ENVIRONMENT

ENVIRONMENT POLICY STATEMENT: 09/02

GEO ENGINEERING

Institution of MECHANICAL ENGINEERS

Global CO_2 emissions have risen 30%[1] since the UN Framework Convention on Climate Change (UNFCCC) was agreed in 1992 and continue to rise at 3% per annum[2,3]. Without radical changes in energy sources and usage, global economics and human behaviour dangerous climate change resulting from global warming is projected to occur in just over thirty years[4]. It is therefore vital policy makers consider all possible approaches to combating climate change and it is the duty of governments to protect their citizens against its consequences.

Geo-engineering offers another potential cost-effective approach to combating global warming (alongside mitigation and adaptation). Put simply, geo-engineering involves large-scale human intervention in the Earth's climate system by either removing CO_2 from the atmosphere or reducing the amount of solar radiation that is absorbed by the atmosphere. Despite this, there is no significant public funding of research into the potential for geo-engineering to combat global warming or its practical feasibility[5,6].

Given its potential to combat climate change and the continuing increase in global emissions, the Institution of Mechanical Engineers urges the Government to do more to support geo-engineering. In particular, IMechE recommends:

- **Government instigate a comprehensive assessment of geo-engineering** approaches through a national programme of publicly funded research and development;
- **We use the resources we already have**. The Tyndall Centre should lead, co-ordinate and deliver a multi-disciplined programme which needs to bring together climate scientists, modellers, engineers, economists, social scientists and philosophers;
- **Promising geo-engineering approaches be piloted**. Geo-engineering programmes that show the most promise should be taken through to a pilot phase to enable their practical potential and risks to be accurately assessed;
- **A realistic roadmap for decarbonisation of the global economy be developed integrating geo-engineering**. Building on knowledge acquired through a rigorous comprehensive technology assessment the Institution recommends that a roadmap to implementation be devised for a global transition to a low-carbon future incorporating geo-engineering.

GEO-ENGINEERING

Despite stark warnings from scientists about the consequences of global warming and worldwide mitigation efforts, fossil fuel CO_2 emissions have grown by more than 30% since the UN Framework Convention on Climate Change was agreed in 1992. As such, policymakers must consider all possible approaches for combating dangerous climate change; governments have a duty to protect their citizens against its consequences.

So far the efforts of scientists, climate modellers, policymakers, governments, engineers and social scientists have concentrated on:

- Understanding the Earth's climate system and how human activity influences it;
- Reducing global greenhouse gas emissions (mitigation);
- Adapting to the inevitable effects of climate change in the near to medium term (2020–2100).

However, the possibilities of geo-engineering as a third option for combating climate change has largely been ignored to-date. Understanding of geo-engineering's potential is therefore fairly limited.

With emissions continuing to rise and climate change deals yet to bear fruit[2,7], it is increasingly important to explore geo-engineering's potential role. The mechanisms to achieve a geo-engineering approach are conceptually straightforward. They may involve physical, chemical or biological interventions; for example, shading or reflecting sunlight[8], stimulating plankton growth in the ocean[9], or removing CO_2 from the air[10]. As such, geo-engineering has the potential not only to reduce CO_2 or cool the planet but do so cost effectively.

WHAT IS GEO-ENGINEERING?

Geo-engineering is an approach to climate change that involves large-scale human intervention in the Earth's climate system. This can be done in one of two ways:

- by either removing greenhouse gases (primarily CO_2) from the atmosphere
- or by reducing the amount of solar radiation that is absorbed by the climate system, known as Solar Radiation Management (SRM).

As such, geo-engineering can complement existing approaches to climate change (namely mitigation and adaptation). Generally, methods that remove CO_2 from the atmosphere are considered less risky than SRM, which may result in wide ranging side-effects.

At this stage it is important to carry out research and development at the feasibility level so that as a nation the UK is technically informed of the potential of geo-engineering. This will not only allow the UK to lead the world in geo-engineering if it fulfils its potential but also participate in any international or bilateral discussions, or indeed discussions with individual entrepreneurs who wish to bring the approach forward. Secondly, given the lead times likely to be associated with the development of engineering schemes on this scale it is important to instigate research and assessment activity so that the technical community can be prepared for the potential 'emergency' deployment of geo-engineering systems should they be required to do so.

Some organisations have rejected geo-engineering out of hand without sufficient evidence. The large scale nature of geo-engineering interventions may result in complex and far-reaching consequences and these should be adequately investigated as part of a complete assessment. In its Fourth Assessment Report11, the Intergovernmental Panel on Climate Change (IPCC) highlights that the options put forward, to date, remain largely speculative. The other key concern about the further exploration of geo-engineering approaches, largely voiced by green organisations and a number of scientists researching the concepts, is that it could divert funding, public attention and specialist expertise away from mitigation and adaptation. A similar concern is that further work in this area could provide countries which are not keen on getting a global agreement on mitigation with an excuse for doing nothing.

There is currently insufficient information to adequately support an informed debate on this topic and a pressing need to know more about the effectiveness, side-effects, feasibility, cost and potential risks before the approach can be adequately evaluated for the formation of robust government policy. Mechanical engineers will play an essential role in assessing geo-engineering proposals and the conversion of concepts into practical working devices and machines. The engineering profession will need to inform policymakers and the public of the practical potential of geo-engineering schemes, but the question of whether these technologies should be implemented or not requires a number of other issues also to be addressed; issues such as the wider environmental impact (particularly in relation to CO_2 removal schemes that involve major interference in eco-systems, such as ocean fertilisation), social, ethical and moral questions.

"CO_2 EMISSIONS FROM FOSSIL FUELS HAVE GROWN BY MORE THAN 30% SINCE 1992.

CURRENT GEO-ENGINEERING RESEARCH

Geo-engineering approaches to combating global warming originate largely from North America where they have been actively pursued by a number of highly motivated and interested scientists. However, most of the research to-date has been relatively small scale and none of the work, either in North America or UK, has received public funding[5,6]. The view that more research into geo-engineering is warranted is reflected by an increase in the number of workshops and meetings being held on the topic. Notably, The Royal Society has recently published a special volume of papers on the subject[12] and is about to publish a wide ranging review of the approach. In addition, the EPSRC is planning to have a 'geo-engineering ideas factory' in autumn 2009, which is an exercise in encouraging proposals in this area, and has set aside £3 million for this[6,13].

THE UK GOVERNMENT'S APPROACH TO GEO-ENGINEERING

The potential options for geo-engineering are slowly gaining prominence both in the media and government. However the UK Government's current approach can be described as ambivalent. Although the government regards its priority as continuing to focus on emissions abatement[6,14,15], it recognises that the challenge of significantly reducing greenhouse gas emissions is great and the risks associated with failing to do so are high. The Government therefore considers that some further research on geo-engineering approaches is merited, particularly in the area of desk studies, theoretical thinking and climate model-based studies[6,15]. Despite this, the UK Government still considers geo-engineering a low priority. Indeed, Joan Ruddock MP, then Under-Secretary of State at DECC stated in November 2008 "I regard [geo-engineering] as being somewhere down the list of priorities and potentially a Plan B."[5].

A key concern of government is that most of the types of geo-engineering approaches being proposed would require international agreement[6,15]. Indeed, implementation could not be done in one country without consequent effects in others. So in the Government's view if the global political community has failed to bring the world together to implement mitigation, which is a well understood need, it is unlikely to succeed with the far more complicated issue of geo-engineering approaches[6]. However, circumstances might be quite different by the time the global community reaches a point where geo-engineering is seriously considered for implementation; in this respect it might be an emergency situation in which the motivation for global cooperation is considerably greater than today.

The Government's ambivalence to geo-engineering may well be because it does not wish attention to be diverted from its mitigation goals. However, two decades of failed global mitigation efforts should be a wake-up call. It could be geo-engineering that provides the global community with those extra years to introduce effective mitigation and adaptation strategies and, in the long term, remove some of the existing CO_2 from the atmosphere. As such, Plan B needs to be upgraded to become a fully integrated part of a comprehensive three-point approach embracing Mitigation, Adaptation and Geo-engineering; a 'MAG approach' to policy. If certain geo-engineering techniques require research and testing, we should not wait until it's too late for them to have lasting effect.

At present geo-engineering is barely visible to industry in the UK. Given this low-level of interest and the inherent high financial risks involved it is likely that government funding would be needed in the early stages of testing. However, depending on the technology, it is possible that some forward thinking industries might take an interest and invest in R&D to prepare for a potential emerging market. A major issue for industry would be the potential for profit if a technology was successful. A globally recognised price for carbon might provide a financial incentive for some sequestration technologies. However for schemes that increase the albedo or reflect incoming solar radiation away from the earth the mechanisms for rewarding private investors would be harder to determine. It is therefore unlikely for a private company to consider such an option without direct government involvement.

POLICY RECOMMENDATIONS

1. **Geo-engineering research be supported**. The Institution of Mechanical Engineers calls upon the Government to support a national programme of geo-engineering feasibility research and development in an international context. As little as £10m could provide us with more reliable quantitative understanding of the effectiveness, risks and costs of geo-engineering, as well as the ethical, governance and moral perspectives associated with it. This needs to bring together climate scientists and modellers, engineers, economists, social scientists and philosophers. Given the urgency of our climate challenge, we should wait no longer.

2. **We use the resources we already have**. The UK is already a world leader in climate modelling and impact studies, as well as mitigation and adaptation research. The world-renowned Tyndall Centre, working with the Hadley Centre, is therefore ideally placed to lead, co-ordinate and deliver geo-engineering research. The centre's programmes are characteristically multi-disciplined in nature and therefore ideally suited to the task.

3. **Promising schemes be piloted**. Schemes that show the most promise should be carried through to demonstrator phase to enable their relative potential and risks to be accurately assessed and for the best schemes to become available for possible deployment. Such work requires investment in new modelling capabilities, tools and pilot-project scale engineering studies.

4. **A realistic roadmap for decarbonisation of the global economy be developed integrating geo-engineering**. Building on knowledge acquired through a rigorous comprehensive technology assessment the Institution recommends that a roadmap to implementation be devised for a global transition to a low-carbon future incorporating geo-engineering.

5. **The UK lead the way commercially**. If the engineering industry sees Government policy moving research spend into geo-engineering, commercial companies are highly likely to start investing in their own research and initial feasibility assessments to try to second-guess the market opportunities which might arise out of the policy being pursued.

REFERENCES

1 Marland, G., Andres, R. J., and Boden, T. A., in Trends: A Compendium of Data on Global Change (Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A., 2008).

2 Raupach, M. R. et al. (2007) Global and regional drivers of accelerating CO_2 emissions. Proceedings of the National Academy of Sciences of The United States of America **104**(24), 10288-10293.

3 Canadell, J.G. et al. (2007) Contributions to accelerating atmospheric CO_2 growth from economic activity, carbon intensity, and efficiency of natural sinks. Proceedings of the National Academy of Sciences of The United States of America **104**(47), 18866-18870.

4 IMechE (2009), Climate Change: Adapting to the Inevitable? Institution of Mechanical Engineers, London.

5 House of Commons (2008) Minutes of Evidence taken before Innovation, Universities, Science and Skills Committee, Geoengineering, Monday 10 November 2008. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/c1064-i/c106402.htm

6 House of Commons (2008) Minutes of Evidence taken before Innovation, Universities, Science and Skills Committee, Geoengineering, Monday 17 November 2008. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/c1202-i/c120202.htm

7 Anderson, K. and Bows, A. (2008) Reframing the climate change challenge in light of post-2000 emission trends. Phil. Trans. R. Soc. A **366**, 3863-3882

8 Angel, R. (2006) Feasibility of cooling the earth with a cloud of small spacecraft near the inner Lagrange point (l1). Proceedings of the National Academy of Sciences of The United States of America 103 (46), 17184-17189.

9 Lampitt, R.S. et al. (2008) Ocean fertilisation: a potential means of geoengineering? Phil. Trans. R. Soc. A 366, 3912-3945

10 Keith, D.W. et al. (2006) Climate strategy with CO_2 capture from the air. Climate Change **74**, 17-45.

11 IPCC (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

12 Launder, B. and Thompson, M. T. (eds.) (2008) Theme Issue 'Geoscale engineering to avert dangerous climate change' Phil. Trans. R. Soc. A **366**.

13 House of Commons (2008) Memorandum of Evidence, Engineering Inquiry (Geoengineering Case Study), Innovation, Universities & Skills Committee. Memorandum15. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/memo/1264/ucm1.pdf

14 House of Commons (2008) Memorandum of Evidence, Engineering Inquiry (Geoengineering Case Study), Innovation, Universities & Skills Committee. Memorandum1. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/memo/1264/ucm1.pdf

15 House of Commons (2008) Memorandum of Evidence, Engineering Inquiry (Geoengineering Case Study), Innovation, Universities & Skills Committee. Memorandum25. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/memo/1264/ucm1.pdf

Institution of Mechanical Engineers

1 Birdcage Walk
Westminster
London
SW1H 9JJ

T 020 7304 6862
F 020 7222 8553

publicaffairs@imeche.org
www.imeche.org/policy

PUBLISHED AUGUST 2009