PLAN B

CLIMATE ENGINEERING TO COPE WITH GLOBAL WARMING

BY LEE LANE

In December 2009, the UN climate summit in Copenhagen ended with little to show for itself but a nonbinding agreement to keep on trying. That was no surprise: After all, 20 years of prior talks had yielded no discernable change in emissions. What is surprising, though, is that so many analysts continue to view climate policy as a thing apart from global power politics. Indeed, one needed really big blinders to miss the fact that the growing rivalry between the United States and China was central to the (in)action in Copenhagen.

Adding geopolitics alters the picture considerably. The most direct (and, to some, the most desirable) means of slowing climate change – by containing greenhouse gas emissions – appears far less practical, while a new approach called climate engineering (or, sometimes, geo-engineering) emerges as a potential winner. To date, the debate about such engineering has focused on the science. I would argue, though, that the central issue is political rather than technical. And while climate engineering faces a variety of hurdles, they are quite different than those facing emissions-containment initiatives – and may prove less challenging.

KEITH NEGLEY (ALL)

CLIMATE POLICY AND POWER

Lloyd Gruber, a political economist at the London School of Economics, offers a taxonomy of power that is a good starting point for thinking about the politics of climate policy. First, Gruber observes, nations can have "go-it-alone power" – that is, they can act without other states' consent. For instance, in 1988, the United States and Canada had go-it-alone (well, go-it-alone with a neighbor) power to create a free-trade zone. Other countries might well have preferred that the two not act without multilateral approval, but they had little choice in the matter; indeed, some ultimately chose to join the agreement rather than face isolation.

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Second, states may be able to block actions they oppose – that is, they may have "holdup power." Technology can determine where holdup power exists. For example, nations have little power to stop satellite-based spying, but plenty of power to block unwished TV signals.

Third is the power to coerce with sanctions or force. Coercion, though, is often costly. It is most likely to work at an acceptable price to the coercer when strong states impose their will on weak ones. And it can take several forms short of military action – for example, states with market power over some vital good or service may threaten to withhold it. But the threat to limit access to a large, rich market is often even more potent. Indeed, the relative size of two states' domestic markets is a key metric of their relative power to use economic coercion.

Power would not matter so much in climate policy if states' interests were harmonious. But in reality, they diverge. India, for example, with a relatively warm climate, will suffer more from further warming than will Russia, which may actually benefit from longer growing seasons, and the availability of new opportunities for oil and gas drilling in the Arctic Sea.

The level of a country's economic development can also matter, and in several (sometimes conflicting) ways. On one hand, a more-advanced economy is likely to depend less on weather-sensitive agriculture and forestry, and it will command more of the wealth needed to cope with harm from climate change once it occurs. On the other, affluence may strengthen environmental values that raise public awareness of climate change and spark demands to halt it.

Greenhouse gas emissions have the same impact on climate whatever their point of origin, and halting the rise of greenhouse gas levels in the atmosphere would require limiting discharges to quite low levels. Thus, to be effective, stringent greenhouse gas controls would have to cover all major regions of the globe. That task demands a global regime. And one, in fact, already exists: the problematic United Nations Framework Convention on Climate Change.

The UN framework convention's widely recognized fecklessness is, in some ways, less of a puzzle than the fact that some other global regimes – for example, the World Trade

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Organization – work pretty well. A regime that tackles a big international problem might, to be sure, hope to offer big benefits, but it is also subject to the challenge posed by the need for collective action. In such cases, each state will be tempted to try to reap the benefits of others' adherence to the rules while seeking to shirk its own obligations. Yet, in the anarchic milieu of world politics, no authority exists to impose and enforce those rules.

How, then, are successful regimes formed and maintained? In the modern era, the answer has largely been that the most powerful state in the global system coerced and cajoled others into joining and obeying. Britain played this role first, dominating the globalization of trade and setting the rules for European investment and colonization. Then, after World War II, the United States took up the mantle in stabilizing international financial flows.

Because of the large size of their economies, these "hegemons" often had stronger motives than other states did to bear the costs of organizing regimes. Moreover, their power gave them the means of enforcing membership and adherence to the rules. Even so, the role could be vexatious.

BARRIERS TO EMISSIONS CONTROL

The task of building an effective greenhouse gas control regime is especially daunting. Count the ways:

1. Contrary to conventional wisdom, the net benefits from even the most cost-effective greenhouse gas controls are likely to be relatively modest if the future gains from curbing climate change are discounted at the interest rates used to discount the gains from other sorts of investments. One recent estimate pegged their "present value" at slightly more than $3 trillion – not a very big number in a global economy with annual output exceeding $60 trillion. To be sure, some analysts reject a formulation in which the welfare of our great-great-grandchildren carries virtually no weight because of the discount rate. But while academic debate continues on the issue the world goes on discounting the future, just as it always has.

2. Reconciling the disparities in national preferences and interests over climate is bound to involve complex bargaining. In principle, those countries most anxious to rein in emissions (at the moment, the European Union nations) could offer side payments to those that are opposed or indifferent (Russia? China? India?). In practice, the prospect of such payments encourages all states to display reluctance in hopes of being paid.

3. The distribution of power among states could hardly be less conducive to an agreement. The states best able to implement controls are those with high and rising emissions and disproportionate bargaining power in world politics. Yet these countries appear to be the ones least exposed to direct harm. Of course, they must still fear spillovers from disease, migration, poverty, crime and government instability. But those concerns have not been acute enough to lead countries to assume the high and immediate costs of greenhouse gas controls.

4. The nature of the task empowers holdouts. Successful controls would require nearly universal cooperation; therefore, go-it-alone power, although it exists, is modest and holdup power dominates. Emerging markets have chosen to exploit this fact by demanding financial transfers as the price for their cooperation. Since they would be the main beneficiaries of controls, they are, in effect, demanding to be paid to help themselves.

5. The current incomplete and fragmented global greenhouse gas control regime serves more to assuage domestic political interests than as a means to achieve concrete national interests. The countries most committed to containment are the ones that have been rich enough for long enough to develop strong green movements. Such movements are, by their nature, inspired more by symbols than by substance; hence, the Kyoto Protocol, an accord that asked nothing from rapidly growing low- and middle-income countries, and thus would have done little to curb greenhouse gas emissions even if it had been honored by the signatories, became the holy grail of green causes. Governments subject to demands of this type have strong motives to substitute pomp for substance.

Evidence that emissions-as-usual could lead to catastrophic climate change – say an explosive acceleration of warming from a destabilizing feedback mechanism – might yet alter this recipe for gridlock. But the operative word here is "might." Unwelcome information is often ignored. And, in any case, bad news wouldn't make much difference if greenhouse gas controls were perceived to be too late to prevent the catastrophe.

Hopes have centered instead on creating a less-unwieldy control regime than that of the UN framework – the G-20 countries, perhaps, or the so-called Major Economies Forum. A simpler structure is clearly a necessary step, but I doubt it would be sufficient to make real progress on global emissions containment.

PLAN B: THE ENGINEERING OPTION

Those concerned about the potential harm from climate change, but mindful of the high cost and dim prospects of greenhouse gas controls, have had little choice but to seek other options. One would be to try to engineer the climate in ways that restrain warming despite the continued rise in greenhouse gas levels in the atmosphere.

This idea is gaining political and technical credibility. The U.S. House of Representatives, the British House of Commons and the European Union have launched investigations of the potential for climate engineering. The Royal Society in Great Britain has recently issued a research report. And several private-sector studies are under way.

While there are other possible ways of managing the approach, the most plausible approaches to climate engineering work by offsetting the heat-trapping effect of greenhouse gases in the atmosphere by reducing the amount of solar energy available to be trapped. Such measures would not lower greenhouse gas concentrations; rather, they would reflect a portion of the incoming sunlight back into space.

To make a difference, the energy mirrored back into space need not be that great. Reflecting 1 to 2 percent of the sunlight that reaches the Earth could roughly offset the warming that is likely to result from doubling preindustrial levels of greenhouse gases. Today's aerosol emissions (a variety of non-greenhouse gas air pollutants) are already offsetting about 40 percent of the warming that man-made greenhouse gas emissions would otherwise have caused. Climate engineering aims to extend the scale of this effect while causing fewer and less costly side-effects.

At least two technologies may offer workable means of offsetting the warming expected in this century. One of them, proposed by Edward Teller (yes, *the* Edward Teller) and his colleagues, involves injecting very fine sulfate particles into the stratosphere. After perhaps a year or two, these particles would fall to the surface in acidic rain or snow. But the quantities would be quite small compared to baseline industrial sulfur emissions, which have much less protective effect because of their large particle size, low altitude and brief stay in the

atmosphere. The global cooling that has occurred in the wake of several volcanic eruptions offers an analogue to this concept and suggests – though it does not prove – that the process could effectively cool the planet.

The second approach, developed by two scientists, John Latham and Stephen Salter, involves lofting a fine mist of seawater droplets into low-level marine clouds. There, the droplets would cause the clouds both to whiten –

that is, to reflect more sunlight – and to last longer before they disperse. Climate models suggest that this approach might cool the planet enough to offset the warming caused by doubling atmospheric greenhouse gas levels.

The somewhat uneven geographic impact of this latter approach would increase the prospects of unwanted regional effects. However, this very unevenness may offer a means of fine-tuning the regional impact of cooling where it would be undesirable.

While the benefit-cost ratio of climate engineering would probably be quite large, there is more to the story because its development costs are almost laughably small in absolute terms.

The rapid emergence of such an option has triggered a diverse range of objections. Some advocacy groups view the control of greenhouse gas emissions as a means to the greater end of defeating materialism and the hubris of attempting to dominate nature. If climate engineering proved to be a technologically viable alternative, it would both delay the need for emissions controls and affirm human command over the climate.

Among climate scientists, reactions have varied. One school of thought has come to regard climate engineering as being much like chemotherapy – no one wants to have it, but everyone wants the option should the need arise. A second camp seems to feel that some research is acceptable, but that large-scale tests would not be; yet a third is ethically opposed to any research.

The potential benefits of climate engineering are very large compared to the likely costs of developing and deploying it. Of course, these net benefits depend on the severity of the threat from climate change and the type of greenhouse gas control regime that would otherwise be needed to achieve the same end. Eric Bickel of the University of Texas has estimated that if climate engineering were held in reserve and used in the event of an emergency, the net benefits of the option would be as high as $14 trillion. Other scenarios yield similarly dramatic estimates.

Against this potential benefit must be weighed several kinds of potential cost. Climate engineering might, for example, change global precipitation patterns. One major concern is the possible impact on India's summer monsoon, which plays a key role in the Indian subcontinent's agricultural productivity. Current models are still too imperfect even to determine the direction of the effect on the monsoon – which, incidentally, may also be threatened by warming.

Climate engineering might generate other unwanted side effects, too. The early use of sulfur aerosols in the stratosphere could delay recovery of the damage to the ozone layer that took place before the successful containment of chlorofluorocarbon gases used in air conditioning. The identified risks appear to be small, however, and the larger fears center on the unknowns in a great ecological experiment.

It is also very important to note that such engineering could not be a complete response to the threats posed by rising greenhouse gas levels. It could do nothing to curb ecological harm from ocean acidification through absorption of carbon dioxide. Further, its effectiveness might well be subject to diminishing returns. It might, however, reduce the need for controls in the short- and medium-terms – and, given the performance of the UN framework convention's process, that might be a boon of no small worth.

While the benefit-cost ratio of climate engineering would probably be quite large, there is more to the story because its development costs – unlike the development costs of virtually all other sorts of large-scale engineering projects – are almost laughably small in absolute terms. Initial research would run to a few tens of millions of dollars per year. Scaled-up experiments would probably cost only a few billion dollars, with much of the money spent on monitoring the system's full range of global effects.

To be sure, a full-blown stratospheric aerosol system would be much more expensive – perhaps more than $50 billion a year, although recent research suggests the costs would be much lower. But even this number is an order of magnitude less than the potential benefits, or the cost of a workable emissions-containment regime.

Note, too, that climate engineering might produce large global net benefits and still cause harm to some regions – for example, from unwanted cooling in countries including Russia. One could imagine, then, the need for side payments from winners to losers to manage international conflicts. And such compensation might well dwarf the direct cost of the climate engineering itself.

Finally, as mentioned above, the impact of climate engineering is subject to large uncertainties. Countries cannot know exactly what will happen as the system is deployed; thus much trial and error will be built into the task of managing the process. New knowledge is likely to suggest new approaches and refinements, and those approaches would require testing – from which further lessons will flow. Each change could alter the distribution of costs and benefits among states, requiring the need for ongoing bargaining over burdens and side payments.

THE POWER POLITICS OF CLIMATE ENGINEERING

While a medium-sized state might well acquire the technology and resources to put in place a global climate engineering system, it would be unlikely to act in the teeth of opposition from the major powers. In contrast, a great power might well persevere even in the face of pressure to halt. For such states, go-it-alone power in regard to climate engineering is far stronger than holdup power. This situation is the opposite of that prevailing with greenhouse gas control: sanctions would be a costly and impractical tool for exercising holdup power against the United States, China, Russia or the European Union.

A military response designed to stop climate engineering is even less plausible; the powers likely to deploy climate engineering are all nuclear states. Remember, too, that at least for the remainder of this century, the cooling needed to limit temperatures to the two-degree-Celsius increase that is widely viewed as acceptable would be relatively modest. The odds are, then, that the potential costs of using armed force will dwarf any perceived harm of allowing neighbors to impose such engineering on others.

Another option may, however, offer a stronger check: climate counter-engineering. Black-carbon emissions could be used to warm the lower atmosphere, and there would be a multiplier effect as the particles fell and the darker color increased the sunlight absorbed on the earth's surface. The technology of counter-engineering is extremely simple: merely taking the particulate filters off coal-

fired electric power plants would generate the desired warming emissions.

Of course, counter-engineering has its downside for the country that attempts it. Today, states pay to avoid black-carbon emissions' impacts on health and property, and it is hard to imagine a democracy resorting to such an option. But authoritarian states might well credibly threaten to release carbon particulates. Russia, the large country with the most to gain from warming, is an obvious candidate.

Some analysts, looking only at predictions that climate engineering will be cheap to deploy, have leapt to the conclusion that unilateral initiatives – say, by China or the United States – pose a grave risk. Their concern is not entirely groundless. But a variety of factors will be working to constrain such a unilateral imposition.

- At some point, climate engineering will reach a stage at which it will become necessary to test the climate's responses to it. As the tests grow in size, the risk of one approach interfering with another would rise. So if more than one country becomes capable of such engineering, there will be pressure for cooperation among them.

- A stable climate is hardly the only objective of sovereign governments, so countries will have good reason to shield the vital interests of their allies in deciding whether or not to deploy climate engineering. The United States, for instance, values a strong, politically stable India. Any plan that would endanger the Indian summer monsoon would, therefore, be a cause for concern by the United States. It follows that, if the United States did choose to go forward with climate engineering, it would be willing to entertain ways to protect India from adverse consequences.

China, to be sure, might be less fastidious in weighing its own benefits against others' costs. But China is economically vulnerable to Western countries; it would not lightly ignore the threat of trade sanctions.

- More generally, global interdependence reinforces open societies' interest in the stability and welfare of other nations. In short, linked markets and mobile populations broaden the definition of enlightened national self-interest. Developed states are increasingly afraid of climate change spillovers from emerging markets, and harmful climate engineering spillovers, whatever form they might take, would be equally unwelcome.

- Democracies are constrained by domestic pressure groups, and they are likely to impose tight limits on climate engineering. In the EU, opposition from the "greens" may sink such proposals entirely. In the United States, the split between a left driven by a quasi-religious commitment to greenhouse gas controls and a right unpersuaded of the seriousness of climate change could yield a similar outcome. Thus, short of a clear global climate crisis, it is hard to see democratic nations acting alone on climate engineering.

- The possibility of climate counter-engineering reinforces the grounds for caution. This may be an effective check on climate engineering go-it-alone power. And at least one technologically advanced country, Russia, has both the capacity and the motivation to use that option, if challenged.

THE ROAD NOT YET TRAVELED

I believe that the United Nations regime focusing on greenhouse gas control is beyond repair. And with emissions containment stalled, the world needs an alternative.

The road to creating an effective climate engineering initiative is bound to be bumpy. To manage such engineering, some structure would have to limit real control to a few of the most powerful states. This may seem unfair, and perhaps it is. What's more, such engineering would open the door to environmental harm that cannot be properly assayed without years of research and testing. But for those of us who believe that climate change might, at some point, pose a grave threat – and that emissions containment is both costly and politically impractical – climate engineering is beginning to look like the last, best hope.