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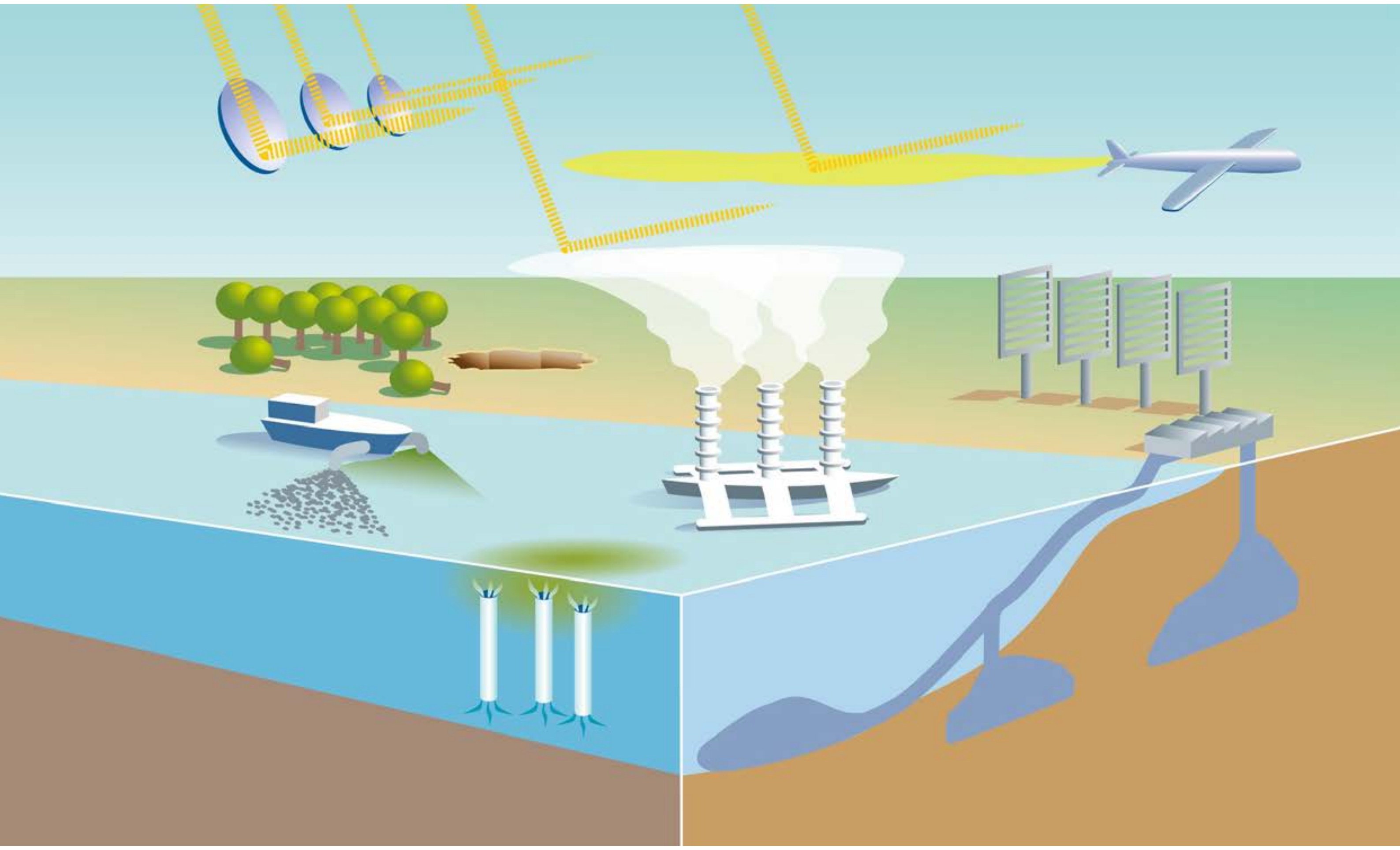
Large-Scale Intentional Interventions into the Climate System?

Assessing the Climate Engineering Debate



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Large-Scale Intentional Interventions into the Climate System?

Assessing the Climate Engineering Debate
Executive Summary

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Executive Summary

CLIMATE ENGINEERING: LARGE-SCALE INTENTIONAL INTERVENTIONS INTO THE CLIMATE SYSTEM

"Climate engineering" (CE) encompasses technologies designed to remove the causes of anthropogenic climate change and to treat the symptoms associated with it. The former are referred to as carbon dioxide removal (CDR) technologies because they reduce CO_2 in the atmosphere, the latter as radiation management (RM) technologies because they directly influence the radiation budget and hence the temperature. CDR technologies draw upon biological, chemical, or physical processes to cause the ocean or the terrestrial biosphere to absorb atmospheric CO_2 or directly store it geologically. RM technologies reduce the Earth's short-wave solar radiation input, enhance its reflection, or increase long-wave thermal radiation to space.

STATE OF THE DEBATE ON CLIMATE ENGINEERING

Research and public debate on climate engineering are still in their early stages. The public at large is almost totally unfamiliar with climate engineering, so the debate takes place within a small circle of predominantly academic participants plus a few representatives from the business community, non-governmental organizations (NGOs), and governments. Research on climate engineering began with very general considerations about how to manipulate the Earth's radiation budget. Today, it also focuses specifically on the implementation and application of suitable technologies. Research to date has revealed that CDR and RM technologies differ greatly, not only in terms of their mode of operation, efficiency, and side-effects, but also in terms of their social implications. Accordingly, they need to be assessed in different ways.

DIMENSIONS OF THE DEBATE ON CLIMATE ENGINEERING

The current debate on climate engineering is far more complex and variegated than the majority of academic publications would appear to suggest. To understand the complexity of research into and use of climate engineering, it is first necessary to collect, structure, and relate the very different arguments that have been advanced for and against climate engineering. In support of its use or operative readiness, three main arguments are usually presented: (i) CE technologies are more efficient than conventional emission control; (ii) without CE technologies ambitious climate targets could not be achieved; and (iii) CE technologies are necessary as an emergency option, should there be hazardous anthropogenic interference with the climate system as referred to in the United Nations Framework Convention on Climate Change (UNFCCC).

In addition to reservations about the effectiveness and economic efficiency of such technologies, arguments against the use of climate engineering include those centering on risk ethics and fairness plus a variety of other fundamental (e.g., religious) arguments. Hence it is claimed that the operational readiness of any CE technology should include the investigation of all consequences associated with it. Others argue that CE research has harmful side-effects and violates ethical and legal principles (such as the "polluter-pays" principle). In addition to normative assumptions, all these arguments are based on empirical premises that can, in principle, be scientifically tested. Scientific results can thus inform the CE debate, but they cannot be the sole basis of a decision for or against climate engineering.

INTENTIONAL AND UNINTENTIONAL CONSEQUENCES OF CE TECHNOLOGIES AND THEIR PREDICTABILITY

To assess the intentional consequences of CE technologies, it is vital to know what targets their effectiveness is to be measured by. What types and degrees of anthropogenic climate change should actually be compensated for? And how quickly should these climate changes be corrected? Measured against the objective of a comparatively rapid reduction in average global temperature, some RM technologies appear to be more effective than others. However, if we set our sights on other consequences of climate change such as shifts in precipitation patterns or changes in oceanic acidification, we find that these technologies are less or not effective. Moreover, we must bear in mind that lasting temperature reduction via the use of RM technologies requires continued use of these technologies over very long periods, because the concentration of greenhouse gases and especially of CO_2 will only decrease very gradually by natural means. Only if RM deployment were complemented by a decrease in the concentration of CO_2 would it be possible to discontinue their use at an earlier stage without causing a sudden rise in temperature. So a reversal of climate change and with it the long-term correction of anthropogenic climate changes can only be achieved through CDR technologies, which, however, do not allow for rapid temperature reduction.

To evaluate the unintentional consequences or side-effects of a CE technology, it is important to consider the material and energy flows affected by the technology and the extent to which this happens. Fundamentally, it can be said that the risk of unintentional consequences is greater, the larger the scale of the technology used, the more sensitively the material cycles affected react, and the longer these cycles are influenced by the technology in question. The deployment of RM technologies represents an additional intervention into the radiation budget with the aim of compensating for the greenhouse gas-induced reduction of long-wave radiation via the corresponding reduction of short-wave radiation. Little research has yet been done to find out how the high-feedback system Earth will react to such compensation and what fundamental side-effects may arise in the climate system, in other material cycles, and in the biosphere. Accordingly, RM technologies in general are expected to have a greater potential for producing unpredictable side-effects than CDR technologies. The potential side-effects of individual CDR technologies result predominantly from the ability they have to influence material cycles. Biological cycles are assumed to be those most severely affected. However, feedback processes (e.g., as a result of a change in the Earth's albedo) may also cause CDR technologies to trigger unpredictable meteorological side-effects.

Though further research may be able to reduce or even eliminate some of the uncertainties regarding effectiveness and side-effects, the complexity of the Earth system makes it difficult to predict all the effects and side-effects of CE technologies, particularly at a regional level. So ongoing research endeavors involving model calculations and field trials will not result in risk-free climate engineering. These general considerations also apply of course to anthropogenic climate change. Its global and particularly its regional effects are difficult to predict in detail. This means that decisions on climate policy will continue to involve trade-offs between a number of different risks and uncertainties.

THE ROLE OF FIELD TRIALS

Sooner or later, the improvement of our understanding of CE technologies will necessitate large-scale field trials that come very close to an actual application of the technologies. Such field trials should be accompanied by comprehensive monitoring programs. Even if we assume the best possible design for large-scale trials, unequivocal identification and quantification of the effects and side-effects of particular technologies would take many years or even decades. In the course of a field trial extending over such a long period, apparent effects and side-effects unrelated to the application of the technology would also occur. The conduct of such a large-scale trial without the occurrence of significant social and political impacts must be considered one of the major challenges of climate engineering.

THE INTERNATIONAL LEGAL FRAMEWORK

Given the largely transboundary effects of most of the technologies concerned, the legal permissibility of climate engineering is determined primarily by the provisions of international law. International law has not as yet instituted any standards that would generally and comprehensively regulate research into, or the use of, climate engineering. Nevertheless, there are individual treaties that are applicable to CE technologies. Treaties dedicated to specific problems are very broadly worded, with the express intention of being comprehensive enough to cover future developments not actually referred to specifically in the treaties themselves.

We have no binding definition of climate engineering under international law. In legal terms, no specific consequences have been attached to the distinction between RM and CDR technologies. Instead, the question of whether climate engineering is legal needs be assessed separately for each individual CE technology with regard to international treaty law and customary international law. However, what we can say specifically against the background of the requirements of the UNFCCC is that there is, first of all, no general ban on climate engineering under international law. Second, detailed analysis of the individual CE technologies supports the conclusion that CDR technologies tend to attract fewer legal objections than RM technologies. Third, the vast majority of CE technologies require due regard to be given to the existing rights and territorial integrity of other states. This is why there is a rebuttable presumption that purely unilateral CE action is not in accordance with international law. Fourth, particularly with regard to RM technologies, legal assessment depends above all on how the phenomenon of conflicting environment-related objectives will be handled in the future. Given the current degree of scientific uncertainty, any decision on the pros and cons of CE research or its use inevitably requires that a balancing of the risks involved be carried out, provided of course that specific CE technologies are not prohibited in international law.

Against this background, it is important for the risk-balancing process underlying any decision to be carried out in a legitimate and transparent way. To this end, the general obligations imposed by customary international law to inform potentially affected states, to conduct consultations, and to carry out environmental impact assessments in the context of the specific or potentially pertinent treaty must be applied in light of the specific features of the CE technologies in question and be effectively implemented.

POTENTIAL FOR INTERNATIONAL CONFLICT

Emission control can only be effective when it is carried out within the framework of an agreement between a large numbers of states. By contrast, some CE technologies can be readily implemented, both technically and financially, by a single state or a small number of states. This might conceivably lead to international conflicts. The promise of a quick and highly effective technical solution (particularly one involving RM technologies) that can be carried out by one or a small number of states, is held out by precisely those technologies that give reason to expect particularly vehement politicization and large-scale social and political resistance, with potentially far-reaching consequences for the UNFCCC process. Against this background, international coordination of climate engineering appears desirable, notably with a view to avoiding international social and political conflicts.

The institutional integration of research on, and possible implementations of, CE technologies into an international regime would provide a sound basis for bringing about adequate social acceptance at the international and transnational level. Such integration would also favor the coordination of all measures pertaining to climate policy by linking climate engineering to existing environmental regulations. Requirements for institutional integration are (i) international coordination of research and technical evaluation, (ii) creation of an independent supervisory authority, (iii) definition of international norms and rules, (iv) comparability of emission control and CE deployment, (v) coordination of research to deal with the slippery-slope problem, and (vi) a definition of terms for phasing out the use of climate engineering.

COSTS OF CE TECHNOLOGIES

At present, our knowledge of the costs generated by different CE technologies is rudimentary and bedeviled by major uncertainties. Estimates of these costs are primarily limited to the operating costs of individual CE technologies, while for the majority of these technologies explicit estimates of the research and development costs involved in attaining operational readiness and the capital costs associated with their use quite simply do not exist. Furthermore, these estimates disregard economies of scale and price, which are likely to occur if CE technologies are implemented on a large scale. Finally, we still have no studies dealing with the overall economic costs arising from side-effects of the use of CE technologies. Despite the uncertainties about the side-effects resulting from our limited understanding of the Earth system, it is fair to assume that the economic costs will increase with the magnitude of CE deployment and that the associated economic, political, and social impacts will also increase accordingly.

While the costs of CDR technologies are assessed on the same basis as the costs of CO_2 emission control and thus allow for direct comparison, this is not the case with RM technologies. If RM technologies were used to compensate anthropogenic radiative forcing, they would have to be sustained over very long periods. Hence, even in the case of very low annual costs, the cumulative costs of RM technologies might exceed the costs of emission control or CDR technologies. Currently, we have no comparative analysis of different emissions and compensation scenarios that takes into account such long-term factors and the feedback effects of RM technologies on natural CO_2 uptake. Accordingly, assessments can only be made on the basis of investment expenditures and annual operating costs. Assessment of the costs accumulating over time is not feasible.

EFFECTS OF CLIMATE ENGINEERING ON EMISSION CONTROL

Economic analyses on aspects of climate engineering come to the conclusion that the use of CE technologies is generally accompanied by a decrease in emission control if emission reductions are more costly than the application of CE technologies for a given target. Given the limitations of our current knowledge on the economic costs of climate engineering, we cannot confirm that this is genuinely the case. In fact, a number of studies indicate that already CE research itself, can be expected to result in a lower level of emission control. These studies argue that the risks of sudden climate change can best be averted by RM technologies, so that maintenance of especially intensive emissions control is no longer necessary.

PUBLIC DEBATE

The prospect of the availability of climate engineering leading to less intensive emission control efforts is also a concern in the public debate on the subject. Analysis of reader opinions and blogs indicates widespread concern that the use or availability of climate engineering will make climate change appear less threatening, thus slackening the pressure on politicians to control emissions and/or promote renewable energies. But studies show that the reverse case may also occur: Efforts to control emissions might increase among the general public because this would be seen as a lesser evil compared with climate engineering.

There are indications from sociological studies that CE critics would act in a more environmentally friendly way if there were progress in the development of CE technologies, while CE advocates would tend to have a more carefree attitude towards greenhouse gas emissions. However, the extent to which a rising level of awareness of CE technologies in society would lead to a general change in attitudes towards climate protection is currently unclear. Similar game theory-based considerations could also apply to the analysis of international relations. This line of reasoning is not restricted to CE deployment. It also applies to CE research, since decisions on CE research and decisions on the range of emission control to be used cannot be made in isolation.

COMMERCIAL CONTROL OF CE DEPLOYMENT

One general risk in the development of new technologies is that researchers or their sponsors may pursue their own interests and promote the technology they are investigating or sponsoring even if the application of this technology does not seem objectively necessary. The fear that CE research might become self-sustaining is frequently expressed in public debate. However, the vast majority of CE technologies do not currently seem to have any commercial application. Commercial applications would only arise if the appropriate incentives were created via government regulation. If there were relevant markets (as for CO_2) or if regulatory provisions were made regarding the implementation of climate engineering, it would be incumbent on the relevant jurisdiction or the authorities supervising competition to limit the extent of commercial control.

IRREVERSIBILITY OF CE TECHNOLOGIES

In principle, every kind of CE technology can be discontinued without serious consequences if the technology is phased out smoothly and gradually. The precise conditions under which this is possible depend on the extent to which the Earth system has been influenced by the CE technology itself. Given that it is possible to securely store carbon, the use of air capture, for example, would affect relatively few material cycles in comparison with RM technologies. We can legitimately assume that the use of the majority of CDR technologies could be discontinued without having too great an influence on the Earth system. If RM technologies were phased out too quickly or were subject to unscheduled disruption over a lengthy period of time, this could trigger rapid climate change that might even be more intense than it would have been without the prior use of RM technologies. However, discussion of the potential reversibility of CE interventions into the climate system should also bear in mind that untrammeled CO_2 emissions would probably lead to equally irreversible changes.

NECESSITY FOR AN INTEGRATED APPROACH

Irrespective of the role individual CE technologies may play in future climate protection, it is obvious that the discussion revolving around CE technologies and research into them cannot be considered in isolation. The assessment of CE technologies alone, for example, depends on the extent to which other climate protection measures are being implemented. Recent research findings indicate clearly that greater attention must be paid not only to the various anthropogenic influences on the radiation budget, such as greenhouse gas or aerosol emissions, but also to changes in land use and associated economic and social interactions. Political decisions on climate protection should therefore consider all anthropogenic influences on the climate. In other words, an integrated climate policy should also encompass the various effects of anthropogenic aerosol emissions and anthropogenic surface changes on climate, whether they are caused by

CE technologies or represent side-effects of economic development.

We can safely say that further research into the Earth system is not only a prerequisite for a better understanding of the intentional effects of CE technologies but also for the quantification of their side-effects. This knowledge is essential for research into the individual cause-effect chains on land and in the oceans. A better understanding of these effects could then serve as a basis for the legal, economic, and sociological analysis of the advantages and disadvantages of CE technologies. Initial analytic studies have gone some way toward indicating the potential societal implications of the use of, and even research into, CE technologies at a qualitative level. But the actual extent of these implications is still largely unknown. These studies also indicate that that CE technologies and CE research are expected to have implications on national and international emission control policies. It is therefore also important to assess the significance of these implications in quantitative terms.

The natural impacts of climate change and the social contexts of international efforts toward effective climate protection have been accorded high priority in research. The same cannot be said as yet for climate engineering. However, research has revealed that climate engineering and emission control cannot be considered in isolation from one another. The fact that climate engineering is receiving greater academic and societal attention makes it increasingly important to investigate all aspects of climate engineering, including its interaction with emission control. Knowledge of the side-effects of CE technologies, in particular their ecological, economic, and social dimensions, is still insufficient for us to draw conclusions about the role of climate engineering in an integrated climate policy strategy designed to comply with the 2° C target.

Imprint

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