Full Committee Hearing - "Climate Change Science and Economics"
Thursday, July 21, 2005

Sir John Houghton

Testimony to the US Senate - Energy and Natural Resources Committee
Sir John Houghton, 21 July 2005

I consider it a privilege to be asked to testify to your committee this morning. Thank you for inviting me. On my last visit to the United States in March I was briefing the National Association of Evangelicals and was most pleased to find that large and influential body engaging with this issue of global climate change - the most serious environmental issue facing the world today.

The basic science of global warming

Let me start with a quick summary of the basic science of Global Warming. By absorbing infra-red or ‘heat’ radiation from the earth’s surface, ‘greenhouse gases’ present in the atmosphere, such as water vapour and carbon dioxide, act as blankets over the earth’s surface, keeping it warmer than it would otherwise be. The existence of this natural ‘greenhouse effect’ has been known for nearly two hundred years; it is essential to the provision of our current climate to which ecosystems and we humans have adapted.

Since the beginning of the industrial revolution around 1750, one of these greenhouse gases, carbon dioxide has increased by over 30% and is now at a higher concentration in the atmosphere than it has been for many hundreds of thousands of years (Fig 1). Chemical analysis demonstrates that this increase is due largely to the burning of fossil fuels - coal, oil and gas. If no action is taken to curb these emissions, the carbon dioxide concentration will rise during the 21st century to two or three times its preindustrial level.

Fig 1. Concentration of carbon dioxide in the atmosphere from 1000 AD and projected to 2100 under typical IPCC scenarios .

Fig 2. Variations of the average near surface air temperature: 1000-1861, N Hemisphere from proxy data; 1861-2000, global instrumental; 2000-2100, under a range of IPCC projections with further shading to indicate scientific uncertainty .

The climate record over the last 1000 years (Fig 2) shows a lot of natural variability – including, for instance, the 'medieval warm period' and the 'little ice age' . The rise in global average temperature (and its rate of rise) during the 20th century is well outside the range of known natural variability. The year 1998 is the warmest year in the instrumental record. A more striking statistic is that each of the first 8 months of 1998 was the warmest on record for that month. There is strong evidence that most of the warming over the last 50 years is due to the increase of greenhouse gases, especially carbon dioxide. Confirmation of this is also provided by observations of the warming of the oceans . The period of 'global dimming' from about 1950 to 1970 is most likely due to the increase in atmospheric particles (especially sulphates) from industrial sources. These particles reflect sunlight, hence tending to cool the surface and mask some of the warming effect of greenhouse gases. Global climate models that include human induced effects (greenhouse gas increases and particles) and known natural forcings (e.g. variations in solar radiation and the effects of volcanoes) can provide good simulations of the twentieth century profile of global average temperature change.

Over the 21st century the global average temperature is projected to rise by between 2 and 6 ºC (3.5 to 11 ºF) from its preindustrial level; the range represents different assumptions about emissions of greenhouse gases and the sensitivity of the climate model used in making the estimate (Fig 2). For global average temperature, a rise of this amount is large. The difference between the middle of an ice age and the warm periods in between is only about 5 or 6 ºC (9 to 11 ºF). So, associated with likely warming in the 21st century will be a rate of change of climate equivalent to say, half an ice age in less than 100 years – a larger rate of change than for at least 10,000 years. Adapting to this will be difficult for both humans and many ecosystems.

The impacts of human induced climate change

Talking in terms of changes of global average temperature, however, tells us rather little about the impacts of global warming on human communities. Some of the most obvious impacts will be due to the rise in sea level that occurs because ocean water expands as it is heated. The projected rise is of the order of half a metre (20 inches) a century and will continue for many centuries – to warm the deep oceans as well as the surface waters takes a long time. This will cause large problems for human communities living in low lying regions, for instance in the Everglades region of Florida. Many areas, for instance in Bangladesh (where about 10 million live within the one metre contour – Fig 3), southern China, islands in the Indian and Pacific oceans and similar places elsewhere in the world, will be impossible to protect and many millions will be displaced.

Fig 3. Land affected in Bangladesh by various amounts of sea level rise

There will also be impacts from extreme events. The extremely unusual high temperatures in central Europe during the summer of 2003 led to the deaths of over 20,000 people. Careful analysis shows that it is very likely that a large part of the cause of this event is due to increases in greenhouse gases and projects that such summers are likely to be the norm by the middle of the 21st century and cool by the year 2100.

Water is becoming an increasingly important resource. A warmer world will lead to more evaporation of water from the surface, more water vapour in the atmosphere and more precipitation on average. Of greater importance is the fact that the increased condensation of water vapour in cloud formation leads to increased latent heat of condensation being released. Since this latent heat release is the largest source of energy driving the atmosphere's circulation, the hydrological cycle will become more intense. This means a tendency to more intense rainfall events and also less rainfall in some semi-arid areas. Since, on average, floods and droughts are the most damaging of the world's disasters (see box), their greater frequency and intensity is bad news for most human communities and especially for those regions such as south east Asia and sub-Saharan Africa where such events already occur only too frequently.

BOX
Major floods in the 1990s
• 1991, 1994-5, 1998 – China; average disaster cost 1989-96, 4% of GDP
• Mississipi & Missouri, USA; flooded area equal to one of great lakes
• 1997 – Europe; 162,000 evacuated and > 5bn $ loss
• 1998 - Hurricane Mitch in central America; 9000 deaths,
economic loss in Honduras &Nicaragua 70% & 45% of GDP
• 1999 – Venezuela; flooding led to landslide, 30,000 deaths
• 2000-1 - Mozambique; two floods leave more than half a million homeless
END OF BOX

Regarding extreme events and disasters, it is often pointed out that climate possesses large natural variability and such events have been common occurrences over the centuries. It is not possible, for instance, when a disaster occurs to attribute that particular event to increasing greenhouse gases (except perhaps for the 2003 heat wave mentioned above). So, what is the evidence that they will increase in a globally warmed world? First, there is our understanding of the basic science of climate change that I have briefly outlined. Secondly, increasing evidence is provided from observations. Significant increases have been observed in the number of intense rainfall events especially over areas like the USA where there is good data coverage. Data from insurance companies show an increase in economic losses in weather related disasters of a factor of 10 in real terms between the 1950s and the 1990s. Some of this can be attributed to an increase in vulnerability to such disasters. However, a significant part of the trend has also arisen from increased storminess especially in the 1980s and 1990s.

Thirdly, increased risk of heat waves, floods and droughts are some of the most robust projections of climate models that take into account in a comprehensive way all the physical and dynamical processes involved in climate change. For instance, a study for the area of central Europe, with doubled atmospheric carbon dioxide concentration (likely to occur during the second half of the twenty first century), indicates an decrease in the return period of flooding events by about a factor of five (e.g. from 50 years to 10 years) .

Tropical cyclones are particular damaging storms that occur in the sub tropics. They require special mention because no evidence exists for an increase in their number as the earth warms although an increase is considered likely in peak wind and precipitation intensities in such systems.

Sea level rise, changes in water availability and extreme events will cause the most damaging impacts of human induced climate change . They will lead to increasing pressure from many millions of environmental refugees.

In addition to the main impacts summarised above are changes about which there is less certainty, but if they occurred would be highly damaging and possibly irreversible. For instance, large changes are being observed in polar regions. If the temperature rises more than about 3 ºC (~5 ºF) in the area of Greenland, it is estimated that melt down of the ice cap would begin. Complete melt down is likely to take 1000 years or more but it would add 7 metres (23 feet) to the sea level.

A further concern is regarding the Thermo-Haline Circulation (THC) – a circulation in the deep oceans, partially sourced from water that has moved in the Gulf Stream from the tropics to the region between Greenland and Scandanavia. Because of evaporation on the way, the water is not only cold but salty, hence of higher density than the surrounding water. It therefore tends to sink and provides the source for a slow circulation at low levels that connects all the oceans together. This sinking assists in maintaining the Gulf Stream itself. In a globally warmed world, increased precipitation together with fresh water from melting ice will decrease the water's salinity making it less likely to sink. The circulation will therefore weaken and possibly even cut off, leading to large regional changes of climate. All climate models indicate the occurrence of this weakening. Evidence from paleoclimate history shows that such cut-off has occurred at times in the past. It is such an event that is behind the highly speculative happenings in the film, The day after tomorrow.

I have spoken so far about adverse impacts. However, there are some positive impacts. For instance, in Siberia and other areas at high northern latitudes, winters will be less cold and growing seasons will be longer. Also, increased concentrations of carbon dioxide have a fertilising effect on some plants and crops which, providing there are adequate supplies of water and nutrients, will lead to increased crop yields in some places, probably most notably in northern mid latitudes. However, careful studies demonstrate that adverse impacts will far outweigh positive effects, the more so as temperatures rise more than 1 or 2 ºC (2 to 3.5 ºF) above preindustrial.

Many people ask how sure we are about the scientific story I have just presented. Let me explain that it is based very largely on the extremely thorough work of the Intergovernmental Panel on Climate Change (IPCC) and its last major report published in 2001. The scientific literature on climate change has increased enormously over the last decade. The basic science of anthropogenic climate change has been confirmed. The main uncertainties lie in our knowledge of feedbacks in the climate system especially those associated with the effects of clouds. Recent research has tended to indicate increased likelihood of the more damaging impacts.

The Intergovernmental Panel on Climate Change (IPCC)

Let me explain more about the work of the IPCC. It was formed in 1988 jointly by the World Meteorological Organisation and the United Nations Environment Programme. I had the privilege of being chairman or co-chairman of the Panel's scientific assessment from 1988 to 2002. Hundreds of scientists drawn from many countries were involved as contributors and reviewers in these assessments. The IPCC has produced three assessments - in 1990, 1995 and 2001 – covering science, impacts and analyses of policy options. The IPCC 2001 report is in four volumes each of about 1000 pages and containing many thousands of references to the scientific literature . Each chapter of the Report went through two major reviews, first by hundreds of scientists in the scientific community (any scientist who wished could take part in this) and secondly, by governments. No assessment on any other scientific topic has been so thoroughly researched and reviewed.

Because the IPCC is an intergovernmental body, the reports' Summaries for Policymakers were agreed sentence by sentence by meetings in which governmental delegates from about 100 countries (including all the world's major countries) work with around 40 leading scientists representing the scientific community. It is sometimes supposed that the presence of governments implies political interference with the process. That has not been the case. In any event, governments taking part come from the complete spectrum of political agendas. These are scientific meetings in which all proposals for changes in the text must be based either on scientific arguments or on a desire for clearer presentation. In every case, the process has resulted in documents with overall improved scientific clarity and balance.

The work of the IPCC is backed by the worldwide scientific community. A joint statement of support was issued in May 2001 by the national science academies of Australia, Belgium, Brazil, Canada, the Caribbean, China, France, Germany, India, Indonesia, Ireland, Italy, Malaysia, New Zealand, Sweden and the UK. It stated 'We recognize the IPCC as the world's most reliable source of information on climate change and its causes, and we endorse its method of achieving consensus.' In 2001, a report of the United States National Academy of Sciences commissioned by the President George W Bush administration, supported the IPCC's conclusions . A joint statement issued in June 2005 by the science academies of all the G8 countries together with the academies of Brazil, China and India also endorsed the work and conclusions of the IPCC .

Let me comment further on the issues of uncertainty and balance as expressed in the work of the IPCC. There are very large amounts of data available to the scientist looking for evidence of climate change. Examples abound of those who approach the data with preconceived agendas and who have selected data to fit those agendas - for instance purporting to prove either that there is little or no evidence for human induced change or that the world is heading for a future that could mean the end of the human race. The task of the IPCC has been to review all the evidence in a balanced manner and honestly and objectively to distinguish what is reasonably well known and understood from those areas with large uncertainty. The reports have differentiated between degrees of uncertainty, where possible providing numerical estimates of uncertainty. A large part of the IPCC process, taking many days of scientists' time, has been taken up with discussion and correspondence about how best to present uncertainty.

Let me mention a further point on the uncertainty issue. In the IPCC reports, because they are scientific documents, uncertainty tends to be mentioned frequently giving the impression to the casual reader that the uncertainty in the conclusions is larger than it is in many other areas of our experience with which comparison could be made. What is important to realise is that there is a high degree of certainty that significant human induced climate change is occurring and will continue to occur. A forecast of little or no such climate change is almost certainly wrong.

The Framework Convention on Climate Change

Because of the work of the IPCC and its first report in 1990, the Earth Summit at Rio de Janeiro in 1992 could address the climate change issue and the action that needed to be taken. The Framework Convention on Climate Change (FCCC) - agreed by over 160 countries, signed by President George Bush Snr for the USA and subsequently ratified unanimously by the US Senate – agreed that Parties to the Convention should take "precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects. Where there are threats of irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures."

More particularly the Objective of the FCCC in its Article 2 is "to stabilise greenhouse gas concentrations in the atmosphere at a level that does not cause dangerous interference with the climate system" and that is consistent with sustainable development. Such stabilisation would also eventually stop further climate change. However, because of the long time that carbon dioxide resides in the atmosphere, the lag in the response of the climate to changes in greenhouse gases (largely because of the time taken for the ocean to warm), and the time taken for appropriate human action to be agreed, the achievement of such stabilisation will take at least the best part of a century.

Stabilization of carbon dioxide

Global emissions of carbon dioxide to the atmosphere from fossil fuel burning are currently approaching 7 billion tonnes of carbon per annum and rising rapidly (Fig 4). Unless strong measures are taken they will reach two or three times their present levels during the 21st century and stabilisation of greenhouse gas concentrations or of climate will be nowhere in sight. To stabilise carbon dioxide concentrations in accordance with the FCCC Objective, emissions during the 21st century must reduce to a fraction of their present levels before the century's end.

The reductions in emissions must be made globally; all nations must take part. However, there are very large differences between greenhouse gas emissions in different countries. Expressed in tonnes of carbon per capita per annum, they vary from about 5.5 for the USA, 2.2 for Europe, 0.7 for China and 0.2 for India (Fig 5). Ways need to be found to achieve reductions that are both realistic and equitable.

Fig 4. Global emissions of carbon dioxide from fossil fuel burning (in billions of tonnes of carbon) up to 1990 and as projected to 2100 under World Energy Council scenarios , A's and B's with various 'business as usual assumptions' and C for 'ecologically driven scenario' that would lead to stabilisation of carbon dioxide concentration at about 450 ppm.

Fig 5. Carbon dioxide emissions in 2000 per capita for different countries and groups of countries .

The Kyoto Protocol set up by the FCCC represents a beginning for the process of reduction, averaging about 5% below 1990 levels by 2012 by those developed countries who have ratified the protocol. It is an important start demonstrating the achievement of a useful measure of international agreement on such a complex issue. It also introduces for the first time international trading of greenhouse gas emissions so that reductions can be achieved in the most cost effective ways.

Serious discussion is now beginning about international agreements for emissions reductions post Kyoto. These must include all major emitters in both developed and developing countries. On what eventual level of stabilisation, of carbon dioxide for instance, should these negotiations focus? To stop damaging climate change the level needs to be as low as possible. In the light of the FCCC Objective it must also allow for sustainable development. Let me give two examples of stabilisation proposals. In 1996 the European Commission proposed a limit for the rise in global average temperature from its preindustrial value of 2 ºC – that implies a stabilisation level for carbon dioxide of about 430 ppm (allowing for the effect of other greenhouse gases at their 1990 levels). The second example comes from Lord John Browne, Chief Executive Officer of British Petroleum, one of the world’s largest oil companies, who in a recent speech proposed 'stabilisation in the range 500-550 ppm' that 'with care could be achieved without disrupting economic growth.'

Let us consider carbon dioxide stabilisation at 500 ppm. If the effect of other greenhouse gases at their 1990 levels is added, it is about equivalent to doubled carbon dioxide at its preindustrial level and a rise in global averaged temperature of about 2.5 ºC. Although climate change would eventually largely be halted – although not for well over a hundred years - the climate change impacts at such a level would be large. A steady rise in sea level will continue for many centuries, heat waves such as in Europe in 2003 would be commonplace, devastating floods and droughts would be much more common in many places and Greenland would most likely start to melt down. The aim should be therefore to stabilise at a lower level. But is that possible?

The International Energy Agency (IEA) in 2004 published a World Energy Outlook that in their words ‘paints a sobering picture of how the global energy system is likely to evolve from now to 2030’. With present governments’ policies, the world’s energy needs will be almost 60% higher in 2030 that they are now. Fossil fuels will dominate, meeting most of the increase in overall energy use. Energy-related emissions of carbon dioxide will grow marginally faster than energy use and will be more than 60% higher in 2030 than now (Fig 6, reference scenario). Over two-thirds of the projected increase in emissions will come from developing countries.
Fig 6. Carbon dioxide emissions from fossil fuel burning and profile leading to stabilisation at 500 ppm (a, b and c) and 450 ppm (d). Emissions data from International Energy Agency scenarios ; reference (a), alternative (b) for developed countries (red) and developing (blue). For (c) and (d) see text.

The Outlook also presents an Alternative Scenario that analyses the global impact of environmental and energy-security policies that countries around the world are already considering as well as the effects of faster deployment of energy-efficient technologies. However, even in this scenario, global emissions in 2030 are substantially greater than they are today (Fig 6). Neither scenario comes close to creating the turn around in the global profile required.

The UK government has taken a lead on this issue and has agreed a target for the reduction of greenhouse gas emissions of 60% by 2050 - predicated on a stabilisation target of doubled carbon dioxide concentrations together with a recognition that developed countries will need to make greater reductions to allow some headroom for developing countries. Economists in the UK government Treasury Department have estimated the cost to the UK economy of achieving this target. On the assumption of an average growth in the UK economy of 2.25 % p.a., they estimated a cost of no more than the equivalent of 6 months' growth over the 50 year period. Similar costs for achieving stabilisation have been estimated by the IPCC.

The effect of a reduction of 60% on average by developed countries is shown in Fig 6(c) together with a scenario for developing countries that increases by 1% p.a. until 2030 followed by level emissions to 2050. For this the 500 ppm curve is approximately followed but for developing countries to be satisfied with such a modest growth presents a very large challenge. Even more challenging for both developed and developing countries would be the measures required to stabilise at 450 ppm (Fig 6(d). Governor Schwarzenegger of California has begun to address this challenge by proposing an even more demanding reduction target of 80% by 2050.

Can we wait and see?

In order to achieve reductions on the scale that is required to stabilize carbon dioxide concentrations, large changes will have to occur in way we use energy (through energy efficiency improvements) and generate it (through moves to energy sources with zero or low carbon emissions). But how urgent are the changes required. It is sometimes suggested that we can 'wait and see' before serious action is needed. This is an area where policy needs to be informed by the perspective from science.

There is a strong scientific reason for urgent action. Because the oceans take time to warm, there is a lag in the response of climate to increasing greenhouse gases. So far we have only experienced a small part of the climate response to the greenhouse gas emissions that have already occurred. If greenhouse gas emissions were halted tomorrow, climate impacts much greater than we have so far experienced but to which we are already committed will be realized over the next 30 years and more into the future . Further emissions from now on just add to that commitment. It is for this reason that the June 2005 statement from the world's major science academies urges all nations , 'to take prompt action to reduce the causes of climate change and adapt to its impacts' and to 'identify cost-effective steps that can be taken now to contribute to substantial and long-term reduction in net global greenhouse gas emissions, recognizing that delayed action will increase the risk of adverse environmental effects and will likely incur a greater cost.'

Two further reasons can be identified for urgent action. One is economic. Energy infrastructure, for instance in power stations also lasts typically for 30 to 50 years. As was stated by the leaders of the G8 countries meeting at Gleneagles in the UK earlier this month , We face a moment of opportunity. Over the next 25 years, an estimated $16 trillion will need to be invested in the world's energy systems. According to the IEA, there are significant opportunities to invest this capital cost-effectively in cleaner energy technologies and energy efficiency. Because decisions being taken today could lock in investment and increase emissions for decades to come, it is important to act wisely now.

A third reason is political. Countries like China and India are industrialising very rapidly. I heard a senior energy adviser to the Chinese government speak recently. He said that China by itself would not be making big moves to non fossil fuel sources. When the developed nations of the west take action, they will take action - they will follow not lead. China is building new electricity generating capacity of about 1 GW power station per week. To move the world forward we have to be seen ourselves to be moving.

The UK and Climate Change

I would like to add a few remarks about the UK and climate change. It was Prime Minister Margaret Thatcher who in 1988, speaking as a scientist as well as a political leader, was one of the first to bring the potential threat of global warming to world attention. Subsequent UK governments have continued to play a leading international role in this issue. This year, Prime Minister Tony Blair has put climate change at the top of his agenda for his presidency of the G8 and the EU.

This international activity has brought the realisation within the UK government that a big environmental issue such as climate change needs to be brought much closer to the centre of the government machine. For instance, Gordon Brown, UK's Chancellor of the Exchequer has clearly stated the importance of addressing the economy and environment together. In a recent speech he said , 'Environmental issues - including climate change – have traditionally been placed in a category separate from the economy and from economic policy. But this is no longer tenable. Across a range of environmental issues –from soil erosion to the depletion of marine stocks, from water scarcity to air pollution – it is clear now not just that economic activity is their cause, but that these problems in themselves threaten future economic activity and growth.'

The need for leadership

We, in the developed countries have already benefited over many generations from abundant and cheap fossil fuel energy – although without realising the potential damage to the climate and especially the disproportionate adverse impacts falling on the poorer nations. The Framework Convention on Climate

Change (FCCC) recognized the particular responsibilities this placed on developed countries to be the first to take action and to provide assistance (e.g. through appropriate finance and technology transfer) to developing countries for them to cope with the impacts and to develop cost effective sources of energy free of carbon emissions. The moral imperative created by these responsibilities is reflected in the statement on climate change made by the leaders of the G8 countries meeting at Gleneagles in the following paragraph , 'It is in our global interests to work together, and in partnership with major emerging economies, to find ways to achieve substantial reductions in greenhouse gas emissions and our other key objectives, including the promotion of low-emitting energy systems. The world's developed economies have a responsibility to act.'

People often say to me that I am wasting my time talking about Global Warming. 'The world' they say 'will never agree to take the necessary action'. I reply that I am optimistic for three reasons. First, I have experienced the commitment of the world scientific community (including scientists from many different nations, backgrounds and cultures) in painstakingly and honestly working together to understand the problems and assessing what needs to be done. Secondly, I believe the necessary technology is available for achieving satisfactory solutions. My third reason is that, as a Christian, I believe God is committed to his creation and that we have a God-given task of being good stewards of creation – a task that we do not have to accomplish on our own because God is there to help us with it. As a recent statement on climate change by scientific and religious leaders in the U.S. says : 'What is most required at this moment … is moral vision and leadership. Resources of human character and spirit – love of life, far sightedness, solidarity – are needed to awaken a sufficient sense of urgency and resolve.'

In my work with the IPCC I have been privileged to work with many climate scientists from the USA who are world leaders in their field. The USA is also a world leader in the technologies aimed at reducing greenhouse gas emissions. But science and technology are only part of what is required. Mr Chairman, the moves recently made by the Senate to develop a strategy for addressing the issue of human induced climate change are of great importance. Is it too much to hope that they are the start of a bid for leadership by the US in the wider world as all countries - both developed and developing – set out to meet this challenge together?

Sir John Houghton was co-chairman of the Scientific Assessment for the IPCC from 1988-2002. He was previously chairman of the Royal Commission on Environmental Pollution (1992-1998), Chief Executive of the UK Meteorological Office (1983-1991) and Professor of Atmospheric Physics, University of Oxford (1976-1983). He is currently chairman of the John Ray Initiative, a Trustee of the Shell Foundation and Honorary Scientist at the Hadley Centre.

Captions to Figures

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