Briefing Sheet

Energy Reports – Climate Change

The ICE Energy Board has written a series of status reports concerned with the various forms of energy such as wind, hydro, nuclear and energy from waste. Designed to be both informative and contemporary, the current reports are updated regularly in view of providing accurate information to a varied audience. The present report focuses on the current status of climate change.

Defining the Issue

In the last century there has been a steady and significant increase in global temperatures. There is an accumulating body of scientific evidence that man-made greenhouse gas emissions are contributing to this increase.

This briefing reviews the global climate change issue and the possible contribution of man-made emissions. The policy responses to this issue are also described.

The greenhouse effect

There is a balance between the energy coming in from the sun in the form of visible radiation (sunlight) and the energy constantly being emitted from the surface of the earth to space. This balance determines the temperature of the earth.

A key feature of the atmosphere is that the incoming solar energy passes through the atmosphere almost unchanged and warms the earth. However, the energy radiated back from the warmed earth's surface is at a longer, infrared radiation and this is partly absorbed by greenhouse gases in the atmosphere, with some energy re-emitted back downwards. This further warms the surface of the earth and the lower atmosphere. An analogy is made with the effect of a greenhouse, which allows sunshine to penetrate the glass that in turn keeps the heat in, hence the greenhouse effect.

The natural greenhouse gases are mainly water vapour and carbon dioxide.
Without this natural greenhouse effect, the earth would be over 30°C cooler and would be too cold to be habitable. However, a potential problem arises as greenhouse gas concentrations rise well above their natural levels, leading to substantial additional warming and increases in global temperatures.

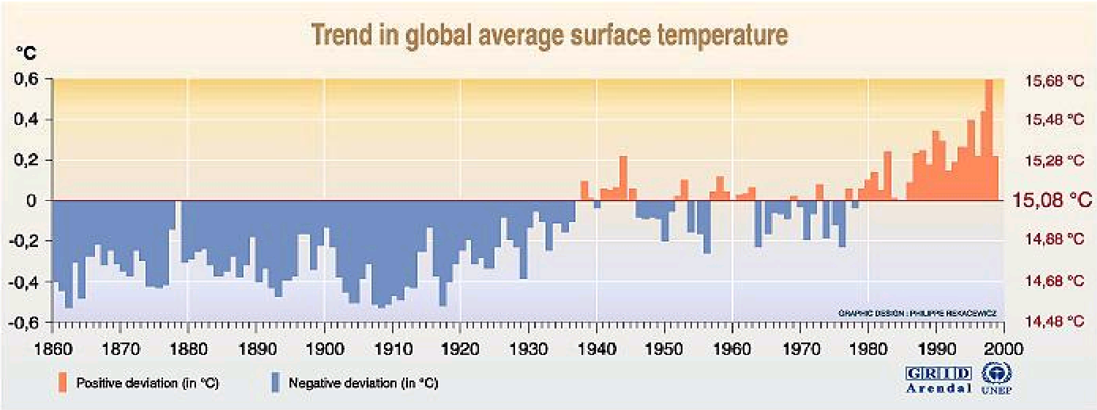
Evidence for Global Warming

Long term temperature records across the world show a consistent trend in increasing temperatures. Figure 1 shows the overall trend and the significant variations between individual years. The average global temperature has risen by about 1 degree Celsius in the last 500 years, with about half of this occurring in the last century.

In parallel with this, the atmospheric concentrations of carbon dioxide and other greenhouse gases have been steadily increasing. Figure 2 shows the carbon dioxide concentrations measured at Mount Kea observatory over the last 50 years. Other important greenhouse gases are methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, concentrations of which have also been increasing. These increases are almost entirely due to emissions from human activities, which greatly exceed the absorptive capacity of the biosphere.

There is clearly an association between increasing global temperatures and increasing greenhouse gas concentrations. Is there a causal link?

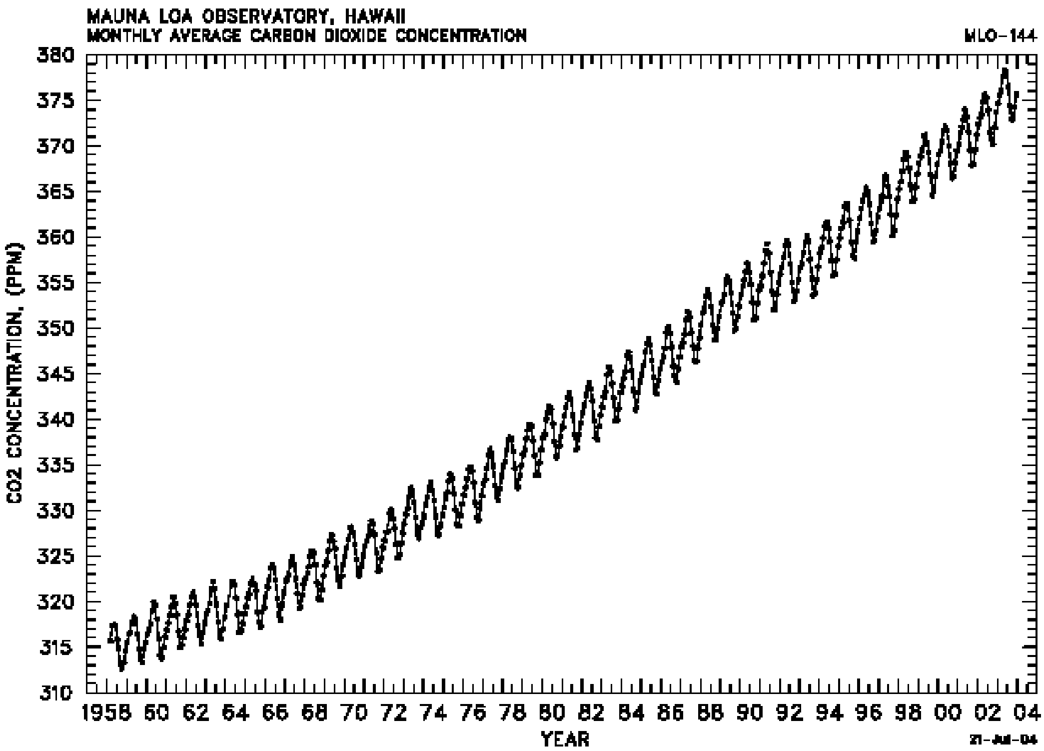
Figure 1



Source: School of environmental sciences, climatic research unit, university of East Anglia, Norwich, United Kingdom, 1999.

Figure 2

Source: http://cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm



Institution of Civil Engineers

Briefing Sheet

Assessing man-made contributions to global warming

There is now an enormous body of work on atmospheric and climate modelling to determine the relative causes of observed global warming. Two natural causes of the observed warming are now generally accepted:

- An increase in solar radiation, particularly over the last 150 years,
- Variations in the frequency of volcanic eruptions.

However, these factors cannot explain the greater increase in very recent years. However, when increased concentrations in greenhouse gases are taken into account in the modelling, predictions match recorded temperatures quite closely, although earlier modelling appeared to overestimate the effect.

However, these early models did not take account of the cooling effect of other man-made emissions, such as soot and other particulate matter, which have a cooling effect as they reflect solar energy directly. When this “global dimming” effect was included in the models, very close agreement with recorded temperatures was obtained. This has final step has convinced the vast majority of scientists in the field that:

- Climate modelling is sufficiently accurate for broad conclusions to made,
- A key conclusion is that man-made greenhouse gases have contributed perhaps 0.5 degree Celsius of the recorded global warming to date.

Carbon dioxide is considered to be responsible for about two thirds of man-made global warming.

How much will global temperatures increase in the future?

The concentration of carbon dioxide in the atmosphere currently stands at 375 parts per million (ppm), compared to 280 ppm in pre-industrial times. The UN Intergovernmental Panel on Climate Change (IPCC) has concluded that doubling the pre-industrial level to 550 ppm will lead to an increase in global temperature between 1.4 and 5.8 degrees Celsius.

This is based on the findings of many separate studies taking into account both positive and negative feedback effects as the global temperature rises. The IPCC has concluded that net feedback effect will be overwhelmingly positive, but there remain many uncertainties in key factors such as:

- The degree to which polar ice cap melting increases heat absorption,
- The net effect of clouds, with both trap and reflect heat.
- The heat absorptive capacity of the oceans.
- Increased absorption of carbon dioxide by vegetation.

These uncertainties lead to a very wide range of actual model outcomes, including a zero temperature change and an 11 degree temperature change in some extreme scenarios.

A central scenario which many policy makers have adopted is a 2 degree Celsius increase in temperature from a doubling to 550 ppm. The 550 ppm level has been put forward as one possible stabilisation target for climate change policy to achieve.

What are the consequences of further increases in global temperatures?

This question is at the heart of the climate change debate. Reducing emissions will incur cost, so if the consequences of global warming are not substantial, there is little incentive to reduce. Conversely, if the consequences are potentially catastrophic, there is every incentive to reduce emissions as quickly as possible.

There are a number of potential consequences of global warming, including:-

Rises in sea level

As temperatures increase, the sea level will rise due to the thermal expansion of the oceans. Much of the observed rise in sea-level (10 - 20 cm) during the 20th century may be due to this effect. The IPCC predicts that global mean sea levels will rise by 9 to 88 cm by 2100. More dramatic increases in sea level are possible should the land-based Greenland and Antarctic ice sheets melt. Increases in sea level will lead to greatly increased risks of flooding in coastal areas and threaten the continued existence of island nations.

Effects on agriculture

Global warming could lead to significant changes in rainfall and temperature. These in turn could have a dramatic effect on agriculture in different parts of the world.

Water supply

Similarly, changes in rainfall patterns have major implications for water supply and river flows.

Biodiversity

Ecosystems have always adapted to changes in climate and individual species have moved with climate bands in the past (for example, during and after Ice Ages). However, the pace of climate change may exceed the ability of species to migrate in this way and ecosystems may go extinct.

In some scenarios, by the 2070s, large parts of northern Brazil and central southern Africa could lose their tropical forests because of reduced rainfall and increased temperatures.

Climate and Weather Patterns

Modelling suggests that there is a possibility of sudden switches in features of the global climate due to global warming. A widely discussed example is the “shut down” of the North Atlantic gulf stream due to meltwater from Greenland. Such events could occur relatively quickly and could have very dramatic regional effects (such as a major cooling of Europe).

Discussion

The consensus is that each of these effects of global warming is already occurring. However, there are major arguments over the final extent of each and the degree to which reductions in GHG emissions will prevent or reduce these effects. These arguments are at the heart of the climate change policy debate.

From a civil engineering perspective, all of these effects have major implications for the future need, design, construction and maintenance of civil engineering works. More accurate projections of the actual degree of change will be essential in planning for future responses.

Appendix A summarises current views on how the UK in particular might be affected.

Climate Change Policy Responses

A number of national and international policy responses are already in progress, with the basic aim of reducing GHG emissions. Foremost amongst these is the United Nations Framework Convention on Climate Change, adopted on 9 May 1992. Five years later, on 11 December 1997, governments took a further step forwards and adopted the landmark Kyoto Protocol.

The Kyoto Protocol built on the framework of the Convention and introduced legally-binding constraints on greenhouse gas emissions and innovative "mechanisms" aimed at cutting the cost of curbing emissions. After some delay, the required number of parties ratified the Kyoto Protocol, which came into force in 2005 [check].

However, the Protocol remains controversial and is somewhat undermined by the absence of the USA and China as signatories or any binding requirements on developing nations. Nonetheless, it forms the basis of the newly introduced European Community carbon Emissions Trading Scheme, in which sources trade permits to emit, achieving emission reductions at the least overall cost. The Protocol also signals an intention to take internationally co-ordinated action on climate change.

The Kyoto Protocol runs until 2012 and discussion continues on what further policy measures should be put in place. An alternative concept of “Contraction & Convergence” has attracted interest. In outline, this requires developed nations to reduce (contract) their relative emissions whilst developing nations, although initially increasing emissions, are also on a pathway to converge with the developed nations’ emission rates. There are many options for detailed implementation.

Others have suggested straight taxes on carbon emissions, rather than go through the complexities of trading schemes or other commitments. At present, all options appear to be open as early discussions commence on the post-Kyoto period.

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Appendix A - How the UK could be affected by climate change

(reproduced from the DEFRA website reference http://www.defra.gov.uk/environment/climatechange/01.htm#uk)

New climate change scenarios were launched by Defra in April 2002 (see www.ukcip.org.uk/scenarios). They show that average annual temperatures across the UK may rise by between 2° and 3.5°C by the 2080s, with the degree of warming dependent on future levels of greenhouse gas emissions. In general there will be greater warming in the south and east than in the north and west of the UK (see figure, below). High summer temperatures will become more frequent and very cold winters will become increasingly rare. For example, a very hot August, such as that experienced in 1995 may occur as often as two years in three by the 2080s under the higher emissions scenarios.

It is not just temperatures that will change in the UK, but also rainfall amounts and frequency. Winters will become wetter and summers may become drier across all of the UK (see figure, below). The largest relative changes will be in the south and east where summer precipitation may decline by up to 50 % by the 2080s. Heavy winter precipitation will become more frequent, but the amount of snow could decline by 60% - 90% by the 2080s. In addition, sea levels will continue to rise and could be between 26 and 86 cm above the current level in southeast England by the 2080s. Extreme high water levels, which currently have a 2 % annual probability of occurring, could become 10 to 20 times more frequent at some east coast locations by the 2080s