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Oil, Oil, Toil & Trouble

Climatic Engineering

Fred C. Iklé & Lowell Wood

THE POLITICS of global warming is heating up. Activists are often taking sharply opposing sides on nearly every one of the warming issues. Trite and *ad hoc* political arguments intrude unapologetically upon the science of climatology. But thoughtful people prefer to have science to show the way. After all, climate change is not a political fashion. It is about observable alterations in the natural environment of our planet regarding which scientists seek to understand the causes and thus forecast future trends and eventual outcomes.

Unfortunately, among all the issues governments have to deal with, none is as scientifically complex as climate change. Disparate causes, natural and man-made, alter the climate through innately complicated and incompletely understood mechanisms and quite insufficiently mea-

sured networks of interaction. And they do so over timescales which are generally quite long compared to those on which we humans have made precise measurements—or on which we make decisions. Climate, after all, is simply weather averaged over decades to millennia. This intricacy of climate change makes forecasts about global warming seem unreliable. And the seeming unreliability offers a wide berth for endless political disagreements. It makes it easy to disparage as “alarmist” those who warn us of rising sea levels and other compelling consequences of warming.

Yet, the climate change skeptics cannot offer convincing proof as to why we should accept their assertion that global warming is harmless. Their core concern may not be the idea that warming won't hurt us, but rather the growing clamor for costly laws and burdensome regulations meant to curtail greenhouse gas emissions sharply. That such measures are likely to impair economic growth and suppress freedom of action is what troubles the skeptics. China and India adamantly assert that they must expand the use of fossil fuels so that their countries can benefit from economic growth. And in the wealthier democracies, parliamentarians refuse to vote for effective curbs

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on emissions of greenhouse gases lest they antagonize powerful business lobbies or are blamed for raising the price of gasoline and other transport fuels. As Paul J. Saunders and Vaughan C. Turekian observe, multilateral cooperation to impose negotiated limits on greenhouse gas emissions is unattractive: "Absent new technologies, it cannot but limit economic growth."¹

To reduce these concerns about damaging economic growth, "carbon (emissions) trading" has been invented. In theory, it would authorize businesses that can rather inexpensively reduce their carbon dioxide emissions to sell allowances that license expanding businesses to increase their emissions. In practice, carbon trading involves the creation of the equivalent of "fiat money", new scrip to pay for carbon emissions permits which can easily offer opportunities for fraud and corruption. Moreover, "carbon offsets" can be created that purportedly do something equivalent to reduce greenhouse warming but don't actually reduce carbon emissions. In any event, unless the rules of such trading are uniform and universal, such practices will merely drive carbon-emissions-rich activities to *de facto* less burdensome jurisdictions.

The European system for carbon trading provides a lesson. *Washington Post* columnist and author Sebastian Mallaby reports that the European system was captured by lobbies:

Permits were given away rather than auctioned, which was a windfall for incumbent polluters. . . . Equally, the Clean Development Mechanism, set up to allow the purchase of pollution credits from poor countries, has turned out to be farcical. Chinese factories are being engineered to maximize greenhouse emissions, and then reengineered to generate pollution credits by reducing the emissions.²

When considering all of this, keep

in mind some economic fundamentals: Carbon emissions trading will have to become an international, hundreds-of-billions-of-dollars-per-year business in order for it to make a significant contribution to the slowing of emissions-based global warming.³ It has been suggested that the United Nations should monitor this fractional trillion-dollar-per-year business, which brings to mind the bribery and malfeasance of the UN oil-for-food program for Saddam Hussein's Iraq.

THAT CARBON dioxide in the atmosphere may cause global warming is a scientific hypothesis dating back to the 19th century. As Spencer Weart explains in his book, *The Discovery of Global Warming*, the British scientist John Tyndall conducted experiments in 1859 with coal gas, an early product of the Industrial Revolution. He discovered that this gas (primarily methane) reflects heat rays. And when Tyndall tested CO₂ he found that it also reflects heat rays. These thermal-infrared opaque gases, if present in the atmosphere, could cause warming of our planet, Tyndall concluded. Evidently, he had understood the

¹Paul J. Saunders & Vaughan C. Turekian, "Warming to Climate Change", *The National Interest*, No. 84 (Summer 2006), pp. 80.

²Sebastian Mallaby, "Climate Obstacles Ahead", *The Washington Post*, November 26, 2007, pp. A15.

³The costs of carbon emissions must become at least comparable to the present-day prices of fossil fuels themselves in order to price-ration the use of these fuels and thus attain the roughly five-fold emissions reductions over present levels needed to adequately curtail global warming, as predicted by current climate models. Indeed, since observed price-demand elasticities for transport fuels are of the order of 0.1–0.2, prices will have to rise by remarkably large factors in order to attain a five-fold drop in demand, especially as the world economy continues to expand.

principle of the greenhouse effect.

It is fitting that this first explanation of the atmospheric gas-driven greenhouse effect was offered as the Industrial Revolution had just begun to transform our civilization—and our planet. A century and a half later, this transformation has increased the world population sixfold and the world's economic output about thirtyfold. It is plausible that such an enormous expansion of human activity on our planet might change the world's climate, and, indeed, global warming has ascended to a prominent spot on the political agenda of the developed world. Many glaciers have shrunk noticeably, some have disappeared entirely, the permanent Arctic Ocean ice sheet has shriveled, and large regions of permafrost have begun to thaw. Thus, anthropogenic global warming morphed from a possibility recognized by a few scientists into a driver. Humanity began to engineer the Earth in a new way, as its agriculture and urbanization have changed the Earth in ages past. This time, the atmosphere is being altered, rather than land surfaces and watercourses; but the basic principle was identical: The purposeful, large-scale alteration of the physical environment for human ends.

To develop effective policies on climate change we need to recognize that global warming is part and parcel of mankind's historic development. It is now deeply woven into the fabric of economic growth. Breeding stronger horses and building better windmills did not bring about the thirtyfold increase in mankind's economic production since the advent of the Industrial Revolution. It was the steady increase in the burning of coal, oil and natural gas that caused it. Fossil fuel-fired engines have been the sinews of the fabulous economic growth of the developed world.

But as John Tyndall and many scientists since him have explained, by burning fossil fuels we gradually enhance the existing greenhouse effect of the atmo-

sphere—although, if the atmosphere conferred no greenhouse effect, the Earth would be covered almost completely by ice and snow. The inconvenient fact of a growing greenhouse effect has enticed environmental radicals to impute guilt to people who drive gas-guzzling SUVs, politicians who oppose imposition of carbon taxes and promoters of coal-fired power plants. But banging the drums of guilt is fatuous. It impairs our comprehension of climate change and distracts us from useful remedial measures. Restricting the burning of fossil fuels is not the only way to halt global warming, and by itself is unlikely to be sufficient.

As if meant to confuse us further, the “guilt” of burning too much fossil fuel has a politically charged corollary totally unrelated to climate change. We currently need to import oil from Middle Eastern and other countries to slake the thirst for liquid hydrocarbon fuels. Yet to protect our arrangements with some of these countries we deploy military forces at great cost and risk. Most irritatingly, what we have to pay for oil imports enriches countries that often tilt against us in our struggle with terrorism. That importing fossil fuels evokes this political corollary further confuses the debate about global warming. Listen to speeches in Congress. The rhetoric veers from measures to curtail our carbon dioxide emissions to demands that we reduce our current energy dependence on imported oil.

SINCE CLIMATE change ignores national borders, many governments, as well as the United Nations, have tried to establish a worldwide framework for enforceable, national policies. The result has been a cavalcade of international conferences—meetings of the Intergovernmental Panel on Climate Change (IPCC) since 1988, the Earth Summit in 1992 that resulted in the Rio Framework Convention, the 1997 Kyoto

conference and follow-up meetings without end.

Every one of these conferences focused on man-made emissions of greenhouse gases as the current cause of global warming, yet, none of them reached agreement on truly binding targets for reducing these emissions. Decades since the politics of global warming began to heat up, we neither have internationally agreed limits on future greenhouse gas emissions nor the administrative capabilities to implement such limits. A large majority of the nations that agreed to lower emission levels called for by the Kyoto Protocol have failed to stop the increase of their emissions, let alone reduce them to the agreed lower levels. Indeed, at the time of this writing, the global warming conference in Bali has not achieved better results.

Moreover, climate scientists now warn us we cannot be sure that the envisaged future emission controls would stabilize the climate anywhere close to its present state. Instead, we are told that substantially more warming is “locked in” by what has already transpired. We clearly need to find more promising ways to address the whole global warming issue.

The policies discussed to date in the global warming conferences have addressed only half the arena for remedial action—the inside of the “greenhouse.” They seek to end the accumulation of greenhouse gases (principally carbon dioxide and methane) within the atmosphere, where these gasses entrap infrared radiation rising from the Earth-surface and lower atmosphere. This entrapment is akin to the glass cover of a greenhouse that keeps the planted vegetables warmer than if they were left exposed to the open air, by admitting the shorter wavelengths of sunlight while reflecting back into the greenhouse the longer wavelengths of thermal infrared radiation and thus preventing the loss of “trapped” heat.

The other arena for action is out-

side of the “greenhouse.” It offers opportunities for reducing global warming by increasing the fraction of incoming sunlight that is reflected outward by the upper atmosphere back into space. Expressed in the metaphoric language of the “greenhouse effect”, this type of climate geoengineering would put a parasol over the greenhouse to scatter away roughly 2 percent of incoming sunlight, instead of letting this small fraction impinge on our planet’s biosphere through the “greenhouse roof” (which in fact is the Earth’s lower atmosphere). In the language of climate science, such geoengineering would increase by a few percent the Earth’s albedo—the ratio of incoming sunlight reflected back into space relative to the total inbound from the Sun.⁴

Nature routinely varies the local values of the Earth’s albedo by substantial amounts, with clouds being the most familiar and quantitatively most important reflective entities, and ice- and snow-covered regions the next most significant. Episodically, large regions of our planet have been cooled for several years by major volcanic eruptions, which inject millions of tons of fine particulate material—mostly sulfate aerosols—into the stratosphere, where they increase the albedo until they’re slowly removed by natural processes. For instance, the Mount Pinatubo eruption in 1991 caused a cooling of most of the Earth for a few years, of a magnitude which was roughly equivalent to reversing half of the total global warming that occurred during the entire twentieth century.

The idea of artificially increasing the

⁴The current value of the incoming sunlight is approximately one-third. The other two-thirds of incoming sunlight is absorbed at or near the Earth’s surface, and is subsequently re-radiated as thermal infrared radiation, roughly half during the daytime and half at night, for most of the inhabited regions of the Earth.

Earth's albedo is not new. In 1992, a report by the National Academy of Sciences found the prospect of lower stratospheric-based albedo enhancement to be "feasible, economical, and capable. . . ." And it doesn't necessarily have unpleasant side effects. Professor Paul Crutzen, who received the Nobel Prize for his work on atmospheric ozone, wrote in 2005 that climate geoengineering with sulfate aerosols sufficient to offset the global warming caused by a doubling of the atmospheric carbon dioxide content (which might occur by 2100) would probably do less damage to the upper stratospheric ozone layer than did the Mount Pinatubo volcanic eruption in 1991.

Injecting sulfate aerosols into the stratosphere certainly is not the only climate geoengineering option. It's simply the one that occurs most often naturally. For example, the huge eruption of Mount Tambora in November 1815 caused "the year without a summer" in 1816, with frosts in July in New England and famines from crop failures that reportedly led to the deaths of several hundred thousand people in Europe.

In the 1990s, Professor Edward Teller and his colleagues analyzed some of the most promising advanced approaches to climate geoengineering, those aimed at minimizing the amount of materials to be deployed in the upper atmosphere by a careful use of materials better-suited than sulfate aerosols, while also enhancing beneficial side effects, such as reductions in the ultraviolet component of sunlight. They found that various approaches might involve deploying as much as a million tons per year to offset global warming levels anticipated for the later 21st century, with estimated annual operating costs of less than a billion dollars. More recent proposals from Professors Stephen Salter and John Latham offer a remarkably near-term, low cost, almost instantly reversible climate engineering option. It involves the spraying of fine

mists of seawater into low-lying maritime cloud-layers to enhance their albedo for post-injection intervals of a week or so. But deploying mirrors or lenses in space to enhance the planetary albedo or to modify the incident intensity of sunlight—an idea that has been mentioned in newspaper stories—will not possibly be attractive options until space-launch costs become far lower.

RECENT COMPUTER modeling studies led by Stanford's Ken Caldeira suggest that inexpensive, readily implemented geoengineering measures could swiftly and lastingly stabilize at present levels the climate of the Arctic, or of the entire Earth, and could even stabilize these regional or global climates at the cooler levels that prevailed decades ago.

Alas, environmental extremists fiercely oppose any proposal for any type of climate geoengineering. They regard the advocates of geoengineering as doubly guilty. First, because these advocates allege that their proposed measures avert global warming while doing no discernible harm to our planet (a false assertion according to the extremist position); and second, because such geoengineering would reduce political pressure to restrict the burning of fossil fuels. Thus, while several climate geoengineering options promise to be eminently cost-effective, readily available and innately reversible, ideological opposition to them is intensely emotional and remarkably obstinate. Because of this ferocious resistance, no serious experimental research programs have been started by Congress or the always timorous bureaucracies in charge of funding research.

Such willful ignorance is plainly irresponsible. Without some small-scale testing in the "real" atmosphere, not enough data will become available to assess the benefits, costs and side effects of conceptually attractive climate geoengineering

options. Much could be learned about the other half of the global warming story for a tiny fraction of the funds that have been allocated to climate change studies focused on greenhouse gas emissions; that is to say, global warming problems as viewed exclusively from *inside* the “greenhouse.”

The opponents of geoengineering should understand that none of the suggested options is meant to be a free-standing, long-term solution to global warming issues. To keep pace with a *growing* greenhouse effect associated with ever-increasing levels of greenhouse gases, such geoengineering measures would not only have to be maintained indefinitely but also gradually augmented, while the accumulating carbon dioxide in the atmosphere would make the oceans harmfully acidic on multi-century timescales. Most certainly then, we should be intellectually prepared for both—near-term geoengineering and longer-term reductions in carbon emissions. We should continue to pursue all reasonable measures for reducing emissions of greenhouse gases so that longer-term atmospheric levels of these gases are kept within tolerable bounds. And we should more vigorously explore geoengineering options for climate stabilization in the near term and for use in the event of a global warming emergency situation.

It is prudent to prepare for such an emergency, in light of the significant risk that our current or near-term policies for addressing carbon emissions might prove insufficient. At the IPCC’s most recent meeting in November, warnings were voiced that greenhouse gas emissions were substantially outpacing previous estimates, while the Earth’s natural “sinks” for CO₂—forests and oceans, for example—were becoming less effective than previously projected, so that atmospheric CO₂ levels have been rising more rapidly over the past half-decade than forecast even quite recently. The measures actually implemented to reduce

CO₂ emissions have accomplished little, while the world’s total burning of fossil fuels keeps increasing. This should not be surprising. The world population is still growing, mainly in poorer countries, where the people aspire to the lifestyles of the citizenry of wealthy nations. In order to remain in power, governments in developing nations of all ideological persuasions will seek to service these basic human yearnings—a fundamental point about which the Chinese government is charmingly candid.

SO THE task ahead is clear. Programs should be funded to conduct serious research in climate geoengineering and to carefully evaluate the most promising options, while international efforts to curtail greenhouse gas emissions continue. The United Nations’ IPCC could be a forum for commenting on specific geoengineering options and helping to monitor field tests. But maneuverings under varied international umbrellas should not prevent a coalition of like-minded nations from moving ahead with such research. When the research and test results warrant, nations technically capable of implementing specific climate geoengineering options, and willing to provide the necessary financing, might aptly form an *ad hoc* group to carry out the chosen options.

Such a coalition of the capable might include China, India, the Gulf States, the United States and other nations that could suffer significant damage from higher temperatures, rising sea levels or other warming effects. Fossil fuel-exporting nations may also be interested in climate geoengineering as it might temper the current near-frantic character of moves to restrict the burning of fossil fuels. Some nations, however, might oppose any initiative for climate geoengineering unless it has been blessed by the United Nations. Some other nations might object because they surmise that

their own benefits from warming will outweigh the probable damage for them.

LET US admit that even the most successful geoengineering initiatives would leave us with unfinished business. As already noted, we likely need both: effective climate geoengineering and long-term measures for keeping atmospheric levels of greenhouse gases within bounds. The long-term management of greenhouse gas emissions will require a gradual transformation of the worldwide system for meeting mankind's energy needs.

The current fossil fuel-based energy system evolved gradually during the twentieth century as an offspring of the Industrial Revolution. The history of major human energy systems suggests that it may take almost as long to replace this system with the novel energy sources and distribution networks that future generations will need. This historic transition would be greatly facilitated if geoengineering options had been developed and evaluated to provide a safe breathing space in which large-scale substitution of energy sources could take place in a reasonably comfortable and efficient manner.

History teaches that long-range technological forecasting is often a fool's errand. Today, when science and technology are advancing at paces never seen before, it seems especially hazardous to predict over a half-century, let alone a full century, the nature and shape of future energy systems. For instance, less than a half-century ago, nuclear fission and nuclear fusion both seemed to occupy major positions in the early 21st-century

global energy picture. But today nuclear fission labors under a cloud of geopolitical mistrust—problems of safety, cost and risks of proliferating nuclear weapons. On the other hand, nuclear fusion seems to have a perennially brilliant future that might never arrive.

As we are confronted by such uncertainties about the future, the economists among us will remind us that future returns—even seemingly certain ones—must be risk-weighted and then discounted to values of present-time, which is “where” we all live, work—and allocate resources. The practice of discounting is self-evidently rational for businesses or private-sector investors. In these terms, a geoengineering research and assessment program—or *any* long-range energy-related effort—whose perceived benefits might not materialize for a half-century or more may not be regarded as an attractive business investment. For policy decisions on such issues as climate change that can affect the future of a country, or of mankind, it may be useful to create a range of discounting calculations to better inform the decision process, while recognizing that “fat tails” of consequences versus likelihood distributions can render such calculations innately flimsy as decision aids. Thus, wider horizons may be appropriate, as one attempts to apply modern decision tools to problems of war and peace, religiously motivated terrorism, large-scale energy supply, climate change and the host of other painfully complex issues with which heads of state, governments and societies as a whole must grapple over the next several decades. □