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DISCLOSURE-BASED GOVERNANCE FOR CLIMATE ENGINEERING RESEARCH

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EXECUTIVE SUMMARY

Transparency has become a dominant theme within academic and policy discussions on climate engineering (CE) research governance. As CE research moves from modelling and laboratory studies to field experiments, there is a need to operationalize transparency; that is, to move from transparency in principle to transparency in practice. This, in turn, requires greater attention be paid to the purposes that CE research transparency is intended to serve since the ends sought, as well as the context in which they will operate, will drive the design features of disclosure mechanisms.

The objective of this paper is to focus attention on the implementation challenges that disclosure faces in the realm of CE research governance. To this end, we identify and elaborate on two distinct roles that disclosure-based governance is anticipated to play: minimization of the potential for environmental and social concerns associated with CE research; and to generate and maintain legitimacy in the research process itself. Drawing on that discussion, we then identify a number of key design features that disclosure-based governance will need to achieve those ends, and we argue in favour of an approach to disclosure-based governance that recognizes the iterative and inherently normative nature of CE governance and supports the development of a decentralized system of disclosure serving multiple ends.

INTRODUCTION

CE is a constellation of possible technologies that are bound together by intention and scale (Royal Society 2009, 1). To fall within the scope of CE, an activity must be directed at counteracting the build up of greenhouse gases (GHGs) in the atmosphere or at the climatic effects caused by GHGs and at sufficient scale to affect climate at a planetary scale. Within this broad array of potential technologies there are diverse methods, which in turn have different potential impacts and risk profiles (Long et al. 2011; Keith 2000). At present, CE technologies are experimental with current research activities focused on upstream activities, such as modelling, and some limited field experimentation aimed at understanding the underlying processes and informing models. There are no large-scale experiments seriously proposed at this time. Notwithstanding the relative early stages of technological development, these ongoing research activities related to CE and their contribution to the possibility of future deployment have given rise to governance demands at both the national and international levels (Royal Society 2009, 12; Rayner et al. 2013; Lin 2009).

Responding to the governance debate in CE, David Victor and his colleagues caution that the politics of CE and the desire to regulate it are in danger of impeding the science. "The result," they argue, "is that the scientific community knows little more than it did four years ago about how geoengineering would actually work or what its consequences would be. These technologies might not be well understood when and if they are needed, and could be deployed prematurely. In the growing efforts to regulate geoengineering, governments and activists are flying blind as they conjure up new regulations" (Victor et al. 2013).

Victor et al.'s comments highlight an increasing tension between science and research governance within the CE debate. Until there is a better understanding of the underlying science supporting CE, as well as understanding the nature of the risks it poses, developing a fully formed governance structure for the conduct of CE research is premature. However, the research itself presents environmental and social concerns that require public consideration and precautionary regulation. The relationship between CE research and governance is iterative in the sense that CE research is both the object of regulation and a source of information that informs the design of future regulatory frameworks.

In situations where there is a demand for governance but an inadequate scientific and normative basis to prescribe substantive rules, law and policy often turn to process. In the case of CE research governance, the principal demand for procedural governance takes the form of calls for transparency (Rayner et al. 2013, 30).[1]

Transparency as a governance principle in the CE context is ubiquitous and largely unquestioned in its ability to promote more legitimate and effective governance structures. At the level of principle, this faith in transparency is not misplaced as transparency is often, and rightly, viewed in non-instrumental terms — transparency in public decision making is an end itself (Ebbeson 2007). However, the implementation of transparency requirements reveals a more ambiguous reality, in which the desired effectiveness of disclosure cannot be assumed. Legal scholar Lawrence Lessig (2009) has argued that unqualified disclosure of salient public information (such as political contributions) will not in and of itself result in greater accountability, and careful consideration needs to be given to the purpose of disclosure and how that information will be used. Similarly, transparency scholars Archon Fung, Mary Graham and David Weil (2007), find that the success of disclosure-based regulation is dependent upon the relevance of the disclosed information for the intended audience, the manner in which the disclosed information is presented, how it is mediated by third parties and how the disclosers themselves understand the responses to disclosure (see also Gupta 2010; Mitchell 2011).

1 See also Conference of the Parties to the Convention on Biological Diversity (CBD). Decision X/33 "Biological Diversity and Climate Change." www.cbd.int/decision/cop/default.shtm?id=13181. (para. 8(w), calling for prior assessment of CE field experiments) (hereinafter "CBD Decision x/33").

If the success of disclosure-based governance is dependent upon the underlying purpose of disclosure and on the context of its application, then in relation to CE research governance, it will be useful to more precisely identify the goals of disclosure and consider the key contextual factors that are likely to affect the implementation of disclosure-based governance. To this end, this paper considers the demands for CE research transparency in light of the complicated environmental and social terrain that CE governance structures must navigate. We identify two forms of disclosure that are differentiated by their goals and the approaches required to achieve those goals. The first requires disclosure as a means to ensure that the risks associated with CE research activities are fully and openly considered, with an understanding that risk disclosure leads to risk minimization. Transparency also has a legitimizing function, whereby openness of the scientific and policy processes are understood to contribute to the public's trust that institutions will carry out activities aligned with public goals. While these modes of transparency are complementary in many ways, they operate on different audiences and through different mechanisms. In light of this discussion, the second part of the paper looks more specifically at the design of disclosure mechanisms for CE research. The intention here is not to suggest the precise form of such mechanisms, but rather to identify approaches to disclosure that will be more successful in meeting the intended ends sought.

CE RESEARCH AND THE DEMAND FOR DISCLOSURE-BASED GOVERNANCE

Much of the CE research conducted to date has involved either modelling or encapsulated laboratory research, neither of which involve environmental perturbation and associated risks. From a governance standpoint, it is the prospect of field experiments that have triggered regulatory responses. For example, the rules on marine-based CE adopted by the Contracting Parties to the London Protocol on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the "London Protocol") in 2013 are directed to field experiments, and were developed partially in response to concerns surrounding the environmental risks and scientific legitimacy of proposed ocean fertilization experiments.[2] In 2010, the parties to the Conference on Biological Diversity sought to prevent "climate-related geoengineering activities that may affect biodiversity"(CBD Decision x/33, para.8(w)) although they made allowances for small-scale scientific research studies within waters of national jurisdiction.

In the near term, the likely field experiments of solar radiation management (SRM) techniques will be conducted at small scales, in terms of both geographic range and overall radiative forcing (Parson and Keith 2013). These small-scale experiments are likely to be concerned with developing a better understanding of physical interactions and processes, as opposed to seeking to predict large-scale climate impacts (through extrapolation). However, to generate more predictive understandings at the scale of deployment, it is necessary for researchers to engage in larger-scale field experiments, since it cannot be assumed that processes will operate in the same manner at meso- and macro-scales as they were observed at a micro-scale. As a result, it is likely that experimentation would proceed sequentially, in that smaller-scale experiments would precede larger-scale experiments and that large-scale experiments would only proceed if the risks and scientific merit of proceeding were justified at smaller scales (Long et al. 2011; Olson 2011). One suggested approach is to identify thresholds based on radiative forcing or geographic scale, above which field experiments could not occur until there is greater scientific certainty respecting the potential impacts of field experiments (Solar Radiation Management Governance Initiative [SRMGI] 2011; Parson and Keith 2013). However, such an approach is complicated by the difficulty of developing agreed upon thresholds of this type. One potential concern of creating a de facto "safe zone" is that this research may be conducted within this threshold without more rigorous governance considerations.

In looking at the various CE governance recommendations and discussions, the demand for transparency responds to a number of concerns. First, the potential for environmental risks triggers a right to be informed of potentially harmful activities that could affect individual, group or state interests. This right is well-developed in both domestic and international law, and is typically triggered by the prospect of an activity that poses some likelihood of significant harm (Handl 2007). The procedural right to prior knowledge of a potentially harmful activity serves to protect the substantive right to not be subjected to environmental harm in the absence of due process. Procedural safeguards are particularly important in cases where rules are not standardized (into legislated rules respecting emission limits or harm thresholds), but are made on a case-by-case basis. In the CE context, the diversity of methods, locations and interests affected, as well as the presence of uncertainty, particularly at larger scales, militates in favour of a more context-specific approach. Transparency enables affected parties to understand their interests and effectively participate in case-by-case decisions.

Looking strictly at physical risks, small-scale CE experimentation is not likely to involve high-risk activities. For example, most of the ocean iron fertilization

2 Contracting Parties to the London Protocol to the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter, "Resolution LP.4(8)" adopted at Eighth Meeting, October 14-18, London. (amending London Protocol to include provisions for the regulation of marine geoengineering) (hereinafter "LP.4(8)").

experiments carried out to date have involved small depositions with generally well understood risk parameters (Wallace et al. 2010). Similarly, proposed stratospheric aerosol injection and marine cloud brightening experiments involve short duration releases of substances that are similar in risk to other accepted activities, such as airplane or ship emissions. The small geographic scale is not likely to engage international concerns unless the activity is carried out in a global commons area, as has been the case with marine CE on the high seas. It is probable that small-scale field experiments would not trigger extensive disclosure requirements under national and international rules, as the likelihood of significant harm is small. The physical risk profile of experimentation changes as the activities scale up, since at broader scales there are more complicated feedback mechanisms and interactions that make causal pathways more difficult to establish and prediction less certain (Long et al. 2011).

There is a second species of indirect risks associated with experimentation that tie environmental and social concerns to the prospect of technological change. The concerns here are not with the activity per se, but with the future implications of technological development (Dilling and Hauser 2013; Preston 2013). Arguments for early research governance which reflect these concerns therefore mirror debates about planetary-scale deployment. The underlying assumption is that the conduct of early stage research will affect the likelihood or character of any possible future deployment.

A "moral hazard" concern has been raised in numerous reports and papers, whereby the possibility of future geoengineering solutions may create incentives for states and emitters to reduce their mitigation and adaptation efforts. In essence, CE research becomes a sort of insurance policy that allows actors to engage in riskier climate-impacting (in other words, less mitigation, less adaptation) activities (Preston 2013, 25; Lin 2013).

Further, it has been argued that research on new technologies runs the risk of technological "lock-in" (Preston 2013, 26; SRMGI 2011, 21). Here the argument is more sociological in that it relies on the possibility that geoengineering research will generate vested interests in technology development that in turn create institutional inertia in favour of a particular technology or approach despite other solutions may be preferable. These concerns could range from commercial interests that seek to profit from the development of CE technology to institutional interests whose existence or funding is dependent upon a continuation of CE experimentation (Long and Scott 2013).

Finally, there are concerns regarding the kind of political challenges CE might pose for democratic governance (Stilgoe, Owen and Macnaghten 2013; Szerzynski et al. 2013; Stirling 2008). The concerns here relate to the political tensions associated with transboundary impacts, and the ability of a single state or group of states to engage in activities that have planetary implications. The benefits and burdens of CE technology experimentation and deployment will be unevenly distributed, raising distributive justice concerns; which may be exacerbated by the relative lack of experimental capacity in developing countries (Preston 2013, 30).

This second type of risk triggers different transparency demands. First, the social and ethical concerns are much less scale-dependent and less likely to be resolved by improved scientific understandings. As a consequence, transparency here is oriented toward promoting ongoing deliberative interactions among various actors. In addition to revealing impacts, disclosure mechanisms need to shed light on the intentions of scientists and other supporters of proposed research, including states. This includes information respecting the potential vested interests of researchers, but will also require researchers to reflect on and disclose their understanding of the technological and social implications of their research (Stilgoe, Owen and Macnaghten 2013).

A further characteristic of these social and ethical concerns is that they are spatially unbounded. The protocol for who receives disclosure regarding environmental impacts depends on whether the person or state is potentially affected by the physical impacts. However, the social and ethical concerns of a distant, small-scale experiment may be felt anywhere and may be understood as involving a wide set of interests. Accommodating these demands in a practical manner presents a serious challenge in light of prevailing international legal norms, which tend to focus on physical impacts as the basis for international governance jurisdiction.

Concerns about the emerging technology that this research focuses on may in fact extend the scope of disclosure obligations beyond potentially harmful field experimentation to include studies that have minimal (or no) direct physical impacts. This reflects a broader trend toward greater openness and public accountability occurring across a number of science policy debates.

A model of science policy that no longer treats scientific knowledge as an exogenous and neutral input to the policy process, but rather understands that scientific knowledge is impacted by the context of its application and has a constitutive relationship with public policy, also influences the requirement for CE research transparency. CE research falls quite squarely into the post-normal science framework or what Sheila Jasanoff (2003) refers to as demanding "technologies of humility" (see also Funtowicz and Ravetz 1993). The conditions of normative contestation and high levels of uncertainty challenge the traditional forms of assessing scientific merit, such as peer review and scientific autonomy. The result is increased attention to accountability in research and technological innovation processes (Stilgoe, Owen and Macnaghten 2013), which in turn require more direct public involvement in the processes of technology development. Transparency is a central component of such processes through its role in the opening up of expert-dominated processes to assessment and participation by non-experts.

Following from above, it can be seen that transparency serves two distinct purposes within CE research governance. First, transparency serves a regulatory purpose by aiding in risk minimization. Second, transparency requirements are directed toward generating and maintaining accountability in research processes and public legitimacy in the results they produce. These dual roles are captured in the Oxford Principles on Geoengineering Research, which were developed by a group of academics, and largely adopted by the UK House of Commons Science and Technology Committee, which indicate, "There should be complete disclosure of research plans and open publication of results to facilitate better understanding of the risks and to reassure the public as to the integrity of the process. It is essential that the results of all research, including negative results, be made publicly available" (Rayner et al. 2013, 21).

These two purposes are clearly related as risk avoidance will contribute to legitimacy. In turn, the uncertainty and disagreement that arise in attempting to resolve the social and ethical concerns requires scientists, regulators and the public engage one another in order to develop a normative basis for regulating CE research; a process that serves both risk avoidance and legitimacy.

That said, there are important differences between these purposes that justify their differentiation. Risk minimization is primarily directed to researchers' behaviour, asserting pressures that will push researchers, research funders and policy makers toward less risky activities. The legitimacy goal is directed to the public, with a view to creating conditions by which the processes and outputs of the research are trusted by the public. Trust in this context includes confidence in the validity of the research claims, but also confidence that the goals of the research are consistent with community norms (Barber 1983).

A further difference is that risk minimization is primarily concerned with front-end disclosure. Specifically, this involves providing details about proposed research activities before they occur, although monitoring activities and learning from past activities also contribute to the risk minimization function. Public trust building is concerned with both front-end and back-end disclosure, so there is focus on the publishing research results, data and experiment design information, as well as acknowledging the intentions of researchers and research funders.

Finally, since risk minimization is directed toward modifying researcher behaviour, information has to be provided in a manner that can be acted upon and that is meaningful to those that are its intended recipients. This requires that information be presented in ways that allow it to be measured against accepted standards, or relative to other disclosers (such as other polluting facilities) or against other alternative means of operating. For example, a key feature of environmental impact assessment is requiring the evaluation of alternatives to the particular activity subject to scrutiny. The proponent considers less impactful ways of achieving the same goal, which then places a burden of justification on a proponent who does not chose the least harmful alternative.

The key point here is that the disclosed information must be meaningful in the context of its use. Transparency, as a regulatory mechanism, relies on the ability of those receiving the information to influence outcomes directly by using the information to alter the incentives for the proponents, through, for example, political, social or market pressures (Weil, Graham and Fung 2013; Mitchell 2011). If the disclosed information is likely to inform market decisions, it must be presented in a way that benefits and informs consumer choice. Similarly, if the disclosed information is projected into political and social processes, the information must allow the public to identify how their interests are impacted and the extent to which the proposal adheres to accepted values and norms.

The causal link between transparency and legitimacy is more attenuated and complex. Legitimacy has normative and sociological dimensions. On the one hand, the relationship between transparency and legitimacy is embedded in our normative understanding of legitimacy, which includes openness as a value that justifies authority in liberal democracies. Rayner et al. (2013, 30) frame the importance of transparency in CE research in this non-instrumental fashion, "The normative reason to value transparency is that it is one aspect of respecting people. Even if one does not have a direct say over any particular matter, to be informed of decisions is an acknowledgement of one's moral status. Without transparency, an agent is effectively 'kept in the dark,' with the danger of exploitation on the one hand, or benign but disrespectful paternalism on the other."

On the other hand, legitimacy is instrumental in the sociological sense, as it seeks to further the goal of public trust in institutions. Empirical research on the relationship between transparency and public trust indicates that trust is strongly influenced by pre-existing beliefs regarding the institutions in question, and on the kinds of issues that are the subject of transparency requirements (de Fine Licht 2013; Grimmelikhuijsen and Meijer 2014). For example, in issues that are already divisive, transparency on its own may increase polarization, as opposed to leading to higher levels of trust (de Fine Licht 2013, 4).

In the context of CE research, public trust is critical to the sequential unfolding of CE field research. Debates on future larger-scale experiments will be strongly influenced by the research results of small-scale field experiments, but the ability of scientific research to influence policy outcomes will depend in part on the public's acceptance of the authoritativeness of those results (Clark, Mitchell and Cash 2006). The importance of transparency is amplified further because of the likelihood of uncertainty or at least disagreement over the requisite level of certainty required to determine future research activities. Here the role of transparency is less about creating incentives to promote socially desirable behaviour and more oriented toward creating a decision-making environment that is properly informed by science, is broadly acceptable to the public and where shared understandings of risk and uncertainty can emerge between stakeholder communities through interaction and co-learning.

The trust-building function of transparency focuses on the creation of conditions that promote the legitimacy of the research itself. The principal concern here is that a lack of openness regarding research activities and research results will influence the public's perception of the credibility of the research. For example, there are concerns that researcher incentives and publication biases may cause researchers to downplay or select out more equivocal findings in favour of results that appear more "statistically significant, novel and theoretically tidy" (Miguel et al. 2014, 30). These concerns, which have been prevalent in the area of medical clinical trials, (which are often financed by private firms with pecuniary interests in the outcomes), transcend any particular research field and are leading to an ethos of disclosure across the natural and social sciences. The issue for CE research is identifying the extent to which these concerns are likely to manifest themselves.

It is not clear the degree to which vested interests are likely to influence CE research, but the possibility of this effect is identified across a number of CE assessments and reports (UK House of Commons Science and Technology Committee 2010; Virgoe 2009; Vaughan and Lenton 2011). In this regard, transparency links directly to the principle that CE ought to be regulated as a "public good," that is, regulation must be primarily directed toward public benefits and public consideration, as opposed to market standards or other private goals. The transnational scale of CE research and possible future deployment raise the prospect of states themselves viewing CE research activities through a lens of strategic self-interest. Thus, openness should also facilitate trust at an inter-state level, by providing states with a clearer basis to assess one another's intentions related to CE.

The transnational nature of CE research raises a further objective related to the benefits of sharing research information in order to build research and policy capacity in all regions of the world. This ties transparency to the participation principle, by promoting the co-production of knowledge. This, again, has important implications for legitimacy, as different actors are more likely to accept the authoritativeness of research that has accounted for their perspectives and interests (Clark, Mitchell and Cash, 2006, 4). In an environment of high normative disagreement, transparency promotes interactions that might shape public values and policy responses surrounding CE research in a more democratic and equitable manner.

Transparency is, of course a necessary, but insufficient condition for legitimacy, and should not be considered in isolation from other procedural and substantive sources of legitimacy. On the process side, transparency is facilitative of the broader engagement goals, and the degree of public trust will be affected by the deliberative quality of this engagement. On the substantive side, transparency also enables the public to assess more clearly whether research activities are adhering to substantive norms and goals. The challenge in the CE context is that those norms are ambiguous and disputed.

DESIGNING DISCLOSURE MECHANISMS FOR CE: WHAT, WHO AND HOW

Turning to the design of disclosure mechanisms for CE research, it is clear that we should not think of disclosure in this context as a unitary enterprise that can be satisfied by a single mechanism. It is more likely that the multiple objectives of transparency will require different approaches. Careful attention must be taken to understand what activities ought to be subject to disclosure requirements, when that information will be required, who will be required to disclose, the audiences to which disclosure is directed, the uses to which that information will be put and how disclosure can best be implemented.

What: The Object of Disclosure

Turning first to the object of disclosure. The fundamental issue here will be to determine which types of research activities require disclosure. This, of course, engages a more general challenge surrounding the definition and boundaries of CE and CE research. Defining CE for regulatory purposes is complicated by a definition that incorporates intent and scale. The question of scale relates to the ultimate aim of CE, but does not help define CE research, which will be conducted at multiple scales. Defining an activity in terms of intent is problematic, since intent may not always be apparent and a single experimental activity may inform multiple intentions. For example, small-scale atmospheric process experiments may inform basic climate science, as well as CE (Long and Scott 2013). Another class of study difficult to categorize are those that use natural and anthropogenic analogs to CE processes, such as volcanic eruptions or ship tracks, to inform CE models (Robock, MacMartin, Duren and Christensen 2013).

There are particular concerns that the failure to identify and scrutinize research activities that subsequently become part of the policy discussion on future CE activities will erode legitimacy (Long and Scott 2013). The tension that has to be acknowledged here is that, on the one hand, there are demands for greater control to address social and ethical concerns that accompany the early stages of technology development. On the other hand, the further these technologies are being deployed, the more difficult the boundaries, which are defined by intent, become to discern.

An additional question that arises in relation to the sort of activities that ought to be subject to disclosure is whether these declarations should be restricted to field experiments. The discussion has focused on field experiments because modelling and laboratory experiments do not pose direct environmental risks, and as such do not trigger pre-activity disclosure concerns. However, modelling and laboratory experiments raise similar social and ethical issues, and may also give rise to back-end (post-activity) disclosure related to legitimacy.

In relation to field experiments, the key consideration will be to identify those activities that pose risks substantial enough to justify disclosure. Given that in the case of small-scale studies, it is likely that physical risks are minimal — perhaps negligible in many cases — one possible approach is to subject all CE field research to reporting obligations aimed at reducing risk and enhancing legitimacy (Parson and Keith 2013), effectively, imposing disclosure obligations irrespective of the degree of predicted physical risk.

The arguments against such an approach are that given their low or negligible physical risks, some of these activities may not pose a different type of risk as say computer modelling and should not be subject to stricter disclosure obligations than are applied to many ongoing outdoor experiments with much larger physical impacts, such as controlled pollutant release experiments. However, these arguments appear to eschew concerns that CE research presents a special case for governance as compared with other areas of scientific research. These viewpoints also rely on a hard distinction between physical risks and social and ethical risks. As understood by Jasanoff (2003) and others, these distinctions are not nearly so clear. Viewed in light of the public trust function, the rationale for disclosure requirements at negligible levels of physical risk is directed toward providing assurances that the activities undertaken are serving public ends. In the event that a higher threshold is used, for example the "likelihood of significant harm," many small-scale activities would not be subject to extensive disclosure obligations. However, this lack of scrutiny would likely fuel suspicion about the intentions and credibility of experimental activities.

The resort to such standards has some precedence. The Antarctic environmental regime, which given the development restrictions in the Antarctic, largely regulates scientific activities, is triggered by any planned activity that is likely to have at least a "minor or transitory" impact.[3] In the CE context, the London Protocol requirements governing ocean fertilization experiments require full disclosure and assessment regardless of impact, and will only be permitted where an assessment demonstrates that "pollution of the marine environment from the proposed activity is, as far as practicable, prevented or reduced to a minimum".[4] The underlying idea for a lower assessment-triggering threshold under the Antarctic regime is that the fragile Antarctic environment justifies a more precautionary approach. A similar argument appears to underlie the London Protocol, which also justifies its low threshold in precautionary terms.

Typically, the focus of environmental assessment processes (which are the standard tools for evaluating the environmental risk of activities) is on individual experiments, but in some cases it may be more appropriate to target disclosure obligations at the program, policy or plan level. Many of the issues concerning the social implications of CE technology, such as its effect on climate change mitigation and adaptation policy, are not dependent on the results of individual experiments and could be obscured by focusing exclusively on specific projects. There are existing mechanisms for programmatic assessment or strategic environmental assessment which may be useful models, but require consideration of how these more abstract evaluations, including high-level technology assessment processes, are integrated with the disclosure of individual experiments (Lin 2010). There are examples in other fields of tiered assessments, where policy level decisions, such as whether to fund a CE research program, consider a set of threshold issues, and then provide a basis for more narrow evaluations that focus on the specific characteristics of an individual project.

Turning from the activities subject to disclosure, to the kind of information that ought to be disclosed, the objective of public trust and credibility should require wide dissemination of results, data, and research design information in order to allow other scientists to assess results and to promote replication. While data disclosure is largely directed toward the scientific community, there is a clear demand for disclosure of results in a form that is comprehendible to the public.

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3 Protocol to the Antarctic Treaty on Environmental Protection, 30 ILM (1991) 1461, Article 8.

4 LP.4 (8), Article 6 bis (2).

Because a driving concern is the identification of vested interests, disclosure should also address researcher intentions, including any pecuniary interests, such as intellectual property rights and funding sources. This objective is implemented in the London Protocol through a requirement that an ocean fertilization activity will only be permitted where the proponent can demonstrate it is engaged in "legitimate scientific research."[5] The kinds of considerations that will be considered in determining what constitutes "legitimate scientific research" include: the activity will add to scientific knowledge:

- the experiment employs an appropriate methodology;
- the activity is subject to peer review;
- the absence of economic influences;
- a commitment to publish the results in a peer reviewed venue and to make the results more publicly available; and
- the project is appropriately resourced.[6]

The relevance of research for CE may in some cases not become clear until after the research is carried out. For example, the Eastern Pacific Emitted Aerosol Cloud Experiment used smoke generators to create mock ship tracks and study aerosol cloud interactions in order to better inform climate models. However, the results suggested that ship tracks had a significant effect on radiative forcing that could potentially be used as an effective CE technique — marine cloud brightening. These findings were subsequently published by the project team, although they claim not to have intended to explore CE in the experiment (Russell et al. 2013). In these instances, disclosure ought to be understood as an ongoing activity that may require researchers to release information about those research activities that turned out to have CE implications.

Who: The Subjects of, and Audiences for, Disclosure

The primary target of transparency-based governance in CE research will be the research community, which may include funders and research agencies, along with the researchers themselves. The key consideration here will be the presence of (dis)incentives to disclose, which may affect the degree to which disclosure will be mandated. This requires, in turn, consideration of the extent to which researcher objectives align with the objectives of disclosure.

Disclosure in practice may raise several issues. First, disclosure requirements will likely increase the transaction costs of conducting research. It should not be assumed that information relevant to CE research is free, abundant and easily accessible. Extensive information gathering requirements and disclosure costs, such as preparing and filing impact assessment reports or providing disclosure of research results and data, are likely to raise concerns, particularly where costs are seen as disproportionate to the level of risk or the need to engender public trust in the research processes and outcomes. Second, while there are emerging scientific norms on transparency, there are also competing norms respecting non-interference with scientific activity, for example, those set out in the International Covenant on Economic, Social and Cultural Rights.[7] If the results of disclosure are understood by scientists as interfering with their research activities, for example, through interest group pressure on funders or universities, researchers may resist disclosure. This is not an abstract concern for CE research, as prior CE experiments have been the subject of intense interest group pressure. This scrutiny is not a bad thing, but the politicization of scientific activity may potentially cause unease among many CE scientists.

The intended audience for CE research disclosure varies with the objective. Risk minimization is directed toward those whose interests are potentially affected by the research activity, but low thresholds and the presence of social concerns suggest a more general audience that is not tied to direct physical risks. Directing disclosure to the public generally affirms the status of CE research as a public good in which everyone has an interest.

Publicly oriented objectives of communicating CE research point to the need for any information disclosed to be accessible by lay audiences. Returning to the clinical trials case, recent legislation adopted by the European Parliament will require disclosure of a range of information, including preparation of one page summaries accessible to the public.[8] If the information is provided in the manner of an accessible summary, then determining who performs that knowledge translation function will be a further point of contention. In the CE context, interpretation of research information can be expected to be particularly vexing because of uncertainty and the absence of agreed upon assessment criteria. Communicating risk to the public in the context of climate change has proven to be challenging. However, comparing analogous activities, such as airplane emissions or ship exhaust, in which risk is better understood may help.

5 LP.4 (8), Annex 4, Art.1(3).

6 LP.4 (8), Annex 5, Art.9.

7 International Covenant on Economic, Social and Cultural Rights, 16 December 1966, United Nations, Treaty Series, vol. 993, p. .3

8 European Union. 2014. Council Regulation 40/94/EC on the Community Trade Regulation (EU) no 536/2014 Clinical Trials on Medicinal products for Human Use. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.158.01.0001.01.ENG.

The transboundary nature of CE research complicates identifying the audience and raises questions as to which country's public is entitled to disclosure, and what are the rights of states to receive disclosure and to be subject to a corresponding duty to disclose. On the former issue, there are emerging norms, such as those found in the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, that extend disclosure rights beyond national boundaries.[9] On the latter issue, many of the same issues around public trust, such as understanding intentions and the nature of state interests in CE research, will affect the confidence that states have in scientific processes that are unfolding elsewhere. However, there is little support in existing international law for a state to demand disclosure of another state's CE research activities in the absence of physical interference. Thus, any state level disclosure requirements will either require a new treaty or a voluntary, soft law approach.

How: The Mechanisms and Institutions of Disclosure

This brings us to the final question of how disclosed information could be made available. Several existing mechanisms or models have been put forward as likely vehicles to achieve the disclosure objectives associated with CE research. Most prominently, environmental impact assessment (EIA) has been identified as a central tool for risk identification and minimization (Abelkop and Carlson 2012; Bodle 2010; Scott 2013). Clearly, EIA procedures could play a broader role in ensuring CE research decisions are made in a consultative and evidenced-based manner. EIA is the basis for ocean fertilization regulation under the London Protocol, which requires an assessment to be undertaken prior to any marine geoengineering activity involving authorization to place matter into a body of water. Environmental assessments were the central regulatory tools used in the review of prior CE field experiments, such as the LOHAFEX, (the name is taken from LOHA, the Hindu word for iron and FEX, which stands for fertilization experiment), project (Martin et al. 2013; Ebersbach et al. 2014). For most small-scale experiments, domestic EIA processes will play a central role in CE research activities with purely domestic impacts.

As noted, the suitability of EIA processes to address the wider social issues associated with CE research is an open question. The London Protocol's inclusion of criteria for legitimate scientific research gets at a few of these concerns, but does not address more of the fundamental ethical concerns around moral hazard, technological hubris and technological lock-in. Typically, these more abstract concerns are addressed through technology assessment processes, which could serve as a basis for transparent public discourse, but which address broader policy questions rather than individual research activities.

There is some precedent for hybrid processes, which are designed to allow for an expanded consideration of some of the social concerns in the context of a particular proposal. The Stratospheric Particle Injection for Climate Engineering (SPICE) experiment in the United Kingdom, which sought to test equipment that could be used for future CE related research, was made subject to a highly deliberative and staged process, which allowed for a fuller consideration of the intentions of the researchers and the implications of their research by the concerned public, in conjunction with consideration of the environmental impacts of the project itself (Stilgoe, Owen and Macnaghten 2013).

Both the London Protocol and SPICE processes suggest that assessment procedureswill need to be developed, or at least modified, specifically for CE research to account for disclosure and consideration of a wider set of issues. As a disclosure mechanism, EIA, or a variant thereof, has the advantage of requiring information in a standardized form that is designed to promote evaluation, without being substantively prescriptive. EIA processes also feed into an approvals process, so that the disclosure is directed toward a political process. The adequacy of that process to produce legitimate outcomes will depend upon whether the disclosed information can meaningfully inform the decision-making process and address the issues of actual concern. Again there is a balance that will need to be struck between the need for deliberation and the burden placed on individual researchers to satisfy public concerns over abstract policy issues.

Part of how disclosure affects outcomes is by allowing the public, as well as those subject to disclosure requirements, to assess the extent to which activities conform to accepted norms. EIA processes, by focusing on significant levels of harm, require proponents to reflect on whether the potential risks are acceptable and whether there are alternative means to achieve the same end. Given the absence of clear norms of evaluation, groups with different predispositions respecting CE research will seek to project their own values over the process. The success in doing so will impact their perceived legitimacy of the outcomes, since the outcomes will be judged, in part, on the degree to which the decision is understood to adhere to accepted norms. In this regard, it is worth noting that EIA processes are underlain by the goal of preventing adverse environmental change (often as measured against some baseline data). As CE research scales up, this goal becomes much more complicated, since the intention of CE is to induce environmental change, albeit in the context of a system that is itself changing.

The second mechanism commonly mentioned is a form of online research registry or information clearinghouse, whereby details of research results, as well as other material, are made publicly available in a standardized

9 Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus), 38 ILM (1999) 517.

form (Parson and Keith 2013; Rayner et al. 2013, 30). Here, a useful analogy is to clinical trials registries, in that the primary function is to protect against non-disclosure or selective disclosure of findings, although the context of CE research is significantly different from the clinical trial environment, where research is more likely to be privately funded and has had a history of confidentiality restrictions placed on researchers. Research registries are inclined to be directed toward public trust concerns rather than risk minimization concerns, since they typically operate on the back end of research activities, requiring disclosure of results and data. This focus on *ex post* activities does not foreclose opportunities for pre-activity registration, including disclosure of research design and expected results.

Unlike EIAs, which have a fairly well understood and consistent structure, research registries simply describe a mechanism that structures information in ways that allow it to usefully contribute to policy debates on science-based issues. In this regard, registries and clearinghouse mechanisms could be implemented to suit a variety of purposes and contexts.

Registries are less overtly evaluative than EIA processes, but still function to allow interested parties to make assessments on the adequacy and desirability of a research enterprise. For non-experts, a registry mechanism could function as a central node for finding information that provides an overview of how various activities fit together into a broader research and public policy agenda and where they may be able to engage with these processes. One important feature of a registry will be its perceived neutrality; the institution prescribing the information ought to be viewed as an "honest broker" (Pielke 2007; Hoffman 2011).

Registries could operate at multiple (national, regional or international) levels, but given the transnational nature of CE research, consistency across disclosure mechanisms will be important. Institutions that might be well placed to manage such a mechanism include research centers and universities, international legal organizations and research funding councils. Funders may be particularly well-suited because they have the power to require the disclosure of information as part of the research funding process and to elicit wider stakeholder feedback for direct use in funding decisions. Finally, the objective of international co-operation may be furthered through the joint management of a registry or clearinghouse by a coalition of geographically distributed organizations.

EIA and registries ought to be understood as complementary to one another. Looking at the London Protocol oceans assessment process, it appears that the process needs a further mechanism, such as a registry, that publicizes the data and the results of the research. Just as harm minimization contributes to legitimacy, registries could disclose the particulars of any assessment process that a CE research activity has undergone, and may also be utilized as a source of monitoring and verification. This information could provide assurance that the front-end approvals process is serving its intended purpose.

CONCLUSION

Disclosure is not a panacea, and our intention here is not to suggest that the provision of information is sufficient to minimize the potential for environmental and social concerns or engender legitimacy. It is, however, a necessary and important component to achieving both these aims.

Our primary conclusion is that in designing disclosure mechanisms for CE research, careful attention must be paid to both the risk minimization and legitimation functions. These goals suggest complementary but different approaches to disclosure, including the disclosure of different types of information, different audiences and mechanisms. It is further necessary to unpack each of these functions to ensure that disclosure is in fact responsive to the demands of the communities of interest. Framing risk minimization in terms of environmental harm, for example, ignores the broader concerns surrounding the social and ethical implications of CE research. Attending to procedural legitimacy to the exclusion of substantive considerations runs the risk of developing a thin version of social acceptance of CE research activities that will not be sufficiently robust to maintain the public's trust in future science-based policy decisions.

The importance of disclosure to maintaining the condition for future debates over CE research suggest that a key source of tension in the design of disclosure mechanisms will be balancing the demands for high levels of participation and deliberation against the burdens that these demands place on researchers. This tension is heightened by the presence of ethical concerns that are not easily resolved and the likelihood of diverse views on the degree of social consensus required to proceed with CE experimentation.

This brings us back to Victor et al.'s (2013) point regarding the iterative relationship between governance and science. Elsewhere Victor argues in favour of a "bottom-up" governance structure that evolves over time, as both the science and the governance norms coalesce. His central point is that "[m]eaningful norms are not crafted from thin air" (Victor 2008, 332). Instead, norms are articulated and applied in the context of actual activities, such as assessments of experiments, through which key participants and the public can understand their interests. Victor continues, "If done openly with extensive review as well as complementary funding to examine scenarios for actual geoengineering deployment, then such a process will likely create a base of accepted, shared information that could inform later formal efforts to create norms" (ibid.). This points to a further purpose to which transparency can contribute. In a decentralized governance environment, such as the one emerging in CE research, there is a demand for coherence among the various sites of governance activity. Coherence, as Victor suggests, demands openness in order to allow information to flow between these sites.

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