MIRRORS IN SPACE, CLOUD-CREATING GHOST SHIPS... CLIMATE CHANGE SCIENTISTS DRAW UP PLAN B

Even if the world does adopt a radical accord to curb emissions, there is still the possibility that it won't be enough to halt disastrous climate change, which is why some scientists are looking at other, more radical means of intervention.

By Mike Scott

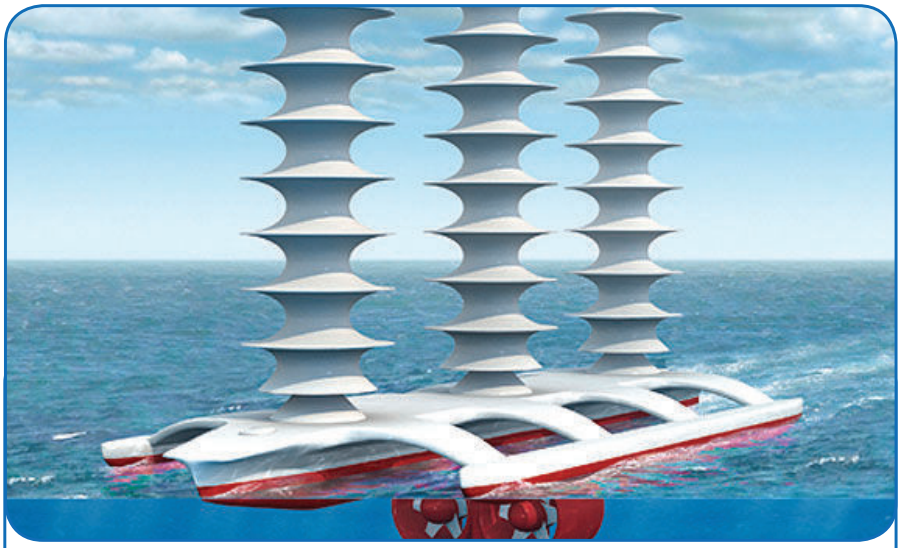
While much of the focus of the environmental community over the last year has been on Copenhagen, a small group of academics and engineers has been concentrating on what might have to happen if the global consensus on climate change fails to make any progress in combating global warming.

Some would argue that is exactly what happened at Copenhagen, while the latest science suggests that even the best possible agreement would not have been enough to prevent dangerous climate change. As a result, a growing number of respected scientists, most notably in the UK, are looking seriously at a "last resort" alternative – geo-engineering.

Proponents of further work on geo-engineering include James Lovelock, creator of the Gaia hypothesis, Sir David King, the former chief scientific adviser to the UK government, and Professor Stephen Salter, one of the founding fathers of the modern marine energy sector.

Both the Royal Society and the Institute of Mechanical Engineering (IMechE) produced reports on the issue in 2009 and it was also considered in the UK Parliament's Science and Technology Select Committee in a unique collaboration with the equivalent committee of the US Congress.

According to the International Risk Governance Council, geo-engineering "is a term which is increasingly used to describe a number of technologies which have the potential to offset the global warming caused by greenhouse gases".



One geo-engineering idea envisages fleets of these wacky-looking ships – powered using rotor sails directly connected to a propeller – spraying a fine mist of salt water into the atmosphere to create more reflective clouds over the world's oceans.

Source: Natural Environment Research Council

The Royal Society defines it as "the deliberate large-scale intervention in the earth's climate system, in order to moderate global warming". There are two main areas of study in the field – CO2 removal techniques that would reverse the build-up of emissions of greenhouse gases in the atmosphere, and solar radiation management (SRM) schemes that involve increasing the earth's albedo (reflectiveness) or reflecting light back into space before it reaches the earth.

The most eye-catching of the latter is a proposal to position an array of giant mirrors between the earth and the sun. "In principle, the climate could be cooled by such a scheme but it is thought that the costs (estimated in the range of $1 trillion) and reliance on as yet undeveloped technologies mean that this proposal is unlikely to be taken further," remarks the UK Parliamentary Office of Science & Technology drily. Nonetheless, Professor Roger Angel of the University of Arizona has recently secured funding from NASA for a pilot project.

Receiving more serious consideration are plans to introduce aerosols into the stratosphere (upper atmosphere), mimicking the effect of volcanic activity such as the 1991 eruption of Mount Pinatubo in the Philippines. The resultant sulphate particles reflected enough solar energy back into space to cool the global climate by an average of 0.5°C over the following 1-2 years. Chemistry Nobel Prize winner Paul Crutzen has argued that reproducing this effect artificially could be used to counteract climate change.

Professors John Latham of the US National Center for Atmospheric Research and Stephen Salter of the University of Edinburgh, one of the key figures in the fledgling wave power industry, have come up with plans for a prototype unmanned wind-powered ship that would spray seawater into the air in order to create more clouds. The idea is based on the principle that a fine mist of sea salt would create more condensation nuclei – the tiny

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particles that determine the number and size of water droplets in a cloud – so creating larger, whiter, more reflective clouds that could, in principle, cool the climate. About 1,500 of the so-called Flettner ships would be needed to undo all of the damage done since pre-industrial times, Salter says, at a cost of about GBP 1m to GBP 2m ($1.6m to $3.3m) per ship.

He has been working on the mechanics of the scheme for four to five years and has "gone about as far as I can go without laboratory tests," he says.

In CO2 removal, the best-known and most commercially-advanced schemes involve "ocean fertilisation", whereby iron is added to particular sites in the ocean where plankton production is limited by a lack of iron. In theory, the resultant bloom of plankton fix CO2 from the atmosphere for their exo-skeletons and a proportion of them die and sink to the sea floor, sequestering the carbon.

Planktos, the highest-profile proponent of the technique, which aimed to generate carbon credits from its operations, had to cease operations in 2008 because of a lack of funding. Climos, another company working on ocean fertilisation, announced the close of a $3.5m Series A round of financing led by Braemar Energy Ventures in March 2008.

The Royal Society report suggested that ocean fertilisation would be "feasible but not very effective" with "high potential for unintended and undesirable ecological side effects", while IMechE did not include it on its list of promising technologies.

Another ocean sequestration scheme is being developed by Tim Kruger of the Oxford Geoengineering Institute and a company called Cquestrate. Its scheme involves the counter-intuitive measure of heating limestone to a very high temperature until it breaks down into lime and CO2.

"Then you put the lime into the sea, where it reacts with carbon dioxide dissolved in the seawater," says Kruger. "When you put lime into seawater it absorbs almost twice as much CO2 as is produced by the breaking down of the limestone in the first place.

This has the effect of reducing the amount of carbon dioxide in the atmosphere. It also helps to prevent ocean acidification." His company has received two rounds of funding from Shell through the oil major's Gamechanger programme.

IMechE identifies three promising technologies – forests of "artificial trees" that remove CO2 from the atmosphere, only several thousand times more effectively, photo bioreactors in buildings than not only absorb CO2 but can also be periodically harvested for use as biofuel, and reflective or white buildings, which would increase the albedo in a specific area. This last suggestion may be the least effective solution from a geo-engineering perspective but it could be the most widely-adopted because it is cheap, straightforward and it reduces the impact of urban heat islands and thus the need to use electricity for cooling.

Geo-engineering remains the stuff of science fiction for many people but those involved in the field say that it is not the science that is the limiting factor but the political will. "No-one would enter into geo-engineering willingly," says Kruger, while the Royal Society describes it as a Plan B if we fail to deal with emissions adequately.

"The safest and most predictable method of moderating climate change is to take early and effective action to reduce emissions of greenhouse gases. No geo-engineering method can provide an easy or readily acceptable alternative solution to the problem of climate change," it says.

Nonetheless, many people are wary of the field because of its potential to create moral hazard and distract attention from ongoing efforts to cut emissions. In addition, sceptics claim it offers an alternative to mitigation efforts – something that the American Enterprise Institute, for example, is doing with some gusto.

Geo-engineering projects will of course need to be enormous to be effective – Kruger's plan, for instance, would require 10 cubic kilometres of limestone every year. This means they will be very costly and will likely have knock-on effects on other areas of the climate, ecosystems and the atmosphere. Lawrence Livermore National Laboratory in the US suggests that SRM techniques would affect the hydrological cycle and would do nothing to reduce emissions and so would have to be maintained indefinitely. They would also affect the viability of solar PV generation projects by reducing the amount of light available to them.

Any efforts to geo-engineer the planet would raise major international legal and geopolitical issues, notes the UK Parliamentary Office of Science & Technology. Many prominent scientists argue that research in the area should be as international as possible. "This would give all governments greater confidence in the results and allow costs to be shared. In addition, perceptions of international research will not be affected by the policy aims of any specific country," it added.

Some people say that the global nature of geo-engineering projects means that they should not be undertaken on a commercial basis, although Kruger asserts that "if geo-engineering were to work it would be something that would have to be done on a very large scale so it would involve significant economic activity".

Current funding for geo-engineering is limited, with less than $1m of public money directed towards the sector in the US. In the UK, the Engineering and Physical Sciences Research Council has proposed an "Ideas Factory" to be held in March, with up to £3.5m ($5.7m) available to fund research projects, while in the US, scientists interested in the area will gather in California at an event organised by the Climate Response Fund. ■

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