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THE ENERGY CHALLENGE | EXOTIC VISIONS

How to Cool a Planet (Maybe)

By WILLIAM J. BROAD

In the past few decades, a handful of scientists have come up with big, futuristic ways to fight global warming: Build sunshades in orbit to cool the planet. Tinker with clouds to make them reflect more sunlight back into space. Trick oceans into soaking up more heat-trapping greenhouse gases.

Their proposals were relegated to the fringes of climate science. Few journals would publish them. Few government agencies would pay for feasibility studies. Environmentalists and mainstream scientists said the focus should be on reducing greenhouse gases and preventing global warming in the first place.

But now, in a major reversal, some of the world's most prominent scientists say the proposals deserve a serious look because of growing concerns about global warming.

Worried about a potential planetary crisis, these leaders are calling on governments and scientific groups to study exotic ways to reduce global warming, seeing them as possible fallback positions if the planet eventually needs a dose of emergency cooling.

"We should treat these ideas like any other research and get into the mind-set of taking them seriously," said Ralph J. Cicerone, president of the National Academy of Sciences in Washington.

The plans and proposed studies are part of a controversial field known as geoengineering, which means rearranging the earth's environment on a large scale to suit human needs and promote habitability. Dr. Cicerone, an atmospheric chemist, will detail his arguments in favor of geoengineering studies in the August issue of the journal Climatic Change.

Practicing what he preaches, Dr. Cicerone is also encouraging leading scientists to join the geoengineering fray. In April, at his invitation, Roger P. Angel, a noted astronomer at the University of Arizona, spoke at the academy's annual meeting. Dr. Angel outlined a plan to put into orbit small lenses that would bend sunlight away from earth — trillions of lenses, he now calculates, each about two feet wide, extraordinarily thin and weighing little more than a butterfly.

In addition, Dr. Cicerone recently joined a bitter dispute over whether a Nobel laureate's geoengineering ideas should be aired, and he helped get them accepted for publication. The laureate, Paul J. Crutzen of the Max Planck Institute for Chemistry in Germany, is a star of atmospheric science who won his Nobel in 1995 for showing how industrial gases damage the earth's ozone shield. His paper newly examines the risks and benefits of trying to cool the planet by injecting sulfur into the stratosphere.

The paper "should not be taken as a license to go out and pollute," Dr. Cicerone said in an interview,

emphasizing that most scientists thought curbing greenhouse gases should be the top priority. But he added, "In my opinion, he's written a brilliant paper."

Geoengineering is no magic bullet, Dr. Cicerone said. But done correctly, he added, it will act like an insurance policy if the world one day faces a crisis of overheating, with repercussions like melting icecaps, droughts, famines, rising sea levels and coastal flooding.

"A lot of us have been saying we don't like the idea" of geoengineering, he said. But he added, "We need to think about it" and learn, among other things, how to distinguish sound proposals from ones that are ineffectual or dangerous.

Many scientists still deride geoengineering as an irresponsible dream with more risks and potential bad side effects than benefits; they call its extreme remedies a good reason to redouble efforts at reducing heat-trapping gases like carbon dioxide. And skeptics of human-induced global warming dismiss geoengineering as a costly effort to battle a mirage.

Even so, many analysts say the prominence of its new advocates is giving the field greater visibility and credibility and adding to the likelihood that global leaders may one day consider taking such emergency steps.

"People used to say, 'Shut up, the world isn't ready for this,' " said Wallace S. Broecker, a geoengineering pioneer at Columbia. "Maybe the world has changed."

Michael C. MacCracken, chief scientist of the Climate Institute, a private research group in Washington, said he was resigned to the need to take geoengineering seriously.

"It's really too bad," Dr. MacCracken said, "that the United States and the world cannot do much more so that it's not necessary to consider getting addicted to one of these approaches."

Martin A. Apple, president of the Council of Scientific Society Presidents, said of geoengineering at a recent meeting in Washington, "Let's talk about research funding with enough zeroes on it so we can make a dent."

The study of futuristic countermeasures began quietly in the 1960's, as scientists theorized that global warming caused by human-generated emissions might one day pose a serious threat. But little happened until the 1980's, when global temperatures started to rise.

Some scientists noted that the earth reflected about 30 percent of incoming sunlight back into space and absorbed the rest. Slight increases of reflectivity, they reasoned, could easily counteract heat-trapping gases, thereby cooling the planet.

Dr. Broecker of Columbia proposed doing so by lacing the stratosphere with tons of sulfur dioxide, as erupting volcanoes occasionally do. The injections, he calculated in the 80's, would require a fleet of hundreds of jumbo jets and, as a byproduct, would increase acid rain.

By 1997, such futuristic visions found a prominent advocate in Edward Teller, a main inventor of the hydrogen bomb. "Injecting sunlight-scattering particles into the stratosphere appears to be a promising approach," Dr. Teller wrote in The Wall Street Journal. "Why not do that?"

But government agencies usually balked at paying researchers to study such far-out ideas, and even ones that were more down to earth. John Latham, an atmospheric physicist at the National Center for Atmospheric Research in Colorado, told how he and his colleagues had unsuccessfully sought for many years to test whether spraying saltwater mists into low ocean clouds might increase their reflectivity.

"We haven't found a way in," Dr. Latham said of government financing. "It's been a bit dispiriting."

Other plans called for reflective films to be laid over deserts or white plastic islands to be floated on the world's oceans, both as ways to reflect more sunlight into space.

Another idea was to fertilize the sea with iron, creating vast blooms of plants that would gulp down tons of carbon dioxide and, as the plants died, drag the carbon into the abyss.

The general reaction to such ideas, said Alvia Gaskill, president of Environmental Reference Materials Inc., a consulting firm in North Carolina that advocates geoengineering, "has been dismissive and sometimes frightened — afraid that we don't know what the consequences will be of making large-scale changes to the environment."

Dr. Gaskill said small experiments would let researchers quickly pull the plug if such tinkering started to go awry.

Critics of geoengineering argued that it made more sense to avoid global warming than to gamble on risky fixes. They called for reducing energy use, developing alternative sources of power and curbing greenhouse gases.

But international efforts like the Kyoto Protocol — which the United States never ratified, and which China and India as members of the developing world never had to obey, freeing the current and projected leaders in greenhouse gas emissions from its restrictions — have so far failed to diminish the threat. Scientists estimate that the earth's surface temperature this century may rise as much as 10 degrees Fahrenheit.

Geoengineering's advocates say humankind is already vastly altering the global environment and simply needs to do so more intelligently.

Dr. Angel, the University of Arizona astronomer, told members of the science academy of his idea for an orbital sunshade, calling the proposal less important than the goal of encouraging bold thought.

"This could engage a whole generation," he said in an interview. "All I'm saying is, let's start thinking about these kinds of things in case we need them one day." Such visionary plans are still far from winning universal acclaim. James E. Hansen of the NASA Goddard Institute for Space Studies in New York, who attended the talk and strongly advocates curbing emissions, belittled the orbital sunshade as "incredibly difficult and impractical."

Dr. Crutzen, the Nobel laureate from the Max Planck Institute, has also drawn fire for his paper about injecting sulfur into the stratosphere. "There was a passionate outcry by several prominent scientists claiming that it is irresponsible," recalled Mark G. Lawrence, an American scientist who is also at the institute.

The stratospheric plan called for fighting one kind of pollution (excess greenhouse gases like carbon dioxide) with another (sulfur dioxide), though it appeared that any increase in sulfur at the earth's surface would be small compared with the tons already being emitted from the smokestacks of coal-fueled plants.

Dr. Cicerone of the science academy helped broker a compromise: Dr. Crutzen's paper would be published, but with several commentaries, including his own. They will appear in the August issue of Climatic Change. The other authors are Dr. Lawrence of the German chemistry institute, Dr. MacCracken of the Climate Institute, Jeffrey T. Kiehl of the National Center for Atmospheric Research, and Lennart Bengtsson of the Max Planck Institute for Meteorology in Germany.

In a draft of his paper, Dr. Crutzen estimates the annual cost of his sulfur proposal at up to $50 billion, or about 5 percent of the world's annual military spending.

"Climatic engineering, such as presented here, is the only option available to rapidly reduce temperature rises" if international efforts fail to curb greenhouse gases, Dr. Crutzen wrote.

"So far," he added, "there is little reason to be optimistic."

Andrew C. Revkin contributed reporting for this article.