuss and decide on GE or that (democratic) debate may result in suboptimal choices. While skepticism is healthy when contemplating the in-, through- and output legitimacy of public discourse in democracies and other political systems, we hold that the challenge is to structure the GE-debate equitably.

As mentioned above, our research design is based on the assumption that democratic societies will differ considerably in their respective discourse structure when debating risks (Tänzler 2002). We hold that three corporate actors are important to the risk analysis of GE: the „public opinion's view“ as emerging from public opinion polls and newspaper editorials; the „scientific community's view“ as emerging through research publications, expertise and legislative hearings, and the „political system's view“ as emerging from legislative debates, executive orders, laws and their implementation.

Just how these three actors do interact in the respective national and transnational discourses depends, in our view, on institutional factors – parliamentary system – as well as existing „risk cultures“, i.e. collectively held attitudes on risks of technology and the credibility of actors (Westlind 1996: 116). We hope to find distinctive structural patterns of discourse that will help us to explain why certain discourse formations, i.e. alliances of actors which use specific arguments to make their case, are able to attain discourse hegemony (Torfing 2005: 15, 23).

As a first step of our discourse analysis we will introduce a typology of possible discourse patterns that do focus on the responsiveness between the public, scientists and the political systems. Secondly, we seek to identify distinct elements of the respective risk culture (responsibility, solidarity etc.) which are used to argue in favor or against research and/or introduction of GE-techniques. Thirdly, we strive to distinguish several discursive patterns and their respective policy recommendations. The use of discourse formations, which do not replicate party lines, allows us to focus on the evolving discourses which will involve an increasing number of both political and social actors in a national and transnational discourse. Hence, we neither do assume homogenous and fixed risk cultures (e.g. Trombetta 2008; Richert 2009) nor do we privilege actors over arguments (Hansen 2006: 52).

Our conceptualization of discourse formation implies that central elements of existing risk cultures may be reconfigured in the GE-discourse. E. g. acting responsibly with regard to GE technologies may imply to impose a no-first use commitment by certain actors or governments in the early stages of a debate (Ricke et al. 2008: 12). Later, responsibility, may be used quite differently: Governments of coastal states may legitimize their unilateral pro-active GE-policy as „appropriate actions against the immediate and rising threat of coastal area devastation“ (Davies 2009: 9). In this sense, discourses, may re-constitute actors themselves as these actors change the content of their „role“ vis-à-vis others in the discourse. In our case a government may change its role as a protector of the public against the long-term implications of GE and thus limiting GE- technologies to a fervent propagator of GE thereby turning into a protector against short-term threats.

In short, we hope to identify the discursive conditions necessary for successful change in the GE-debate, intended to be analyzed in different national and possibly transnational risk cultures. We find little reason to believe that climate change and the application of GE as a remedy is different from other potential moral hazard problems. Although GE technologies may pose quite different challenges – short- vs.

long-term; levels of affectedness – if discourses constitute risks and regulate risk policy accordingly, then the relative weight of discursive formations in the ensuing public debates is crucial to understand and predict the potential political space for GE application.

GE does not necessitate multilateral cooperation per se as any industrialized state with moderate resources may apply one or more technologies unilaterally. We do, however, base our analysis on the assumption that member states of the European Union, will, under the given treaty obligations for a coherent climate change policy, at least coordinate their GE behavior. We thus start from the assumption that EU actorness in GE policies is not given, but should be part and parcel of our investigation.

At this time, it is unclear whether the delegation of national GE competences will create a strong EU actorness (capacity). National politics are about to aggregate their preferences through parliamentary committee debates and research assignments, but delegation of the implementation to the executive branch and/or specialized agencies is still rare. At the European level, there are of course two distinct policy channels which could be used: through the European Parliament, which serves to aggregate the preferences directly from voters, and through the European Council, which sums up the preferences of member states and their respective polities (Pollack 2006). Early action by the Commission in the field of CCS technologies, under the competence framework of EU technology policy, does suggest that the Commission may want to establish itself as an important protagonist of (common) GE research funding (EU Commission 2007).

Against this background and in the wake of the literature on EU actorness, the proposed research project sets out to analyze the patterns of pooling and delegation of the three EU member states under review towards a common EU GE policy. From our point of view, delegation is possible, but by no means given.[7] The content, structure and compatibility of national and transnational risk cultures will determine the degree to which the EU becomes an actor in GE. We do, however, assume that even if the Union does not become an actor for GE technology cooperation, then it may well be emerge as an important policy forum, e.g. if another concerned state does implement GE technologies with obvious implications for various EU policies, including mitigation efforts.

Contribution to Public Policy debate on GE

> „I want to make sure you understand the reality of this situation. I'‘ve given you all the sincerity that I could give you. But the reason you are here is not why you think you are here, OK? The reason you are here is to try to win a debate with some industries in this country who are afraid to look forward to a new energy future for this nation. And the reason you are here is to try to create doubt whether this country should move forward with the new technological, clean energy future, or whether we should remain addicted to fossil fuels. That‘s the reason why you here.“ (MOC in a 2006 Congressional Hearing on Climate Change as cited in Pielke 2007: 10-11).

As noted above, our research project will not only seek to identify different discoursive patterns of how democratic societies do construct risks institutionally when assessing risks and defining respective policies. It will also discuss, as part of its public outreach effort, the normative implications of scientific research under the conditions of uncertainty.

More specifically, we address the question of how scientists may change the meaning of intended or unintended consequences or deliberate climate change. The meaning of the term “intention” is crucial because intentions and deliberative action

[7] The Council has, however, strongly supported the Commission’s introduction and funding of CCS technologies, both within and beyond the Union’s borders: EU Council 2009: 13, para. 58.

imply actorness and motives, thereby turning risks into threats.[8] We posit that the current legal framework for climate change will provide the normative context in which various parties will judge the „intentionality“ and “deliberative actions“ by actors implementing GE technologies.

While no national or international legal regime regulates GE technology at this point, existing treaties and decisions by international bodies indicate how the international community has dealt with intended and unintended consequences of climate change in the past (Davies 2009). Since these “institutions” shape the state’s conception of what is considered right and just, not the least because these states all had a chance to participate in the creation of these norms, they will form the normative context which protagonists and skeptics alike will try to connect their arguments with (Lin 2009: 15).

To begin with, the UNFCCC stipulates as the convention’s objective to prevent „dangerous anthropogenic interference in the climate system“ (Art. 4.1 (d)) which leaves considerable room for interpretation what „dangerous“ exactly means (Schneider 2001). Assume that climate scientists may provide knowledge that CO_2 emission, hencetoforth considered as an unintentional act which changes the climate, causes irreversible costs for some members of the international community, then the interpretation of what „deliberate action“ means may shift considerably. This is all the more so, because the convention defines climate change „as attributed directly or indirectly to human activity that alters the composition of the global atmosphere“ (Art. 1). As some GE techniques, such as SRM, tinker with the composition of the atmosphere, some parties may interpret GE as a „deliberate act“

8 In a more abstract fashion threats are composed of three things an actor, conflictual intentions and capabilities to inflict considerable harm whereas risks imply situations with potential negative outcomes in which that one or more of these components are uncertain (Daase 2007).

under the definition of the UNFCCC. In this case, the UNFCCC Conference of the Parties may want to look at the Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (ENMOD) which bans environmental modification for military purposes (Lin 2009: 20).

It is also noteworthy, that the Rio Declaration on Environment and Development establishes in Principle 7 (common but differentiated responsibilities) and Principles 16 (polluter pays principle) politically binding precedents that may frame respective arguments with regard to GE (Virgoe 2009: 112).

Scenarios

In order to sketch out how scientific research and the respective knowledge may constitute the political world in the future, we examine three scenarios: the long drag; the Indian brake-out; a collaborative adjustment and GE-management system.

The long drag: Although the foundation scenario for GE protagonists is a steady decline in CO_2 mitigation efforts, this is a relatively unlikely path toward a short- or medium term implementation of GE technologies. The Kyoto-process and the Copenhagen Summit have, to a limited extent, legitimized common action to cap CO_2 emissions. On balance, of course, these measures have serious short-comings: a) the targets under Kyoto set have hardly ever been met, b) the so-called Annex-1 countries (industrialized states committed to specific targets) emissions have increased in absolute and per-capita terms and c) in spite of the „Clean Development Mechanisms“ industrialized countries have offered little to address the concern of developing countries how to reconcile the triple challenge of economic development, CO_2 mitigation and adaption. But current path-dependency of the international negotiation process, technological innovation in CO_2 mitigation as well as positive effects of global warming may hamper an early introduction of GE technologies.

Scientists may, of course, influence the discourse in the long-drag scenario in various roles and ways: either scientists as opposing issue advocates may keep each other at bay or science arbiters may continue to prioritize mitigation measures over GE technologies, thereby “lengthening the political fuse” for “precautionary action”. As the current debate about the “trustworthiness” of the IPCC shows, science that has been accepted as “common knowledge”, i.e. anthropogenic climate change is a clear and growing, if distant danger may be questioned and reappraised.

The Indian brake-out: A second scenario, more likely to initiate an early use of GE technologies, starts with a profound environmental emergency in one of the most vulnerable high-impact countries, India, which might even provoke the Indian government to organize a wider coalition of concerned Coastal and Island states in favour of GE deployment. Since India’s government depends on public consent and because this consent is based on the government’s ability to secure development through the access to energy, India’s coal-dominated energy and economic strategy poses an enormous challenge for the reconciliation of development and environmental goals. While India has been hesitant to join international climate mitigation efforts in the past, increasing domestic pressure may effectuate that the government seeks a technological solution out of this vexing policy dilemma. This, of course, may include CCS-technologies early on which may even be transferred under a post-Kyoto framework agreement from Annex-1 countries to India and other developing states (Joshi/Patel 2009). But, given the vulnerability of India’s coastal areas, a technological solution may also include other GE technologies as these become available and plausible means to address public concerns about the detrimental effects of India‘s CO_2 intensive development path.

In this scenario, a coalition of issue advocates may fuse arguments of “justice and equity” with tacit knowledge on the technological viability of some GE measures, e.g. SRM. While these scientists must not reside in India, they should be part and parcel of the Indian discourse on the costs and benefits of “unilateral geo-engineering”.

A collaborative GE-management system: A plausible third scenario has its roots in the collective understanding that the „international community“ has thus far been unprepared to address CO_2 mitigation and adaption challenges in time and therefore has to find a cooperative implementation of GE research and application (Victor et al. 2009; Davies 2009). This scenario comes in two distinct scripts: one confrontational, the other collaborative: in the first instance, a plurality of states, possibly exasperated development countries, seek to hold fast to their development goals while addressing the rising concerns of their publics to master the already visible effects of global warming. This scenario for early first use of GE technologies by a „coalition of willing and aggrieved states“ is most plausible when this coalition perceives the current mitigation policies as „unfair“ and as a potent and immediate threat to the well being of a considerable part of their electorate. The second scenario involves a larger community of states which seeks either an early „palliative application of GE as an „emergency measure“ to counter „environmental emergencies“ (Blackstock et al. 2009) or as a medium to long-term phased-application, substituting for deficits in ongoing mitigation efforts. This last scenario obviously includes the initiation of GE-research and the implementation of SRM and CCM at different stages in the scenario.

In this scenario, scientists of various disciplines are involved but international legal scholars may play an exceptional role as “honest brokers”, because diverse interpretations of responsibility and liability have to be brought together in a way that resonates with established international legal norms or community norms that legitimate plurilateral actions. Such an aggregate effort is susceptible to free-riding, as some countries may create incentives for others not to cooperate (increase emissions), but blatant illegitimate behavior, such as unilateral GE deployment for adversarial purposes, may even push a group of countries to act collectively.

8. Conclusion

It is easy to suggest to bring together various disciplines in a research design and to play several roles as a scientists at the same time. It will be much harder to show it can be done. The reasons for this are the following: there are only a few IR or political science studies that use risk culture and discourse theory to compare risk policies by three states with regard to the delegation of competences to an international institution. Secondly, typologies of risk cultures in comparative politics are very hard to find and if, they lack the dynamic element we need to study an evolving discourse. Moreover, the impact of the various roles scientists may play in the discourse and the evolution of distinct discourse patterns on the risks of a yet unproven technology will have to be “conceived” rather than “detected”.

Nevertheless, given the aforementioned caveats, we hope that our study will expand on previous work in several ways. It seeks to explore cues from risk analysis for assessing GE policies, using a discourse approach. It considers the role of scientists in the discourse, where this role may vary over time, space and political setting. Furthermore, the project will address the (constitutive) effects of science on political decision-making under conditions of deep uncertainty. We, thus, hope to contribute to a reflexive risk sociology that expands rather than limits the scope of choice for the stakeholders in the evolving climate engineering debate.

Literature

Alphen, Klaas/van Voorst tot Voorst, Quirine/Hekkert, Marco P./Smits, Ruud E.H.M. (2007): Societal acceptance of carbon capture and storage technologies, in: Energy Policy 35: 8, pp. 4368-4380.

Baker, Tom (1996): On the Genealogy of Moral Hazard, in: Texas Law Review 75: 2, pp. 236-292.

Barret, Scott (2007): The Incredible Economics of Geo-engineering, in: Environmental and Resource Economics 39: 1, pp. 45-54.

Barroso, José M. D. (2008): "Europe's Climate Change Opportunity". London, 21st of January 2008, http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/08/26&format=PDF&aged=1&language=EN&guiLanguage=en (accessed February 12, 2010).

Beck, Ulrich (2008): World at Risk, Cambridge: Polity Press.

Beckert, Jens (2007): What is Sociological about Economic Sociology? Uncertainty and the Embeddedness of Economic Action, in: Theory and Society 25, pp. 803-840.

Behrends, Maria/Reichwein, Alexander (2007): Global Governance. In: Benz, Arthur/Lütz, Susanne/Schimank, Uwe/Simonis, Georg (Eds): Handbuch Governance. Theoretische Grundlagen und empirische Anwendungsfelder, Wiesbaden, VS Verlag, pp. 311-325.

Bengtsson, Lennart (2006): Geo-engineering to Confine Climate Change: Is it at all Feasible? In: Climatic Change 77: 3, pp. 229-234.

Bial, Joseph/Houser, Daniel/Libecap, Gary D. (2001): Public Choice Issues in International Collective Action: Global Warming Regulation, http://www.entrepreneurship.arizona.edu/docs/fac_pubs/Libecap_GlobalWarmingRegulation_2001.pdf (accessed February 12, 2010).

Bickel, Eric J./Lane, Lee (2009): An Analysis of Climate Engineering in response to Climate Change, Kopenhagen, http://fixtheclimate.com/component-1/the-solutions-new-research/climate-engineering/#c230 (accessed February 10, 2010).

Blackstock, Jason J./Caldeira, Ken/ Eardley, Douglas M./Keith, David W./Patrinos, Aristides A.N./Schrag, Daniel P./Socolow, Robert H./Koonin, Steven, E. (2009): Climate Engineering Responses to Climate Emergencies (Novim, 2009), http://arxiv.org/pdf/0907.5140 (accessed February 10, 2010).

Blackstock, Jason/Long, Jason (2010): The Politics of Geo-engineering, in: Science 327, p. 527.

Bodansky, Daniel (1996): May we engineer the climate? In: Climatic Change 33: 3, pp. 309-321.

Bulkeley, Harriet (2001): Governing climate change: the politics of risk society? In: Transactions of the Institute of British Geographers 26: 4, pp. 430-447.

Bulkeley, Harriet (2005): Reconfiguring environmental governance: Towards a politics of scales and networks, in: Political Geography 24: 8, pp. 875-902

Cicerone, Ralph J. (2006): Geo-engineering: Encouraging research and overseeing implementation, in: Climatic Change 77: 3, pp. 221-226.

Convery, Frank J. (2009): Origins and Development of the EU ETS, in: Environment and Resource Economics 43: 3, pp. 391-412.

Crutzen, Paul J. (2006): Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma? In: Climatic Change 77: 3, pp. 211-220.

Daase, Christopher (2002): Internationale Risikopolitik. Ein Forschungsprogramm für den sicherheitspolitischen Paradigmenwechsel, in: Christopher Daase/Freske, Susanne/Peters, Ingo (Eds.): Internationale Risikopolitik. Der Umgang mit neuen Herausforderungen in den internationalen Beziehungen, Baden-Baden: Nomos Verlag, pp. 9-35.

Daase, Christopher (2007): International Risks and the Perils of Proactive Security Policy. Paper prepared for the Sixth Pan-European International Relations Conference Turin, 12-15 September 2007, http://archive.sgir.eu/uploads/Daase-daase_perils.pdf (accessed February 12, 2010).

Douglas, Aaron/Wildavksy, Mary (1982): Risk and Culture. An Essay on the Selection of Technical and Environmental Dangers, Berkeley: University of California Press.

Drori, Gili et al. (Eds.) (2003): Science in the Modern World Polity. Institutionalization and Globalization, Stanford, CA.

Egenhofer, Christian/Georgiev, Anton (2009): The Copenhagen Accord. *A* first stab at deciphering the implications for the EU, Centre for European Policy Studies, www.ceps.be/ceps/download/2830 (accessed February 12, 2010).

ETC Group (2009): Retooling the Planet? Climate Chaos in the Geo-engineering Age, http://www.etcgroup.org/upload/publication/pdf_file/Retooling%20the%20Planet.hi_.pdf (accessed February 12, 2010).

EU Commission (2007): Communication from the commission to the council and the European parliament. Sustainable power generation from fossil fuels: aiming for near-zero emissions from coal after 2020. http://ec.europa.eu/energy/energy_policy/doc/16_communication_fossil_fuels_en.pdf (accessed February 10, 2010).

EU Commission (2008): Community guidelines on state aid for environmental protection, Bussels (2008/C82/01).

EU Council (2009): Council Conclusions on EU position for the Copenhagen Climate Conference (7-18 December 2009), 2968th environment council meeting Luxembourg, 21 October 2009.

EU Parliament (2009): Directive of the European Parliament and of the Council on the geological storage of carbon dioxide (2009/31/EC), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF (accessed February 10, 2010).

EurActive (2010): Carbon Capture and Storage, http://www.euractiv.com/en/climate-change/carbon-capture-storage/article-157806 (accessed February 10, 2010).

European Biochar (2008): Biochar in Summary, http://www.biochar-europe.org/ (accessed February 11, 2010).

Gibbins, John/Chalmers, Hannah (2008): Carbon capture and storage, in: Energy Policy 36: 12, pp. 4317-4322.

Finnemore, Martha/Sikkink, Kathryn (1998): International Norm Dynamics and Political Change, in: International Organization 52: 4, 887-917.

Goes, Marlos/Keller, Klaus/Tuana, Nancy (2010): The economics (or lack thereof) of aerosol geo-engineering, Philadelphia: University of Pennsylvania.

Greenpeace (2008): False Hope. Why carbon capture and storage won't save the climate, http://www.greenpeace.org/raw/content/international/press/reports/false-hope.pdf (accessed February 12, 2010).

Haas, Peter M. (1992): Introduction: epistemic communities and international policy coordination, in: International Organization 46:1, pp.1-35.

Hajer, Maarten A. (1995): The politics of environmental discourse. Ecological modernization and the policy discourse, Oxford: Clarendon Press.

Hansen, Lene (2006): Security as Practice. Discourse Analysis and the Bosnian War, London/New York: Routledge.

Harris, Paul (2007): Collective action on climate change: the logic of regime failure, in: Natural Resources Journal, 47:1, pp.195-224.

Hellmann, Gunther (2008): Forschung und Beratung in der Wissensgesellschaft: Das Feld der internationalen Beziehungen und der Außenpolitik – Einführung und Überblick, in: Hellmann, Gunther (Ed.): Forschung und Beratung in der Wissensgesellschaft. Das Feld der internationalen Beziehungen und Außenpolitik, Baden Baden: Nomos, pp. 9-45.

Helm, Dieter (2008): Climate-change policy: why has so little been achieved? In: Oxford Review of Economic Policy 24: 2, 211-238.

Herzog, Howard (2003): Assessing the feasibility of Capturing CO_2 from the Air. MIT Laboratoy for energy and the Environment, MIT, Cambridge, http://web.mit.edu/coal/working_folder/pdfs/Air_Capture_Feasibility.pdf (accessed February 11, 2010).

Holdren, John P. (2006): The energy innovation imperative, addressing oil dependence, climate change, and other 21st century energy challenges. innovations, technology, governance & globalization, in: Innovations, Technology, Governance, Globalization 1: 2, pp. 3-23.

International Energy Agency (2008): Energy Technology Perspectives 2008. Scenarios and Strategies to 2050, Organization for Economic Cooperation and Development.

International Institute for Sustainable Development (2006): CDM Conference & CCS Roundtable Bulletin. A Summary Report of the First International Conference on the CDM in Saudi Arabia, http://www.iisd.ca/download/pdf/sd/ymbvol124num1e.pdf (accessed February 11, 2010).

IPCC (2007): Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press.

Izrael, Yuri A./ Ryaboshapko, Alexey G./Petrov, Nikolai, N. (2009): Comparative Analysis of Geo-engineering Approaches to Climate Stabilization, in: Russian Meteorology and Hydrology 34: 6, pp. 335-347.

Jamieson, Dale (1996): Ethics and intentional climate change, in: Climatic Change 33: 3, pp. 323-336.

Jasanoff, Sheila S. (1987): Contested Boundaries in Policy-Relevant Science, in: Social Studies of Science 17: 2, pp. 195-230.

Johnson, Branden, B./Covello Vincent T. (1987): The Social and Cultural Construction of Risk. Essays on Risk Selection and Perception, Dordrecht: Reidel.

Joshi, Vijay/Urjit, Patel R. (2009): India and climate change mitigation. Smith School Working Paper Series 2009: 3, Oxford, http://www.smithschool.ox.ac.uk/__data/assets/pdf_file/0019/10666/Joshi__and__Patel_online.pdf (accessed February 11, 2010).

Katzenstein, Peter (1996): The Culture of National Security: Norms and Identity in World Politics. New York: Columbia University Press.

Keith, David W. (2000): Geo-engineering the Climate: History and Prospect. In: Annual Review of Energy and the Environment 25: 1, pp. 245-284.

Keith, David W. (2009): Why Capture CO_2 from the Atmosphere? In: Science 325: 5948, pp. 1654-1655.

Kraemer, Andreas R. (2010): Schöner leben im Labor? Geoengineering und das Recht, die Welt zu verändern, in: Internationale Politik 65: 1, pp: 70-75.

Lampitt, Richard S./Achterberg, Eric P./Anderson, Thomas R./Hughes, Alan J./ Iglesias-Rodriguez, Debora M./Kelly-Gerreyn, Boris A./Lucas, Mike/Popova, Ekaterina/Sanders, Richard/Sheperd, John/Smythe-Wright, Denise/Yool, Andrew (2008): Ocean fertilization: a potential means of geo-engineering?, in: Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 366: 1882, pp. 3919-3945.

Lapid, Yosef /Kratochwil, Friedrich (1996) (Eds.): The Return of Culture and Identity in IR Theory. London: Lynne Rienner.

Lawrence, Mark G. (2006): Geo-engineering: To speak or not to speak, in: Climatic Change 77: 3, pp. 323-336.

Lenton, Timothy M. /Held, Hermann/Kriegler, Elmar/Hall, Jim W./Lucht, Wolfgang /Rahmstorf, Stefan/Schellnhuber Hans J. (2008): Tipping elements in the Earth's climate system, in: Proceedings of the National Academy of Sciences 105: 6, pp. 1786-1793.

Lin, Albert C. (2009): Geoengineering Governance, in: Issues in Legal Scholarship 8: 3; http://bepress.com/ils/vol8/iss3/art (accessed February 11, 2010).

Lindenthal, Annette (2009): Leadership im Klimaschutz. Die Rolle der Europäischen Union in der internationalen Umweltpolitik. Frankfurt a.M.: Campus.

Liverman, Diana M. (2009): Conventions of climate change: constructions of danger and the disposession of the atmosphere, in: Journal of Historical Geography 35: 2, pp. 279-296.

Lunt, Dan J./Ridgwell, Andy/Valdes, Paul J./Seale, Anthony (2008): „Sunshade World": a fully coupled GCM evaluation of the climatic impacts of geo-engineering, in: Geophysical Research Letter 35: L 12710.

MacCracken, Michael (2006): Geo-engineering: Worthy of Cautious Evaluation? In: Climatic Change 77:3, pp. 235-243.

Marchetti, Cesare (1977): On geo-engineering and the CO_2 problem. Climatic Change 1, pp. 59–68.

Matthews, Damon H./Caldeira, Ken (2007): Transient climate-carbon simulations of planetary geo-engineering. Proceedings of the National Academy of Sciences 104, 9949–9954.

Matthews, Damon H./Gillett, Nathan P./Stott, Peter A./Zickfeld, Kirsten (2009): The proportionality of global warming to cumulative carbon emissions, in: Nature 459: 7248, 829-832.

McLean, Craig/Patterson, Alan/Williams, John (2009): Risk Assessment, Policy-Making and the Limits of Knowledge: The Precautionary Principle and International Relations, in: International Relations 23: 4, pp. 548-566.

Milliken, Jennifer (1999): The Study of Discourse in International Relations: A Critique of Research and Methods, in: European Journal of International Relations 5:2, pp. 225-254.

Moreno-Cruz, Juan B/Keith, David W. (2009): Climate Policy under Uncertainty: A Case for Geo-engineering, Calgary, CA.

National Academy of Sciences (1992): Policy implications of Greenhouse Warming. Mitigation, Adaptation and the science base, Washington D.C.: National Academy Press.

Netherlands Environmental Assessment Agency (2007): News in climate science and exploring boundaries: A Policy brief on developments since the IPCC AR4 report in 2007, http://www.rivm.nl/bibliotheek/rapporten/500114013A.pdf (accessed February 10, 2010).

Oberthür, Sebastian/Kelly, Claire R. (2008): EU leadership in international climate policy: achievements and challenges, in: The International Spectator (Roma), 43: 3, pp. 35-50.

Ott, Konrad (2010): Die letzte Versuchung. Geo-Engineering als Ausweg aus der Klimapolitik, in: Internationale Politik 65: 1, pp: 58-65.

Pettenger, Mary E. (2007): The Netherland's Climate Change Policy: Constructing Themselves/Constructing Climate Change, in: Pettenger, Mary E. (Ed.) Climate Change. Power, Knowledge, Norms, Discourses, Aldershot: Ashgate, pp. 51-75.

Pidgeon, Nick/Butler, Catherine (2009): Risk analysis and climate change, in: Environmental Politics 18: 5, pp. 670-688.

Pielke, Roger A. (2007): The Honest Broker. Making sense of science in policy and politics, Cambridge: Cambridge University Press.

Pollack, Mark A. (2006): Delegation and discretion in the European Union, in: Hawkins, Darren G./Lake, David A./Nielson, Daniel L./Tierney, Michael J. (Eds.): Delegation and Agency in International Organizations, Cambridge: Cambridge UP, pp. 165-196.

Rayner, Stephen (1984): Disagreeing about risk: The institutional cultures of risk management and planning for future generations, in: Hadden, Susan G. (Ed.): Risk Analysis, Institutions, and Public Policy, New York: Associated Faculty Press, pp. 150-178.

Renn, Ortwin (2008): Risk Governance. Coping with Uncertainty in a Complex World. London: Earthscan.

Rathbun, Brian (2007): Uncertainty about Uncertainty: Understanding the Multiple Meanings of a Crucial Concept in International Relations Theory, in: International Studies Quarterly 51:3, pp. 533-557.

Richert, Jörn (2009): Is there a Clash of Risk Cultures in International Climate Politics? Beck's World Risk Society and the Transatlantic Climate Divide, Papier zur Tagung des Arbeitskreises "Soziologie der Internationalen Beziehungen" der Deutschen Vereinigung für Politische Wissenschaft (DVPW). DVPW- Kongress "Politik im Klimawandel –Keine Macht für gerechte Lösungen" in Kiel 24. September 2009.

Ricke, Katherine (2008): Unilateral Geo-engineering, Washington, DC: CFR, http://www.cfr.org/content/thinktank/GeoEng_041209.pdf (accessed February 11, 2010).

Robock, Alan (2008): 20 reasons why geo-engineering may be a bad idea, in: Bulletin of the Atomic Scientists 64: 2, pp. 14-18.

Robock, Alan et al. (2010): A Test for Geo-engineering, in: Science 327, pp. 530-531.

Robock, Alan et al. (2009): Benefits, risks, and costs of stratospheric geo-engineering, in: Geophysical Research Letters 36: L. 19703, pp. 1-9.

Rohrmann, Bernd/ Renn, Ortwin (2000): Risk Perception Research: An Introduction, in: Renn, Ortwin /Rohrmann, Bernd (Eds.): Cross-Cultural Risk Perception. A survey of empirical studies. Dordrecht/Boston/London: Kluwer, pp. 11-53.

Salter, Stephen/Sortion, Graham/Latham, John (2008), Sea-going hardware for the cloud albedo method of reversing global warming, Philosophical Transactions of the Royal Society A (2008) 366, 3989-4006.

Schmidt, John (2008): Why Europe leads on Climate Change, in: Survival 50: 4, pp. 83-96.

Schneider, Stephen H. (1996): Geo-engineering: Could - or should - we do it? In: Climatic Change 33: 3, pp. 291-302.

Schneider, Stephen H. (2001) Earth systems engineering and management, in: Nature 409: 6814 pp. 417-421.

Schreurs, Miranda A. (2004): The Climate Change divide: the European Union, the United States, and the future of the Kyoto Protocol, in: Norman Vig J./ Michael

Faure G. (Eds.): Green Giants? Environmental Policies of the United States and the European Union, Cambridge, Mass: MIT Press, pp. 207-230.

Schwarz, Michiel/Thompson, Michael (1990): Divided we stand: Redefining Politics, Technology and Social Choice, Philadelphia: University of Pennsylvania Press.

Sharp, Jacqueline D./Jaccard Mark K./Keith, David W. (2009): Anticipating Public Attitudes toward Underground CO_2 Storage, in: International Journal of Greenhouse Gas Control Technologies 3, pp. 641-651, http://people.ucalgary.ca/~keith/papers/110.Sharp.PublicAttitudesCO2Storage.e.pdf (accessed February 11, 2010).

Tänzler, Dennis (2002): Klimawandel: Divergierende Perzeptionsbedingungen als Ursache gescheiterter Klimaverhandlungen in: Christopher Daase/Freske, Susanne/Peters, Ingo (Eds.): Internationale Risikopolitik. Der Umgang mit neuen Herausforderungen in den internationalen Beziehungen, Baden-Baden: Nomos Verlag, pp. 87-112.

Taylor-Gooby, Peter/Zinn, Jens O. (2007): Risk as an Interdisciplinary Research Area, in: Taylor-Gooby, Peter/Zinn, Jens O. (Eds.): Risk in social science, Oxford: Oxford University Press, pp. 20-54.

Teller, Edward/Hyde Roderick/Ishikawa, Muriel/Nuckolls, John/Wood, Lowell (2003): Active Stabilization of Climate: Inexpensive, Low-Risk, Near-Term Options for Preventing Global Warming and Ice Ages via Technologically Varied Solar Radiative Forcing, University of California Lawrence Livermore National Laboratory.

The Royal Society (2009): Geo-engineering the Climate. Science, governance and uncertainty, http://royalsociety.org/geo-engineeringclimate/ (accessed February 10, 2010).

Torfing, Jacob (2005): Discourse Theory: Achievements, Arguments, and Challenges, in: Howarth, David /Torfing, Jacob (Eds.): Discourse Theory in European Politics. Identity, Policy and Government, Houndmills: Palgrave/MacMillan, pp. 1-32.

Trombetta, Julia M. (2008): Environmental security and climate change: analyzing the discourse, in: Cambridge Review of International Affairs 21: 4, pp. 585-602.

UK Parliament (2009): Engineering: turning ideas into reality: Government Response to the Committee's Fourth Report - Innovation, Universities, Science and Skills Committee, http://www.publications.parliament.uk/pa/cm200809/cmselect/cmdius/759/75908.htm (accessed February 10, 2010).

Ulbert, Cornelia (1997): Die Konstruktion von Umwelt: Der Einfluss von Ideen, Institutionen und Kultur auf (inter-)nationale Klimapolitik in den USA und der Bundesrepublik Deutschland, Baden Baden: Nomos.

UN (2007): United Nations Framework Convention on Climate Change. Subsidiary Body for Scientific and Technological Advise, http://unfccc.int/resource/docs/2007/sbsta/eng/misc18.pdf (accessed February 10, 2010).

Van Zwanenberg, Patrick/Millstone, Erik (2000): Beyond Skeptical Relativism: Evaluating the Social Constructions of Expert Risk Assessments, in: Science, Technology and Human Values 25: 3, pp. 259-282.

Victor, David G./Morgan, Granger M. /Apt, Jay/Steinbruner, John/Ricke, Kathrine (2009): The Geo-engineering Option. A last resort against global warming? in: Foreign Affairs 88: 2, pp. 64-67.

Victor, David/Morse, Richard (2009): Living with Coal. Climate policy's most inconvenient truth, in: Boston Review (September/October), pp. 7-14.

Virgoe, John (2009): International governance of a possible geo-engineering intervention to combat climate change, in: Climatic Change 95: 1, pp. 103-119.

Vogler, John (1999): The European Union as an Actor in International Environmental Politics, in: Environmental Politics 8: 3, pp. 24-48.

Bretherton, Charlotte/Vogler, John (2006): The European Union as a Protagonist to the United States on Climate Change, in: International Studies Perspectives 7: 1, pp. 1-22.

Von Goerne, Gabriele (2009): CO_2 Abscheidung und Lagerung (CCS) in Deutschland, Bonn: Germanwatch, http://www.germanwatch.org/klima/ccsdeu09.pdf (accessed February 10, 2010).

Wagner, Norbert/Machnowski, Michal K. (2009): US Climate Policy on the Road to Copenhagen, Länderbericht, Konrad Adenauer Stiftung, http://www.kas.de/wf/doc/kas_18123-544-2-30.pdf (accessed February 12, 2010).

Weidner, Helmut/Mez, Lutz (2008): German climate change policy: a success story with some flaws, in: The Journal of Environment & Development 17: 4, pp. 356-378.

Weldes, Jutta/Laffey, Mark/Gusterson, Hugh/Duvall, Raymond (Eds.) (1999): Cultures of Insecurity: States, Communities and the Production of Danger, Minneapolis: University of Minnesota Press.

Wendt, Alexander (2007): Social theory of international politics. Cambridge: Cambridge University Press.

Westlind, Dennis (1996): The Politics of Popular Identity, Lund: Lund University Press.

Wiertz, Thilo (2009): Neue Technologien gegen den Klimawandel: Der Diskurs um Geo-engineering im Rahmen globaler Klimapolitik. Thesis, University of Heidelberg, unpublished.