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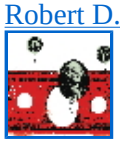

My Inflation Nightmare

Michael Kinsley

Ideas: Energy & Environment **July/August 2009 ATLANTIC MAGAZINE**

Re-Engineering the Earth

As the threat of global warming grows more urgent, a few scientists are considering radical—and possibly extremely dangerous—schemes for reengineering the climate by brute force. Their ideas are technologically plausible and quite cheap. So cheap, in fact, that a rich and committed environmentalist could act on them tomorrow. And that's the scariest part.

By Graeme Wood

I F WE WERE transported forward in time, to an Earth ravaged by catastrophic climate change, we might see long, delicate strands of fire hose stretching into the sky, like spaghetti, attached to zeppelins hovering 65,000 feet in the air. Factories on the ground would pump 10 kilos of sulfur dioxide up through those hoses every second. And at the top, the hoses would cough a sulfurous pall into the sky. At sunset on some parts of the planet, these puffs of aerosolized pollutant would glow a dramatic red, like the skies in *Blade Runner*. During the day, they would shield the planet from the sun's full force, keeping temperatures cool—as long as the puffing never ceased.

Technology that could redden the skies and chill the planet is available right now. Within a few years we could cool the Earth to temperatures not regularly seen since James Watt's steam engine belched its first smoky plume in the late 18th century. And we could do it cheaply: $100 billion could reverse anthropogenic climate change entirely, and some experts suspect that a hundredth of that sum could suffice. To stop global warming the old-fashioned way, by cutting carbon emissions, would cost on the order of $1 trillion yearly. If this idea sounds unlikely, consider that President Obama's science adviser, John Holdren, said in April that he thought the administration would consider it, "if we get desperate enough." And if it sounds dystopian or futuristic, consider that *Blade Runner* was set in 2019, not long after Obama would complete a second term.

Humans have been aggressively transforming the planet for more than 200 years. The Nobel Prize–winning atmospheric scientist Paul Crutzen—one of the first cheerleaders for investigating the gas-the-planet strategy—recently argued that geologists should refer to the past two centuries as the "anthropocene" period. In that time, humans have reshaped about half of the Earth's surface. We have dictated what plants grow and where. We've pocked and deformed the Earth's crust with mines and wells, and we've commandeered a huge fraction of its freshwater supply for our own purposes. What is new is the idea that we might want to deform the Earth intentionally, as a way to engineer the planet either back into its pre-industrial state, or into some improved third state. Large-scale projects that aim to accomplish this go by the name "geo-engineering," and they constitute some of the most innovative and dangerous ideas being considered today to combat climate change. Some scientists see geo-engineering as a last-ditch option to prevent us from cooking the planet to death. Others fear that it could have unforeseen—and possibly catastrophic—consequences. What many agree on, however, is that the technology necessary to reshape the climate is so powerful, and so easily implemented, that the world must decide how to govern its use before the wrong nation—or even the wrong individual—starts to change the climate all on its own.

I F GEO-ENGINEERS HAVE a natural enemy, it is the sun. Their first impulse is to try to block it out. Stephen Salter, a Scottish engineer, has mocked up a strategy that would cool the planet by painting the skies above the oceans white. Salter's designs—based on an idea developed by John Latham at the National Center for Atmospheric Research—call for a permanent fleet of up to 1,500 ships dragging propellers that churn up seawater and spray it high enough for the wind to carry it into the clouds. The spray would add moisture to the clouds and make them whiter and fluffier, and therefore better at bouncing sunlight back harmlessly into space. Salter, who has investigated the technical feasibility of this idea minutely (down to the question of whether ship owners would mind affixing spray nozzles to their hulls with magnets), estimates the cost to build the first 300 ships—enough to turn back the climatological clock to James Watt's era—to be $600 million, plus another $100 million per year to keep the project going.

Roger Angel, an astronomy and optics professor at the University of Arizona, would block the sun by building a giant visor in space. He proposes constructing 20 electromagnetic guns, each more than a mile long and positioned at high altitudes, that would shoot Frisbee-size ceramic disks. Each gun would launch 800,000 disks every five minutes—day and night, weekends and holidays—for 10 years. The guns would aim at the gravitational midpoint between the Earth and the sun, so that the disks would hang in space, providing a huge array of sunshades that would block and scatter sunlight and put the Earth in a permanent state of annular eclipse. Angel's scheme relies on launch technology that doesn't yet exist (no one has ever wanted to shoot Frisbees at the sun before), and would cost several trillion dollars. "I know it sounds like mad science," he says. "But unfortunately we have a mad planet."

Of all the ideas circulating for blocking solar heat, however, sulfur-aerosol injection—the *Blade Runner* scenario—may actually be the least mad. And it provides an illustrative example of the trade-offs that all geo-engineering projects of its scale must confront. The approach is already known to work. When Mount Tambora erupted in Indonesia in 1815 and spewed sulfur dioxide into the stratosphere, farmers in New England recorded a summer so chilly that their fields frosted over in July. The Mount Pinatubo eruption in the Philippines in 1991 cooled global temperatures by about half a degree Celsius for the next few years. A sulfur-aerosol project could produce a Pinatubo of sulfur dioxide every four years.

The aerosol plan is also cheap—so cheap that it completely overturns conventional analysis of how to mitigate climate change. Thomas C. Schelling, who won the 2005 Nobel Prize in economics, has pointed out how difficult it is to get vast international agreements—such as the Kyoto Protocol—to stick. But a geo-engineering strategy like sulfur aerosol "changes everything," he says. Suddenly, instead of a situation where any one country can foil efforts to curb global warming, any one country can curb global warming all on its own. Pumping sulfur into the atmosphere is a lot easier than trying to orchestrate the actions of 200 countries—or, for that matter, 7 billion individuals—each of whom has strong incentives to cheat.

But, as with nearly every geo-engineering plan, there are substantial drawbacks to the gas-the-planet strategy. Opponents say it might produce acid rain and decimate plant and fish life. Perhaps more disturbing, it's likely to trigger radical shifts in the climate that would hit the globe unevenly. "Plausibly, 6 billion people would benefit and 1 billion would be hurt," says Martin Bunzl, a Rutgers climate-change policy expert. The billion negatively affected would include many in Africa, who would, perversely, live in a climate even hotter and drier than before. In India, rainfall levels might severely decline; the monsoons rely on temperature differences between the Asian landmass and the ocean, and sulfur aerosols could diminish those differences substantially.

Worst of all is what Raymond Pierrehumbert, a geophysicist at the University of Chicago, calls the "Sword of Damocles" scenario. In Greek legend, Dionysius II, the ruler of Syracuse, used a single hair to suspend a sword over Damocles' head, ostensibly to show him how precarious the life of a powerful ruler can be. According to Pierrehumbert, sulfur aerosols would cool the planet, but we'd risk calamity the moment we stopped pumping: the aerosols would rain down and years' worth of accumulated carbon would make temperatures surge. Everything would be fine, in other words, until the hair snapped, and then the world would experience the full force of postponed warming in just a couple of catastrophic years. Pierrehumbert imagines another possibility in which sun-blocking technology works but has unforeseen consequences, such as rapid ozone destruction. If a future generation discovered that a geo-engineering program had such a disastrous side effect, it couldn't easily shut things down. He notes that sulfur-aerosol injection, like many geo-engineering ideas, would be easy to implement. But if it failed, he says, it would fail horribly. "It's scary because it actually could be done," he says. "And it's like taking aspirin for cancer."

I N 1977, THE PHYSICIST Freeman Dyson published the first of a series of articles about how plants affect the planet's carbon-dioxide concentrations. Every summer, plants absorb about a tenth of the carbon dioxide in the atmosphere. In the fall, when they stop growing or shed their leaves, they release most of it back into the air. Dyson proposed creating forests of "carbon-eating trees," engineered to suck carbon more ravenously from the air, and to keep it tied up in thick roots that would decay into topsoil, trapping the carbon. He now estimates that by annually increasing topsoil by just a tenth of an inch over land that supports vegetation, we could offset all human carbon emissions.

Dyson's early geo-engineering vision addressed a central, and still daunting, problem: neither sulfur-aerosol injection nor an armada of cloud whiteners nor an array of space-shades would do much to reduce carbon-dioxide levels. As long as carbon emissions remain constant, the atmosphere will fill with more and more greenhouse gases. Blocking the sun does nothing to stop the buildup. It is not even like fighting obesity with liposuction: it's like fighting obesity with a corset, and a diet of lard and doughnuts. Should the corset ever come off, the flab would burst out as if the corset had never been there at all. For this reason, nearly every climate scientist who spoke with me unhesitatingly advocated cutting carbon emissions over geo-engineering.

But past international efforts to reduce emissions offer little cause for optimism, and time may be quickly running out. That's why a few scientists are following Dyson's lead and attacking global warming at its source. David Keith, an energy-technology expert at the University of Calgary, hopes to capture carbon from the air. He proposes erecting vented building-size structures that contain grids coated with a chemical solution. As air flows through the vents, the solution would bind to the carbon-dioxide molecules and trap them. Capturing carbon in these structures, which might resemble industrial cooling towers, would allow us to manage emissions cheaply from central sites, rather than from the dispersed places from which they were emitted, such as cars, planes, and home furnaces. The grids would have to be scrubbed chemically to separate the carbon. If chemists could engineer ways to wash the carbon out that didn't require too much energy, Keith imagines that these structures could effectively make our carbon-spewing conveniences carbon-neutral.

The question then becomes where to put all that carbon once it's captured. Keith has investigated one elegant solution: put it back underground, where much of it originated as oil. The technology for stashing carbon beneath the earth already exists, and is routinely exploited by oil-well drillers. When oil wells stop producing in large quantities, drillers inject carbon dioxide into the ground to push out the last drops. If they inject it into the right kind of geological structure, and deep enough below the surface, it stays there.

We might also store carbon dioxide in the oceans. Already, on the oceans' surface, clouds of blooming plankton ingest amounts of carbon dioxide comparable to those taken in by trees. Climos, a geo-engineering start-up based in San Francisco, is trying to cultivate ever-bigger plankton blooms that would suck in huge supplies of carbon. When the plankton died, the carbon would end up on the sea floor. Climos began with the observation that plankton bloom in the ocean only when they have adequate supplies of iron. In the 1980s, the oceanographer John Martin hypothesized that large amounts of oceanic iron may have produced giant plankton blooms in the past, and therefore chilled the atmosphere by removing carbon dioxide. Spread powdered iron over the surface of the ocean, and in very little time a massive bloom of plankton will grow, he predicted. "Give me half a tanker of iron," Martin said, "and I'll give you the next Ice Age." If Martin's ideas are sound, Climos could in effect become the world's gardener by seeding Antarctic waters with iron and creating vast, rapidly growing offshore forests to replace the ones that no longer exist on land. But this solution, too, could have terrible downsides. Alan Robock, an environmental scientist at Rutgers, notes that when the dead algae degrades, it could emit methane—a greenhouse gas 20 times stronger than carbon dioxide.

Just a decade ago, every one of these schemes was considered outlandish. Some still seem that way. But what sounded crankish only 10 years ago is now becoming mainstream thinking. Although using geo-engineering to combat climate change was first considered (and dismissed) by President Johnson's administration, sustained political interest began on the business-friendly right, which remains excited about any solution that doesn't get in the way of the oil companies. The American Enterprise Institute, a conservative think tank historically inimical to emission-reduction measures, has sponsored panels on the sulfur-aerosol plan.

By now, even staunch environmentalists and eminent scientists with long records of climate-change concern are discussing geo-engineering openly. Paul Crutzen, who earned his Nobel Prize by figuring out how human activity punched a hole in the ozone layer, has for years urged research on sulfur-aerosol solutions, bringing vast credibility to geo-engineering as a result.

With that growing acceptance, however, come some grave dangers. If geo-engineering is publicly considered a "solution" to climate change, governments may reduce their efforts to restrict the carbon emissions that caused global warming in the first place. If you promise that in a future emergency you can chill the Earth in a matter of months, cutting emissions today will seem far less urgent. "Geo-engineering needs some government funding,

but the most disastrous thing that could happen would be for Barack Obama to stand up tomorrow and announce the creation of a geo-engineering task force with hundreds of millions in funds," says David Keith.

Ken Caldeira, of the Carnegie Institution for Science, thinks we ought to test the technology gradually. He suggests that we imagine the suite of geo-engineering projects like a knob that we can turn. "You can turn it gently or violently. The more gently it gets turned, the less disruptive the changes will be. Environmentally, the least risky thing to do is to slowly scale up small field experiments," he says. "But politically that's the riskiest thing to do."

Such small-scale experimentation, however, could be the first step on a very slippery slope. Raymond Pierrehumbert likens geo-engineering to building strategic nuclear weapons. "It's like the dilemma faced by scientists in the Manhattan Project, who had to decide whether that work was necessary or reprehensible," he says. "Geo-engineering makes the problem of ballistic-missile defense look easy. It has to work the first time, and just right. People quite rightly see it as a scary thing."

T HE SCARIEST THING about geo-engineering, as it happens, is also the thing that makes it such a game-changer in the global-warming debate: it's incredibly cheap. Many scientists, in fact, prefer not to mention just how cheap it is. Nearly everyone I spoke to agreed that the worst-case scenario would be the rise of what David Victor, a Stanford law professor, calls a "Greenfinger"—a rich madman, as obsessed with the environment as James Bond's nemesis Auric Goldfinger was with gold. There are now 38 people in the world with $10 billion or more in private assets, according to the latest *Forbes* list; theoretically, one of these people could reverse climate change all alone. "I don't think we really want to empower the Richard Bransons of the world to try solutions like this," says Jay Michaelson, an environmental-law expert, who predicted many of these debates 10 years ago.

Even if Richard Branson behaves, a single rogue nation could have the resources to change the climate. Most of Bangladesh's population lives in low-elevation coastal zones that would wash away if sea levels rose. For a fraction of its GDP, Bangladesh could refreeze the ice caps using sulfur aerosols (though, in a typical trade-off, this might affect its monsoons). If refreezing them would save the lives of millions of Bangladeshis, who could blame their government for acting? Such a scenario is unlikely; most countries would hesitate to violate international law and become a pariah. But it illustrates the political and regulatory complications that large-scale climate-changing schemes would trigger.

Michaelson—along with many others—has called for public research on some possible legal responses to geo-engineering. "It would be a classic situation where the problem should be handled in an official capacity," he says. In practice, that would likely mean industrialized governments' regulating geo-engineering directly, in a way that lets them monopolize the technology and prevent others from deploying it, through diplomatic and military means, or perhaps by just bribing Bangladesh not to puff out its own aerosols. Such a system might resemble the way the International Atomic Energy Agency now regulates nuclear technology.

And since geo-engineering—like nuclear weapons—would most likely be deployed during a moment of duress, legal experts like Victor have urged establishing preliminary regulations well in advance. "Suppose the U.S. or Brazil decided it needed some combination of emissions-cutting and geo-engineering in a sudden catastrophe," Victor says. "How would the rest of us respond? There's been no serious research on the topic. It has to be done right now, and not in a crisis situation." An outright ban on geo-engineering could lead other countries to try out dangerous ideas on their own, just as a ban on cloning in the United States has sent research to Korea and Singapore; it would constrain all but the least responsible countries.

Victor doesn't believe geo-engineering will solve anything by itself, but he expects that ultimately we will have a cocktail of solutions. Perhaps we could start with a few puffs of sulfur in the atmosphere to buy time, then forests of plankton in the ocean, and then genetically engineered carbon-hungry trees. What isn't an option, Victor says, is refusing to fund more research, in the hope that geo-engineering won't be needed.

Thomas Schelling, who won his Nobel Prize for using game theory to explain nuclear strategy and the behavior of states in arms races, shares Victor's frustration about the way geo-engineering has been ignored. Multinational agreements to cut emissions amount to a game of chicken that tends to end unhappily in Schelling's models. The

ideal outcome would be a technology that changes the game. “We just have to consider that we may need this kind of project, and might need it in a hurry,” he says. “If the president has to go by boat from the White House to the Capitol, we should be ready scientifically—but also diplomatically—to do something about it.”

We should keep such images in mind. And they should remind us that, one way or another, a prolonged love affair with carbon dioxide will end disastrously. A pessimist might judge geo-engineering so risky that the cure would be worse than the disease. But a sober optimist might see it as the biggest and most terrifying insurance policy humanity might buy—one that pays out so meagerly, and in such foul currency, that we’d better ensure we never need it. In other words, we should keep investigating geo-engineering solutions, but make quite clear to the public that most of them are so dreadful that they should scare the living daylights out of even a Greenfinger. In this way, the colossal dangers inherent in geo-engineering could become its chief advantage. A premonition of a future that looks like *Blade Runner*, with skies dominated by a ruddy smog that’s our only defense against mass flooding and famine, with sunshades in space and a frothy bloom of plankton wreathing the Antarctic, could finally horrify the public into greener living. Perhaps a Prius doesn’t sound so bad, when a zeppelin is the alternative.

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SaveWorld 2 weeks ago

At the chapter of bad ideas, solar radiation management using sulfur is probably one of the worst. The reasoning is simple:
gases in the atmosphere -> less light -> less photosynthesis -> less vegetation growth -> less water retention -> more drought and floods -> less biomass -> the earth becomes a cold desert
...this is on top of not solving the CO2 issue, of course. It is a decision no one has the right to take.

there are other wealth-producing (hence overall cheaper) way to deal with climate change. I would advise you have a look at TED talks from Willie Smits http://goo.gl/ycAN and Paul Stamets http://goo.gl/V3mr

You should also have a look at the work of Geoff Lawton on greening the desert http://goo.gl/68Yc or how China transformed a desolate arid valley the size of Belgium into a lush fertile food producing place http://goo.gl/qEAr

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