November 2009

Briefing Note

Geoengineering

Friends of the Earth

Friends of the Earth position paper on managing carbon sinks and solar radiation

Introduction

It is certain that we are committed to a global temperature rise of about 1.4 degrees even if greenhouse gas emissions were stopped immediately (which clearly is not feasible). Some research papers have suggested that it is even possible that we are already committed to a global temperature rise greater than 2 degrees due to carbon already emitted and the likely decrease in aerosol pollution which is currently providing a cooling effect. However this research assumes that other greenhouse gases such as methane remain constant, which is not a given in practice[i]. A theoretical possibility therefore remains for keeping temperature rises below the 2 degree danger threshold identified by the EU and the G8, although the scale of greenhouse gas emissions reductions required are far beyond that so far contemplated by politicians.

For example, to have a 70 per cent chance to avoid 2 degrees the UK would need to make emissions reductions in the order of 70 per cent emissions cuts by 2020[ii], alongside similar reductions in other developed countries, whereas UK politicians have so far only indicated a willingness to cut emissions by between 34-42 per by 2020, and even these targets allow some offsetting. It is the lack of political will to reduce emissions, coupled with the carbon pollution already emitted, which is leading to scientists calling for greater research into geoengineering options to remove carbon from the atmosphere or reflecting greater amounts of solar radiation out to space.

This briefing looks at the most commonly cited geoengineering options. These options are not offered as alternatives to mitigation (reducing the release of carbon). Friends of the Earth, and leading scientists studying geoengineering options[iii], believes that making rapid carbon reductions is the priority but that geoengineering may have some necessary role in supplementing this action.

It should also be stated that the 2 degree threshold identified by governments was a political judgement that has been interpreted as an acceptance, as least by rich countries, of temperature increases below this threshold. A global 2 degrees increase will have a significant impact on people, especially poorer communities, will have a devastating impact on the marine environment through the acidification of oceans and the destruction of the marine food supplies that hundreds of millions depend on. It will also have a very significant negative impact on global biodiversity. A 2 degree global average rise also hides differences, with land warming faster than seas, and some regions warming faster than others.

Scientific understanding has moved on since the 2 degree threshold was first suggested, with an understanding now that the impacts of 2 degrees are likely to be much greater than originally envisaged and that a threshold of 1 to 1.5 degrees would be more appropriate (diagram 1).

Our ability to reduce temperatures without geoengineering is limited, as carbon cycling leaves around 35 per cent of carbon present in the atmosphere for 100 years and 20 per cent for 1000 years. In other words, even with very significant mitigation effort far in excess of that being contemplated at present global carbon dioxide concentrations will not return to pre-industrial levels for millennia[iv]. Research has also suggested that temperature increases are largely irreversible for 1000 years even as global carbon concentrations fall[v].

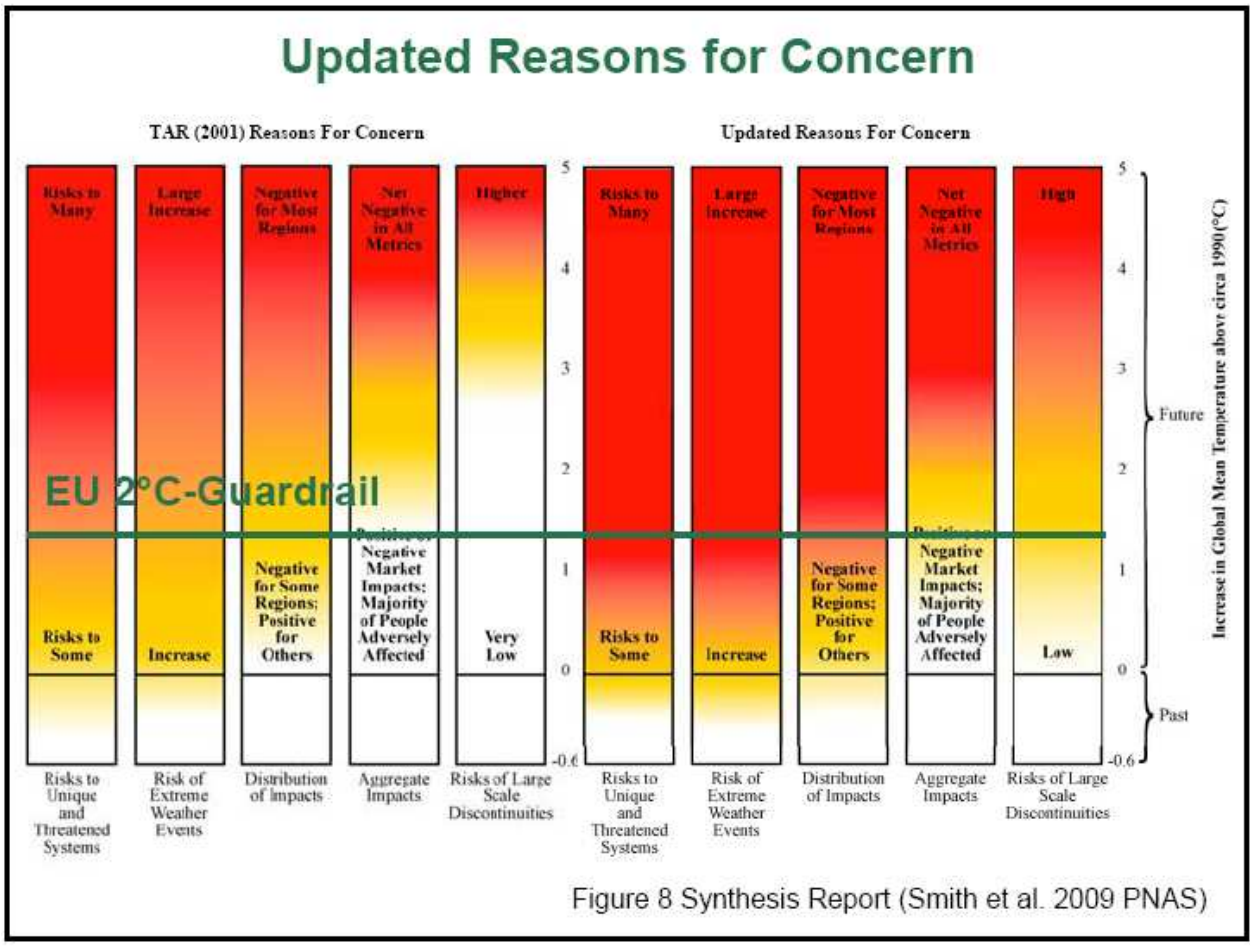

Diagram 1 – impacts of 2 degrees now thought to be much greater than they were in 2001

Geoengineering – the options

The Royal Society in the UK has carried out an extensive review on geoengineering options[vi]. The geoengineering options most suggested are listed below in 2 categories; carbon sink management that removes carbon from the atmosphere and management of solar radiation which reflects radiation back to space.

Carbon sink management

- Bio-char production[vii], afforestation and biomass with CCS are all options that involve using plants to capture carbon and then storing it. Bio-char involves producing charcoal from plant material and incorporating this into soil. As bio-char is resistant to decomposition by micro-organisms it decomposes over a much longer period and hence stores the carbon in soil. However more research is needed on how long the carbon remains in soils in practice in different conditions and the impact on soil productivity of large additions of bio-char. Afforestation is well understood and a straight-forward carbon-capture technique, although afforestation in some areas may have a negative climate impact, for example afforestation of snow covered areas reduce the amount of solar radiation reflected back to space. Biomass with carbon capture and storage involves capturing carbon in plants, burning it to make energy, and capturing the carbon from the exhaust fumes to store it in aquifers or old oil wells for example. The storage capacity for safely storing large amounts of carbon is not known, although the IPCC has suggested that it is likely to be large. The greatest challenge of all these plant-based carbon storage techniques is land availability. Large-scale afforestation, bio-char production and biomass production run headlong into land-use conflicts with food production and biodiversity protection. The Royal Society suggests that the carbon impacts of all of these techniques are limited.
- Chemical air capture of carbon involves using chemicals to capture carbon dioxide as the air passes over a chemical and then storing the carbon in oil wells or aquifers. The technique is straight-forward and the Royal Society suggest the potential for carbon removal is high. However the main drawbacks are a) the very high cost and b) the requirement for renewable

energy in competition with renewable energy for fossil fuel replacement. The latter could theoretically addressed by generating renewable energy close to storage sites where it is remote and impracticable to use for other uses.

- Ocean pipes & pumps are suggested to enhance ocean upwelling or down-welling and thereby increase deep-sea carbon storage, however the impact of these are considered to be negligible.
- Altering ocean chemistry through adding nitrogen, phosphorus, iron or carbonate has been suggested using the ocean as a sink to store carbon. The very large downsides of these techniques are the potentially very significant changes to ocean ecosystems. In addition the impact of these techniques is considered to be low.
- Mechanical weathering of rocks is suggested to accelerate the natural removal of carbon dioxide from the air that occurs over thousands of years. However it is thought that it would take around 2 tonnes of rock to remove 1 tonne of carbon dioxide. The extraction of rock would involve significant energy and create significant local environmental and social impacts.

In addition to these techniques, better soil management techniques can provide an additional method for carbon capture (as well as for better soil productivity), and there is now research being carried out on growing algae, for example, in tubes mounted on buildings, to create a source of biomass that does not generate land conflict issues. The impact of these on global carbon levels will be limited but nonetheless useful.

Management of solar radiation

- Solar shades in space have been suggested to reflect solar radiation away from reaching the Earth. The energy this requires and the practicalities of it are an enormous barrier. For example it has been suggested that to construct a solar-shade of sufficient size would require over 100,000 rocket launches per year.
- Increasing reflectivity of clouds through spraying sea water from specially designed ships has been suggested as a relatively cheap method of geoengineering compared to, for example, chemical air carbon capture and storage. However there are only a few areas across the globe where this could be implemented so it would only result in a regional reduction in temperatures rather than a uniform global reduction. The impact of carrying out this technique is poorly understood. It also brings unknown risks to regional weather patterns with consequent risks to regional food production and ecosystems.
- Injecting aerosols into stratosphere as happens when volcanoes erupt has been suggested as a very cheap method for having a significant impact on global temperatures quickly. However the risks are poorly understood and could be very considerable, for example significant disruption of the Africa or Asian monsoons upon which billions of people depend upon for their food production.
- Increasing albedo (reflectivity) of urban areas by painting roofs white, for example, is thought to have negligible impact on global temperatures but potentially may be useful as a local adaptation strategy for hotter temperatures by reducing the heat island in cities. This may compete with the use of city roofs for solar pv and solar thermal renewable energy production.
- Increasing albedo of crops has also been suggested through plant breeding or GM technology, however big questions remain about whether this can be done without impacting on the ability of crop photosynthesis and hence food production. The impact is thought to be very small.
- Increasing the albedo of deserts has also been suggested utilising reflective materials however the scale of material that would be required to have any worthwhile impact is vast, and the challenges of preventing degradation of the materials electiveness by dust and dirt, make this a very expensive option.

Discussion

A failure to reduce carbon emissions means that ecosystems and especially the poorest people in the World are already suffering from man-made climate change. The chance of avoiding the 2 degrees threshold is fast slipping away. Geoengineering options are being suggested to prevent global temperatures going far beyond 2 degrees because the impacts of greater global temperature will be devastating. Without significantly greater carbon reductions than envisaged currently by politicians many of these impacts could be felt within this century. A global temperature increase above 2 degrees is likely to lead to global sea level rises of 7m or more over following centuries.

The Royal Society in the UK has identified that governance issues urgently need addressing. There are no criteria developed and agreed yet to assess the desirability of geoengineering options. Governments should begin a dialogue process between themselves and with their electorates to develop criteria to guide decision making. There are also significant ethical and liability issues that have yet to be addressed. Other significant issues include the continuous monitoring and maintenance of carbon storage sites over many generations, or continuous management of solar radiation management. All these issues need to be addressed as a matter of priority.

Of the two types of geoengineering options, carbon removal from air is less problematic than management of solar radiation in Friends of the Earth's view because it addresses the root cause of the climate change problem which is too much carbon in the atmosphere. Solar radiation management fails to deal with higher carbon concentrations and the associated problems, such as the acidification of oceans.

The use of large-scale afforestation, bio-char production and biomass carbon capture and storage have some limited carbon reduction potential but there are very significant land use issues associated with these. These geoengineering techniques could seriously compete with land needed to produce food (the quantity of land required varies hugely dependent on diet) and land for the protection of ecosystems. Until these land-use issues are better understood Friends of the Earth cannot support the use of large-scale afforestation, bio-char production and biomass carbon capture and storage.

Chemical air capture of carbon is the most promising carbon reduction option, although some research is still needed into safe storage sites. This is a very expensive option which is far more costly than mitigation. However rich countries have already far exceeded their fair share of "environmental space" through releasing far more than their fair share of carbon emissions over the last 200 years. If safe storage sites can be identified rich countries should carry out significant air capture of carbon, in additional to very significant cuts in emissions[viii]

The following air capture techniques should be rejected in Friends of the Earth's view: the accelerated mechanical weathering of rocks to absorb carbon due to the apparent significant negative energy and site-related impacts yet limited impact on sequestering atmospheric carbon; ocean-pipes because they will have negligible impact on carbon levels; and altering ocean chemistry because of the significant negative impacts on marine ecosystems.

For the solar radiation techniques solar shades remains the stuff of children's sci-fi films. Increasing the albedo of deserts is impracticable. Increasing the albedo of clouds deserves some further research particularly on any impacts on regional weather patterns, but not in preference of more promising techniques.

Injection of aerosols could bring global temperatures down quickly at low cost but it brings very significant unknown risks to global weather systems and food production, for example it may negatively disrupt the Asian and African monsoons which are essential to agriculture and water availability for billions of people. Also it does not address issues such as ocean acidification. For these reasons alone Friends of the Earth opposes the use of this technique. There are significant political risks also associated with this option as some politicians may see this option as a 'get out of jail free' option that reduces pressure for mitigation and provides a low cost option. This is despite any lack of evidence that this option can ever be utilised with no unacceptable side effects.

There is a risk with all of the cheaper geoengineering options that they distract attention from mitigation. However the evidence from scientists is that mitigation need to be pursued with much greater urgency and that in addition to mitigation some of the geoengineering options may need to be pursued to keep global temperatures to below 2 degrees or less.

Conclusion

Friends of the Earth condemns the lack of action by rich countries to significantly reduce carbon emissions since they signed the UN Climate Convention in 1992, and indeed from the 1970s and 80s when politicians were warned about the danger of carbon emissions to the climate. Concentrations are now too high in the atmosphere and are leading to unacceptable impacts on especially the

poorest communities in the World.

Mitigation has to be the priority for action, action far in excess of currently being considered by politicians is needed. It is now clear that mitigation alone cannot keep global temperatures below a safer threshold of 1-1.5 degrees above pre-industrial levels. However many of the geoengineering options suggested are totally unacceptable due to the adverse environmental or social impacts they bring or risk bringing.

Large amounts of chemical air capture of carbon and storage – funded and carried out by rich countries – will probably be necessary, as long as safe storage sites can be identified and governance issues addressed. This should be in addition to significant reduction in emissions. Research into increasing the albedo effect of clouds is worth carrying out but not at the cost of mitigation or more promising air capture techniques, and only once a governance regime is agreed.

Friends of the Earth opposes injection of aerosols. We also currently oppose the large-scale use of afforestation, biomass with carbon capture and bio-char until land use competition issues with food production and biodiversity are solved. And we oppose the GM modification of plants to enhance the albedo affect due to the unknown risks associated with GM technologies.

Carbon sink geoengineering options should not be included within carbon markets because they are not yet proven to work over the necessary timeframe (thousands of years), also doing so would distract from mitigation which is the priority. Solar radiation geoengineering does not reduce carbon levels and therefore cannot be included in carbon markets.

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[i] Ramanathan & Feng (2008), On avoiding dangerous anthropogenic interference with the climate system: formidable challenge ahead, PNAS 105 (38), 14245-14250

[ii] Whether the UK is able to deliver 70 per cent cuts in 2020 in practice is unclear, it would certainly be an unprecedented rate of reduction. It it were unable to make such cuts then it would need to fund cuts in other countries, in addition to its financing obligations of developing countries low carbon development due to its historical responsibility for the quantity of CO2 within the atmosphere.

[iii] Lenton& Vaughan (2008), A review of climate geoengineering options, Tyndal Centre for Climate Change Research, UEA

[iv] Dependent on the peak concentration and rate of decline it is possible that emissions will not decline to the level of 350 CO2 or less advocated by scientists James Hanson and others for at least a 1000 years. For example, Solomon's work (see below) indicates that at peak at 450 CO2 (500-550 CO2e) followed by complete cessation of emissions may return CO2 levels back to 350 CO2 by the end of the millenium. A peak at 410 CO2 (450 CO2e) with complete cessation afterwards would result in a decline to around 330 CO2 by the end of the millennium. Current CO2 levels are about 385 CO2.
To avoid 410 CO2 (which gives a 50:50 chance of avoiding CO2) would require living with a carbon budget of around 1400 GtCO2 between 2000 and 2050 and none after (of which around 230GtCO2 were used between 2000 and 2006). A tougher budget to give a 75 per cent chance of avoiding 2 degrees would require a budget of 1000 GtCO2 and result in a lower peak in concentrations, but would require something like a global cessation of carbon emissions by around 2020-2030 which seems unlikely. Removing CO2 for the atmosphere (negative emissions) may buy some time to achieve zero emissions.

[v] Solomon et al (2009), Irreversable climate change due to carbon dioxide emissions, PNAS, 106 (6) 1704-1709.

[vi] The Royal Society (2009) Geoengineering the climate. Science, governance and uncertainty.

[vii] In this context, biochar production excludes the traditional small-scale rotation methods of slash & burn carried out in many parts of the world which in themselves are likely to enhance carbon stored in soils.

[viii] This storage space is already being earmarked for carbon captured by existing fossil fuel plants (coal, gas, cement) without the limits to safe storage being fully worked out. Friends of the Earth recognises that to make big reductions in emissions quickly it will be necessary to use carbon capture from fossil fuel plants as a transition is made to a renewable powered future. Because storage space is limited we do not believe that the development of carbon capture technology should be used as an excuse to expand the production of fossil fuel energy, or overly prolonging its use.