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Can Solar Geoengineering be Part of an Effective Global Strategy to Fight Climate Change?

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"Geoengineering" refers to technologies that people might use to intentionally alter the planet's climate system to address the threat of global warming. One of the most frequently discussed approaches is *solar geoengineering* – blocking some of the sun's energy by, for example, injecting tiny particles into the atmosphere. But solar geoengineering is controversial. Some experts argue that it is a relatively cheap and quick fix for rising temperatures, the most pressing aspect of climate change. But critics point to potential negative side effects that could result from manipulating the climate in this way.

Although much has been written about the potential benefits and drawbacks of solar geoengineering, relatively little systematic evaluation has been done. In a pair of working papers, we modify an economic model of optimal climate policy to include solar geoengineering. Our results show that solar geoengineering can play an important role in the short term by lowering global temperatures while limiting the costs of climate policy. But this is at best an interim solution. In the long run, greenhouse gas emissions must be eliminated.

A Cheap but Unpredictable Alternative

The earth is getting warmer because humans are emitting more greenhouse gases like carbon dioxide. These gases trap heat in the earth's atmosphere. The most obvious and direct way to solve this problem is to stop emitting greenhouse gases. But there are two difficulties. In the first place, eliminating greenhouse gas emissions is neither cheap nor easy to do quickly, because most countries in the global economy depend on burning fossil fuels for energy. Secondly, even an immediate halt to further emissions would not stop the global warming already under way, because accumulated greenhouse gases would remain in the atmosphere and warm the planet for decades.

Solar geoengineering gets around the two difficulties, because it would reduce temperatures not by eliminating greenhouse gas emissions but by blocking a fraction of incoming sunlight to offset the warming spurred by those emissions. How does this work? Sunlight can be blocked by spreading particles in the atmosphere – such as sulfate aerosols – that act as tiny reflectors. This human-made approach mimics what happens naturally to cool the climate after large volcanic eruptions.

As a tool for reducing global temperatures, solar geoengineering could be up to 100 times cheaper than reducing greenhouse gas emissions. And it can work quickly – reducing temperatures nearly instantaneously. However, it comes with drawbacks. Because it does nothing to reduce greenhouse gas concentrations in the atmosphere or the oceans, solar geoengineering does not address serious issues other than temperatures – such as rising ocean acidification. Unpredictable negative side effects could also happen, like disrupting tropical monsoons.

Modeling Solar Geoengineering as a Policy Option

To spell out and weigh these costs and benefits, we use a tool called an "integrated assessment model." This includes both an economic model and a climate model, so it can explore how the climate and the economy affect each other and at the same time examine the impact of various policy interventions. So far, this approach has focused on abatement – greenhouse gas emissions reductions – as the policy of interest. We adapted the approach to consider solar geoengineering as an alternative kind of climate intervention.

Ours is not the first study to model effects of solar geoengineering, but it is the first to probe systematically for the optimal combination of abatement and solar geoengineering in order to provide advice on trade-offs to policymakers. Additionally, to achieve a state-of-the-art analysis, we carefully calibrate the costs, benefits, and risks of solar geoengineering. Our results confirm that solar geoengineering can buy time but not fully replace emission reduction policies. When we simulate optimal policy trade-offs far into the future, over the next 600 years, here is how things could unfold if solar geoengineering is used:

- By using solar geoengineering, humans can modestly reduce the immediate need to reduce emissions.
- Over the longer run, the optimal policy mix must still include substantial emissions reductions and an eventual elimination of emissions entirely.
- The date at which a complete emissions elimination must occur is pushed back by about a decade when solar geoengineering is used, "buying time" for policymakers.

Global temperature increases can be kept substantially lower if geoengineering is used, despite the fact that more carbon would continue to be emitted into the atmosphere. Temperature increases without solar geoengineering would peak at about 3.5 degrees Celsius above pre-industrial levels, but solar geoengineering could limit this increase to just two degrees Celsius (or 3.6 degrees Fahrenheit). Coincidentally, this scenario using solar geoengineering matches the two-degree target recently set by world leaders at the Paris climate change conference.

Next Steps

Although our results must be interpreted with caution and more research is necessary, the analysis provides concrete numerical justification for previously speculative policy ideas. Solar geoengineering has the potential to reduce costs, suppress temperature increases, and lessen global warming risks. However, it would only be a part of a climate strategy, and emissions reductions would also be necessary. Deploying solar geoengineering on a large scale requires a global coordination that has not yet been reached, but it seems likely that this approach will be an important part of successful efforts to combat global warming.

This article is a modified version of: Garth Heutel, "Can Solar Geoengineering be Part of Responsible Climate Policy?," *The Conversation*, December 4, 2015. Read more in Garth Heutel, Juan Moreno Cruz, and Soheil Shayegh, "Solar Geoengineering, Uncertainty, and the Price of Carbon," The National Bureau of Economic Research, July 2015; and Garth Heutel, Juan Moreno Cruz, and Soheil Shayegh, " Climate Tipping Points and Solar Geoengineering," The National Bureau of Economic Research, September 2015.