Centre for Climate Science and Policy Research, CSPR

Policy brief on climate engineering

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Centre for Climate Science and Policy Research

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Policy brief on climate engineering

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Introduction

Climate engineering (geoengineering) has been widely discussed as a potential instrument for curbing global warming if politics fails to deliver green house gas emission reductions. This debate has lost momentum over the last couple of years, but is now being renewed in the wake of the December 2015 Paris climate change agreement. Resurgent interest primarily stems from two elements of the Paris agreement. First, by defining the long term goal as "achiev[ing] a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" instead of *decarbonization*, the agreement can be interpreted as providing leeway for climate engineering proposals. Second, the agreement formulated a temperature goal of "well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C". In response, several scientists argued that these goals may require climate engineering.

As these discussions will affect the forthcoming review of pathways toward 1.5°C warming, this policy brief takes stock of climate engineering. It draws on the expertise of Linköping University's Climate Engineering (LUCE) interdisciplinary research programme. The brief provides an overview of the status of academic debate on climate engineering regarding bioenergy with carbon capture and storage (BECCS); stratospheric aerosol injection; and mass media reporting and public engagement.

Key points

- Resurgent debate on climate engineering (CE) in the wake of Paris climate agreement.
- Development of CE is at the basic research stage.
- Research literature highlights few positive side effects, important risks, and unresolved governance challenges.
- Discrepancies between wide use of BECCS for negative emissions in climate models and feasibility, resource requirements, and acceptability.
- Scientific support for short term stratospheric aerosol injection deployment is very weak and major environmental risks are identified
- Public awareness is low and media coverage increasingly negative.
- CE is qualified as treatment of symptoms rather than real solution by focus group participants.

Climate engineering in the academic debate

Climate engineering refers to the large-scale, deliberate manipulation of the Earth's climate to combat human-induced climate change. It is an umbrella term for several technologies which have proven to be controversial because they give rise to a number of social, ethical, technical, and governance challenges. Climate engineering aims to reduce global temperatures by either modifying the amount of sunlight reaching the atmosphere (solar radiation management) or removing CO_2 from the atmosphere (carbon dioxide removal). Examples of solar radiation management are sunlight reflection through the injection of small reflective particles into the upper atmosphere (stratospheric aerosol injection), or the creation of bright clouds over dark areas such as oceans by spraying seawater into the air. Examples of carbon dioxide removal include CO_2 scrubbers, bioenergy with carbon capture and storage (BECCS), and fostering marine algae blooms through iron fertilization. The post-Paris debate focuses primarily on carbon dioxide removal, which is in line with the long-term goal of balancing emissions and sinks.

Research on climate engineering technologies is at a concept stage. It primarily focuses on understanding basic physical, chemical and biological mechanisms and on assessing social and governance implications; there is thus very little actual technology development. Since all climate engineering options involve major challenges, environmental risks, and current lack of understanding of negative impacts, their ethical and governance issues remain unresolved.

Although the climate engineering research community is small, scientific organizations such as the Royal Society, the IPCC, and the US National

Academy of Sciences have dedicated assessment reports to the topic. Both social and natural scientists are increasingly active in discussing climate engineering. Many natural science research papers also go beyond internal scientific concerns to highlight ethical, social and governance issues.

In a review of climate engineering research papers we found that the peer-reviewed literature does not generally identify any positive side-effects of climate engineering. The literature emphasizes the potential dangers of pursuing climate engineering or the climate change risks of not considering such technologies. An exception is BECCS, which is framed in the literature as leading to negative greenhouse gas emissions while also producing energy.

We do not expect public support for climate engineering technologies that have the sole aim of avoiding catastrophic climate impacts, since research in environmental communication shows that appealing exclusively to fear seldom generates long-term public engagement.

Carbon dioxide removal: the case of bioenergy with carbon capture and storage (BECCS)

According to most of the more stringent scenarios compiled by the IPCC, the 2°C goal can only be met at a reasonable cost if negative emission technologies are deployed on a large scale. Negative emission technologies would have the Herculean task of removing more emissions than all other sources produce. Bioenergy with carbon capture and storage (BECCS) achieves negative emissions by combusting biomass, a carbon sink, while capturing and storing the resulting CO_2 emissions; the ensuing heat can, for example, drive a steam turbine for electricity generation.

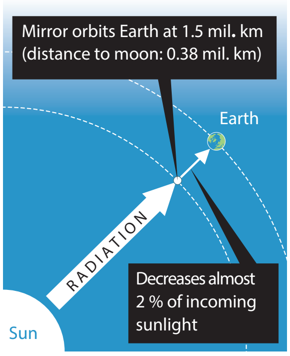
4 Four Solar Radiation Management Concepts

GRAPHICS: THOMAS MOLÉN, SvD

Reducing atmospheric warming by decreasing the amount of incoming sunlight. It does not affect the atmospheric concentration of greenhouse gases, which drive the greenhouse effect and contribute to ocean acidification.

Space Sunshade

A sunshade as big as Greenland in orbit between sun and Earth to reduce incoming radiation.

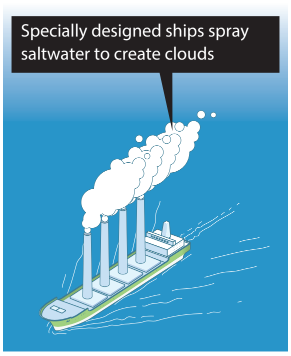


Stratospheric Veil

Continuous spraying of millions of tons of aerosols into the stratosphere to act as a mirror.

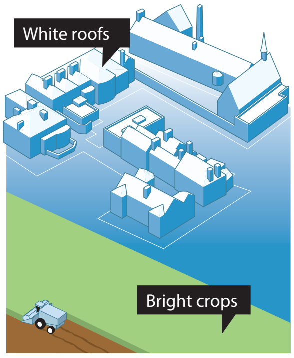
Marine Cloud Brightening

Ships spray saltwater vapour over seas to generate bright, refective clouds.



Brightening of Land Areas

Painting roofs white and planting bright crops to reflect incoming sunlight.

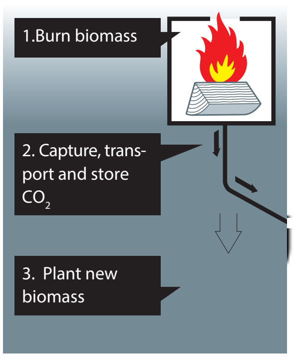


5 Five Carbon Dioxide Removal Concepts

Removing carbon dioxide from the atmosphere, which is the most significent cause of climate change. The effect of these technologies on atmospheric warming is slow.

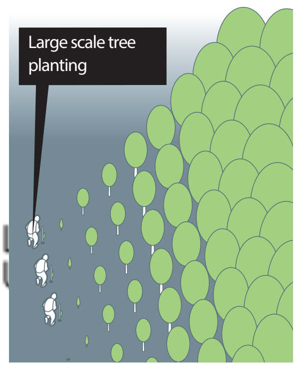
CO_2 from Biomass

Use of biomass for various industrial operations, capture and storage of CO_2. Planting of new biomass to remove more CO_2.



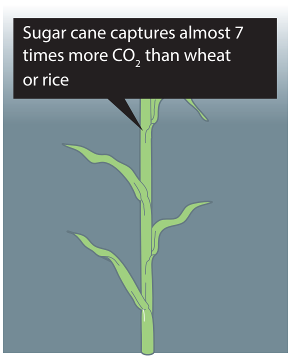
Afforestation

More trees (than today) are planted. The trees capture CO_2.



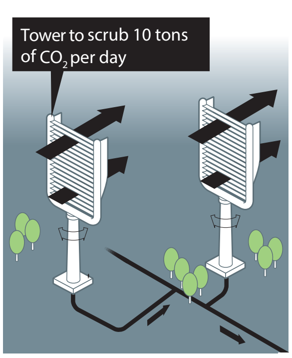
New Agricultural Practices

Development and cultivation of crops with high CO_2 capture capacity. Enhanced plowing technologies to improve CO2 capture in soil.



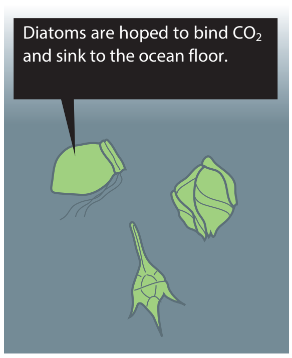
Artificial Trees

Large towers scrub CO_2 from the atmosphere. The captured gas is stored.



Ocean Fertilization

Iron, nitrogen or phosphor dust is spread into the oceans to stimulate CO_2 absorbing algae blooms.



BECCS is the most favored negative emissions technology in modeling studies. There is a significant discrepancy between this reliance on BECCS in models and its technological development, which has only just entered the small-scale demonstration phase. Moreover, there are several unresolved questions, such as the available storage capacity for CO_2, risks associated with CO_2 leakage from stores, and resource demands in terms of water, nutrients and required land area for growing biomass, which may compete with food production. One of the most profound uncertainties is the socio-political acceptance of large scale deployment. In our International Negotiations Survey of 140 delegates at the UN climate change conference in Bonn, June 2015, BECCS was among the least prioritized technologies for future low–carbon electricity generation. These results suggest a mismatch between the technology portfolios suggested by modelers to reach ambitious climate stabilization goals and socio–political preferences.

Solar radiation management: the case of stratospheric aerosol injection

The principle of stratospheric aerosol injection resembles the cooling effect of large scale volcano eruptions, which introduce a veil of small sulphur particles into the upper atmosphere that reflect some of the incoming solar radiation back into space. Relevant research is mostly confined to computer simulations, and there have only been a few minor field trials because of the risks involved in open air experimentation. Due to the complexity, grand scale, and global character of the technology, many important uncertainties remain unresolved. Our literature review on stratospheric aerosol injection found that the research literature reported massive global environmental risks of stratospheric aerosol injection, including radically changed precipitation patterns, ocean acidification, and ozone depletion. Scientific support for short term stratospheric aerosol injection deployment is therefore very weak. Findings from modelling studies also involve major uncertainties that theoretical investigation cannot resolve. Overall, the scientific results remain highly uncertain. The direct costs of stratospheric aerosol injection could be relatively low, but inclusion of indirect costs due to environmental risks and uncertainties increases the total cost considerably. We found no scientific consensus on the merits of stratospheric aerosol injection as an instrument of climate action, other than the recommendation to pursue further research and calls for caution. However, research is faced with the problem that reducing the prevailing uncertainties would necessitate large scale outdoor experiments with potentially huge and socially unacceptable environmental risks.

Climate engineering in public debate

International print media reports on climate engineering have changed over time. Early coverage, starting in 2006, mostly portrayed climate engineering as a crisis-averting instrument that could be deployed if the climate system suddenly passed a critical threshold (a so-called climate emergency), or if political efforts failed to deliver necessary greenhouse gas emission reductions. These contingencies were portrayed as strong arguments in favour of climate engineering research and occasionally even for deployment. However, the climate emergency argument came under attack for lacking a solid scientific basis and for being authoritarian. As of 2015 the frequency of statements critical of climate engineering has increased and positive discussion of climate engineering seems to have dropped. The December 2015 Paris climate change agreement, however, has boosted arguments for certain CO_2 removal options.

Global public awareness of climate engineering is low, regardless of media coverage intensity, which may seem an impediment to the early and broad public engagement that contemporary scientific governance calls for. Nevertheless, our focus group studies demonstrated that lay people were capable of discussing ethical aspects, risks, potentials, and trustworthiness of social institutions in the context of limited information about climate engineering.

Our studies find that lay people in Sweden perceive climate engineering as addressing the symptoms rather than the causes of climate change, to have negative environmental side-effects, to distract from mitigation efforts, and to engender various governance challenges. Preliminary findings from an ongoing, cross-country focus group study show that similar arguments are also present in Japan, New Zealand, and the US, and in particular that the criticism that climate engineering treats only the symptoms of climate change is widespread.

Recommendations

A starting point for the studies undertaken in the LUCE programme is that climate engineering's future cannot and should not be guided primarily by scientific feasibility studies, but that social and ethical aspects need to be scrutinized openly and at an early stage.

In conclusion:

- We recommend caution concerning treating carbon dioxide removal and BECCS as a feasible option on the scale of gigatons of CO_2 per year on any timescale until its technical, political and social feasibility are better understood.
- Stratospheric aerosol injection should not be considered a substitute for mitigation or adaptation efforts, nor as a long-term back up strategy.
- The tendency to lump together a variety of proposed technologies under a common umbrella of 'climate engineering' has been increasingly contested. When discussing climate engineering it is important to be clear about specific methods rather than only talking about carbon dioxide removal or solar radiation management.
- Some climate engineering options may have the potential to fulfill requirements for responsible, transparent research and reversibility, but on a limited scale. Broader and more inclusive public and scientific debates, not colored by emergency framings, are needed in order to delineate which options and under what conditions. This debate is close to non-existent in Sweden and most other countries, but should be encouraged.

This is an excerpt from CSPR Briefing No. 15, 2016.

Further reading

For information about Linköping University Climate Engineering Programme (LUCE), please visit http://www.cspr.se/forskning/luce?l=en or contact Victoria.Wibeck@liu.se

Project findings are reported in:

Anshelm, J & Hansson, A (2015) Has the grand idea of geoengineering as plan B run out of steam? The Anthropocene Review. DOI: 10.1177/2053019615614592

Anshelm, J & Hansson, A (2014) Battling Promethean dreams and Trojan horses: Revealing the critical discourses of geoengineering. Energy Research and Social Science 2:135-144.

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Hansson, A (2014) Ambivalence in calculating the future: the case of re-engineering the world. Journal of Integrative Environmental Sciences 2:125-142.

Hansson, A, Rayner, S & Wibeck, V (2015) Climate engineering. In: Bäckstrand, K. & Lövbrand, E. (eds.). Research Handbook of Climate Governance. Cheltenham, UK: Edward Elgar Press.

Linnér, B-O & Wibeck, V (2015), Dual high-stake emerging technologies: a review of the climate engineering research literature. WIREs Climate Change 6:255-268.

Uhrqvist, O and Linnér, B-O (2015). Narratives of the past for Future Earth: The historiography of global environmental change research. The Anthropocene Review 2:159-173.

Wibeck, V, Hansson, A & Anshelm J (2015) Questioning the technological fix to climate change – Lay sense-making of geoengineering in Sweden. Energy Research & Social Science 7: 23-30.

Linköping University Climate Engineering Programme analyzes policy, science and communication related to climate engineering technologies. The programme is conducted in collaboration between Centre for Climate Science and Policy Research and the Department of Thematic Studies - Units of Environmental Change, and Technology and Social Change, Linköping University. The program is funded by The Swedish Research Council (VR) and Formas. LUCE consists of three interrelated projects which aim to examine how climate engineering is made sense of in media, scientific communities and among laypersons.

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