

## PROPOSAL FOR AN EARTH SYSTEM INITIATIVE LECTURE SERIES ENTITLED “GEOENGINEERING: WILL IT SAVE THE WORLD?”

### ***Abstract***

There is great need for unbiased information on geoengineering and global warming. This document begins with background information that explains the various perspectives related to geoengineering and why unbiased information is difficult to obtain. This paper proposes a lecture series to provide education through speeches by well-known players from both sides of the global warming and geoengineering debates. Speakers at the lecture series would include representatives of government, industry, and academia. The final sections of the proposal outline the stages of planning, budget items, and possible co-sponsors.

### ***Background on Geoengineering***

With growing consensus that human activities influence global climate, geoengineering, which refers to attempts to solve environmental crises by globally altering the Earth system, has become a legitimate field of study. A project must incorporate both “scale and intent” to be geoengineering; one might call this field *global environmental engineering* (Chisholm 2006). This view of the world acknowledges that humans have great impacts on global element cycles; instead of ending human activities to bring conditions back to how they were in the past, geoengineering proposes making larger changes to maintain the Earth's current climate. The purpose of these changes would be to reduce carbon dioxide emissions into the atmosphere and prevent Earth from becoming uninhabitable by humans.

Debates abound as to whether humans with our current understanding of the Earth system can safely modify parts of the system to maintain global climate within reasonable bounds. Until recently, any large-scale modification of the Earth system has been viewed as unfeasible and irresponsible. Many scientists now cautiously favor geoengineering research due to rising greenhouse gas concentrations in the atmosphere. If geoengineering can counteract the negative influences of past and present human activities, it also faces the challenge of implementation and effectiveness before Earth's climate enters an irreversible feedback loop.

## ***Problem Statement***

Scientists generally agree that any response to global warming will be ineffective if the response is not implemented soon. The best solution to increasing greenhouse gases and global temperature is the subject of a polarizing debate. So far much of the debate has occurred only among scientists. Politicians and the general public must also know the effects of global warming and the types of solutions that have been proposed; these methods to mitigate global warming include geoengineering. Environmental impacts, human responsibility, cost-benefit analysis, and the desire to maintain current lifestyles all figure into the debate. Any possible fix to global warming would involve or affect the entire world. Knowledge of global warming and suggested solutions will guide industry and policymakers towards an optimal solution to global warming. Unfortunately, much of this knowledge remains widely inaccessible. This lack of information must be reversed to allow for informed decision-making.

## ***Literature Review***

A broad analysis of geoengineering may be gathered from the available literature. Several types of geoengineering have been evaluated, while others have yet to be studied in depth. Much of the literature is concerned with the future and how geoengineering will be used to solve future global warming. This review will cover the following topics:

- Feasibility analysis of geoengineering proposals
- Overview of the reasons to pursue geoengineering
- Overview of the reasons to discontinue geoengineering research
- Geoengineering in the future

## **Feasibility**

Feasibility studies have been performed on few geoengineering proposals. Until recently, studies on feasibility were neither published nor funded (Broad 2006). Strong opposition to manipulating the Earth system keeps most geoengineering proposals out of the peer-reviewed journals where the proposals would gain significant credibility. One geoengineering proposal by a Nobel laureate required support of the director of the National Academy of Sciences before it could be published in a peer-reviewed journal. Paul Crutzen, the atmospheric scientist who won a Nobel prize for discovering that sulfates destroy ozone proposed that sulfate injection into the atmosphere could mitigate global warming. Costs of continuously injecting sulfate into the atmosphere also play a role in the general agreement that this proposal is unfeasible except as a last resort.

Another proposal has been made to stimulate plankton growth in the ocean through iron fertilization. Iron limits the productivity of large parts of the ocean; these areas have high concentrations of unused nutrients like phosphorus and nitrogen but low productivity. Adding small amounts of iron to the

ocean would increase productivity in these areas. However, small-scale experiments have shown that iron fertilization does not increase the net amount of carbon being sequestered in the ocean and might cause anoxia in the oceans (Chisholm 2001). According to Kerr, the iron fertilization idea went away after experiments showed it wouldn't help as much as expected (2006). Some companies like Planktos, Inc. continue to address the World Bank for funds to realize this proposal (Planktos, Inc. 2006).

Iron fertilization and sulfate injection have been proven to be either infeasible or economically unviable by most researchers. This is not to say that no method of geoengineering will work. Many ideas have been rejected, but even more have never been tested. One problem with many proposals is that they will probably maintain global temperature, but they do not address increased acidification of the ocean (Schulte 2006). The next two sections will address the arguments for and against future attempts to monitor the Earth's climate through geoengineering.

### **Reasons to Pursue Geoengineering**

Most geoengineering proposals address the increasing levels of greenhouse gases, especially atmospheric carbon dioxide. Nations will not decrease rates of fossil fuel burning; neither developing nations like India and China nor developed nations like the United States will want to sacrifice future or current quality of life. According to most climatologists, global warming is inevitable and happening now. One way to prevent this disastrous global warming without making sacrifices is through geoengineering.

Geoengineering may be the best way to prevent a future climate crisis. This type of technical fix may also be the only way to reverse global warming (Benford 1997). We haven't evaluated most geoengineering proposals thoroughly enough to entirely rule out the possibility of one or more proposal working. Even if some of these ideas do not work in the long term, they may buy us time in the short term (Schulte 2006). Knowledge of the Earth system comes through thought experiments and ecological experiments that address global warming as a technical problem that may be solved by geoengineering (Kerr 2006). Ralph Cicerone, director of the National Academy of Sciences brought geoengineering to the center of the global warming debate by allowing Nobel laureate Paul Crutzen to publish his sulfate injection proposal in a peer-reviewed journal. In the editorial that accompanied Crutzen's paper, Cicerone explained his opinion that only open discussion and unbiased experimentation will determine which proposals are good and which are incomplete or irresponsible. Openness will free scientists, engineers, and policymakers to make sound decisions of each idea in terms of its costs and benefits (Cicerone 2006); it will also free geoengineering from some of the stigma it has so far possessed.

Some people feel that there is no option remaining; geoengineering must be used. These reluctant proponents often do not endorse geoengineering as an optimum solution; they see themselves as realists with "wild-eyed fixes of last resort" (Just add iron 1996). Since greenhouse gas emission trends do not seem ready to decrease any time soon, proponents see geoengineering as a last resort to save the Earth from complete destruction. If there truly is no other solution, geoengineering is not the

“ultimate state of hubris” (Kiehl 2006) that it has been called.

In summary, geoengineering may solve the current global warming crisis. Some proponents of geoengineering see it as a wonderful developing technology; others see this technology as the only way to fix global warming before Earth's climate gets too far out of control. Those in favor of discussion and research but not implementation want to keep all options open for the future. Science and technology may make new problems, but it will also get humanity out of the difficulties created by improvement.

### **Reasons to Discontinue Geoengineering Research**

Geoengineering, by its very definition, would have to be a global project. All nations of the world would be affected even if they did not agree with geoengineering projects. Many opponents feel that wealthy nations should not dictate an option to the rest of the world that may severely impact quality of life. Nobody knows whether most geoengineering ideas would have the desired results once tried. All models are limited by the knowledge and foresight of their creators (Kiehl 2006). Since there is only one Earth, there is no control experiment (Chisholm 2006). Models provide predictions, but they are often biased by the expectations of the programmers. Uncertainty reigns about who makes the decisions about geoengineering when the entire world is at stake; in the end, those nations that could afford to implement projects would also be those that chose whether to pursue geoengineering.

Many scientists oppose geoengineering based on economic arguments. Available estimates of the costs of geoengineering suggest that costs of geoengineering would be similar to the costs of ending all dependence on fossil fuels (MacCracken 2006). These costs for either mitigation or fewer fossil fuels would be large no matter how they would be distributed. The consensus is that wealthy developed nations would bear a greater burden of the cost of the project while developing or underdeveloped nations would have minimal economic contributions. Opponents of geoengineering accept that costs will be high; these people feel that it is far better to improve efficiency of electric devices and reduce greenhouse gas emissions than to create solutions that do not address the source of the problem (Just add iron 1996).

Many geoengineering proposals would involve large-scale implementation without knowing the effectiveness of the project or whether dependency on other geoengineering projects would result. Unanticipated side effects of geoengineering may result in continual dependence on new untested geoengineering plans to fix problems. The current increasing greenhouse gases were not intentional changes to the Earth system, yet they result in changes in how the Earth's climate operates. Intentional manipulation of the Earth system through geoengineering may result in even worse consequences than the changes brought about by ignorance of the anthropogenic influences on Earth's climate (MacCracken 2006).

Even stopping a geoengineering project would bear great risks. Holding the Earth at a fixed temperature may buy some time, but removing controls on global warming may result in even worse

consequences than would have been caused by greenhouse gases alone (MacCracken 2006). For example, stopping injection of sulfate into the stratosphere to halt global warming might hold the Earth's temperature constant for as long as sulfate remains in the atmosphere. Greenhouse gases would still be accumulating while sulfate injections continued. Within a few years of the end of sulfate injection, most of the sulfate would settle out of the atmosphere (Kerr 2006). Then a runaway greenhouse effect might occur due to the effect of much higher greenhouse gas concentrations. This rapid temperature increase might be much more dangerous than the more gradual increase that is happening now.

Geoengineering may be just one of many technical fixes that cause more trouble than the original problem. Dams may have solved flooding problems, but they also wreak havoc on downstream ecosystems and the distribution of silt through rivers. Pesticides protect crops; they also poison people and animals and encourage pests to develop resistance (Begley 1991). Opponents of geoengineering fear that geoengineering will cause more problems of these types while not sufficiently maintaining global temperature.

Proposals for geoengineering have been called contrary to natural instinct. One article sarcastically welcomes this "brave new world of geoengineering" (Air Repair 1993). Technological advances have included more efficient and clean plane engines and less rusty boat hulls. Scientific knowledge has increased to the level that we know negative effects of some anthropogenic gases in the atmosphere. For example, sulfate destroys ozone and contributes to acid rain. Geoengineering would act in direct opposition to some of this knowledge. Various proposals would include fertilizing the ocean through rusty old boats, flying 747s with incomplete fuel combustion, and spraying sulfate in the atmosphere (Begley 1991). Many scientists feel that this "planned pollution" (Air Repair 1993) is no less harmful than inadvertent pollution that has occurred for as long as humans have lived on the Earth.

Other opponents to geoengineering are concerned about the legal risks taken by anybody who attempts to change global warming. There are legal precedents in suits taken against cloud-seeding projects. Lawsuits have been filed against scientists who have attempted to make rain through adding particles to clouds. Although little to no scientific evidence supports the claim that cloud-seeding causes undesirable weather, these lawsuits have been successful. Cloud-seeders have been sued for both floods and droughts (Just add iron 1996). Anybody who undertakes geoengineering must accept the legal ramifications of global lawsuits should anything go wrong. Climate-changers will be held legally responsible by victims of bad weather and natural disasters.

To summarize, there are many reasons why some people disapprove of geoengineering as a means to mitigate global warming. Implementing global warming would put an undue economic burden on the nations that support it while denying choice to nations that do not agree. Large-scale implementation would have to be done before the effectiveness of many geoengineering proposals could be evaluated. Risks of geoengineering include lawsuits and worsened global warming. Opponents see no place for planned pollution in the fight against global warming.

## **Future direction**

Mediated discussion and closely watched research will be important in the future of geoengineering (Cicerone 2006). Opponents of geoengineering encourage higher efficiency and more energy conservation (Just add iron 1996). These are reliable and possibly less expensive methods of reducing the effects of carbon dioxide on the Earth system. Proponents of geoengineering encourage further research; further research without implementation will provide an emergency plan if the Earth's climate gets too far out of control (Kerr 2006). Other proponents say that pursuing geoengineering is the most effective way to gain a vast body of knowledge that would never be collected otherwise.

Continued dialogue is widely acknowledged as an important part of reaching a consensus in the debate over whether geoengineering should be allowed. Most proponents and some opponents of geoengineering agree that feasibility and ethics should be determined separately (Cicerone 2006); research of questionable morality must be allowed on a small scale to either validate or disprove the feasibility of geoengineering to mitigate global warming. The general consensus in the field is that research should continue or accelerate in the presence of careful regulation.

## ***Objectives***

The primary objective of the proposed lecture series is to increase understanding of geoengineering and global warming. A lecture series at the Massachusetts Institute of Technology would have high attendance rates. The packed lecture hall in 26-100 for the showing of Al Gore's "An Inconvenient Truth" should be sufficient proof that the MIT community has interest in learning more about issues related to global warming. Promotion of the lecture and webcasts would deliver the lectures to a wider audience that would include policymakers and the general public.

## ***Producing the series***

Most of the work involved in the proposed series will be in the preparation stages. Planning for the series would begin with reserving 26-100, MIT's largest lecture hall, for Monday through Saturday evening of one week in April. Scheduling lectures for different days of the week will allow people who might have evening commitments on some days to attend one or more of the lectures. Possible sponsors should be contacted at this time.

Next, possible lecturers would be approached with a description of the lecture series and an invitation to speak. Various areas such as ecological, energetic, and environmental impacts of geoengineering will be addressed through the lecture series. Some speakers will encourage geoengineering research, while others will be in opposition to ensure the dissemination of as much information as possible. Some experts who would be invited to speak include:

- William Broad: Analyzed effectiveness of methods to cool a planet.
- Sallie Chisholm: Opposes ocean fertilization because of long-term ecological effects.
- Ralph Cicerone: Director of the National Academy of Sciences, opened discussion of geoengineering.
- Richard Kerr: Wrote about the ironies of purposely polluting Earth to maintain the current climate.
- Jeffrey Kiehl: Suggests reduction of emissions before treating the symptoms of global warming.
- Michael MacCracken: Cautiously approving of geoengineering research.
- Mario Molina: MIT professor and chemistry Nobel laureate for work in atmospheric science.
- Representative of Planktos, Inc.: A company that has industrialized iron fertilization of the oceans.
- T. Wigley: National Center for Atmospheric Research, climate stabilization through a combination of mitigation and geoengineering.

Promotion of the series would be the next step. This would include emails, posters, and a posting on the MIT events page. Emails would be sent a month before the event and then every day from Sunday through Saturday the week of the event. Each email would be sent to relevant mailing lists. Postings advertising the event would be on the bulletin boards of the Infinite Corridor. An article or editorial in The Tech and on the web.mit.edu homepage would also increase visibility of the event.

Finally, the lecture series would be ready to run. The organizers would accommodate the needs of each speaker. Fitting the audience into the hall might be a problem, so the organizers should have a computer ready to play the webcast for any overflow. Organizers would also introduce the speaker and mediate question and answer sessions if needed. At the end of each lecture, the organizers would thank and/or pay the speaker.

### ***Time Schedule***

December 2006	Reserve 26-100
December 2006-January 15, 2007	Contact possible lecturers Create Schedule Contact potential cosponsors
March 2007	Preliminary promotion with posters
April 1-10, 2007	More intense promotion: (posters, MIT homepage, emails)
Mid-April 2007	Lecture series

### ***Budget***

- **Costs**
  - 1 Speaker Compensation: \$1000 per speaker for time and travel
  - 2 Promotion: \$50 for posters

3 Total: \$6,050

● **Possible Sponsors**

4 Earth System Initiative

5 Lab for Energy and the Environment

6 Lecture Series Committee

7 Various environmental groups on campus (SAVE, SFGS, Pugwash).

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