Geoengineering's Governance

Written Statement

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by

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There are two ways to look at the policy challenges posed by the threat of global climate change. The first is "top down," from the perspective of the world as a whole. Looked at in this way, the fundamental challenge is to reduce risk. The second is "bottom up," from the perspective of each of nearly 200 countries. Looked at in this way, the fundamental challenge is to realign incentives. Ultimately, the aim of policy should be to realign incentives so that states will make choices, either on their own or in concert with others, that serve the same purpose as the first perspective—choices that reduce global risks.

Reducing global risks requires that we do five things. First, we need to reduce global emissions of greenhouse gases. Second, we need to invest in research and development and demonstration of new technologies so that we can reduce global emissions substantially, and at lower cost, in the future. Third, we need to adapt, and help vulnerable countries to adapt. Fourth, we need to invest in technologies that can directly remove greenhouse gases from the atmosphere. Finally, we need to consider the possible role that geoengineering can play in reducing global risks.

The important point is that geoengineering's role should be looked at in the context of all the other things we need to do, just as these other things should now be looked at in the context of us possibly choosing to use geoengineering.

Defining geoengineering

The term "geoenginering" lacks a common definition. I take it to mean *actions taken deliberately to alter the temperature without changing the atmospheric concentration of greenhouse gases*. More formally, the temperature is determined by the amount of incoming shortwave radiation and outgoing longwave radiation. Actions to limit concentrations of greenhouse gases seek to increase the amount of longwave radiation emitted by the Earth. Geoengineering options, as defined here, limit the amount of shortwave radiation absorbed by the Earth.

Some people define the term more broadly, to include interventions that remove greenhouse gases directly from the atmosphere. This approach to reducing risks is very important. It was the fourth of the five things I said we need to do to reduce risks. But it is very different from technologies that reduce incoming shortwave radiation, which is why I think it is better to distinguish between these approaches. Industrial air capture, assuming that it can be scaled to nearly any level, would be a true backstop technology. It is a nearly perfect substitute for reducing emissions. Changes in shortwave radiation—as defined here, "geoengineering" techniques—are an imperfect substitute for efforts to reduce emissions.

There are four basic ways to change incoming shortwave radiation—by increasing the amount of solar radiation reflected from space, from the stratosphere, from low-level clouds that blanket the skies over parts of the ocean, and from the Earth's surface. There are significant differences as between these approaches. There are interesting questions as to whether one approach may be better than the others, whether combinations of approaches may be better still, and whether new approaches, as yet unimagined, may be even better. In my testimony, I shall ignore all these distinctions and consider "geoengineering" as a generic intervention.

Geoengineering and related risks

From the perspective of risk, reducing emissions is a conservative policy. It means not putting something into the atmosphere that is not currently in the atmosphere. Energy conservation is an especially conservative policy for reducing climate change risks.

Adaptation lowers the damages from climate change. It would therefore reduce the benefit of cutting emissions. In other words, adaptation is a substitute for reducing emissions. It is often asserted that these approaches are complementary. What people mean by this, however, is that we will need to do both of these things. This is true; we should reduce emissions now and we will need to adapt in the future and make investments today that will help us to adapt in the future. But it is also true that the more we reduce emissions now, the less we will need to adapt in the future; and the more able we are to adapt to climate change in the future, the less we need to reduce emissions now.

R&D and demonstration is a complement to emission reductions. As we invest more in these activities, the costs of reducing emissions will fall. As we do more R&D, we will therefore want to reduce emissions by more; and the more we want to reduce emissions, the more we will want to spend on R&D.

Air capture is a substitute for reducing emissions, but it could be a more flexible option. Emission reductions, by definition, cannot exceed the "business as usual" level. Air capture, by contrast, can potentially remove more greenhouse gases from the atmosphere than we add to it. Only air capture can produce "negative" emissions.

Geoengineering is also a substitute for reducing emissions. It would be used to reduce climate change damages. One reason often mentioned for not considering geoengineering is the fear that, if it were believed that geoengineering would work, less effort would be devoted to reducing emissions. But if we knew that geoengineering would work, and if the costs of geoengineering were low relative to the cost of reducing emissions, then it would make sense to reduce emissions by less.

As noted before, however, geoengineering is an *imperfect* substitute for reducing emissions. For example, geoengineering would not address the problem of ocean acidification. Also, we don't know if geoengineering will work, or how effective it will be, or what its full side effects will be. We may contemplate using geoengineering to reduce climate change risks, but using geoengineering would introduce new risks. It would mean trying to reduce the risks of one planetary experiment (adding greenhouse gases to the atmosphere) by carrying out another planetary experiment (reducing shortwave radiation). As compared with reducing emissions by promoting energy conservation, geoengineering is a radical approach to reducing climate change risks.

We need to be careful how we think about this. We can reduce emissions somewhat by means of energy conservation, even using existing technologies. To reduce emissions dramatically, however, will require other approaches. It is difficult to see how emissions could be reduced dramatically without expanding the use of nuclear power. This may mean spread of this technology to countries—many of them non-democratic—that currently lack any experience in using it, increasing the risk of proliferation. It would certainly mean the need to dispose of more nuclear waste. Abatement of emissions can thus also involve risks.

I mentioned before that "air capture" is a near perfect substitute for reducing emissions. But if the carbon dioxide removed from the atmosphere were stored in geologic deposits, it might leak out or affect water supplies. If it were put into the deep ocean, it may harm ecosystems the importance of which we barely understand. It would also, after a very long time, be returned to the atmosphere. This technology also involves risks.

The main point I am trying to make here is that we face risk-risk tradeoffs. Geoengineering would introduce new risks even as it reduced others. But the same is true, more or less, of other approaches to reducing climate change risk. Adaptation may be an exception (we don't yet know this; there may be some kinds of adaptation that introduce new risks), but adaptation, like geoengineering, is an imperfect substitute for reducing emissions.

I can imagine some people thinking that we can address the challenge entirely through energy conservation and by substituting renewable energy for fossil fuels. Some people might think that we can do this while also closing down all our existing nuclear power plants. It might even be believed that we could do this without having to remove carbon dioxide from the atmosphere and storing it underground. All these choices are certainly feasible. But they will also be costly. The question is whether people are willing to bear this cost in order to reduce the associated risks.

Even if we make all these choices, risks will remain. The threat of climate change has now advanced to the stage where every choice we make requires risk-risk tradeoffs. Many people believe that it is imperative that we limit mean global temperature change to 2 degrees Celsius. Indeed, some people believe that we ought to limit temperature change to no more than 1.5 degrees Celsius. Due to "climate sensitivity" and long delays in thermal responses, however, there is a chance we may overshoot these targets, even if we reduced global emissions to zero immediately. People who believe we must stay within these temperature limits should be especially open to the idea of using geoengineering. Alternatively, if they perceive that geoengineering is the greater threat, then they should reconsider the imperative of staying within these temperature change bounds.

Policy options for deployment

There are four main options.

First, we could ban geoengineering. One reason for doing so would be that use of geoengineering poses unacceptable risks. Another reason would be that, if use of geoengineering were banned, efforts to reduce emissions would be shored up.

One problem with this proposal is that, as already mentioned, our other options also pose risks. We need to be rational and consistent in how these risks are balanced.

Another problem is that a ban lacks credibility. Suppose that our worst fears about the future start to come true, and we are confronting a situation of "runaway climate change." At that point, adaptation would help very little. Air capture would reduce concentrations only over a period of decades, and because of thermal lags it would take decades more before these reductions translated into significant temperature change. Meanwhile, the climate changes set in motion could, and probably would, be irreversible. The only intervention that could prevent "catastrophe" would be geoengineering. If we had banned its use before this time, we would want to change our minds. We *would* change our minds.

In a referendum thirty years ago, voters in Sweden supported a phase-out of nuclear power. Today, the government says that new reactors are needed to address the threat of climate change. Polls indicate that the public supports this change. Bans can be, and often are, reversed.

Second, we could make geoengineering the cornerstone of our climate policy, and not bother to reduce emissions or do the other things I said we needed to do. One reason would be that this would spare us from having to incur costs in the short term. Another is that we wouldn't need to take action until uncertainties about climate change were revealed. Geoengineering would be a "quick fix."

A problem with this proposal is that we may find that geoengineering does not work as expected. It may not reduce temperature by much, or it may change the spatial distribution of climate. It may, and probably would, have unexpected side effects. We know it would not address ocean acidification. But it might also fail to address the "catastrophe" we face at that particular time, even if worked precisely as expected. For example, this catastrophe may be due to ocean warming, which geoengineering could alter only over a long period of time. Putting all our eggs, as it were, in the geoengineering basket would be reckless.

Third, we could use geoengineering soon and in combination with emission reductions, as suggested by Wigley (2006). By using geoengineering soon, we could prevent global mean temperature from increasing, or from increasing by much. By reducing emissions we could avoid serious climate change in the future. We could limit ocean acidification. We could also avoid the need to use geoengineering in the future. As noted before, it is extremely unlikely that we could limit global mean temperature change to 1.5 degrees Celsius by reducing emissions only. The goal is likely to be achievable only if we used air capture or geoengineering or a combination of the two approaches in addition to reducing emissions. By extension, the same may also be true for meeting the more modest but still very ambitious goal of limiting mean global temperature change to 2 degrees Celsius.

Finally, we might hold geoengineering in reserve, and use it only if and when signs of "abrupt and catastrophic" climate change first emerged. The advantage in this proposal is that we would avoid the risks associated with geoengineering until the risks of climate change were revealed to be substantial. The disadvantage is that, when we finally used geoengineering, we might discover that it does not work as expected, or that it cannot prevent the changes taking place at that time.

Overall, the third and fourth options have merit. I cannot see the case for the first and second options.

Implications for R&D

Having now contemplated when we might one day use geoengineering, let me now turn to the question of near-term decisions to carry out R&D.

A ban on R&D would expose the world to serious risks. Suppose we face a situation of "abrupt and catastrophic" climate change, and decide that we must use geoengineering, but that, because of the ban put in place previously, we had not done any R&D before this time. Then we would deploy the technology without knowing whether it would work, or how it would work, or how we could make it work better and with fewer side effects.

R&D can involve computer simulations, examination of the data provided by "natural, large-scale experiments" like volcanic eruptions, and "small-scale" experiments. Ultimately, however, large-scale experiments, undertaken over a sustained period of time, would be required to learn more about this technology. If such an experiment were done for the purpose of learning how geoengineering might be deployed to avoid a future risk of "abrupt and catastrophic" climate change, it would resemble using geoengineering along with emission reductions to prevent significant climate change. This makes the distinction between R&D and deployment somewhat blurred. It also blurs the distinction between the third and fourth options discussed above.

It might be argued that carrying out R&D would hasten the use of the technology. That depends on what we discover. We might discover that it doesn't work, or that it has worrying side effects of which we were previously unaware (in addition to the worrying side effects of which we were previously aware). This would make us less inclined ever to use geoengineering. Alternatively, we might discover that we can make it work better, and reduce its side effects. This would make us more inclined to use it—but this knowledge *should* make us more inclined to use it.

It is very hard to understand how knowing less about this option could possibly make us better off.

The geopolitics of geoengineering

Thus far I have considered geoengineering's role in a climate policy oriented towards reducing global risks. As mentioned in my introduction, this is one of two important perspectives. The second is the perspective of the nation state.

It is important that we consider the perspective of different states and not only our own. Many countries are capable of deploying geoengineering. Over time, more and more countries will be capable of deploying geoengineering.

Risks and incentives

Let us now reconsider all the things that can and should be done to reduce the risks associated with climate change, but do so from the perspective of individual countries.

Emission reductions are a global public good. Emissions mix in the atmosphere. The benefits of reducing emissions are thus diffused. A country that reduces its own emissions receives just a fraction of the global benefit, while paying the full cost. There is thus a temptation for countries to "free ride." In the case of climate change this tendency is particularly powerful because the costs of abating one more ton increase as the level of emission reductions increases. Put differently, starting from a situation in which every state is cutting its emissions, each state has a strong incentive to save costs by abating less.

Countries are also interconnected through trade. As one country or small group of countries cuts its emissions, "comparative advantage" in greenhouse-intensive goods will shift to other countries, causing the emissions of these countries to increase. In addition, as some countries reduce their emissions by reducing their use of fossil fuels, the price of these fuels traded internationally will fall, causing other countries to increase their consumption and, hence, their emissions.

Overall, the incentive for countries to cut back their emissions is weak (Barrett 2005). This explains why international agreements to limit emissions worldwide are needed. This also explains why our efforts to develop effective agreements have failed. It is really because of this failure that we need to consider geoengineering.

We also need to undertake R&D into new technologies that can help us to reduce emissions at lower costs. However, the returns to this investment in R&D depend on the prospects of the knowledge generated being embodied in new technologies that are used worldwide to reduce emissions. In other words, the incentives to undertake R&D are derived from the incentives to reduce emissions. Because the latter incentives are weak, the former incentives are weak, which explains why the world has done remarkably little to develop the new technologies needed to address the threat of climate change fundamentally.

Adaptation is very different. The benefits of adaptation are almost entirely local. The incentives for countries to adapt are very powerful.

The problem here is that some countries are incapable of adapting. Much adaptation will be done via the market mechanism. The rest of it will mainly involve local public goods (dikes being an obvious example). The countries that have failed to develop are the countries that will fail to adapt.

These countries need our assistance, and we and other rich countries have pledged to offer this assistance, most recently in the Copenhagen Accord. But the incentives for the assistance to be given are rather weak. Climate change could widen existing inequalities.

The incentives to undertake air capture are mixed. On the one hand, air capture can be undertaken unilaterally. In theory, a single country could use this technology to stabilize atmospheric concentrations, even if every other country failed to lift a finger to help. Air capture is thus very unlike the challenge of getting countries to reduce their emissions. However, inexpensive options for air capture are of limited scale, while options to remove carbon dioxide from the atmosphere on a large scale are expensive (Barrett 2009). The latter options would only be used if the threat posed by climate change were considered to be very grave.

Geoengineering is like air capture. It can be undertaken as a single project. It can be done by a single country acting unilaterally, or by a few countries acting "minilaterally." It does not require the same scale of cooperation as reducing emissions. But geonengineering is very unlike air capture in other ways. It does not address the root cause of climate change. It does not address the associated problem of ocean acidification. Most importantly for purposes of this discussion, geoengineering is cheap (Barrett 2008a). The economic threshold for deploying geoengineering is a lot lower than the threshold for deploying air capture at a massive scale.

Because the cost of geoengineering is low, the incentives to deploy geoengineering unilaterally or minilaterally are strong. In this sense, geoengineering is akin to adaptation. The difference is that geoengineering undertaken by one country or by a coalition of the willing would change the climate for everyone. Depending on the circumstances, this could be a good thing (recall that the incentives for rich countries to adapt are powerful, but that their incentives to help the poor to adapt are weak) or a bad thing. It is because the incentives for individual countries to use geoengineering may be strong, and yet other countries may be adversely affected, that geoengineering poses a challenge for governance.

A scenario of "gradual" climate change

Imagine first a situation in which climate change unfolds gradually. In this scenario, there will be winners and losers over the next few decades, perhaps even for longer. (Over a long enough period of time, if climate change were not limited, all countries will lose.)

To be concrete, let us consider estimates of the effects of climate change on agriculture as developed by William Cline (2007). According to this work, India's agricultural potential could fall 30 percent for a 3˚C mean global temperature increase by around 2080. Upon doing some back-of-the-envelope calculations, I have found that India might suffer a loss valued at around $70 billion in 2080. Estimates of the costs of offsetting this amount of warming by geoengineering are generally lower than this. Hence, it is at least plausible that India might be tempted to use geoengineering in the future.

To reinforce this point, note that about 70 percent of India's more than one billion people currently live in rural areas. Over time, this percentage will fall, but perhaps not by that much. Is it realistic to expect that a democracy will not act to help a substantial fraction of its people when doing so is feasible and not very costly?

Note as well that India has already sent an unmanned spacecraft to the moon. It is currently planning a manned mission to the moon. It is certainly within India's technical capability to deploy a geoengineering project.

It is also within its political capability. In early 2009, a joint German-Indian research team undertook an experiment on "ocean fertilization" in the South Atlantic, despite protests by environmentalists. India, it should also be remembered, developed nuclear weapons outside of the Nuclear Nonproliferation Treaty, and tested those weapons over the objections of other countries. External pressure for restraint may not deter India from deploying geoengineering, should India believe that its national interests are at stake.

India would also have a moral and quasi-legal case for using geoenginering. The Framework Convention on Climate Change says that "developed countries [need] to take immediate action…. as a first step towards comprehensive response…." India might argue that developed countries failed to fulfil this duty. It might also claim that it lacked any alternative means of protection. India might conceivably assert a need to use geoengineering for reasons of "self-defense."

I am not saying that it is inevitable that India would want to deploy geoengineering. I am only saying that, under plausible assumptions, the possibility needs to be considered.

Of course, India may not be the first country to contemplate using geoengineering. May other scenarios can be imagined.

If "gradual" climate change produces winners and losers, then the use of geoengineering to reduce the effects of gradual climate change will also produce winners and losers. The winners would join India. They might be willing to provide financial support for India's geoengineering effort. If a "coalition of the willing" were to form, the economics of "minilateral" action would likely strengthen the likelihood of geoenginering being deployed.

The losers of any such geoengineering effort would have very different incentives. Cline (2007) finds that, due to gradual climate change, agricultural capacity in China, Russia, and the United States would likely increase 6 to 8 percent by around 2080. Under this scenario, if India, on its own or in concert with others, were to deploy geoengineering to protect their economies, other countries may suffer as a consequence.

What might these other countries do? They would certainly voice their objections. They might threaten to impose sanctions. They might attempt a countervailing geoengineering effort to warm the Earth. They might seek to "disable" India's geoengineering effort by military means. This last possibility is especially worrying, given that many of the states mentioned as being affected, whether positively or negatively, possess nuclear weapons.

But it is also for this reason that a military strike is most unlikely. The situation I have described here points to a clash in rights—the right of one or more states to use geoengineering to avoid losses from climate change versus the right of other states not to be harmed by geoengineering. Clashes like this occur all the time. They rarely, if ever, lead to military conflict.

To give an example, there are no general rules for assigning rights to transboundary water resources. An upstream state will assert its right to divert the waters of a shared river for its own purposes, while the downstream state will claim its right to an uninterrupted flow of this water. Resolution of such disputes invariably demands mutual concessions. Typically, the parties will seek an "equitable" solution, meaning a sharing of rights. The nature of the bargain that is struck will depend on the context, including the characteristics of the parties. For example, if the upstream state is poor and the downstream state rich, the latter state may need to pay the upstream state not to divert its waters. By contrast, if the upstream state is rich and the downstream state poor, the former may need to compensate the latter.

Perhaps, then, India will refrain from using geoengineering, or scale back its plans, in exchange for other countries offering to help India improve the productivity of its agriculture (taking the climate as given). By contrast, if the United States were inclined to use geoengineering first, it seems more likely that there would be an expectation that the US should finance investments in other countries, to blunt the negative impacts on these countries of its use of geoengineering. In both cases, the need for a state to take into account the concerns of other states would have a moderating influence.

A scenario of "abrupt and catastrophic" climate change

The situation changes when we peer farther into the future. Over longer periods of time, even gradual climate change will be harmful all around—melting of the Greenland Ice Sheet, for example, would increase sea level by about seven meters. It is hard to see how any country could gain from this degree of sea level rise, even if it unfolded, as expected, over a period of many centuries.

Abrupt climate change is a greater worry. Warming is expected to be especially strong in the Arctic region. Should this warming trigger massive releases of carbon dioxide and methane, a positive feedback will be unleashed. No country will gain from such a climate shock. A collapse of the West Antarctic Ice Sheet, though unlikely, would also have very serious consequences. No country will gain from this kind of change either.

It thus seems likely that the interests of states as regards geoengineering will tend to converge over time. Tensions that loom large in a world of gradual climate change will evaporate in the longer run and will disappear very quickly should the prospect of abrupt, catastrophic climate change appear imminent.

Outlines of a geoengineering regime

Should there be a regime for using, or not using, geongineering? Currently, no such regime exists. There are some agreements and some aspects of custom that would be relevant to such a decision (Bodansky 1996). But the situation we are contemplating here is unprecedented. Should a country believe that its national security interests were at stake, it would make decisions largely unrestrained by international law. The absence of a regime essentially allows states to act as they please.

This means that the United States could act as it pleased, more or less. But it also means that Russia and China, India and Brazil, Europe, and Japan, and Indonesia and South Africa could all act as they pleased as well. It is in the interests of each county to agree to restrain its own choices in exchange for other countries agreeing to restrain theirs. The governance arrangement needed for geoengineering is thus one of *mutual restraint* (Barrett 2007).

As I have stressed throughout this testimony, geoengineering needs to be considered in the context of all the other things we need to do to limit climate change risk. For this reason, international governance arrangements for geoengineering should be developed under the Framework Convention on Climate Change. Currently, the focus of the Framework Convention is on limiting atmospheric concentrations of greenhouse gases. It would be better, in my view, if the agreement were revised to focus on reducing climate change risk, and on balancing this risk against the risks associated with addressing climate change. Every good international agreement is revised and reworked as circumstances change.

Protocols developed under this convention should address specific collective action challenges that serve to reduce risks. There should be many such protocols, even as regards reducing emissions (Barrett 2008b). There should also be a protocol for geoengineering governance.

A geoengineering protocol should be open to be signed and ratified by every party to the Framework Convention. It is important to underscore that every country is entitled to participate in the Framework Convention, and that nearly every country in the world is a party to this treaty today (the only non-parties are the Holy See and Andorra). This principle of universality is important. Every country will be affected by whatever is decided about geoengineering. Every country should have an opportunity to shape this technology's governance.

The protocol can be more or less restrictive. As it becomes more restrictive, fewer states will consent to participate. An agreement that fails to attract the participation of the geoengineering-capable states would be of little benefit. It will be in every country's interests that as many geoengineering-capable states as possible participate in this agreement. It may not be essential that every geoengineering-capable state participate, but at the very least the agreement should establish normative limits that would restrain the behavior even of non-parties.

As a general approach, negotiations should focus on what countries can agree on rather than on what they cannot agree on. The treaty should enter into force only after being ratified by a substantial number of countries. An additional requirement may be needed to ensure that the geoengineering-capable states also participate in great numbers. Note, however, that as the latter condition for entry into force becomes more restrictive the agreement will essentially hand every such state the veto. A consequence may be that the agreement would never enter into force.

What is it that countries can countries agree on? It is likely that all states will agree that every state ought to be obligated to inform all other states of any intention to deploy geoengineering. One reason for this is that deployment would be observable by other states in any event. As well, deployment must be sustained if it is to affect the climate. The element of surprise would offer no advantages.

Negotiations will likely focus on a state's rights and responsibilities—its right to deploy geonegineering to safeguard its own citizens and its responsibility not to harm other states. It is in the nature of this technology that the latter outcome could not be assured. This is likely to have a restraining influence on the decision to deploy.

Countries may agree that they should cooperate to resolve conflicts. A country declaring an intention to deploy geoengineering may agree to hear opposition to its plans (these will be voiced in any event, but an agreement may help to establish the basis on which opposition can be expressed). It is unlikely that the geoengineering-capable states would be willing to have their hands tied completely. It is also unlikely that they would agree to have their freedom of action be determined by a vote. Even if they did agree to this in principle, it would be very hard to conceive of a voting rule that would be acceptable to all states. It is, however, likely that states would agree to aim to seek a consensus.

Consensus has powerful advantages. It makes each state take into account the collective interests of all states, and the individual interests of every state. It creates a presumption in favor of unanimity. At the same time, however, it does not give any state the veto. Every state may retain the right to act, should a consensus not be possible. But any state contemplating deployment would have to face the consequences of its actions. These consequences would include possible counter measures by other states.

Rules for R&D will be influenced by the rules for deployment. An agreement to cooperate over deployment would reduce any advantages to undertaking R&D secretively. In justifying its decision to deploy, for example, a country would need to present evidence that geoengineering would not harm other states. Undertaking R&D openly, and collaboratively would favor a shared understanding of this technology's capabilities and effects. It would promote trust.

The rules I have sketched here are minimal. The main purpose of the protocol would be to provide a restraining influence, a forum for resolving conflicts, and a setting in which various risks can be balanced. Returning to the two scenarios outlined previously, in the case where some countries might be in favor of geoengineering and some against, the consensus rule would create a space for negotiating conflict resolution. In the case where nearly all countries would favor geoengineering, this arrangement would provide the stamp of approval.

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