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KYOTO PROTOCOL: ASSESSING THE STATUS OF EFFORTS TO REDUCE GREENHOUSE GASES

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

FIRST SESSION

OCTOBER 5, 2005

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ONE HUNDRED NINTH CONGRESS

FIRST SESSION

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KYOTO PROTOCOL: ASSESSING THE STATUS OF EFFORTS TO REDUCE GREENHOUSE GASES

WEDNESDAY, OCTOBER 5, 2005

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Washington, DC.

The committee met, pursuant to notice, at 2:30 p.m. in room 406, Dirksen Senate Building, Hon. James M. Inhofe (chairman of the committee) presiding.

Present: Senators Inhofe, Voinovich, Murkowski, Thune, DeMint, Isakson, Jeffords, Carper, and Obama.

Senator INHOFE. We will come to order.

We always start on time, even when some of our members are a little bit late. I have been informed that on our side, we are going to have a pretty good showing, and I don't know, Senator Jeffords, about how many you will be having.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

This committee today will examine the Kyoto Protocol and the status of the efforts to reduce greenhouse gases. This subject is relevant to policy discussions here in the United States.

Shortly after the Protocol came into force in February 16, the President stated, "the Kyoto debate is beyond us, as far as I'm concerned." Nevertheless, some policymakers continue to clamor for the United States to join in the Kyoto agreement or in creating a follow-on to Kyoto. Perhaps more importantly, the Kyoto framework forms the basis of several legislative proposals to mandate unilateral cuts in carbon dioxide emissions in the United States.

If our Nation were to follow Europe down this path it has chosen, we should understand whether their efforts are working or not. They are not.

Let me be clear at the outset. I believe the countries that have ratified the Kyoto Protocol are wasting their economic resources, because the science does not justify it. Anthropogenic climate change is, I have characterized, is perhaps the greatest hoax ever perpetrated on the American people. Even if humans were causing global warming—and we are not—but even if we were, Kyoto would do nothing to avert it.

At most, Kyoto is projected to reduced temperature growth by only 0.07 degrees Celsius by 2050, which is negligible. Again, that is assuming anthropogenic global warming is happening and also

that parties were meeting their targets. But of course, we will find out, as we know already, that they are not meeting their targets.

I will not mince words: the Kyoto Protocol is a failure and the basic approach it embodies is a failure. The European Union was the primary champion of the Protocol as the best approach to deal with global warming. Yet all but two of the original 15 European Union countries, as well as Canada and Japan, will fail to meet their emissions reductions targets. In fact, some countries are increasing the emissions by more than 40 to 50 percent as these charts show.

Canada, for instance, has a Kyoto target of 6 percent below 1990 levels. But as of 2003, it was already 24 percent above 1990 levels and is projected to be up at least 45 percent in 2010. Meanwhile, New Zealand, which had thought it would have surplus credits of 54 million tons instead will have a credit deficit of 36 tons, leading the National Party to call for an immediate formal review of the country's participation in Kyoto.

Serious questions are being raised not only by critics, but by government agencies that support the Kyoto Protocol. As the European Environment Agency stated in a release in June: "Modest total greenhouse gas emission reductions since 1990 were the result of a combination of one-off structural changes and specific policies and measures. Since 2000, CO_2 emissions in the [original 15 EU countries] have been rising. On present policies, this rise will continue after 2010 with a projected overall 14 percent rise above 1990 levels by 2030."

Some have dismissed these problems by suggesting that these countries would be able to meet their targets by adopting aggressive additional measures. But that ignores economic realities. Europeans are complaining about the high cost of gasoline. Businesses are complaining as well. For instance, on June 28, the International Federation of Industrial Energy Consumers wrote that the EU emissions trading scheme has caused systemic problems with serious negative consequences to the economy and markets. It hinders competition, but does not provide clear incentives to reduce carbon dioxide.

These problems have not gone unnoticed at the political level. On September 15, in speaking of the Kyoto Protocol and efforts to reduce emissions, Prime Minister Tony Blair stated, "We have got to start from the brutal honesty about the politics of how we deal with it. The truth is no country is going to cut its growth or consumption substantially in light of a long-term environmental problem."

This and other comments he made that day have caused quite a bit of hand-wringing in the environmental community and some have tried to say his comments were out of context, but they were not. I have his full comments here and I am entering them into the record at this time.

[The referenced document was not received at time of print.]

Senator INHOFE. Prime Minister Blair had it right. Countries will not sacrifice their economies, and now when reality is setting in, they are demonstrating that fact. Clearly, Kyoto's approach to capping the economy by capping carbon is not working.

I am looking forward to hearing the testimony of our witnesses today. On the first panel we have Dr. Harlan Watson. Why don't you just step up to the table, Dr. Watson. He is the chief negotiator for climate issues in the United States.

On the second panel, we are joined by Lord Nigel Lawson, who I have had a great deal of respect for for quite some time. We certainly will be looking forward to your testimony, Lord Lawson. He has a distinguished career in the British Government and co-authored the House of Lords report that calls for far more scrutiny in climate decisions in many respects.

Also appearing is Dr. Margo Thorning, an economist with the American Council for Capital Formation and Professor Michael Grubb of the Imperial College of London. We thank all of you for coming today.

I am going to ask our members to confine opening comments to about 6 minutes, and we recognize Senator Jeffords.

[The prepared statement of Senator Inhofe follows:]

STATEMENT OF HON. JAMES M. INHOFE, CHAIRMAN, U.S. SENATOR FROM THE STATE OF OKLAHOMA

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Shortly after the Kyoto Protocol came into force on February 16th, the President stated that "the Kyoto debate is beyond us, as far as I'm concerned." Nevertheless, some policymakers continue to clamor for the United States to join in Kyoto or in creating a follow-on to Kyoto. Perhaps more importantly, the Kyoto framework forms the basis of several legislative proposals to mandate unilateral cuts in carbon dioxide emissions in the United States. If our Nation were to follow Europe down the path it has chosen, we should understand whether their efforts are working or not. They are not.

Let me be clear at the outset. I believe the countries that have ratified the Kyoto Protocol are wasting their economic resources because the science does not justify it—anthropogenic climate change is the world's greatest hoax. Even if humans were causing global warming—and we are not—but even if we were, Kyoto would do nothing to avert it. At most, Kyoto is projected to reduce temperature growth by 0.07 degrees Celsius by 2050, which is negligible—and again, that's assuming anthropogenic global warming is happening. Also that parties were meeting their targets. But they will not meet their targets.

I will not mince words—the Kyoto Protocol is a failure. The basic approach it embodies is a failure. The European Union was the primary champion of the Protocol as the best approach to deal with global warming. Yet all but two of the original 15 European Union countries, as well as Canada and Japan, will fail to meet their emission reduction targets. In fact, some countries are increasing emissions by more than 40 or 50 percent, as these charts show.

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I am looking forward to hearing the testimony of our witnesses today. On the first panel is Dr. Harlan Watson, the chief negotiator for climate issues for the United States. On the second panel, we are joined by Lord Nigel Lawson, who has had a distinguished career in the British government and who co-authored a House of Lords report that calls for far more scrutiny in climate decisions in many respects. Also appearing is Dr. Margo Thorning, an economist with the American Council for Capital Formation, and Professor Michael Grubb of the Imperial College London. Thank you all for coming to testify today.

OPENING STATEMENT OF HON. JAMES M. JEFFORDS, U.S. SENATOR FROM THE STATE OF VERMONT

Senator JEFFORDS. Thank you, Mr. Chairman. I want to extend a welcome to the witnesses, two of whom have traveled across the Atlantic to share their views with us. We appreciate the time you have taken to appear today, very much.

Today's hearing tracks the progress that other nations are making to meet the requirements of the Kyoto Protocol which entered into force last February. We are taking this testimony despite the fact that the United States is still not a party to the agreement. The Protocol imposes limits on emissions of greenhouse gases that scientists blame for increasing world temperatures.

The Administration decided to abandon the protocol and any serious international negotiations on this matter in March 2001. Rather than taking testimony about what other countries are doing to implement the Kyoto agreement, we should be finding ways that the United States can join the international community.

Other countries are left to wonder why the Nation that contributes the most greenhouse gas emissions to the global atmosphere refuses to accept responsibility for these emissions. But if Kyoto was the wrong solution for the United States, we should find away to cooperate with the international community so our country can be a player in efforts to stabilize the world's climate.

As we will hear from witnesses today, while the international community builds and expands its own carbon markets, American businesses are missing out on new technologies and jobs. That is why several U.S. States have been developing their own carbon markets, despite the lack of national leadership.

This hearing is not about whether the United States should consider its decision, or reconsider its decision, not to join Kyoto. We have missed that boat for now. It is my hope this hearing will provide insights about the actions we can take to unleash the power

of the American marketplace and allow our companies to fully compete in the alternative energy, energy efficiency and carbon markets. We need to join the nations that have made the decision to address global climate change if we are to see benefits for our health or economy in our environment.

On the event of the Kyoto Protocol entering into force, a White House spokesman stated that the United States has made an unprecedented commitment to reduce the growth of greenhouse gas emissions in a way that continues to grow our economy. However, we have to see evidence of that commitment. As we all know, actions speak louder than words.

I look forward to hearing more from the Administration's witnesses about the current actions taken by the United States to reduce greenhouse gas emissions. It would be my hope that this hearing would prompt us to craft legislation that imposes credible deadlines to cap and reduce our Nation's sizable and growing contribution to greenhouse gases.

For my part, I have already introduced the Clean Power Act of 2005. I also introduced the Renewable Portfolio Standard Act of 2005 and the Electric Reliability Security Act of 2005, two bills designed to use our resources more effectively.

Thank you, Mr. Chairman, and I look forward to hearing from the witnesses.

[The prepared statement of Senator Jeffords follows:]

STATEMENT OF HON. JAMES M. JEFFORDS, U.S. SENATOR FROM THE STATE OF VERMONT

Thank you Mr. Chairman, I want to extend a welcome to the witnesses, two of whom have traveled across the Atlantic to share their views with us. We appreciate the time they have taken to appear before us today.

Today's hearing tracks the progress that other nations are making to meet the requirements of the Kyoto Protocol, which entered into force this past February. We are taking this testimony, despite the fact that the United States is not a party to this agreement. The Protocol imposes limits on emissions of greenhouse gases that scientists blame for increasing world temperatures. The Administration decided to abandon the Protocol and any serious international negotiations on the matter in March 2001.

Rather than taking testimony about what other countries are doing to implement the Kyoto agreement, we should be finding ways that the United States could join the international community. Other countries are left to wonder why the nation that contributes the most greenhouse gas emissions to the global atmosphere refuses to accept responsibility for those emissions. Even if Kyoto was the wrong solution for the United States, we should find a way to cooperate with the international community so our country can be a player in efforts to stabilize the world's climate.

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Thank you, again, Mr. Chairman, and I look forward to hearing from the witnesses.

Senator INHOFE. Thank you, Senator Jeffords.

I don't want to put the pressure on you, Senator Voinovich, but I told both Dr. Watson and Lord Lawson that you probably know more about air issues than any member of the U.S. Senate.

Senator Voinovich.

OPENING STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

Senator VOINOVICH. Thank you, Mr. Chairman.

I would like to say that you know more about climate change than any member of the U.S. Senate and I expect that one of these days you are going to write a book on the subject.

I welcome our witnesses, especially Lord Nigel Lawson and Professor Michael Grubb, who have traveled from Britain to testify before us today. We really appreciate your attendance and we look forward to hearing from you.

As chairman of the Clean Air, Climate Change and Nuclear Safety Subcommittee, I feel it is my responsibility to put this hearing into context with what the United States is doing to address the issue of climate change. Our Nation is often attacked for not doing anything. But this criticism is not warranted.

First, I believe the Bush administration is taking action on many fronts. I would like to share a litany of those that will be in my statement that I would like to have submitted to the record, for my distinguished colleague from Vermont.

President Bush has established a national policy to reduce the greenhouse gas intensity of our economy by 18 percent over the next 10 years. The Administration will have spent over $20 billion by the end of 2005 for climate change activities, including extensive technology and source programs, more than any other nation. Additionally, it is a little known fact that the United States is by far the largest contributor to activities under the United Nations' Framework Convention on Climate Change and the Inter-Governmental Panel on Climate Change. Since I do not have time to go into everything, I will, as I say, insert this record into the record.

Second, Congress recently passed and the President signed an energy bill that deals with climate change in several ways. It provides research and development funding for long-term zero or low-emitting greenhouse gas technologies. These include fuel cells, hydrogen fuels and coal gasification. The bill includes intensive provisions to increase energy efficiency and conservation. It also promotes the growth of nuclear power, which is emissions-free power.

Third, on top of all these initiatives, I worked with Senator Chuck Hagel and Mark Pryor to include an amendment specifically on climate change in the Energy bill. Our amendment, which passed by a vote of 66 to 29, and was enacted as part of the Energy

bill, promotes the adoption of technologies that reduce greenhouse gas intensity both domestically and internationally, and directs the Department of State to work with developing countries.

This amendment addresses one of the main weaknesses of the Kyoto Protocol. I recently visited China and saw first-hand that their involvement in any initiative is critical as they are planning to build a substantial number of new coal-fired power plants. As a developed economy, we are willing to do our part, the United States. But if other nations increase their emissions exponentially, what have we gained?

I have also spoken with British Prime Minister Tony Blair in London and most recently at a breakfast he hosted at their embassy, which brings me to my fourth point. I recommended that he sit down with President Bush and the world's top emitters to work out something realistic, because the Kyoto Protocol will not work. I was pleased that the G8 leaders, including Prime Minister Blair and President Bush, agreed this summer to a plan of action on climate change, clean energy and sustainable development, to speed the development and deployment of clean energy technologies.

Furthermore, the United States recently joined with Australia, China, India, Japan, and South Korea to create a new Asia Pacific partnership on clean development, energy security and climate change. These are exactly the kinds of initiatives that we need to be promoting.

The fact of the matter is, our Nation continues to take comprehensive action, both domestically and internationally, to address climate change. Again, I am glad that we are holding this hearing, Mr. Chairman. I look forward to hearing from our witnesses.

[The prepared statement of Senator Voinovich follows:]

STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

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First, this Administration is taking action on many fronts. President Bush has established a national policy to reduce the greenhouse gas intensity of our economy by 18 percent over the next 10 years. The Administration will have spent over $20 billion by the end of 2005 for climate change activities, including extensive technology and science programs—more than any other nation!

Additionally, it is a little known fact that the United States is by far the largest contributor to activities under the United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change. Since I do not have time to go into everything, I will insert into the record a summary of these many activities.

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The fact of the matter is that our nation continues to take comprehensive action both domestically and internationally to address climate change.

Mr. Chairman, I again thank you for holding this hearing and look forward to hearing from our witnesses.

THE BUSH ADMINISTRATION'S ACTIONS ON GLOBAL CLIMATE CHANGE

"I've asked my advisors to consider approaches to reduce greenhouse gas emissions, including those that tap the power of markets, help realize the promise of technology and ensure the widest possible global participation....Our actions should be measured as we learn more from science and build on it. Our approach must be flexible to adjust to new information and take advantage of new technology. We must always act to ensure continued economic growth and prosperity for our citizens and for citizens throughout the world." – *President George W. Bush*

The Bush Administration Has Delivered on the President's Commitment with a Comprehensive, Innovative Program of Domestic and International Initiatives

National Goal to Reduce Emissions Growth. In February 2002, President Bush committed the United States to a comprehensive strategy to reduce the greenhouse gas intensity of the American economy (how much we emit per unit of economic activity) by 18 percent by 2012. Meeting this commitment will prevent the release of more than 500 million metric tons of carbon-equivalent emissions to the atmosphere. To help achieve this goal, President Bush has taken the following actions:

- **Cabinet Committee on Climate Change Science and Technology Integration:** President Bush has created an interagency, cabinet-level committee, co-chaired by the Secretaries of Commerce and Energy, to coordinate and prioritize Federal research on global climate science and advanced-energy technologies. This Committee develops policy recommendations for the President and oversees the sub-cabinet interagency programs on climate science and technology.

- **Increased Budget for Climate Change Activities:** President Bush's FY 2006 Budget proposes $5.5 billion for climate-change programs and energy tax incentives, which is $250 million (4.8 percent) more than FY 2005, as enacted. This figure includes nearly $3 billion for the Climate Change Technology Program, nearly $2 billion for the Climate Change Science Program, and $200 million for climate-change-related international assistance programs. In addition, conservation programs funded by the 2002 Farm Bill may increase the removal of carbon dioxide from the atmosphere due to agricultural activities.

- **Tax Incentives to Reduce Greenhouse Gas Emissions:** The President's FY 2006 budget proposes energy tax incentives that promote greenhouse gas emission reductions totaling $524 million in FY 2006 and $3.6 billion over 5 years. The incentives are designed to spur the use of cleaner, renewable energy and more energy-efficient technologies that reduce greenhouse gas emissions. Consistent with the President's National Energy Policy, the tax incentives include credits for the purchase of hybrid and fuel-cell vehicles, residential solar heating systems, energy produced from landfill gas, electricity produced from alternative energy sources such as wind and biomass, and combined heat and power systems.

Climate Change Technology Program (CCTP). The President's FY 2006 Budget continues strong support – nearly $3 billion – for the CCTP, a multi-agency program to accelerate the development and deployment of key technologies that can achieve substantial greenhouse gas emissions reductions. CCTP includes climate-change-related technology research, development, and deployment efforts as well as voluntary programs. Some initiatives within CCTP include:

- **Hydrogen:** President Bush launched his Hydrogen Fuel Initiative in his 2003 State of the Union Address. The goal is to work closely with the private sector to accelerate our transition to a hydrogen economy, on both the technology of hydrogen fuel cells and a fueling infrastructure. The President's Hydrogen Fuel Initiative and the FreedomCAR Partnership launched in 2002 will provide $1.7 billion through 2008 to develop hydrogen-powered fuel cells, hydrogen production and infrastructure technologies, and advanced automotive technologies, allowing for commercialization of fuel-cell vehicles by 2020. Through its International Partnership for a Hydrogen Economy (see international section below), the United States is pursuing international cooperation to effect a more rapid, coordinated advance for this technology that could lead to the reduction of air pollutants and a significant reduction of greenhouse gas emissions in the transportation sector worldwide. For more information on this initiative, please visit http://www.eere.energy.gov/hydrogenandfuelcells/president_initiative.html.

- **"FutureGen" -- Coal-Fired, Zero-Emissions Electricity Generation:** In February 2003, President Bush announced that the United States would sponsor, with international and private-sector partners, a $1 billion, 10-year project to create the world's first coal-based, zero-emissions electricity and hydrogen power plant. This project is designed to dramatically reduce air pollution and capture and store carbon dioxide emissions. For more information, please visit http://www.fe.doe.gov/programs/powersystems/futuregen/.

- **Fusion Energy:** In January 2003, President Bush committed the United States to participate in the largest and most technologically sophisticated research project in the world to harness the promise of fusion energy, the same form of energy that powers the sun. If successful, this $5 billion, internationally supported research project will advance progress toward producing clean, renewable, commercially available fusion energy by the middle of the century. Participants include the European Union, Russia, Japan, China, and South Korea. To read the President's statement, please visit http://www.whitehouse.gov/news/releases/2003/01/20030130-18.html.

Climate Change Science Program (CCSP). The President's 2006 budget request includes nearly $2 billion for the Climate Change Science Program (CCSP), a Federal, multi-agency research program to investigate natural and human-induced changes in the Earth's global environmental system; to monitor, understand, and predict global change; and to provide a sound scientific basis for national and international decision-making. Key elements of the CCSP include:

- **Climate Change Research Initiative (CCRI):** Each year, the President identifies the highest priority research within the CCSP as his Climate Change Research Initiative (CCRI). As announced by the President in June 2001, CCRI activities include actions to advance understanding of aerosols, better quantify carbon sources and sinks, and improve

the technology and infrastructure used to observe and model climate variations. The President's FY 2006 Budget proposes $181 million for CCRI.

- **10-year Federal Strategic Research Plan:** In July 2003, the Departments of Energy and Commerce and the White House Office of Science and Technology Policy released the *Strategic Plan for the U.S. Climate Change Science Program*, to guide activities and priorities of the CCSP over the next decade. The document describes a strategy for developing knowledge of variability and change in climate and related environmental and human systems, and for encouraging the application of this knowledge. The plan was developed with extensive consultation with the scientific community, including a 1,300-person workshop hosted by CCSP in November 2002, with representatives from over 35 countries. The National Academies of Science gave the plan high marks as it "articulates a guiding vision, is appropriately ambitious, and is broad in scope. It encompasses activities related to areas of long-standing importance, together with new or enhanced cross-disciplinary efforts." To read the plan, please visit http://www.climatescience.gov/Library/stratplan2003/default.htm.

- **U.S. Leads Earth Observation Efforts:** In April 2005, the United States released a draft 10-year Strategic Plan for the U.S. components of the integrated global Earth Observation System. This plan provides the U.S. contribution to the international planning process initiated at the U.S.-hosted, first-ever Earth Observation Summit, held in July 2003, to generate strong, international support to link thousands of individual technological assets into a coordinated, sustained, and comprehensive global Earth observation system. The purpose of the system is to provide the tools needed to substantially improve our ability to identify and address critical environmental, economic, and societal concerns. More than 30 countries and 20 international organizations participated in the Summit. Participants adopted a Summit Declaration recognizing the need to support development of a comprehensive, coordinated Earth observation system. The 2004 Earth Observation Summit was held in Tokyo and, more recently, the 2005 summit was held in Brussels, where nearly 60 countries and the European Commission agreed to a 10-year implementation plan for a Global Earth Observation System of Systems (GEOSS). Nearly 40 international organizations also support the emerging global network. For more information, please visit http://earthobservations.org.

Near-Term Greenhouse Gas Reduction Initiatives. The Federal government administers a wide array of voluntary, regulatory, or incentive-based programs on energy efficiency, agricultural practices, and greenhouse gas reductions. Major initiatives announced by the Bush Administration include:

- **"Climate VISION" Partnership:** In February 2003, President Bush announced that twelve major industrial sectors and the membership of the Business Roundtable have committed to work with four of his cabinet agencies (Energy, EPA, Transportation, and Agriculture) to reduce greenhouse gas emissions in the next decade. Participating industries include electric utilities; petroleum refiners and natural-gas producers; automobile, iron and steel, chemical and magnesium manufacturers; forest and paper producers; railroads; and the cement, mining, aluminum, lime, and semiconductor industries. This program is one of the many voluntary programs included in the Administration's Climate Change Technology

Program (CCTP). To read the President's statement, please visit http://www.whitehouse.gov/news/releases/2003/02/20030212.html. For more information, please visit http://www.climatevision.gov.

- **Climate Leaders:** Announced in February 2002, Climate Leaders is an EPA partnership encouraging individual companies to develop long-term, comprehensive climate change strategies. Under this program, partners set corporate-wide greenhouse-gas reduction goals and inventory their emissions to measure progress. Since 2002, Climate Leaders has grown to include 68 corporations whose U.S. emissions represent eight percent of total U.S. greenhouse gas emissions. In May 2005, an additional ten corporations committed to new greenhouse-gas reduction goals. This program is one of the many voluntary programs included in the Administration's Climate Change Technology Program (CCTP). For more information and a list of Climate Leaders partners, please visit http://www.epa.gov/climateleaders/.

- **Voluntary Greenhouse-Gas Reporting Program:** Responding to President Bush's February 2002 charge, the Secretaries of Energy, Commerce, and Agriculture, and the EPA Administrator provided the President with their initial recommendations for enhancing and improving DOE's greenhouse-gas emissions reduction registry. The improvements are intended to enhance the accuracy, reliability, and verifiability of greenhouse-gas reductions measurements. Interim Final General Guidelines and a Notice of Availability for the Draft Technical Guidelines were published in the Federal Register of March 24, 2005, for public comment. The Department of Energy hosted a public workshop April 26-27, 2005, to discuss the guidelines and to receive public comment. The agenda for this workshop, the presentation slides used during the workshop, a list of participants, and a full transcript of the plenary sessions are now available. On May 5, 2005, the Departments of Agriculture and Energy held a workshop on the agricultural and forestry elements of the guidelines. For more information, please visit http://www.pi.energy.gov/enhancingGHGregistry/index.html.

- **Targeted Incentives for Greenhouse-Gas Sequestration:** In June 2003, the Secretary of Agriculture announced that, for the first time, the Department of Agriculture (USDA) would provide targeted incentives to encourage wider use of land management practices that remove carbon from the atmosphere or reduce emissions of greenhouse gases. Through USDA's forest and agriculture conservation programs, such as the Environmental Quality Incentives Program and Conservation Reserve Program, USDA is encouraging the increased use of biomass energy, crop and grazing land conservation actions, practices to reduce emissions from agriculture, and sustainable forest management. For more information, please visit http://www.usda.gov/news/releases/2003/06/0194.htm.

- **Fuel Economy Increase for Light Trucks:** On April 1, 2003, the Bush Administration finalized regulations requiring an increase in the fuel economy of light trucks for Model Years 2005 - 2007, the first such increase since 1996. The increase from 20.7 miles per gallon to 22.2 miles per gallon by 2007 more than doubles the increase in the standard that occurred between Model Years 1986 and 1996. The new increased fuel economy standards are expected to save approximately 3.6 billion gallons of gasoline over the

lifetime of these trucks, with the corresponding avoidance of 31 million metric tons of carbon dioxide emissions.

- **SmartWay Transport Partnership:** Announced in February 2004, SmartWay is a voluntary partnership between various freight-industry sectors and EPA that establishes incentives for fuel efficiency improvements and greenhouse-gas emissions reductions. By 2012, this initiative aims to eliminate 33 - 66 million metric tons of carbon dioxide emissions and up to 200,000 tons of nitrogen oxides emissions per year. At the same time, the initiative will result in fuel savings of up to 150 million barrels of oil annually. More than 70 shipping, truck, and rail companies are enrolled in the program, which focuses on reducing unnecessary engine idling, and increasing the efficiency and use of rail and intermodal operations. This program is one of the many voluntary programs included in the Administration's Climate Change Technology Program (CCTP). For more information, please visit http://www.epa.gov/otaq/smartway/index.htm.

International Cooperation. The United States is engaged in extensive international efforts on climate change, both through multilateral and bilateral activities. The President's FY 2006 Budget includes $198 million for international climate change assistance. Multilaterally, the United States is by far the largest funder of activities under the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). The President's FY 2006 Budget contains $5 million for the UNFCCC and IPCC. We remain fully engaged in multilateral negotiations under the UNFCCC, and have created or worked to revitalize a range of international climate initiatives within the last two years, including the following programs:

- **Methane-to-Markets Partnership:** Announced by the EPA in July 2004, the Methane-to-Markets Partnership is a new and innovative program to help promote energy security, improve environmental quality, and reduce greenhouse-gas emissions throughout the world. The Partnership will work closely with the private sector in targeting methane currently wasted from leaky oil and gas systems, from underground coal mines, and from landfills. EPA estimates that this Partnership could recover up to 500-billion cubic feet of natural gas (50-million metric tons of carbon equivalent) annually by 2015. Capturing and using "waste" methane will provide for a new energy source that stimulates economic growth and reduces global emissions of this powerful greenhouse gas. The United States will commit up to $53 million to the Partnership over the next five years. Argentina, Australia, Brazil, China, Colombia, India, Italy, Japan, Mexico, Nigeria, Russia, Ukraine, and the United Kingdom joined the United States in launching the Methane to Markets Partnership at a November 2004 Ministerial meeting in Washington, DC. The private sector, development banks, and other governmental and non-governmental organizations are encouraged to participate in the Partnership through becoming a member of the Project Network. For more information, please visit http://www.epa.gov/methane/international.html and http://www.methanetomarkets.org/.

- **International Partnership for a Hydrogen Economy:** Announced by the Secretary of Energy in April 2003 to implement internationally the goals of President Bush's Hydrogen Fuel Initiative and FreedomCar Partnership, the United States hosted the first Ministerial meeting of the International Partnership for a Hydrogen Economy in Washington, D.C., in November 2003. The Partnership's 15 countries and the European Union (EU) are working

together to advance the global transition to the hydrogen economy, with the goal of making fuel-cell vehicles commercially available by 2020. The Partnership will work to advance research, development, and deployment of hydrogen and fuel-cell technologies, and develop common codes and standards for hydrogen use. For more information, please visit http://www.eere.energy.gov/hydrogenandfuelcells/international_activities.html.

- **Carbon Sequestration Leadership Forum:** The United States hosted the first meeting of the Carbon Sequestration Leadership Forum (CSLF) in Tysons Corner, Virginia, in June 2003. CSLF is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term storage. The purpose of the CSLF is to make these technologies broadly available internationally, and to identify and address wider issues relating to carbon capture and storage. CSLF, which now includes 15 countries and the EU, held its second Ministerial meeting in September 2004 in Melbourne, Australia, where ministers approved 10 capture and storage projects as well as a Technology Roadmap to provide future directions for international cooperation. For more information, please visit http://www.fe.doe.gov/programs/sequestration/cslf/.

- **Generation IV International Forum:** The United States has led the development of the Generation IV International Forum, a multilateral partnership fostering international cooperation in research and development for the next generation of safer, more affordable, and more proliferation-resistant nuclear energy systems. This new generation of nuclear power plants could produce electricity and hydrogen with substantially less waste and without emitting any air pollutants or greenhouse-gas emissions. Since the Forum was formally established in July 2001, the United States has led the development of a technology roadmap, and increased support for R&D projects carried out in support of the Forum's goals. For more information, please visit http://gen-iv.ne.doe.gov/intl.html.

- **Renewable Energy and Energy Efficiency Partnership:** Formed at the World Summit on Sustainable Development in Johannesburg, South Africa, in August 2002, the Renewable Energy and Energy Efficiency Partnership (REEEP) seeks to accelerate and expand the global market for renewable energy and energy-efficiency technologies. As the world's largest producer and consumer of renewable energy, and with more renewable energy generation capacity than Germany, Denmark, Sweden, France, Italy, and the United Kingdom combined, the United States is one of 17 countries who are partners in REEEP. The United States also actively participated in the Renewables 2004 conference sponsored by the German Government in June 2004, and submitted five action items intended to provide specific technology plans and cost targets for renewable energy technologies using solar, biomass, wind, and geothermal resources.

- **Regional and Bilateral Cooperation:** The United States has negotiated agreements with major international partners to pursue research on global climate change and deploy climate observation systems, collaborate on energy and sequestration technologies, and explore methodologies for monitoring and measuring greenhouse-gas emissions. Since June 2001, the United States has launched bilateral partnerships with Australia, Brazil, Canada, China, Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama, the EU, India, Italy, Japan, Mexico, New Zealand, Republic of Korea, the

Russian Federation, and South Africa on issues ranging from climate-change science to energy and sequestration technologies to policy approaches. The countries covered by these bilateral partnerships account for over 70% of global greenhouse-gas emissions.

- **Global Environmental Facility:** The Global Environmental Facility (GEF) is the financial mechanism under the UNFCCC. The United States contributes more than any other country to the GEF. The FY 2006 request for the GEF includes $25 million for climate change-related programs, roughly 23% of the total request for GEF ($107.5 million). This commitment will fund technology transfer and capacity building in developing countries.

- **Tropical Forest Conservation Act (TFCA):** As of May 2005, eight countries have TFCA agreements: Bangladesh, Belize, Colombia, El Salvador, Panama (two agreements), Peru, the Philippines, and Jamaica. These agreements are offered to eligible developing countries to relieve certain official debt owed the United States while at the same time generating funds to support local tropical forest conservation activities that store carbon. These agreements will generate over $95 million for tropical forest conservation in countries over the life of the agreements.

- **President's Initiative Against Illegal Logging:** On July 28, 2003, the Department of State Powell launched the President's Initiative Against Illegal Logging, developed with the objective of assisting developing countries in their efforts to combat illegal logging, including the sale and export of illegally harvested timber, and in fighting corruption in the forest sector. The initiative represents the most comprehensive strategy undertaken by any nation to address this critical sustainable development challenge, and reinforces the U.S. leadership role in taking action to counter the problem and preserve forest resources that store carbon. For more information, please visit http://www.state.gov/r/pa/prs/ps/2003/22843.htm.

Senator INHOFE. Thank you, Senator Voinovich.
Senator Carper.

OPENING STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

Senator CARPER. Thanks, Mr. Chairman.

Dr. Watson, welcome. We look forward to hearing from you and the other witnesses today.

I would just say to my colleagues and to our witnesses, I believe the Senate rightly rejected the Kyoto Protocol in 1997, because it called for what I think were unrealistic cuts over an unrealistic timeframe. I personally liken the Kyoto Accord to one of us driving down a road at 60 miles an hour in our car, and trying to put the car in reverse. If you have ever tried that, it doesn't work.

What makes a whole lot more sense is to, as we all know, slow the car down, stop the car and then put the car in reverse. That is really the approach that I and others, I believe, have advocated for reducing the growth of CO_2 emissions: slow the growth of CO_2 emissions, stop the growth of CO_2 emissions and then reduce CO_2 emissions. In the near future, I hope we can actually start talking about what we can do and focus a bit less on what we cannot do.

When it comes to climate change, I think there is some good news and there is some bad news. First the bad news, the bad news is that the Earth is warming, climate change is real and human beings are the primary cause. What is even worse is that it is turning out not to be a 100-year issue or even a 50-year issue. I believe we are seeing the effects of global warming today.

Just this month, another sobering report was released. In this case it was NASA, along with researchers from the University of Colorado and the University of Washington. They released the latest data showing that during the summer of 2005, the polar ice cap in the Arctic Ocean shrank to its smallest size I believe in over a century. At the current rate of decline, these researchers predict that sea ice in the Arctic will melt entirely by the year 2060.

The effects of this trend are not likely to be pleasant. As the Earth's temperature increases, the extra heat energy in the atmosphere could trigger even greater extremes of heat and drought, of storms, of wind and rain, and sometimes of even more intense cold.

Now for the good news. We can do something about it. We can begin reducing the growth of greenhouse gas emissions and still grow our economy. Forward thinking business has already started to realize that doing something proactive on global warming represents an opportunity to enhance their bottom line. More American businesses are coming to realize that controls on carbon dioxide emissions are becoming necessary. They are saying it makes sense to take small steps now to avoid bigger problems later.

In addition, many companies are realizing that addressing climate change now is having a positive impact on their bottom lines. Let me just give you a couple of examples. In May 2005, General Electric committed to reducing their carbon emissions by simultaneously moving to double revenue from carbon friendly technologies and products to $20 billion within 5 years.

Last week, IBM announced that by reducing more than 1 million tons of greenhouse gas emissions, they saved $115 million. Wayne

Balter, the vice president for corporate and environmental affairs and product safety there at IBM said, these are his words: "While some assume that cutting CO_2 emission costs money, we found just the opposite. Addressing climate change makes business sense."

The Dupont Company meanwhile has reduced their greenhouse gas emissions by more than 60 percent. They believe they have saved the company some $2 billion.

These and others companies have shown that reducing our greenhouse gas emissions is both profitable and possible. I believe it is time to take the next step. It is time for the Federal Government to get in the game. On June 22, the Senate adopted a Senate Resolution as part of the Energy bill. The resolution called on Congress to enact a mandatory, market-based climate change program. Some of you know Senators Chafee, Gregg, Alexander, and I have proposed just such a program for the utility sector in our bill that we introduced in the last two Congresses. It is a modest and achievable approach that has been endorsed by a number of utility companies.

If I could conclude with one sentence, Mr. Chairman, and then I'm done, what do you think?

Senator INHOFE. I think it's all right.

Senator CARPER. Thanks.

Our approach would slow down carbon dioxide emissions from power plants at 2006 levels and 2009, and it would then require power plants to reduce their emissions to 2001 levels by 2012. Thank you very much.

[The prepared statement of Senator Carper follows:]

STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

This Senate rightly rejected the Kyoto Protocol in 1997 because it called for unrealistic cuts over an unrealistic timeframe.

I liken the Kyoto Accord to one of us driving down the road at 60 miles an hour and immediately putting our car in reverse. Obviously, we can't do that and expect good results.

What we can do is slow down the car, eventually bring it to a stop, and then put the car in reverse. That's the approach I have advocated for. Slow the growth of CO_2 emissions. Stop the growth of CO_2 emissions.

And, after doing that, reduce CO_2 emissions.

I hope in the near future we can start talking about what we can do, not what we can't do.

When it comes to climate change, I have some good news, and I have some bad news.

First, the bad news.

The earth is warming. Climate change is real, and we are the primary cause.

What's even worse news, is that this is turning out not to be a 100-year issue, or a 50-year issue. We are seeing the effects of global warming, today.

Just this month, another sobering report was released. NASA along with researchers from the University of Colorado and the University of Washington released the latest data showing that during the summer of 2005 the polar ice cap in the Artic Ocean shrank to its smallest size in over a century.

At the current rate of decline, they predict the sea ice in the Arctic will melt entirely by 2060.

The effects of these trends could be catastrophic. As the earth's temperature increases, the extra heat energy in the atmosphere could trigger even greater extremes of heat and drought, of storms and wind and rain and even sometimes of more intense cold.

Now for the good news.

We can do something about it. We can begin reducing our greenhouse gas emissions, and still grow our economy.

Forward thinking businesses have already started to realize that doing something proactive on global warming represents an opportunity to enhance their bottom line.

More American businesses are coming to realize that controls on carbon dioxide emissions are becoming necessary. They're saying it makes sense to take small steps now to avoid bigger problems later.

In addition, many companies are realizing that addressing climate change now is having a positive impact on their bottom line. Let me give you a few examples.

In May 2005, General Electric committed to reducing their carbon emissions while simultaneously moving to double revenue from carbon-friendly technologies and products—to $20 billion within 5 years.

Last week, IBM announced that by reducing more that 1 million tons of greenhouse gas emissions, they saved $115 million. Wayne Balta, vice president for corporate environmental affairs and product safety at IBM said: "While some assume that cutting CO_2 emissions costs businesses money, we have found just the opposite. Addressing climate change makes business sense," DuPont Corporation reduced their greenhouse gas emissions by more than 60 percent, and SAVED the company $2 billion.

These and many other companies have shown that reducing our greenhouse gas emissions is possible and profitable.

It's time to take the next step. It is time for the Federal Government to get in the game.

On June 22, the Senate adopted a Sense of the Senate Resolution as part of the Energy bill.

The resolution called on Congress to enact a mandatory, market-based climate change program.

I, along with Senators Chafee, Gregg, and Alexander have proposed just such a program for the utility sector in our bill the Clean Air Planning Act. It is a modest and achievable approach that has been endorsed by a number of utility companies.

Our approach would slow down carbon dioxide emissions from power plants at 2006 levels in 2009. It would then require power plants to reduce their emissions to 2001 levels by 2012.

And by allowing these reductions to be achieved through offsets, it will be very affordable.

We've seen the states show leadership on this issue, and begin developing regional climate action plans.

We've seen forward looking companies like DuPont, IBM, and General Electric show leadership and vision and develop a business plan for operating in a carbon constrained economy.

What we haven't seen is leadership from the Federal Government. While we continue to do nothing, our international competitors are preparing for the future. While we provide no direction to our businesses, foreign companies are already developing new technologies.

Therefore, I urge my colleagues to support a mandatory, market-based approach to reducing our country's greenhouse gas emissions. As members of the U.S. Senate, we have a responsibility to lead.

Senator INHOFE. Thank you, Senator Carper. I do apologize you weren't in when I announced we are trying to stay within our time to give maximum time to our witnesses who came all this way today.

Senator CARPER. Thanks, Mr. Chairman.

Senator INHOFE. Senator Murkowski.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM THE STATE OF ALASKA

Senator MURKOWSKI. Thank you, Mr. Chairman. I hope that I do not exceed my time.

I do want to thank you for continuing this series on climate change, a very important discussion that we have had here and that needs to be continued. I too want to welcome those that will be testifying this afternoon and those that have come from so far away to participate with us.

I wish we didn't have so many conflicting things this afternoon. I won't be able to stay for the full hearing. But again, I do appreciate the opportunity to focus on this issue.

When we talk about the status of our efforts to reduce emissions and focus on the Kyoto Protocol, I really appreciate what Senator Voinovich has said, and focusing on what the United States has done as we attempt to reduce our emissions. We have done that not as a signatory to Kyoto, but we have done that because it is the right thing to do.

Regardless of where you stand on Kyoto, I think that as we look at it now, most everyone is saying, and I think even some of the Protocol's very staunch supporters, that there needs to be a new approach taken. The Kyoto Protocol has simply not worked, and it is because most of the world's largest emitters of the greenhouse gases, including China, India and South Korea, were exempt from the requirements of the Protocol. It was rejected by the United States and Australia. Many of the nations participating in Kyoto are nowhere close to meeting the treaty's targets.

We know that in order to meet or to reach Kyoto's goals, that in terms of the actions that will be taken, and Senator Carper, you have mentioned this, you just can't shove it into reverse going 60. There is an effort that needs to be made, a slowing, before you can reverse gears like that. We must be aware of what is happening within the economy.

So in going forward on a post-Kyoto solution, and Mr. Chairman, you mentioned Tony Blair, and I believe you did as well, Senator Voinovich, I too will invoke his name in a comment that he made. His statement was, "What countries will do is work together to develop the science and technology. There's no way that we're going to tackle this problem unless we develop the science and the technology to do it."

Again, it was mentioned, the United States has entered into a recent agreement with Australia, China, India, Japan, and South Korea. This agreement is a pro-growth response to climate change that focuses on the innovative technologies and the sharing of these technologies between nations to truly help reduce greenhouse gas emissions. When you consider that China and India emit twice as much CO_2 per GDP than the United States, we are hopeful that we will see some results.

So I hope to join those who have advocated strongly with Kyoto, that they will now join with us in perhaps a more realistic approach to climate change, utilizing the technology. This technology and the innovation is really going to be the way that we change, the way that the world produces and uses energy.

So I look forward to the comments from those this afternoon and again, thank you, Mr. Chairman.

Senator INHOFE. Thank you, Senator Murkowski. That is exactly what this hearing is all about.

Senator Obama.

OPENING STATEMENT OF HON. BARACK OBAMA, U.S. SENATOR FROM THE STATE OF ILLINOIS

Senator OBAMA. Thank you, Mr. Chairman.

We very much appreciate your holding this hearing. I think it can be a productive way for us to all focus on what I consider to be a very significant problem.

I think that it is unfortunate that the issue of Kyoto Protocol has been conflated all too often in the debate with the issue of greenhouse gases. Because I view these two issues as somewhat separate. There has been, unfortunately, I think, some resistance and foot-dragging on the part of not just this Administration but the United States generally about the significance and potential severity of greenhouse gas emissions and their effects on climate change.

I am one who believes that in fact the science is not in dispute, that we may not know all the details of how it is proceeding and how rapidly some of the adverse effects may be. But what's clear is that our atmosphere and the temperatures around the globe are changing. I think Senator Murkowksi probably knows this better than anybody, because she is seeing it in her backyard.

So my hope in this hearing will be to get some sense from the Administration that there is a sufficiently strong acknowledgement that this is in fact a problem and that we feel some urgency about addressing the problem, particularly since we are the single largest emitter of greenhouse gases and consume a disproportionate share of the world's energy.

The Kyoto Protocol was one effort to deal with this. I think it was a valiant effort in the sense that at a time when more of the science was still in dispute, people were farsighted enough to recognize that we needed to come up with some sort of international response to it.

I actually share the view of a number of my colleagues here, Republican and Democrat, that an agreement that was unevenly applied did not project forward the enormous energy utilization and potential emissions from countries like China and India. That did not set out the sorts of meaningful and achievable targets required to make a real difference, probably was not the best way to go.

So from this hearing, what I hope to learn is not only how has the objectives in the Kyoto Protocol been achieved, but also what kinds of alternatives are we presenting that will allow for us to participate with other countries to address this problem in the future in a constructive way.

I will just close, Mr. Chairman, by saying, though, that I do hope that this Administration takes leadership in this process and is not an idle bystander. I hope that our primary response as a country is not simply to try to study the problem more to death, or to think that voluntary initiatives by the private sector alone are somehow going to achieve the important goals that need to be achieved.

Thank you, Mr. Chairman.

Senator INHOFE. Thank you, Senator Obama.

It should be obvious now to our distinguished panel, both the first panel and the three visitors we have for the second panel, that there is a difference of opinion on this side of the table. When I became Chairman of this committee, I made an effort to see where the science was. You could certainly persuasively argue that the

science is not there, but certainly is not settled, whether you are talking about the Oregon Petition or the Heidelberg Accord or the Smithsonian-Harvard Review or any of the rest of them. Certainly that doubt is there.

But one doubt that is not there is the cost of complying to some type of mandated emissions reductions. The Horton Econometrics Survey made it very clear what it would cost the United States or other countries, which we will hear from today.

So with that, I would say any other members coming in will have to forego any other opening statements. We will now turn to our panel. Dr. Watson, take whatever time you would like, 7 or 8 minutes, if that would do it. Your entire statement will be entered into the record.

STATEMENT OF HARLAN L. WATSON, PH.D., SENIOR CLIMATE NEGOTIATOR AND SPECIAL REPRESENTATIVE, BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, U.S. DEPARTMENT OF STATE

Dr. WATSON. Thank you very much, Mr. Chairman, members of the committee. It is a pleasure for me to be here. In fact, it is a real honor for me to be here today.

I will try to summarize the testimony, I won't read all 15 pages. It sounds as though perhaps Senator Voinovich has stolen my thunder by his submission. I appreciate your warm comments, Senator.

In February 2002, President Bush reaffirmed America's commitment to United Nations Framework Convention on Climate Change and its ultimate objective, which is stabilization of atmospheric greenhouse gas concentrations at a level that prevents dangerous human interference with the climate system.

But he also made clear in that same statement that he would not commit the United States to the Kyoto Protocol that would have cost, according to some estimates at that time, the U.S. economy up to some $400 billion annually and some 4.9 million jobs. I know there are a lot of different studies and numbers thrown out there. But I would agree with you, Mr. Chairman, that it would certainly be costly to our economy.

Addressing the global climate change challenge will require a sustained global effort over many generations. The President has established a robust and flexible climate change policy, with four elements that harness the power of markets and technological innovation, that also maintains economic growth and that encourages global participation.

These four elements are first, implementing near-term voluntary, incentive-based, and mandatory policies and measures to slow the greenhouse emissions growth. Second is to advance our understanding of climate science. Third is accelerating our climate change technology development and deployment, and fourth is promoting international collaboration.

With respect to the first element, in February 2002, President Bush did set out an ambitious national goal to reduce the U.S. economy's greenhouse gas intensity, that is, our emissions per unit economic output, by 18 percent by 2012, a goal if which achieved is estimated to reduce by more than 1.8 billion metric tons of car-

bon dioxide equivalent relative to where we would be under the 14 percent business-as-usual projection of our Energy Information Administration.

Flexibility, which is the hallmark of the intensity approach, is especially important when confronted with the many uncertainties surrounding climate change—uncertainties suggesting a measured response that concentrates first—and I pick up on Senator Carper's comments—first the importance of slowing the emissions growth before trying to stop and eventually reversing it.

Unlike the Kyoto approach, an intensity type of goal can encourage reductions of greenhouse gas emissions without risking adverse economic consequences, which would jeopardize our ability to invest in long term scientific and technological solutions.

Now, Energy Information Administration analyses suggest we are ahead of schedule in meeting the President's goal, and indeed, our performance over the first 3 years of the Bush administration ranks high compared to that of other developed countries while at the same time we have substantially grown our economy, as well as our population.

The second and third elements of the President's policy are advancing climate change science and technology. The U.S. Climate Change Science Program, with a fiscal year 2006 budget request of nearly $1.9 billion, has taken on some of the most challenging questions in climate science.

The climate change technology program, which was created to coordinate and privatize the Federal Government's fiscal year 2006 request of nearly $3 billion in climate related technology research, development, demonstration and deployment in a suite of technologies, a broad potpourri of technologies including energy efficiency and renewable energy, hydrogen, carbon capture and sequestration, clean coal and nuclear fission and fusion. These are technologies that, which if successfully developed, can put us on a path to ensuring access to clean, affordable energy over the longer term, while basically dramatically reducing our greenhouse gas emissions profile over that time.

The deployment of these technologies in developing countries like China and India can make a huge difference in altering the global energy picture.

Turning to the fourth element, promoting international collaboration, I would emphasize that President Bush has repeatedly highlighted its importance in developing an effective and efficient global response to the complex and long term challenge of climate change, which does require developing country participation.

We believe the most effective way to engage developing countries is to focus not solely on greenhouse gas emissions, but rather on a broader development agenda that promotes economic growth, reduces poverty, provides access to modern sanitation, enhances agriculture productivity, provides energy security, reduces pollution and mitigates greenhouse gas emissions.

Under President Bush's leadership, the United States has brought together key nations, both Kyoto and non-Kyoto parties, both developed and developing countries, in well-designed multilateral and bilateral initiatives, collaborations that are focused on producing practical results to achieve these ends.

These collaborations, such as the Asia-Pacific Partnership on Clean Development and Climate, as was mentioned earlier, the Carbon Sequestration Leadership Forum, which we hope will lead to the development of zero emissions coal-fired power plants; the International Partnership for the Hydrogen Economy; the Generation IV International Forum, aimed at developing a new generation of nuclear reactors; the Methane to Markets Partnership; ITER, the fusion project which is to be built in France over the coming decade; the Clean Energy Initiative, which we initiated at the World Summit on Sustainable Development in Johannesburg in 2002; and the Group on Earth Observations.

In addition, our 15 now bilateral and regional partnerships encompassing over 400 collaborative activities mirror the main strategic thrusts of our domestic research programs, while addressing complementary concerns, such as energy security, climate change and environmental stewardship.

Mr. Chairman and members of the committee, I hope my testimony this afternoon, and particularly my submitted testimony, conveys a sense of the vast extent and breadth to which the United States is working to address global climate change and transforming the way the world produces and consumes energy over the next generation and beyond. That is why we are leading many global efforts to advance the science as well as to develop and deploy breakthrough transformational technologies.

Thank you for this opportunity to testify before the committee, Mr. Chairman, and I look forward to responding to your questions.

Senator INHOFE. Thank you, Dr. Watson.

We will begin a 5-minute round of questioning. Most likely we will only get to one for this panel.

Dr. Watson, you used the figures of how many billions of dollars it would cost and all that. I think sometimes it is meaningful to bring it down a little closer to home. It works out to in the neighborhood of $2,715 per family of four, according to the Horton Econometrics. Does that sound like it's very far off?

Dr. WATSON. I've seen those numbers, yes, it's very much in the ballpark that I have seen, sir.

Senator INHOFE. Dr. Watson, how many of the European Union countries look like they are on track to meet the Kyoto targets? You might hold up that blue chart?

Dr. WATSON. I think probably the best gauge of that is a report which was issued by the European Environment Agency, this is from December 2004. It made projections for the first Kyoto period, both progress by the EU, the European Union and its Member States. I would be happy to submit a copy for the record, if you would like, sir.

Senator INHOFE. Is that similar to this chart up here?

Dr. WATSON. I am assuming probably the numbers came out of there, yes, that's very similar.

Basically, if I could just summarize what their results are, again, this is a December 21, 2004 report, which again is based on 2002 data and I did note, I believe, that Ambassador Bruton, the EU Ambassador, had provided, some updated figures from 2003. But again, this is based on 2002 emissions data.

This report says that only two EU countries, the United Kingdom and Sweden, now anticipate meeting 2010 Kyoto targets purely through existing domestic policy and measures, with Germany being close. I want to emphasize, you see, right there, Germany is minus 20 percent, and Germany's target under the European Union, the 15 members of the European Union at that time, their target was minus 21 percent. So they are very close.

Finland, France, Greece, and Ireland project they can meet their targets with additional domestic policies and measures currently being planned. Austria, Belgium, Luxembourg, and the Netherlands project achieving their targets by 2010 by a combination of additional domestic policies and measures and the use of the Kyoto mechanisms, such as the Clean Development Mechanism, Joint Implementation, and emissions trading.

Finally, they named four Member States, Denmark, Italy, Portugal, and Spain, who were not on track at the time of this report and do not project to reach their targets with a combination of additional domestic policies and measures and use of the Kyoto mechanisms. That is almost literally a quote out of that report.

I might note also, Senator, that the recent figures that were provided to you in the Ambassador's letter were based upon a subsequent report, a May 27, 2005 report, which was submitted to the Secretariat of the United Nations Framework Convention on Climate Change. This is the annual emissions report which is required by all the developed country parties. They actually indicated for most of the European Union countries, at least among the 15 of the 25, emissions have grown over the last period from 2002 to 2003, which again would make these targets more difficult to attain.

Senator INHOFE. Dr. Watson, I will wait and ask the next panel the question, it is my understanding that the way Germany got to where it is, they had a rather abrupt cessation of coal-powered plants. But we will ask the next panel that.

Looking at the process of Kyoto, do you realistically think that a process of targets and time lines would ever be embraced by the very large developing nations, India, China and others?

Dr. WATSON. No. Particularly China and India have made it very clear that their focus is on economic development and poverty reduction. They will not, certainly not, I don't believe in my lifetime, and I hope to live to be older, that they will be willing to take on specific targets and timetables. They are very, very willing to talk about, and they are very concerned about environmental issues. They are obviously willing to talk in the context of a broad development agenda, which gives them multiple benefits, while also addressing greenhouse gases. This is the context that we have been able to engage both China and India and a number of the other developing countries.

Senator INHOFE. My time has expired, but I would agree with that. One of the problems you have when you look at this is that you have so many countries whose major thrust is on the economy. They are trying to grow. Africa, I have spent a lot of time in Africa, and I think we have made our position as the U.S. Senate very clear by a vote of 95 to nothing that we would reject an approach

that would treat developing countries differently from developed nations.

Senator Jeffords.

Senator JEFFORDS. Yes, Mr. Chairman. Before I begin my questions, I want to ask consent to submit a letter to you that I received yesterday from the European Union Ambassador John Bruton to the record. In this letter, the Ambassador details the EU's greenhouse gas emissions are currently 2.9 percent below the 1990 levels.

Senator INHOFE. Without objection, so ordered.

[The referenced document follows:]

EUROPEAN UNION

DELEGATION OF THE EUROPEAN COMMISSION

Head of Delegation

The Honorable James M. Inhofe
Chairman, Committee on Environment and Public Works
United States Senate
Washington, DC 20510

Dear Mr. Chairman,

In view of the full hearing the Environment and Public Works Committee will conduct on Wednesday, October 5, 2005, on the Kyoto Protocol to assess the status of efforts to reduce greenhouse gases, I have the pleasure to communicate to you the latest information how the EU and its Member States are progressing to meet their Kyoto targets.

I would very much appreciate, if this information could be included in the record of the hearing.

The EU is fully committed to implement its obligations under the Kyoto Protocol. It has adopted a series of policies and measures, such as the EU's greenhouse gas emissions trading scheme, to meet its target in a cost-effective manner. These measures, together with the EU's participation in the global carbon market, will ensure that the EU meets its target.

To ensure its compliance with the Kyoto Protocol, the EU has adopted a series of measures under the European Climate Change Program (ECCP). Most of these measures have recently entered into force and will start to show their full effect over the next few years. These include:

- The EU greenhouse gas emissions trading scheme;
- The promotion of electricity from renewable energy sources;
- The promotion of cogeneration (CHP);
- Increasing the energy performance of buildings;
- The promotion of the use of biofuels for transport.

The tables in Annex I give a full overview of all recently adopted measures and their projected effect. ECCP policies and other actions by EU Member States to date, in combination with restructuring of European industry, particularly in Central and Eastern Europe, have contributed to an absolute reduction of annual carbon dioxide emissions of some 350 million tonnes (5.5%) across the EU-25 by 2003, equivalent to 5 years of emissions from the Republic of Ireland.

In 2003, the 15 EU Member States that share the EU's Kyoto target of -8% had reduced their greenhouse gas emissions by 1.7% compared to 1990 levels. The average EU-15 emissions over the most recent 5-year period, which is also the period over which Kyoto compliance is assessed, are **currently 2.9% below 1990 level**. An overview of the performance of individual Member States is given in Annex II

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The EU will make use of the cost-effective reduction options offered by its participation in the global carbon market, based on the Kyoto Protocol's flexible mechanisms, to meet its Kyoto target. The table in Annex III gives an overview of the planned use by individual Member States of the Kyoto mechanisms

Whereas the EU is right on track, additional measures at Member States level are required to meet the 8% reduction target. With implementation of those additional measures and use of the Kyoto flexible mechanisms, the EU will reach a 9.4% reduction on base year emissions, of which 6.8% will be achieved by EU Member States measures alone. In other words, the EU will reduce more than is needed to meet the EU-15 Kyoto target.

In summary, the EU has made good progress so far. Further progress depends on the speed and thoroughness of the implementation by Member States of Community legislation and domestic measures. The total of the projections for the EU-15 Member States shows that the Kyoto targets will be met with additional domestic measures and the use of flexible mechanisms, as planned.

Beyond 2012

The EU's climate policy does not stop in 2012. Many of the EU policies that are already in place will have an important impact beyond the Kyoto Protocol's first commitment period. The EU's greenhouse gas emissions trading scheme will automatically continue after 2012. The second phase of the European Climate Change Programme will be launched in late 2005. It will include carbon capture and storage, passenger road transport, aviation and strategies to adapt to the effects of climate change, in addition to the work programme already covered.

The European Commission has also adopted a Communication outlining key elements for a strategy for further action post 2012. While it indicates that the EU is ready to engage in an open dialogue between countries concerning the further development of an international framework post 2012, it has highlighted a number of key elements for a successful global climate policy: the need for broader participation by countries and sectors, the development of low-carbon technologies, the continued and expanded use of market-based instruments, and the need to adapt to the inevitable impacts of climate change.

We believe that these policies, and others like them, provide strong, long-term signals to industry, Member State governments and the wider international community that the EU is committed to tackling climate change and expects all of its institutions, businesses and citizens to play their part.

Yours sincerely,

John Bruton

Ambassador

Annex I:

European Climate Change Programme: Overview table of policies and measures

Explanation of terminology and estimates of emission reduction potential

1. "*In force*": These measures are adopted by the EU institutions, the main task for the Commission is to monitor the implementation and review if appropriate (as sometimes laid down through specific legislative requirements). Important upcoming reviews are also indicated in the table
2. "*In co-decision*": These measures have been proposed by the Commission and are currently in co-decision in the European Institutions
3. "*in implementation*" : these non legislative measures are currently in execution
3. "*Advanced stage of preparation*": the preparatory policy work is to a large extent completed and a concrete proposal is envisaged in the Commission's work plan
4. "*In preparation*": the examination of the measure are still on-going

It should be noted that the emission reduction potential for the various ECCP measures are (ex-ante) estimates. The 'ex ante' ECCP evaluation of the potential of a certain measure does not necessarily coincide with the actual realisation in the field, as not all of the detailed provisions of the proposals or adopted measures have been taken into account in the pre-evaluation. Another reason is that the estimated potential is sometimes based on reaching certain (indicative) targets, which will need to be proven in practice (e.g. CHP and biofuels proposals).

Summary of implemented and planned policies and measures

Cross-cutting issues

Policies and measures 'Cross-cutting'	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
EU emissions trading scheme		In force
Revision of the monitoring mechanism	N/a	In force
Link Kyoto flexible mechanisms to emissions trading		In force

Energy Supply

Policies and measures 'Energy supply'	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
Directive on renewable electricity	100-125[1]	In force Review in 2005
Directives on the promotion of transport bio-fuels	35-40[1]	In force
Directive on promotion of cogeneration	22-42[2]	In force
Further measures on renewable heat (including biomass action	36-48	In preparation

[1] Second ECCP progress report April 2003 - http://europa.eu.int/comm/environment/climat/pdf/second_eccp_report.pdf
[2] COM (2004)366 – final "The share of renewable energy in the EU, May 2004

plan)		
Intelligent Energy for Europe: programme for renewable energy	N/a	Programme for policy support in renewable energy
TOTAL in implementation	193-255	

Energy demand

Policies and measures 'Energy demand'	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
Directive on the energy performance of buildings	20[3]	In force Monitoring and review
Directive requiring energy labelling of domestic appliances Existing labels New (el.ovens &AC) Envisaged revisions (refrigerators/freezers/dish-washers) Planned new (hot water heaters) Extension of scope of Directive	 20[1] 1 10 23 N/k	In force Monitoring and review in preparation In preparation In preparation
Framework Directive on eco-efficiency requirements of energy-using products	2010: dependent on implementation of daughter directives	In co-decision (institutional agreement)
Directive on Energy services	40-55[1]	In co-decision Includes requirements regarding energy efficient public procurement
Action Plan on Energy efficiency as a follow-up to the GreenPaper	N/a	In preparation (2006)
Action under the directive on integrated pollution prevention and control (IPPC) on energy efficiency	N/k	In preparation
Intelligent Energy for Europe programme for energy efficiency	N/a	Programme for policy support in energy efficiency
Public awareness campaign on energy efficiency	N/a	Supporting program as part of Intelligent Energy for Europe: In implementation
Programme for voluntary action on motors (Motor Challenge)	N/a	Supporting programme for voluntary action on efficient motor systems
Public procurement	N/a	EU Handbook developed for guidance for increased energy efficient public procurement
OVERALL in implementation	114-129	

[3] COM (2004)366 – final "The share of renewable energy in the EU, May 2004

Transport

Policies and measures 'Transport'	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
Community strategy on CO_2 from passenger cars (including voluntary commitment – VC - of car associations)	Total 107-115 Of which VC: 75-80[4]	VC: monitoring; review ongoing Labelling: in force Communication on fiscal measures: in implementation Directive on taxation of passenger cars: in preparation
Framework Directive Infrastructure use and charging	N/k	In implementation, in relation to heavy duty road transport only
Shifting the balance of transport modes	N/k	Package of measures in implementation
Fuel taxation	N/k	In force Focus on EU harmonisation of taxation, not on CO_2 reduction
Directive on mobile air conditioning systems: HFCs	See regulation on fluorinated gases	In co-decision, as part of regulation on fluorinated gases
TOTAL in implementation	**107 - 115**	

Industry & non CO_2 gases

Policies and measures 'Industry'	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
Regulation on fluorinated gases	23[5]	In co-decision
IPPC & non-CO_2 gases	N/k	In force Review periodically

Waste

Policies and measures	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
Landfill Directive	41[4]	In force
Thematic strategy on waste	N/k	In preparation

Integration Research & Development

Policies and measures	**Emission reduction potential (Mt CO_2eq) By 2010 – EU-15**	**Stage of implementation /timetable /comments**
R&D framework Program	n/a	In force 6 Framework Programme for research and development Includes support for R&D in the fields of energy, transport and climate In preparation 7 Framework Programme

[4] Second ECCP progress report April 2003 - http://europa.eu.int/comm/environment/climat/pdf/second_eccp_report.pdf

[5] COM (2003) 492 final

Integration Structural funds

Policies and measures	Emission reduction potential (Mt CO_2eq) By 2010 – EU-15	Stage of implementation /timetable /comments
Integration climate change in structural funds &cohesion funds	n/a	For the new budgetary period 2007-2013 renewable energy and energy efficiency have been identified as eligible areas for support –EU strategic guidelines In preparation

Table 1: Agriculture

Policies and measures in 'Agriculture'	Emission reduction potential (Mt CO_2eq) By 2010 – EU-15	Stage of implementation /timetable /comments
Integration climate change in rural development	N/a	For the new budgetary period 2007-2013 renewable energy and energy efficiency have been identified as eligible areas for support –EU strategic guidelines In preparation
Support scheme for energy crops	N/a	In force
N_2O from soils	10	improved implementation of the nitrates Directive
TOTAL in implementation	**10**	

Table 2:Forests

Policies and measures 'Forests'	Emission reduction potential (Mt CO_2eq) By 2010 – EU-15	Stage of implementation /timetable /comments
Afforestation and reforestation: - Afforestation programmes - Natural forest expansion	Not known	Identified potential: 14 Mt of CO2 eq..Possibility for support through forestry scheme of rural development
Forest management (various measures)	Not known	Identified potential: 19 Mt CO2 eq..Possibility for support through forestry scheme of rural development, dependent on national implementation.
TOTAL in implementation	-	

Annex II: the EU's Kyoto performance

Greenhouse gas emissions trends and Kyoto Protocol targets for 2008-2012

(source: European Environment Agency, 2005)

	Base year [1] (million tonnes)	2003 (million tonnes)	Change 2002-2003 (million tonnes)	Change 2002-2003 (%)	Change 1990-2003 (%)	Targets 2008-12 under Kyoto Protocol and EU burden sharing (%)
Austria	78,5	91,6	5,1	5,9%	16,6%	-13,0%
Belgium	146,8	147,7	2,4	1,6%	0,6%	-7,5%
Cyprus	5,3	9,2	0,5	5,3%	72,2%	-
Czech Republic	192,1	147,1	4,3	3,0%	-23,4%	-8,0%
Denmark	69,6	74,0	5,0	7,3%	6,3%	-21,0%
Estonia	43,5	21,4	1,9	9,7%	-50,8%	-8,0%
Finland	70,4	85,5	8,3	10,8%	21,5%	0,0%
France	568,0	557,2	3,5	0,7%	-1,8%	0,0%
Germany	1248,3	1017,5	2,3	0,2%	-18,5%	-21,0%
Greece	111,7	137,6	4,1	3,1%	23,2%	25,0%
Hungary	121,6	83,3	2,4	3,0%	-31,5%	-6,0%
Ireland	54,0	67,8	-1,8	-2,6%	25,2%	13,0%
Italy	510,3	569,6	14,6	2,7%	11,6%	-6,5%
Latvia	25,4	10,5	-0,1	-0,9%	-58,5%	-8,0%
Lithuania	50,9	17,2	-2,4	-12,1%	-66,2%	-8,0%
Luxembourg	12,7	11,3	0,5	4,3%	-11,5%	-28,0%
Malta [2]	2,2	2,9	0,0	-0,5%	29,1%	-
Netherlands	213,1	214,8	1,4	0,6%	0,8%	-6,0%
Poland	566,3	384,0	13,8	3,7%	-32,1%	-6,0%
Portugal	59,4	61,2	-4,5	-5,3%	36,7%	27,0%
Slovakia	71,7	51,7	-0,6	-1,1%	-27,9%	-8,0%
Slovenia	20,5	19,9	-0,3	-1,5%	-2,9%	-8,0%
Spain	286,1	402,3	3,7	0,9%	40,6%	15,0%
Sweden	72,3	70,6	1,1	1,5%	-2,4%	4,0%
United Kingdom	751,4	651,1	7,4	1,1%	-13,3%	-12,5%
EU-15	4252,5	4179,6	53,3	1,3%	-1,7%	-8,0%

([1]) The base year for CO_2, CH_4 and N_2O is 1990; for the fluorinated gases 13 Member States have chosen to select 1995 as the base year, whereas Finland and France have chosen 1990. As the EC inventory is the sum of Member States' inventories, the EC base year estimates for fluorinated gas emissions are the sum of 1995 emissions for 13 Member States and 1990 emissions for Finland and France.

([2]) Malta and Poland did not provide GHG emission estimates for 2003, therefore the data provided in this table is based on gap filling.

Note: **Malta and Cyprus do not have Kyoto Protocol targets**

Annex III:

Use of the Kyoto Mechanisms by Member States

Member State planned use of the Kyoto Mechanisms in Million tonnes of CO_2 equivalent for the entire first commitment period (2008-2012), based on information provided in their National Allocation Plans submitted under the EU emissions trading scheme.

Member State	Planned use of Kyoto mechanisms	Which Kyoto mechanisms? (ET, CDM, JI)	Projected emission reduction 2008–12 through the use of Kyoto mechanisms [a] [Million tonnes CO_2-equivalents per year]
Austria	Yes	Priority on JI and CDM	7.0[b]
Belgium	Yes	Priority on JI and CDM	8.4
Denmark	Yes	CDM, JI	4.5
Estonia	No	-	-
Finland	Yes (Pilot programme to gain experiences implemented)	Not yet decided	0.6 contracted, total quantity not yet decided
France	Yes	Priority on JI and CDM	Not yet decided
Germany	Use of Kyoto mechanisms allowed at company level, no acquisition by government planned	ET JI, CDM	No projected estimate as the amount will depend on private action
Greece	Not yet decided	Not yet decided	Not yet decided
Ireland	Yes	ET	3.7[c]
Italy	Yes	ET, CDM, JI	39.6
Luxembourg	Yes	ET, CDM, JI	3.0
Netherlands	Yes	CDM, JI	20.0[d] (CDM and JI)
Portugal	Yes	ET, CDM, JI	No estimate provided[e] Studies on the use of JI/CDM initiated
Slovenia	Yes	ET CDM, possibly JI	Not yet decided
Spain	Yes	Priority on ET and CDM	20.0
Sweden	Not yet decided, under consideration (Pilot programme to gain experiences)	ET, CDM, JI	Investements made are estimated to amount to 1 Mton/year in emission credits
United Kingdom	Use of Kyoto mechanisms allowed at company level, no acquisition by government planned	ET CDM, JI	No projected estimate as the amount will depend on private action

Notes:

[a] The projected emission reduction through the use of Kyoto mechanisms for Austria, Ireland and Luxembourg stems from the Commission decisions on the national allocation plans of those countries (COM(2004) 500 final, COM(2004) 681 final). The Commission has based its decision on information provided in the NAPs and/or in further correspondence during the assessment of the NAPs. The figures for Belgium,

Denmark, Italy, the Netherlands, Portugal and Spain are derived from the questionnaire, the 3rd national communication or the national allocation plan (for details see below).

[b] Austria assumes in the questionnaire a maximum of 50 % of the efforts required for compliance with its burden sharing target to be accomplished by means of JI and CDM.

[c] Ireland states in the questionnaire that it intends to purchase 3.7 million tonnes CO_2-equivalents per year from international emissions trading.

[d] The Netherlands expect in the questionnaire a contribution of 100 million tonnes CO_2-equivalents from project based activities in 2008-12 (20.0 million tonnes CO_2-equivalents per year).By the end of 2004 99.0 million tonnes CO_2-equivalents have already been contracted, two thirds of which from CDM projects and the remaining third from JI.

[e] Portugal assumes in the questionnaire a maximum of 50% of the additional efforts required (described as the difference, for each of the years of the commitment period, between emissions levels considering the effects of policies and measures, and the burden sharing target) will be accomplished by means of JI and CDM.

Source: EEA, 2005

Senator JEFFORDS. Mr. Watson, you have outlined the Administration's current and prospective policies to address climate change. For a point of comparison, how much money did the United States spend in fiscal year 2005 to address climate change?

Dr. WATSON. I believe the current estimate is $5.2 billion. I will get the exact figures and exact breakout for you, though, Mr. Chairman. [See figures on page 81.]

Senator JEFFORDS. How much reduction was achieved?

Dr. WATSON. Our emissions actually were, I can tell you what we have achieved in the period of 2000 to 2003, our overall greenhouse gas emissions are approximately eight-tenths of a percent below year 2000 and 2003. So we have achieved emissions reductions. There are a lot of reasons for that, obviously.

Senator JEFFORDS. That was one-tenth of a percent?

Dr. WATSON. Eight-tenths of a percent, yes.

Senator JEFFORDS. Much has been made, and other witnesses will testify later in the hearing about the potential economic impact of Kyoto on participating nations. Yet these nations have taken on these risks to alleviate the devastating effects of climate change.

I know you have participated in all the recent negotiation meetings. Do you have a sense about how the Kyoto implementation has affected economic growth, poverty, energy security and pollution reduction objectives among participating countries?

Dr. WATSON. Well, we really don't get into those discussions within those negotiating sessions. I believe it's hard to sort out what the impact of those implementing Kyoto is versus those that are not. Because basically, it is too soon to tell. As a matter of fact, even though the Protocol entered into force on February 16 of this year, the actual real implementation will not occur until decisions are taken at the next Conference of the Parties' meeting in Montreal. There are still some 19 outstanding decisions to be made before the full implementation of the Protocol itself.

So I think it's too soon to tell, sir.

Senator JEFFORDS. Thank you. While the Energy Policy Act of 2005 promotes the development, demonstration and commercialization of innovative technologies, it protects information from public disclosure for 5 years. Since 80 percent or more of the costs of developing these is taxpayer funded, would you support the wider, quicker dissemination and adoption of new energy efficient and carbon capture technologies, and do you think that that would help your negotiating efforts with developing countries?

Dr. WATSON. I am really not qualified to comment on this, but let me just say that what we are doing within the context of our initiatives, such as the Carbon Sequestration, Leadership Forum and our International Partnership for the Hydrogen Economy, to give you two examples. When members come forward with a project and to have a project, for example, endorsed by the Carbon Sequestration Leadership Forum, or the IPHE, it must be supported by two or more members of the partnership and the results of that work, which comes out of the project, are made available to all the other members within.

Obviously, the closer you get to the development world, there are going to be intellectual property issues, which will need to be handled on a case-by-case basis. But we certainly share the philosophy

that obviously the sharing of information, particularly at the basic research side, is very important.

Senator JEFFORDS. Well, the Energy Policy Act of 2005 promotes the development, demonstration and commercialization of innovative technologies. It protects information from public disclosure for 5 years.

Since 80 percent or more of the costs of developing these technologies is taxpayer funded, would you support the wider, quicker dissemination and adoption?

Dr. WATSON. Yes. As I say, sir, we are very much, when we are dealing with basic research and say, on the basic research side, we fully support, obviously, the sharing of information. As I say, when we get more into the applied end of research, we do have to deal with intellectual property issues.

Once again, I am really not qualified to take a position on that right now. I would be happy to respond for the record, however.

Senator JEFFORDS. Thank you very much.

Senator INHOFE. Thank you, Senator Jeffords.

Senator Voinovich.

Senator VOINOVICH. Dr. Watson, we recently had a debate on the Senate floor about mercury emissions from power plants. As you know, the President has recommended a 70 percent reduction in mercury emissions, the first country to come forward and initiate such a program.

At the time we debated this, I think many of my colleagues and the public did not understand that mercury pollution is a global issue and that it can travel hundreds and thousands of miles. In fact, from 1990 to 1999, EPA estimates that U.S. emissions of mercury were reduced by nearly half, which have been completely offset by increases in emissions from Asia.

I think this is very similar to the issue of climate change. During the last several years before this committee, we have been trying to deal with an emissions bill or pollution bill, whatever you want to call it. Senator Jeffords had a bill in a couple of years ago, and I fought it because part of the reason, one of the things they wanted to do was cap greenhouse emissions. The President's Clear Skies Legislation, which I co-sponsored, fell on the rocks because many of the members of this committee wanted us to cap greenhouse emissions.

The argument that we made at the time is that in terms of technology that is available today that it would be penny-wise and pound-foolish; i.e. if we would cap greenhouse gases, it would drive up our energy costs, which are already astronomical, 600 percent of natural gas, we have the highest natural gas costs today in the country, electric rates are skyrocketing. My argument is, and I guess maybe it is a little bit narrow, because I come from Ohio, and we are a manufacturing State. We have seen thousands of jobs leave our State because of high energy costs. In some instances, they have gone to China.

So we have shut down our manufacturing in this country by unrealistic goals in greenhouse emissions and moved the jobs overseas, and the question you have to ask yourself is, what have we done to improve greenhouse gas emission in the world today? I

would like you to comment on that in terms of what you see from your vantage point.

Dr. WATSON. I appreciate your comments, I am certainly concerned. My wife is a native of Ohio, Senator, and we visit there quite often.

You are absolutely right, that is obviously one of the concerns that we had and obviously the U.S. Senate had in its debate in 1997, that we would just spur the movement of jobs overseas. The pollution is not going to go away, it is a global issue, whether it's mercury or carbon dioxide or whatever.

Senator VOINOVICH. By the way, many of the countries those jobs are going to don't have the environmental policies in place that we have here in the United States.

Dr. WATSON. That is absolutely correct. That is one of the reasons, of course, we are investing lots and lots of Federal money, along with a great partnership with the private sector, on trying to develop our carbon capture and storage. I am sure you have heard of a FutureGen project, which the Department of Energy has proposed, to demonstrate a zero emission coal-fired plant by later in the decade.

We are pleased that that is moving ahead. We have lots of technical work to do on it. As you say, the technology is not there currently to address greenhouse gas emissions from coal. We know that coal is a vital part of our country's energy mix. It is typically some 55 percent of our electricity production and higher, I know, in Ohio. We are working very hard on developing that technology and making it economical, sir.

Senator VOINOVICH. I must say to you that we did pass a decent Energy bill. But I am at the point that I think we need a second declaration of independence, and that is energy independence. I think we rely far too much on foreign sources of energy for this country. If we don't wake up very quickly and have some kind of a Sputnik-like commitment to doing something about this problem that we are going to hurt our economic competitiveness, and it will hurt our national security.

I would hope that some thought is being given to that now. You have again the global picture. But I think we are in jeopardy today, and I would hope that some folks over in the Administration are giving some serious thought to what we can do to make that happen.

Dr. WATSON. Yes, sir.

Senator INHOFE. Thank you, Senator Voinovich.

Senator Carper.

Senator CARPER. There are one or two things that Senator Voinovich and I do not agree on. What he just said, there is a lot we do agree on, we agree a lot more than we disagree. But what he just said about energy independence, I could not agree more. Our reliance on foreign oil, the way it boosts our enormous and growing Federal trade deficit is unsustainable and deplorable.

Around here, Dr. Watson, we have a way of characterizing budget cuts that I want to share with you. When someone wants to deter or discourage the rest of us from adopting a reduction in spending, or a reduction in the growth of spending, they will de-

scribe a cut, say it's like an 18 percent cut in a particular program, spending for a program.

When you actually look at the amendment or whatever is being suggested, it's not an 18 percent, well, we'll say it is a $100 million program, 18 percent cut, they will suggest it is reducing the spending to $82 million instead of $100 million. But when you actually looking at the amendments being proposed, it is a cut below what the program would otherwise grow to, given changes in population and inflation and so forth. So it's not really an 18 percent growth.

I just want to understand, if you can just explain, simply and clearly for me, the 18 percent reduction that I think you talked about in CO_2 emissions, is that an outright reduction of 18 percent or is it, are we talking about an 18 percent reduction in the growth of emissions? Which is it?

Dr. WATSON. We are talking about an 18 percent reduction in greenhouse gas intensity. It still means a growth in emissions. The latest projections that I have seen anyway from the Energy Information Administration would indicate that if we did not, if we followed their business-as-usual path, we normally expect some improvement in greenhouse gas intensity just through normal technological improvements, it would be 14 percent through 2012. The President has said we want to do better than that, 18 percent.

What that basically amounts to is, rather than our emissions by 2012 being 34 percent above 1990, they will be some 27 percent above 1990. So yes, our emissions are still growing, but again, it is a bending of the curve, it is a slowing down that you referred to in your opening statement. One can argue whether it is slowing down fast enough, but it is slowing down.

Senator CARPER. What I would like to get to is, I was writing out some notes here trying to do a little bit of calculation to try to figure out if we were to continue the rate of reduction of growth that you have described here, when would we get to the point, going back to my earlier example of, slow the car, stop the car, put the car in reverse, when would we get to the point, given the approach that we are taking here, where we would actually see growth in CO_2 emissions stopped under this approach?

Dr. WATSON. What needs to happen, we need to get new technology and better technology into the marketplace, so that basically, we really need to make sure that our improvement in efficiency is matching our economic growth, so there is a net zero there. Hopefully we can bend that over to get to the stop and then to reverse.

We are not there, our improvement right now in intensity is something on the order of, it has been a little over 2 percent, 2.3 percent in the latest figure. But our economy is still growing at 3 plus percent, which is good. So we need to figure out ways to boost the productivity and efficiency of our economy. We are working on that.

Senator CARPER. What I'm trying to get at is a number. When is the year, when do you think, just roughly, is the year that we are going to be able to say, the car has stopped, or in this case, the rate of growth has stopped.

Dr. WATSON. Well, to a certain extent, Senator, we have stopped the car over the period of 2000 to 2003. We stopped the car. In fact,

over the period of 2000 to 2003, as I mentioned earlier, our absolute greenhouse gas emissions have decreased by .8 percent.

But there are a lot of reasons and we don't know if we can maintain that. A lot is going to depend on various factors: How fast is our economy going to grow, how fast do we get new technologies out there, are we going to have a warm summer, are we going to have a cold winter, and so on. So there are a lot of variables.

We have stopped it temporarily, but I cannot guarantee that it will continue. We just don't know yet.

Senator CARPER. A lot of times I talk to people and we talk about trying to reach certain goals, and I ask them, how do you measure success. How do we measure success with respect to the goal that we might be discussing? How should we measure success with regard to alleviating and reducing the threat of global warming?

Dr. WATSON. It is relatively easy to measure success by the President's measure. We know what our greenhouse gas emissions are in any given year, and report those to the United Nations every April. We know what our GDP growth is, so we can do the simple arithmetic and measure the progress toward meeting the President's 18 percent reduction goal over the period to 2012.

Senator CARPER. I think my time has expired. Thanks, Mr. Chairman.

Senator INHOFE. Thank you, Senator Carper.

Senator Thune.

Senator THUNE. Thank you, Mr. Chairman. I want to thank you for holding the hearing on the Kyoto Protocol. It is not an issue that I hear a lot about in my home State of South Dakota. In fact, it is probably the furthest thing from a lot of the minds of some parts of western South Dakota today, because they woke up to snow.

Given that, I am very much looking forward to hearing the testimony of our witnesses do want to make clear that I support the concept of dealing with global climate change with flexibility. I believe our policy measures in this area ought to include many of the incentives and voluntary programs that I think will help us make progress toward our goal. So I appreciate your having the hearing today, Mr. Chairman. I think it is an important subject for us to be discussing.

I would ask, I guess, one question of our witness, Dr. Watson, and that is, with respect to the goals that you have and the 18 percent reduction in the intensity over the course of the next several years, we have had an opportunity up here enacted on in this committee, or at least voted on, I should say, Clear Skies Initiative, which would implement some policy changes and put some goals in place for sulfur and nitrates and mercury and some other things.

I guess my question would be, how would that change if we were to adopt or implement the policy that is included in the Clear Skies Initiative help us achieve some of those goals, and does that accelerate our ability to reach those goals? We unfortunately didn't have the votes on this committee to report that to the Senate floor. But I am hopeful that eventually we will be able to get that done, because I think it's important.

Dr. WATSON. I appreciate that. I know that the Council on Environmental Quality Chairman, Jim Connaughton, has been very in-

terested in this, and I believe has tasked out a study on the contribution that the passage of Clear Skies can make. We know it is going to have a positive impact on our greenhouse gas emissions profile, it is going to lead to more efficient use of coal, more efficient generation of electricity.

That ought to have the co-benefit of also reducing our greenhouse gas emissions. I can't give you an exact figure on that now, but I do believe a study is underway.

Senator THUNE. That is data, though, at some point when the study is completed, that we would have access to?

Dr. WATSON. Absolutely, sir.

Senator THUNE. Again, I appreciate your answer to that, and Mr. Chairman, I would suggest that hopefully we will be able to jump start that initiative at some point. I know that there is a lot of interest in the subject and different views and approaches about how best to achieve these goals. But I think that was definitely a step in the right direction. I think if we are able to implement some of those policy changes, I would be anxious to see if that changes the schedule in terms of reaching the ultimate goal.

But it seems to me at least that that really was a good piece of legislation and I hope that eventually we will be able to get the votes on this committee to bring it to the floor where we can have a good debate about it.

I yield back the balance of my time.

Senator INHOFE. Thank you, Senator Thune. That is a huge step in the right direction. We are talking about 70 percent mandated reductions in SOx, NOx and mercury. No other president has ever suggested something like that.

Senator Obama.

Senator OBAMA. Thank you, Mr. Chairman.

Dr. Watson, I know you are not a scientist, and the purpose of this hearing is not to rehash all the arguments about whether or not climate change is happening or is a problem or it is not. But it just strikes me that the only way we can intelligently assess our approach and the Kyoto Protocol approach is to determine how urgent of a crisis is this. If it is not a major crisis, then the Kyoto Protocol makes no sense and all these countries that are involved are engaging in a great deal of fuss and trouble for no reason. If it is a problem, then that means that maybe we are a little slow on the uptake.

So I guess I am just trying to figure out, what is the Administration's position right now, just in terms of how much of a problem this is? Is climate change, from the perspective of the Administration, a significant problem, not just to the world, but to the United States in particular?

Dr. WATSON. Yes, the President has made that clear, I believe going back to his first address on climate change, back in June, as I recall, June 11, 2001. He recognizes that climate change is an important issue, an important problem, an important matter of concern. He certainly hears it from his colleagues as he travels and he engages with leaders around the world. We have responded I think robustly——

Senator OBAMA. I don't mean to interrupt you, but before we establish the response, I just want to be clear, I want to make sure

on the record. From the Administration's position, the science indicates that in fact climate change is occurring at a fairly rapid rate that has some sort of potential adverse consequences in terms of ice caps melting or the fluctuations in ocean temperatures, changing weather patterns, is that the Administration's position now or not?

Dr. WATSON. I am going to repeat what the President most recently said in June, I believe, when he addressed the subject. We know the average global mean temperature is increasing. We know that man, human actions, are increasing greenhouse gas concentrations in the atmosphere. There is no doubt, there is no scientific doubt about that. That is associated obviously with warming. So there is a human contribution to that.

But many uncertainties still remain, Senator.

Senator OBAMA. Absolutely. I am not disputing that there may be differences of opinion in terms of how fast this is happening, how much greenhouse emissions are contribution to this process rather than other factors external to human behavior. But there is an acknowledgement by the President that in fact this is a problem?

Dr. WATSON. Yes.

Senator OBAMA. OK. The only reason I wanted to establish that for the record is that is at times sort of a first principal issue that ends up being disputed in this committee.

If in fact the Administration didn't think it was a problem, then even all the stuff that you're doing here wouldn't make much sense, it would be a big waste of money, wouldn't it?

Dr. WATSON. That's true.

Senator OBAMA. Second question that I guess I have is, if it is a problem, did I understand correctly that the President's goal set up an 18 percent reduction in greenhouse gas emission intensity, but that if we did nothing at all that the intensity would have decreased by 14 percent anyway?

Dr. WATSON. That is the projection by the Energy Information Administration, yes, sir.

Senator OBAMA. So all these efforts that are outlined in your briefing are resulting in a 4 percent improvement in the intensity levels of our greenhouse gas emission intensities although the actual emission of greenhouse gases is increasing?

Dr. WATSON. Well, actually, as I said, we have had a very short time to measure this. We are actually a bit ahead of schedule on meeting the President's goal and we are hoping to actually do better than that. But yes, that is correct.

Senator OBAMA. I guess I'm just curious then, what practical impact is a 4 percent improvement in intensity levels? What does that mean in the sense that, as I understand it, the Kyoto Protocol standards that had been set up called for actual reductions and we have got, for example, Sweden, I'm not saying this is a model we should emulate or can emulate, but they reduced their actual emissions by 3 percent from 1990 levels.

Dr. WATSON. Yes.

Senator OBAMA. So I guess I'm sort of comparing apples and oranges here. What's intensity versus reductions of actual emissions and how can we measure whether these efforts are worthwhile at

all if all we're doing is simply reducing intensity levels as opposed to the emissions themselves?

Dr. WATSON. I will just refer you back to, I think Senator Carper's opening comment, the importance of not slamming on the brakes but trying to reduce the growth. This is part of the effort. We are doing better than business-as-usual, which is this President's goal. It will amount to a significant, over the cumulative 2002 to 2012 time period we are talking about 1.8 billion metric tons of carbon dioxide equivalent that will not be released to the atmosphere.

Senator OBAMA. That sounds like a big number, but I guess I just don't know what it means.

Dr. WATSON. It's pretty big.

Senator OBAMA. I'm sorry, am I out of time, Mr. Chairman?

Dr. WATSON. Just to give you an idea, we're emitting about 6.9 billion metric tons of CO_2 equivalent annually.

Senator OBAMA. OK. Thank you, Mr. Chairman.

Senator INHOFE. Thank you, Senator Obama.

Senator DeMint.

Senator DEMINT. Thank you, Mr. Chairman, and Dr. Watson, I apologize for being a little late.

Just a couple of questions. Watching this from a distance and not having been real involved with a lot of the Kyoto debate, the statistics, my concern just as an American businessman in the context of us being competitive as a Nation, the cost of doing business, being competitive with the rest of the world, that perhaps some of the motivation for the participants are not just environmental.

My question to you is are the Kyoto targets fair, and why is it that the European Union targets are so much less costly than the United States, Canada and Japan. They appear to be, and maybe you could first of all say, are they. Are the targets fair, and would the United States be paying an unfair share of the burden?

Dr. WATSON. Fairness is a bit of a value judgment. It's not clear whether things are fair or unfair. It was something that was agreed to in the previous Administration. I don't want to characterize it as fair or unfair. I think it was something that people thought at that time, the people in charge honestly thought that the United States had a chance of doing. So I don't want to cast any doubts on the motives of particular targets.

But the reality was, it was a very difficult target for the United States. We have a growing population. Just take during the 1990s, for example, our population's growth rate was 3.7 times that of Japan and 3 times that of Europe. Our economy grew at a much greater pace than either Japan or Europe, something like 1.7 times for Japan and a similar, maybe 1.5 times that of Europe's GDP growth.

So we had a lot of factors at work which ultimately, of course, made a target just impossible to meet. A lot, very much depends on natural and national circumstances. I don't want to get into particularly Europe's situation, we have certainly one of the world's experts, Professor Grubb who is very learned in this area.

But it was mentioned earlier, we did have the situation where in the United Kingdom where Prime Minister Thatcher liberalized the electricity market that led to basically the collapse of the coal

industry. There happened to be plentiful North Sea gas, so you had enormous reductions occurring because of that. Germany of course, you had the reunification of East and West Germany, which led to an economic restructuring, which led to a lot of emissions decrease overall in Germany.

So you just have these circumstances, and a lot really depends on national circumstances. If I could fault the process, again, I think there were not enough economic studies done on what would be the impact. If we agree to something, what do we really know this is going to cost us?

Senator DEMINT. Just another quick question. Kyoto aside, are American businesses working closely with the Administration to voluntarily reduce emissions? That question may have already been asked, but if it hasn't, just enlighten me a little bit.

Dr. WATSON. I appreciate that, and I have given you a fairly extensive list of activities in my written testimony, which I did submit for the record, Senator. But yes, we are pleased the President has challenged business to step up to the plate, and they have. We are very pleased that they have.

For example, we have a number of new programs which have been initiated in this Administration. One is the so-called Climate VISION Program, which is a Department of Energy program engaging literally hundreds of businesses in 14 different sectors. Of course, we have also our Business Roundtable involved in that effort. It covers some 40 to 45 percent of all U.S. emissions.

We are working through trade associations and companies in those trade associations that are making specific commitments to if not absolutely reduce their greenhouse gas emissions to slow their growth from what they otherwise would be. Our Environmental Protection Agency has initiated, back in February 2002, as a matter of fact, a very innovative program called Climate Leaders, which now has some 70 members, some of the largest corporations. In fact, we heard some examples, I think Dupont, General Electric, IBM and others that are members of that and made substantial reductions in their absolute emissions profile.

We have something called the SmartWay Transport Partnership, which is also an EPA program, involving our freight companies. So business has responded in a large manner. We hope that they will continue to respond and meet those commitments. We are very pleased with their progress so far.

Senator DEMINT. Thank you, Dr. Watson.

Mr. Chairman, I think I'm out of time, so I yield back.

Senator INHOFE. Thank you, Senator DeMint. Senator Isakson.

Senator ISAKSON. Thank you, Mr. Chairman.

I am late, and I apologize. So as not to ask a redundant question, I will submit them for the record. However, I did have the opportunity to read part of your testimony while I was sitting here, and I wanted to ask you one question, if I could.

There is a statement in your written testimony that over 80 percent of the current global anthropogenic greenhouse gas emissions are energy related. Although there are arguments over how much, a tripling of global demand by the year 2100 is not unimaginable.

Do you have any estimate of where that tripling will come from around the world? Has it been analyzed to see where that amount is going to come from?

Dr. WATSON. Yes, there are numerous studies out there and forecasts out there and a lot depends on the assumptions being made. But I think almost, if I could characterize—and I'm sure Professor Grubb can help with this, perhaps if I get this wrong, and correct it in the next panel—basically you're going to see a large growth, obviously, in the large developing countries, China, with 1.3 billion people, Indian, going on 1.1 billion people and growing.

So that is roughly a third of the world's population. So you are clearly going to see large growth in that area, the whole Asia region.

I think most of the projections of growth in the developed countries, in Europe and even the United States are somewhat robust. Of course, we have to remember that we have some 2 billion people without access to modern energy services. So if we really are able to get energy services to the third of the world's population that does not have them right now, that would again lead to a huge demand and potential growth in energy.

That is the basis of the forecast that it might be tripling by the end of the century.

Senator ISAKSON. That was my assumption, that certainly in the remainder of this century, which most of it is left, that most of the demand is going to come from other parts of the world, because we are so developed. It seems, on this whole greenhouse gases, and I am not by any means an expert, but one of the reasons we are burning so much natural gas right now is because we got out of the coal business because of its contribution to greenhouse gases, is that right?

Dr. WATSON. I think we got out of the coal business, as I understand, because of straight economics—that is my understanding of the situation, in the 1990s. We did build very little coal because, quite frankly, natural gas was the cheapest.

Senator ISAKSON. The worm has turned.

Dr. WATSON. Yes, the worm has turned now. That is correct, Senator.

Senator ISAKSON. But I think, and Senator Carper knows a lot more about this than I do, but I think the contribution of coal to the carbon in the atmosphere is a major allegation of the greenhouse gas, is that not correct?

So my guess is I am taking more time than I should have, but the whole point I am getting to, your next statement in here talks about cost-effective technology development, you didn't say this, those were your words, my words, is the only way that you can reduce the increase of greenhouse gases while meeting the demand of a tripling of energy, is that correct?

Dr. WATSON. That is certainly what we believe, Senator, yes.

Senator ISAKSON. So we should be doing everything we can as Members of the U.S. Senate to promote incentives for cost-effective technology developments and a broad based development of energy resources, both renewable as well as nuclear as well as coal gasification. That's the best way, rather than penalties, to solve that problem.

Dr. WATSON. We certainly believe that. We certainly believe the U.S. Senate and Congress made a great contribution to that effort in the passage of the Energy bill.

Senator ISAKSON. It took us a long time to get it, 11 years, I think, but a great effort. That was my point, and Mr. Chairman, I yield back.

Senator INHOFE. Thank you, Senator Isakson.

Dr. Watson, thank you very much for your time and your excellent testimony. We will excuse you at this time and ask for the second panel to come forward.

We previously introduced the panel, but Lord Nigel Lawson is here from the House of Lords. We are delighted to have you. Dr. Margo Thorning, senior vice president and chief economist, American Council for Capital Formation, and Professor Michael Grubb, the Department of Environmental Science and Technology, the Imperial College of London. We are delighted to have all three of you here.

We would like to ask you to make an attempt to restrict your opening remarks to 6 or 7 minutes and your entire statement of course will be made a part of the record.

Lord Lawson, we will begin with you.

STATEMENT OF LORD NIGEL LAWSON OF BLABY, HOUSE OF LORDS, UNITED KINGDOM

Lord LAWSON. Mr. Chairman and gentlemen, Senators, thank you very much indeed for your invitation. I am greatly honored to appear before you.

Let me tell you, since I am not a local figure, perhaps by way of background who I am. I am a member of the House of Lords, as you mentioned. I was a member of the Economic Affairs Committee for the House of Lords which produced the report on the economics of climate change, which is the reason I assume that you have asked me here today.

I might point out about that report that it was an all-party committee and the report was unanimous. We didn't have any votes, it was unanimously agreed by the conservative members, the labor members and the liberal members.

Just to put my cards on the table, my only business interest is that I am chairman of a private company called Central Europe Trust Company, which is engaged in advisory work and private equity in what Secretary Rumsfeld has called the New Europe, the former communist countries of Central and Eastern Europe.

Before entering the House of Lords in 1992, I was for many years a member of the House of Commons. During my time in the House of Commons I served as a senior government minister in all three of Prime Minister Thatcher's administrations. To be precise, from 1979 until 1981, I was financial secretary to the treasury. From 1981 to 1983, I was energy secretary. From 1983 to 1989, I was chancellor of the exchequer, which is the quaint name that we give for treasury secretary.

Therefore, I have come to know Washington quite well, having visited in the past quite frequently to see my opposite numbers from four, in fact, American administrations, the end of the Carter administration, both Reagan administrations and the beginning of

the Bush Sr. administration. Of course, meetings of the International Monetary Fund and what used to be known in my days as the G5, ministerial meetings of the G5.

But this is the first time that I have the honor of appearing before the Senate, or really having anything much to do with the Senate. So it's a new experience for me, and at my time of life, new experiences are few and far between. So I am particularly grateful to you for giving me this opportunity.

I don't want to encroach on your time, particularly. I would obviously direct you to this report, which I think you've all received and I hope some of you in your busy lives have had time to read it. Also, the very brief written testimony which I have provided you.

I just want to say one or two things, principally by way of explanation, why it is a bit odd that I should be giving evidence on this issue. I actually came very late, some time before this report, but nevertheless in my life very late to the issue of climate change. I had always assumed, unthinkingly, as many people do, that this is a scientific issue. I am no scientist, and I have no pretensions to being a scientist.

I have, of course, as a minister, been frequently called upon, as all ministers and all governments are called upon to do, to take decisions on the basis of expert advice, whether it is scientific advice or other kinds of expert advice. I have some experience at assessing that sort of advice, but I make no pretensions to being a scientist or a scientific expert.

I was drawn to it because I then came belatedly to realize that this was even more of an economic issue than it is a scientific issue. I think that the science, as far as I can understand it, is very clear, that growth of carbon dioxide emissions or other kinds of greenhouse gas emissions, that is overwhelmingly the most important in terms of volume.

Growth in carbon dioxide emissions does enhance the greenhouse effect. That does, other things being equal, lead to a warming of global temperatures. Other things being equal, of course, is necessary to say, but it throws up a whole lot of questions, which I don't have the competence to go into. Also, I think it is clear that as economic growth continues, other things being equal, again, these emissions are going to increase.

So there is a problem there, but its magnitude is extremely difficult. Nevertheless, it is a problem and it has to be addressed.

Now, how should it be addressed? It is a curious thing that the world's governments, certainly the British government and most of the world's governments have done is something which I can't believe would have happened just like that in my time, is that the provision of advice to government has been outsourced. It has been outsourced to the Intergovernmental Panel on Climate Change. Now, it is perfectly true that this is a global issue. Nevertheless, the more you look at the operations of the IPCC, the more doubts I think you are bound to have about the objectivity and rigor of that advice.

Therefore, I think it is essential, and this is one of the recommendations we made in our report, that certainly the British government and I think all governments make their own inde-

pendent assessment on a matter as important as this, of what is likely to happen on the scientific and on the economic side. This should be under lead of the treasury, which has no departmental axe to grind.

I am glad to say that one of the consequences of our recommendations is that indeed in the United Kingdom, an inter-departmental working group has now been set up, which wasn't the case before, under the leadership of the treasury, but including all interested departments, to make just this sort of estimate.

Now, what are you trying to look at? Well, one of the things you are trying to look at of course is the scale of the problem. This is not a scientific matter, primarily, obviously science comes into it. But basically what are you trying to guess or make an estimate of is what is likely to be the rate of world economic growth over the next 100 years, and second, what is going to be the energy intensity of that growth.

The curious thing about the IPCC's estimates, which is a persistent upward bias, that doesn't mean to say their scenarios can't happen, but there is a clear upward bias in what they are saying. The project not merely a heroic rate of growth, particularly in the developing countries, so that for example, at the end of this century, and I hope this will happen, but the fact that all their scenarios do this, by the end of the century, living standards in the developing world are projected to be substantially higher than they are in the United States or the United Kingdom today.

I hope that will be so. But it is a pretty heroic assumption. All their scenarios are posited on that.

Second, energy intensity. It is established that over the past 40 years, the energy intensity of economic growth has steadily declined. That is not surprising. First of all, the efficiency, economies develop by greater efficiency in all factors of production, greater efficiency in the use of labor, greater efficiency in the use of land and greater efficiency in the use of energy.

There is a tendency in the world, which is likely to continue, for a shift in the balance from manufacturing to services. Of course, service industries are much less energy-intensive. They use energy, but they are much less energy-intensive than manufacturing is.

Yet, if you look at the IPCC's scenarios, every single one of them, without any explanation, assumes an abrupt reversal of that trend. The various scenarios show either a significant increase in energy intensity over the next 100 years or a even as far as a doubling of energy intensity over the rate of growth of carbon dioxide emissions over the next 100 years.

But anyhow, the question then is, and this is again an economic question, not a scientific question, OK, we have a problem, we are not sure about its magnitude, but we certainly have a problem or we might, and we need to take out an insurance policy, we need to be prudent, we need to be careful. There might well be a problem, what do we do about it? What is the most cost-effective way of dealing with it?

In sum, just to conclude, there are two ways of doing that, and I think both are necessary. One is adaptation. That kicks in much, much earlier. Because Kyoto is not going to have any effect at all, that is accepted. An adaptation, that is to say, taking measures to

bolster defenses, taking measures to improve strains of crops which will cope better with a warmer climate if that happens, and so on across the board.

And mitigation. Mitigation not by Kyoto. There is an economic reason. Not only have we seen on the figures already produced, Mr. Chairman, that the Kyoto targets are not going to be reached, and even if they are reached, they are not going to do anything about global warming.

But there is the so-called free rider problem, classic in economics. That is to say, if you have a public good, a collective good, not having an excessive world global temperature, then the market is not going to solve the problem. We do this with defense, we have the market providing our national defense. The government has to step in, the government has to make sure that everybody pays through their taxes for our national defense and provides defense.

But there is no world government. The way in which we deal with public good on the national level cannot work on the global level. Any country which is particularly zealous in meeting its targets is going to lose out eventually. So we need something where there is possibly a benefit. Investing, government supporting investment in technology has been discussed. There the incentive works the other way, because a country or a company that has this technological breakthrough will benefit competitively.

So that goes with the grain, whereas Kyoto goes against the grain. It's not going to happen. The sooner we get off that track, the better.

Senator INHOFE. Thank you, Lord Lawson.

I would say to Dr. Thorning and Professor Grubb, feel free to go over your time, because we want to give you equal time.

Dr. Thorning.

STATEMENT OF MARGO THORNING, PH.D., SENIOR VICE PRESIDENT AND CHIEF ECONOMIST, AMERICAN COUNCIL FOR CAPITAL FORMATION

Dr. THORNING. Thank you, Mr. Chairman, members of the committee. I very much appreciate the chance to appear before this committee. I would just like to make maybe points and then hopefully there will be some time for questions and answers.

To reiterate the point that Dr. Watson made, the fact is that the European Union's 15 original members, are not on track to meet their emission reductions. As figure one in my testimony (that I would like to be included in the record) shows, countries like Spain are approximately 33 percent, projected to be 33 percent above their Kyoto target in 2010, according to the European Environmental Agency. Denmark, 37 percent above, Austria, even though Austria has a lot of hydropower, still 22 percent above, given the existing measures.

In fact, the United Kingdom, which is one of the two countries supposed to meet their target, and I think for the United Kingdom it is a 12½ percent reduction, they may meet that target, they certainly won't meet their 20 percent aspirational reduction by 2010. But Cambridge Econometrics, a United Kingdom consulting firm, has shown that by 2015, UK emissions will be approximately 3½ to 4 percent above 2010 levels. So UK emissions will, under current

measures, continue to rise. To hold them to the Kyoto level after 2010, that would require much higher emission trading fees. So that issue is something to think about. Even the two countries that are on track may not be able to hold to their Kyoto levels post-2010 because of economic growth.

The second point I would like to make is that there are very significant GDP and employment effects from forcing emissions, forcing energy use down. When accurate models are chosen and used, when for example, macroeconomic models are used to analyze the impact of sharp increases in energy prices, or emission trading fees to drive down energy use, we see very significant impacts on countries' GDP levels, as well as employment levels. These studies are on the ACCF global Web site, that is the Brussels-based affiliate of the American Council for Capital Formation. We have studies on five major EU countries, detailing the negative consequences.

For example, in 2010, if Spain had to meet their emission target, their Kyoto target, their GDP would be approximately 4.8 percent below the baseline forecast, and employment, I think about 800,000 fewer jobs. So there are real consequences. What has made a difference, I think, in some policymakers' thinking in the EU is that groups like the ICCF have been showcasing good, credible research with good, credible macroeconomic models, not energy sectoral models, such as DG Environment uses, to point out there are real costs for trying to meet these very stringent targets.

The third point I would like to make is that in the EU, the emission trading system is beginning to bite. Figure 3 in my testimony shows that the energy prices are rising fairly sharply since the imposition of the emission trading system. Part of that is due, not all of it, certainly, but part of it due to the cost of buying the right to emit a ton of carbon. So the emission trading system is raising energy prices, which of course will tend to slow growth and reduce employment.

The fourth point I would like to make is that an international trading system, which many proponents of the Kyoto Protocol are advocating, is not likely to be an effective way of reducing emissions. First, for an international trading system to work, investors have to believe that the price of emission credits will stay high. It has to be high enough to justify the initial investment in the R&D to come up with alternative technologies.

Second, they have to believe that that price will hold. Given what we've seen about, for example, in the European Union, their stability pact, which requires that countries keep their deficit at 3 percent or less of GDP, and of course, many of the major EU economies are not doing that, and there is no enforcement of that.

So if in the EU they can't even force their own member states to hit these targets that were mandated by the stability pact, think about trying to get an international organization like the U.N. to enforce emission targets made, let's say, in 2005, by the Chinese government in 2020. Think about how we would enforce the agreement if the Chinese government decided that target conflicted with the needs of their economy.

So enforcing the property rights that investors would need to make these kinds of investments through an international trading regime is fraught with difficulty.

To conclude, the question of how to move forward in a productive way on climate change, which is of course an important issue, very important issue, although the Copenhagen Consensus that was released last year, which brought together a dozen or so top Nobel prize winning economists, listed the world's most critical problem, not climate change, but in fact HIV/AIDS and the lack of sanitation and clean water in the developing world. I think climate change was way down, like twelfth or something, in their list of where the world should put its resources.

Nonetheless, climate change is an important issue, and if we want to address it, I think a more fruitful approach would be, as Dr. Watson outlined in his excellent testimony, encouraging the technology development and transfer through partnerships, through the Asia Pacific Partnership, encouraging the use of nuclear power, and in the United States in particular, looking at our tax code. The U.S. tax code doesn't treat investment of all types very favorably.

We have a high capital cost for all types of new investment, and for example, some of the work that the ACCF has produced, and I have testified on, shows that the capital cost recovery, for example, for combined heat and power, after 5 years, a U.S. company gets only 29 cents back on the dollar after 5 years. But in China, an investor would get $1.04 back, and in Germany 50 cents back.

So we have real slow capital cost recovery and we have high corporate tax rates. We now have higher corporate tax rates than the EU average. Of course, many developing countries also have lower tax rates.

So in the United States, not only can we move ahead on the technology side, through many of the international agreements that we have adopted, but we do need to take a hard look at the tax code and see if there aren't ways to incentivize the kind of spending that will help us reduce emissions intensity.

Last, I would like to point out that the United States has reduced its emissions intensity at twice the rate of the European Union. We have reduced our emissions intensity over the past decade by 17 percent. The EU has only reduced its emissions intensity by 7 percent, and part of that is due to our faster economic growth, pulling through the cleaner, less-emitting capital stock more rapidly.

Thank you, Mr. Chairman.

Senator INHOFE. Thank you, Dr. Thorning.

Professor Grubb.

STATEMENT OF MICHAEL GRUBB, PH.D., CHIEF ECONOMIST, THE CARBON TRUST, SENIOR RESEARCH ASSOCIATE, FACULTY OF ECONOMICS, CAMBRIDGE UNIVERSITY, AND VISITING PROFESSOR OF CLIMATE CHANGE AND ENERGY POLICY, IMPERIAL COLLEGE, LONDON

Dr. GRUBB. Thank you very much, Chairman and Senators. I am quite honored to be here. Thank you for the invitation.

Perhaps I should start by updating you on my affiliation. I am Chief Economist for an organization called the Carbon Trust, which is a legally independent government-funded company that assists UK business in implementing carbon reductions and implementing

low carbon technologies. That is a half-time post that I combine with positions both at the Cambridge Economics Department at Cambridge University and a visiting professorship at Imperial. My background is in the academic research side.

A couple of opening comments on the context. First, I am sure that all of you will, and following Lord Lawson's comments, we have experience not to judge the full state of debate in another country just from any one report or one presentation of that. I could call your attention to a number of other reports by the House of Lords' Science and Technology Committee, the House of Commons Environmental Audit Committee, others that have come out this year, which broadly support the government's policies, support Kyoto. A major complaint is they think the actions should be stronger. But as in any healthy democracy, there is a good debate around the issues.

I would add I find the tone of the comments perhaps about IPCC a little surprising, simply in the sense that the report itself does say the IPCC publications, as a whole, contains "some of the most valuable summary information of what we know about climate change, the standards employed are clearly very high." But I do not wish to get involved in a discussion here about the IPCC. I'm sure like any institution or indeed any agreement it is never perfect and certainly needs to be improved. I do share the conclusions of Lord Lawson's committee that a stronger influence from economists in this issue and in the IPCC debate would be welcome.

I think the main thrust of issues before this inquiry appear really to be around claims first that, if I can caricature it, that Europe is all talk and no action on this issue and is simply not on a track to deliver anything serious or to comply. The other is that it is implementing costly measures severely hurting its economy.

I am not actually sure how those two statements can be logically consistent. I do believe that neither are actually true. The EU Ambassador here has written a letter that I believe Senator Jeffords referred to setting out in some detail the policy instruments employed in the European Union and the compliance strategy thereof.

Now, I am an independent witness. I am not here to represent any government view on the United Kingdom or European position. What I would actually like to do in the remainder of my comments is to say that I think to understand what is going on in Europe. I would like to illustrate it with respect to the issue of low carbon technology. Because I think almost every Senator here has mentioned the importance of low carbon technology. It is crucial for solving this problem.

I am not sure that any European government would disagree. Nor would they disagree that economic growth is absolutely crucial as well, from all respects.

But what I do want to do is to set down five points about this technology in relation to business and also drawing upon a piece published in the Financial Times this morning jointly with the chief executive at the Carbon Trust, Tom Delay, no relation, I believe.

[Laughter.]

Dr. GRUBB. The five key points on technology. No. 1, the need to learn from history. That history leads me to be very cautious about

the idea that government should solve this problem by throwing taxpayers' money at very large R&D programs. Both of our countries have had frankly very expensive failures when we've tried this. R&D is obviously crucial, but I think it is market-based innovation that is really required to deliver. One needs the private sector investment and innovation skills in this.

No. 2, from a business perspective, innovation is an ongoing and dynamic process. It responds to incentives, it builds upon established technologies, develops, improves, expands scale. There are actually a huge variety of low carbon technologies already available, more efficient vehicles, buildings, appliances, better production process controls as well as smart combustion and renewable sources.

For example, in my testimony I have appended a presentation I gave at Columbia and gone through charts relating to technology issues and the economics of diffusion of low carbon technologies that are with us now. Drawing directly on the Carbon Trust experience, we spent about 25 million pounds, about $40 million last year. We estimate that the Carbon Trust clients co-invested something between $120 million to $220 million, U.S. terms. The net benefits of that were between $400 million and $700 million.

That's not a bad business. It's a payback rate on energy efficiency programs of between 2 and 4 years.

That reflects the broader UK experience, that actually emission reductions have been consistent and accompanied with good economic news. You will be familiar with the fact that UK greenhouse gas emissions have gone down substantially. They are now around 12 percent below 1990 levels. The UK economy grew 37 percent in that period. In intensity terms, the UK economy improved over that period by more than 40 percent. Over the 10-year period within that, the period of the U.S. goal, the UK intensity improvements was over 30 percent.

That's really frankly, I should say in part, thanks to Maggie Thatcher. It was the privatization of industries, the getting rid of industries that had become bloated and inefficient, and the privatization of the energy industries with introduction of competition and natural gas. Not climate policy, per se, but economic gains that were associated with emission reductions. In that sense, the United Kingdom already had slowed and stopped greenhouse gas emissions by about 1990. The challenge we see is to maintain the descent of the emissions in absolute terms.

No. 3, in this context and from a business perspective, I think national emission targets give business a sense of where the ship is going and emissions cap and trade systems actually give bankable value to emissions reductions. So it is a package that gives a beacon to private investment in both cost-effective and emerging technologies.

The limitations of a purely voluntary approach are such that a group of senior CEOs recently wrote to Tony Blair and said, "if we are going to deliver more, it needs to be bankable and we need government to set the regulations that make those initiatives work in the bankable sense."

No. 4, I mentioned emission cap and trade. I do believe that's necessary. I do not believe it's sufficient. Both our countries over

the years have failed to extract the full value of our government research and development. Commercialization is the real challenge. Innovation is a long, costly chain. There are lots of things, again, in my presentation, covered that needs to be done, not only from the push side, but also the market pull side, to help industries pull technologies through the innovation chain.

No. 5, finally, let me just say, the powerhouse of innovation is in the rich, industrialized countries and the global diffusion of low carbon technologies to developing countries will be largely driven through multinationals and foreign investment. In that sense, my final comment is that the clean development mechanism of Kyoto is very important as a diffusion method for clean technologies.

Let us remember, it is the gap between national targets and delivery domestically that drives the need for credits under the CDM. If countries delivered their targets domestically, there would be no foreign investment in helping to clean up developing countries under the Kyoto system. But I know of no country that is planning to, in a sense, break this investment elastic that ties them to their Kyoto targets.

Thank you very much.

Senator INHOFE. Thank you, Professor Grubb.

You partially approached a question that I asked of Dr. Watson when I observed that it was my understanding that this transition from coal-fired plants to natural gas was accountable for a lot of the reduction in emissions. I kind of wanted to get an idea in my mind as to how much would that be, 50 percent, or what percentage that might be, No. 1.

No. 2, if that's the case, isn't that pretty much behind us now and how is that going to affect the future? In other words, you have already taken that reduction.

Oh, by the way, these will be 6-minute rounds, and then afterwards, if someone wants to stay, we will maybe stay for a couple more minutes.

Any comments on that?

Dr. GRUBB. Yes. No question, it is a very important part of the story. It has helped to give us a more balanced energy mix. Generally, the move to gas in power generation is considered to contribute between a third and a half of the overall UK emission reductions. Obviously with gas prices in the last couple of years, it has reversed some of that, and hence some of the data to which Harlan Watson referred.

Senator INHOFE. Do you all agree with that?

Lord LAWSON. Yes, that is absolutely right, Mr. Chairman. You are also right that that is now behind us, because that great shift which occurred as a result of the privatization undertaken by the government of which I was a member, that has happened. It is finished. There is nothing further to go there.

If I may just add very briefly, and I will try and be very brief, I welcome the fact that Tony Blair has now publicly conceded that Kyoto is not going to work and that there is going to be no successor agreement of that kind. That is quite important, because when he gave evidence to our committee, and incidentally, if you read the report you will see it is severely critical of the IPCC process, documented reasons for that.

But when he gave evidence, he said, and I am sure he's right, that the existing Kyoto accord, even if it were accepted by everybody, is not going to lead to any dilution in temperature. But this is the important point, he said it will lead to further agreements of that kind. That's pie in the sky. There is not going to be. It is quite clear, anyhow, that India and China are not going to sign up to this.

It is also clear that the only Kyoto sanction is a complete Alice in Wonderland sanction. It is a sanction that if you don't attain your targets, and most countries are not going to, and it may well be even for the reason you have just indicated the United Kingdom doesn't, I don't know, that if you don't attain it, then you will have to have a stiffer regime next time around.

As I say, this is just Alice in Wonderland. It's totally unrealistic. Of course, the cost of this route is massive. That is why even if it were politically workable, which it is not, it would not be cost effective.

Senator INHOFE. Yes, one last thought on that, Dr. Thorning.

Dr. THORNING. I would just like to take a moment to respond to something Dr. Grubb said about the inconsistency of saying that the European Union is imposing very costly regimes to curb emissions. An emission trading system, which affects I think only 9,000 to 12,000 industrial plants is not going to curb emissions adequately across the EU, because households and transport and so forth are not included.

So I didn't say that the European Union was actually imposing the measures on its economy to bring down emissions. I said if they did, our econometric work shows that it would be very costly. An important thing for our friends in Europe to understand is that here in the United States, we have a whole different system. If our industry signed up to meet the mission targets under the Kyoto Protocol, we would be sued and forced to meet those targets.

In the EU, that's not the case. Meeting, for example, with regulators in Brussels a couple of years ago, I said to someone in DG industry, well, what will happen if your industries don't meet their targets in 2010? He said, we'll give them more time. So we have a whole different regulatory regime here. To expect the United States to sign up to something that we would be forced and compelled to meet and impose, as our Department of Energy found, perhaps a 3.8 percent reduction in the level of GDP in 2010, when our friends in Europe would not be forced to actually impose the kinds of costs on their own economies is just unrealistic.

Dr. GRUBB. May I add a final point on that?

Senator INHOFE. Make it real quick, because this is running out of time here.

Dr. GRUBB. Simply that those industrial facilities account for 46 percent of European emissions, and the penalty for non-compliance is 40 euros a ton in the pilot period, and 100 euros a ton in the Kyoto period.

Senator INHOFE. Thank you, Professor Grubb.

Lord Lawson, in the report of the Select Committee on Economic Affairs that you were very much involved in, I noticed that there is some discussion of the Michael Mann so-called hockey stick approach. Could you comment on why a controversy over a single

study was highlighted and why it matters so much that the science underlying the study is right or wrong?

Lord LAWSON. That is a good question, Mr. Chairman. I think there are two reasons why we highlighted that, as you say.

The first is that it has achieved, what I think, iconic status, this hockey stick thing, which shows this sort of flat temperature from the year 1000 AD to 1860 when records began. Then a very period, as you can see on the short, when records existed, and then a projection of a huge increase for the future.

It is very suggestive. In fact, when you look at it carefully, I think it is fairly widely agreed now that the law of this straight line is a myth. There is ample evidence, which is even accepted by many people on the other side of the debate, that for example, there was a pronounced medieval warming period around about the 14th century which in many expert's view, I am not a climate expert, led to warmer temperatures than we have today. There was a little ice age around about the end of the 18th century, very early 19th century. So there have been fluctuations.

Also, you have seen this recorded, during the recorded period. There hasn't been a straight line upward, even though emissions have been going up. It went up then down then up again. So this very persuasive, apparently persuasive and iconic chart is extremely doubtful.

But the second reason because, you are right, what we are concerned about is the future. So why do we worry about the past? It is a symptom of how the IPCC works. Michael Mann's findings have been challenged very robustly by other climate experts, experts over this period. In fact, there are very few, there are some others, but very few who would agree with this.

These challenges, very coherent, very well researched challenges, have been put to the IPCC, which after all, first published this in 2001. The IPCC has neither rebutted any of these challenges nor is it prepared to entertain them. There is no scientific objectivity about that in my book. So I think it is a good microcosm, a good snapshot of the problems that we have with the IPCC.

Senator INHOFE. I would actually go further to say that McKittrick and McIntyre and others not just challenged but refuted the science.

Also, I see Dr. Watson is still here. While I can't ask him a question on this panel, I would only observe a question he was asked about, doesn't the Administration agree with the increased temperatures at this time, he said yes, but let's keep in mind that during the medieval warming period, temperatures were actually higher than they are now. These fluctuations have gone back and forth and have nothing to do with anthropogenic gases.

I am sorry, Senator Jeffords, I went a little over my time, feel free to do the same thing. That doesn't go for you, Senator Carper.

[Laughter.]

Senator JEFFORDS. Lord Lawson, the House of Lords report is critical of the Intergovernmental Panel on Climate Change for their lack of monetary comparisons between the costs to control greenhouse gases and the benefits. With 56 nations ratifying the Kyoto Protocol, won't the results of their implementations and efforts yield valuable information upon the cost and the benefits, and how

should such implementation data be collected and used, or how could it be collected and used, and what other approach should be taken to look at the costs and benefits of controlling greenhouse gases?

Lord LAWSON. Senator, if I may answer your question in a slightly oblique way, it may be that if the signatories to the Kyoto agreement carry out what they have pledged themselves to do, that indeed we will discover what the costs are. I think we will discover that they are very great indeed.

But normally, before embarking on a policy, it is wise to make your best estimate of the costs in advance. Because if the cost is prohibitive, then you don't want to go down that route.

That is why one of our recommendations is that the British government should come clean, it may need more work by the British treasury, but it should come clean with the people, which it has not yet done, precisely what the costs of what is official government policy still despite what Prime Minister Blair said in New York last month. I hope there will be a change, but the policy is still allegiance to Kyoto.

Then it should tell the public openly, OK, this is our policy and this will be our best estimate of the costs. It hasn't done that, and we suggest that it should, costs in terms of increased energy prices, which would need to go far higher than we see at the present time, and costs in terms of reduced economic growth, which is of course important, incidentally, not just for the United Kingdom, but perhaps even more so for the developing world.

So these costs need to be spelled out before one can take a view, not, let's do this and see from experience what the costs turn out to be.

Senator JEFFORDS. The House of Lords July report says that it is "far better at government-set goals and the price signals to achieve that goal, leaving the market to select the technologies and the rate of diffusion through the economy." Isn't that what the Kyoto Protocol sets out to do?

Lord LAWSON. What we had in mind, Senator, was that the present policy of the British government is to fix on one particular renewable source of energy, wind power, and to subsidize that and to support that very substantially. We felt that yes, there are a whole lot of ranges of ways, technological ways of reducing carbon emissions.

We have heard a lot to talk about them today, carbon sequestration, various renewable sources, there is also nuclear power, of course, a whole range. And that it is far more sensible for the government, rather than trying to pick one particular winner and to support that heavily, to increase—because in all of our countries there is a governmental research project. This is nothing new, to have a form of assistance to companies to engage in these areas of research in whatever form of technology they believe is most likely to bring profitable results.

Senator JEFFORDS. Dr. Thorning, the northeastern and Pacific Northwest regions of this country are developing climate change programs. Twenty-one Fortune 500 companies joined the Business Environmental Leadership Council to address climate change.

How do you think these States and companies are moving to address climate change in the absence of a concerted U.S. effort? Won't the actions of these States provide important information about costs and benefits to addressing climate change that could help the United States?

Dr. THORNING. I'm glad you asked that question, because the American Council for Capital Formation has done a substantial amount of research on what it would cost the northeastern States, for example, to meet the New England Governors Plan, which requires emission reductions by 2010, I think down to approximately 10 percent below current levels, and then get on a trajectory to reduce emissions by 60 to 70 percent below 1990 levels by 2050.

On the ACCF Web site is an econometric analysis by Charles River Associates and also another firm which shows that the costs to these States, for example, if the nine New England States were to embark on a plan to reduce emissions, they would face significantly slower economic growth than the other States that didn't participate and also face significantly lower employment levels. I believe we have also analyzed the NCEP plan, and that is on our Web site. That too shows less impact than the New England Governors Plan, because it doesn't require emissions as steep.

So while the States are talking about moving in that direction, oh, and by the way, we also have analysis on some other States, in particular Oregon and Washington State and so forth of emission reduction targets. While the States are discussing that, to my knowledge, they have not imposed the sort of legislation that would actually force down energy use in their States.

For example, Maine had been discussing joining the New England Governors Plan, but their legislature enacted a bill this year requiring the use of cost benefit analysis before any future environmental polices are imposed. That bill was signed into law in May.

So I think States are going to be taking a hard look before they impose additional costs on their citizens and on their industry to meet a Kyoto-type target, particularly as they learn that their efforts, given the global nature of the climate change challenge, will mean almost nothing in terms of reducing global concentrations of CO_2. So while there is a lot of talk, I'm not sure there is a lot of action in terms of actually enacting legislation. I would invite everyone to look at the ACCF State by State analyses. I think we have maybe 30 States analyzed.

Senator JEFFORDS. Thank you very much.

Dr. Grubb, you testified that the UK companies invested $120 million to $220 million on energy-saving efforts that resulted in $400 million to $700 million in savings. Do you think there are still more energy-saving efforts companies can invest in or have gains ready to be realized?

Dr. GRUBB. First, let me clarify that figure was about the Carbon Trust's own programs on energy efficiency. The Carbon Trust was set up jointly between government and industry to help the United Kingdom deliver cost-effective emission reductions and to build a low carbon industry technology sector.

There are many other, both policy instruments and initiatives in the United Kingdom, including perhaps most significantly in terms of overall delivery the fact that the government in 2000 introduced

the climate change levy, which is a tax on energy. It reduced corresponding the tax on labor and reached a set of agreements with heavy energy users. They set the emission targets in return for a rebate on that climate change levy.

Those companies have also substantially over-delivered on their targets. They have essentially found that once they had a serious look, they could deliver more than they thought they could in terms of efficiency and improvements.

Overall, we have estimated the total incentive value of the UK policy instruments at about $2 billion a year, incentives toward low carbon investments. The UK energy white paper estimates that the savings from energy efficiency overall, savings potential amounts to several billion pounds. I think that would correspond with our experience at the Carbon Trust.

Senator JEFFORDS. Thank you.

Senator INHOFE. Thank you, Senator Jeffords.

Senator Voinovich.

Senator VOINOVICH. Thank you, Mr. Chairman.

Dr. Thorning, I am tickled to hear what you just said about the northeastern States and Maine and cost benefits. One of the bills I introduced when I first came to the Senate was to ask for cost benefit on our air regs. We were able to get it on water, but for some reason, we haven't been able to get it on air regs. The reason is because they said that doing that wouldn't lend itself to really cleaning up our air, that that ought to be not taken into consideration.

There is a disconnect in this country, I think, about our environmental policies and our economy. Our clean air regulations and laws have put us in a situation today where our natural gas costs are the highest in the world. We have lost over 100,000 jobs in the chemical industry. We have seen fertilizer costs go up dramatically. We have seen companies that produce fertilizer go out of business. People who live in areas where I live, in Cleveland, Ohio, have seen their energy costs, their natural gas costs go up over 100 percent, which has been just terrible on those that are poor and on the elderly.

It seems to me that we have missed the boat in this country somewhere in terms of harmonizing our environmental, our energy and our economy. I would like you to comment on just what impact you believe this has had on where we are in terms of our competitiveness in the global marketplace. In spite of it, we are doing better than some of the other countries. But the fact is that this has had a major impact on our economy.

Last but not least, if we went to cap and trade on greenhouse emissions, what impact do you think that would have on further exacerbating an almost intolerable situation in this country for our businesses and for those that are the least of our brothers and sisters?

Dr. THORNING. Thank you, Senator. Let me take the last part of your question first. The research which again is on the ACCF Web site from a variety of good modeling firms and from our own Department of Energy shows very clearly when you use either a macroeconomic model or a general equilibrium model, which is designed to measure the impact on economy over 20, 30, 40 years of

changes in energy prices, a variety of independent research shows that if we impose cap and trade, including some of the new work I mentioned on the State level, we would face GDP levels anywhere from 2 to close to 4 percent less by 2010 than what we have now.

In terms of overall dollar amount, we might have as much as $400 billion less GDP in 2010, if we imposed that sort of situation. Bear in mind, every time you reduce GDP by a dollar, the Government gets less tax revenue. So it would mean negative impact on Federal budget receipts and spending policies and so forth, if we slow growth under a cap and trade sort of system or impose the taxes on industry sufficiently high and households and transport to force down emission use. It would be undoubtedly a negative impact.

That is the reason, of course, the Senate had that information before the Kyoto Protocol. In 1997, our Members of Congress understood the economics of policies to curb emissions along the lines of the Kyoto Protocol.

Now, back to your first point about the negative impact that high energy prices are having, it is undoubtedly true that we could have done a better job over the last decade of improving our sources of supply and probably policies to promote conservation. One problem right now, which I know you are acutely aware of, is our lack of refinery capacity to try to do something to bring down high gasoline prices.

Part of the reason we don't have more refineries is our environmental regulations have been so burdensome, so difficult that companies have simply abandoned the hope of doing much to put in place new facilities. The only reason they are doing as well as they have is they have managed, I think, to get more out of existing physical refineries.

But again, clearly if we do not manage to address the United State's growing energy needs, and by the way, another factor which I don't think was mentioned is that our population is growing about nine times faster than is the EU population. So we naturally have to have more energy for job growth, for taking kids to school, for all sorts of purposes.

So we really do have to focus on expanding our supply of energy. I am hoping that nuclear power will be given more consideration, that we will some new build in nuclear facilities. Obviously we need to increase where we can pipelines and refinery capacity. Of course coal, clean coal has to be there, too.

Senator VOINOVICH. You would be interested to know that the chairman of this committee and I are co-sponsoring a piece of legislation that is going to encourage the building of at least one new refinery in this country. We haven't built one for 30 years because of our environmental policies and our red tape and the NIMBY, not in my backyard.

The other thing that we tried to do in the Energy bill was to provide some incentives to move forward. I would be interested in your comment, have you observed or have you reviewed those provisions in the Energy bill? I would be interested in your opinion.

Last, do you think it's time for us to sit down and talk about having a declaration of independence in terms of energy?

Dr. THORNING. Well, I'm not an expert on the Energy bill. I know there are probably many people in this room who are. But I think many of the provisions that are in there to incentivize, for example, some of the faster depreciation for pipelines, for example, there are some very helpful provisions in the Energy bill.

But as I said earlier, I think we need to go farther in terms of the tax code to try to lower the cost of capital for all types of new investment and particularly for energy investment. What was the second part of your question?

Senator VOINOVICH. The second part is that at this stage of the game, if you look at those incentives that are in the Energy bill, should we——

Dr. THORNING. Oh, energy independence.

Senator VOINOVICH. Independence, and review where we're at, and try to make some kind of a national commitment to becoming less reliant on foreign sources of energy.

Dr. THORNING. As attractive as it would be to be independent of outside sources, I am not sure that in the next 20, 30 years that's very realistic. I think we are going to be, until we move away from combustion engines, I think we are going to be dependent on foreign oil. We can perhaps try to mitigate that, as people respond to higher price signals and move toward more efficient means of transport.

But I don't think it would be possible to be totally independent in the foreseeable future.

Senator VOINOVICH. I'm not suggesting that. I'm talking about a long range plan to move toward more energy independence. For example, back in 1973, when we had those awful lines, we were 34 percent reliant on foreign oil. Today we are up to about 68 or 70 percent. The world is a lot more unstable, or less stable today than it was then.

Dr. THORNING. Clearly, if we were able to have access to more offshore sites, if we were able to be drilling for oil in places that right now we can't, that would certainly help reduce dependence on foreign oil. Of course, our coal supply is so large and it may be that in due course we will be able to do more in terms of making that a very clean source of energy. Then with nuclear power, I think we are about 20 percent nuclear right now for our electricity production. That could increase.

So there could be a variety of ways over the long term to move toward energy independence. But again, I think we need to take a look at our tax code, which gives the U.S. investor a very high capital cost for new investment, compared to competitors around the world. Of course, environmental regs need to be made less cumbersome, so that they don't preclude good new sources of energy.

Senator VOINOVICH. You don't think the provisions in the Energy bill go far enough in terms of encouraging private sector investment? It does deal with tax incentives.

Dr. THORNING. I think it's a good start. But I don't think it's broad enough. I think it's a good start. But there are many types of investments whose tax lives weren't changed. Also the corporate tax rate has not been lowered. As I said, it's now quite high compared to our competitors.

So those two factors give our competitors a high cost of capital.

Senator VOINOVICH. I would be very interested, and I'm sure the committee would, in fact we will put it into the record if you will suggest what we need to do to get this investment that we need.

Dr. THORNING. I would be happy to. Thank you.

Senator INHOFE. Thank you, Senator Voinovich.

Senator Carper.

Senator CARPER. Thank you, Mr. Chairman.

To each of our witnesses, welcome. We are grateful for your presence and for your testimony. Lord Lawson, I was sitting here when you were sort of going through your testimony. I was wondering, who in the United States has had the kind of portfolio that you have as a cabinet secretary. That is an impressive array of responsibilities. Thank you very much for coming a long way to be here with us today.

I just want to say again, Senator Voinovich, I think he is onto something with this energy independence. It is not just, I know there is coal in the ground, we certainly have the opportunity and I think the obligation to find better ways. We have the technology to burn it, we have the technology to burn it clearly. We simply need to invest and do it.

With respect to nuclear, I think I am encouraged to see Generation Next, progress toward building the next generation of nuclear power plants. I think that is needed and is sound.

I would also remind us that down south, in Brazil, I don't know what the percentage is now but they meet a large and growing percentage of the fuel needs for their cars, trucks and vans out of the things they grow in their fields, whether it is sugar cane or corn or soybeans or what all. It's plain that we can do that in that regard and we are endeavoring to do that.

I want to ask a question, too, if I could, of Professor Grubb. Dr. Thorning, when I was listening to your testimony, at first I wasn't sure I heard you right, but then I believe when I went back and looked at your testimony, I think I understood you to say that the adoption of a cap and trade approach with respect to global warming would lead to, I think you said a 2 to 4 percent drop in GDP by 2010. I think that's what you said. Looking at your testimony, apparently it is what you said.

Let me just say to Professor Grubb, any comments that you might have, any observations you might have on that assertion?

Dr. GRUBB. Yes. I have to say I simply don't recognize the numbers put forward here.

Senator CARPER. Say that again, just a little louder.

Dr. GRUBB. I simply don't recognize the numbers put forward here. I don't see them correlating with anything that I've seen published in the serious academic literature. I don't think I've seen any government assessments of numbers like these. The EU letter, I believe, put forward its assessment.

Certainly the statement in Dr. Thorning's testimony that fully macroeconomic models always produce higher numbers than the kind of model the European Commission was using is simply wrong. Those models can produce all kinds of results, depending on exactly how one designs them.

I do note with interest that she herself referred to one of the major UK models. She referred to the Cambridge Econometrics re-

sults. So it may be of interest to say of the Cambridge Econometrics studies, that one of the interesting things in it is that it predicts that as a consequence of climate policies, UK employment would be increased. In fact, GDP, under a number of their control scenarios, increases slightly. Both are pretty small, the jobs increase is between 5,000 and 50,000 extra jobs.

Essentially the key question to ask about any of these macroeconomic models when they affect an economic instrument is, what is happening to the money? Economists have long said economic instruments are the efficient way to deal with this kind of problem. They raise the costs of things, they allow the market to respond in what seems the most efficient way.

But they raise money. As far as I can see, almost the only way of running a model that generates more than a percent of GDP loss is the model runs that I have seen which simply take the money from those instruments and throw it into the sea. It does not go anywhere in the models.

Those are key questions. In the Cambridge econometrics model what actually happens is they raise the energy price and they reduce the employment costs, the taxes on national insurance. That reduces the cost of labor supply to companies. That leads to a small positive boost to employment, which also feeds through to a slight boost in GDP. I don't want to exaggerate those effects, the specific functions can be debated, etc. You could easily run macro models which will produce a loss in GDP, I don't deny that for a moment.

But the key thing is, no government in my knowledge raises tax money and then throw it out of the economy. It goes somewhere. If the model does not tell you what's happening to that money, it will give you a fundamentally misleading result.

I think the only other circumstance in which I've seen models produce the kind of numbers that Margo Thorning is talking about, and to which Harlan Watson also referred, is if they actually impose emission targets as a draconian, sudden cutback. My understanding is that the U.S. Energy Information Administration 4 percent GDP loss came from a scenario in which effectively the United States did nothing until 2005. It was then forced to cut 30 percent, to achieve its scheduled target within the space of 3 years.

Now, I have no problem in agreeing that that produces a massive macroeconomic shock to any economy. I think it would be a ridiculous way for any country to approach climate change. As you said, the key is slow, stop—I believe we've already achieved that far in a number of the leading European economies—and reverse. I think the more one defers the mechanisms that introduce regulations that really start that process, the greater the risk of being faced with a big shock if the science actually turns really nasty on us.

Senator CARPER. Let me ask maybe one more question before my time expires. We have had, as we have tried to develop a comprehensive four pollutant or four emission bill here dealing with sulfur dioxide, nitrogen oxide, mercury and CO_2, we have had a lot of discussions with the private sector. We have asked them, particularly the utility companies, to come in and to talk with us about how, if they were in our shoes, how would they go about reducing emissions of all four, but especially CO_2.

I don't know to what extent you have relied on businesses in the United Kingdom to help develop your own compliance agenda, but I presume you have, and I would just ask, have you, because it could be a model for us.

Dr. GRUBB. Certainly the evolution of policy in the United Kingdom has been really interesting in this respect. It goes back again to Mrs. Thatcher. She set up the Advisory Council on Business and Environment that has been a very constructive dialog between government and business, stretching back to 1990. That has helped to design and craft the regulatory instruments that are in place.

As part of that, I should say also led to the creation of the Carbon Trust, which was a joint deal between British government and industry to help British industry deal with this problem cost effectively and to develop the carbon technology industries that we believe is going to be a place where the United Kingdom can make money in the future.

Senator CARPER. I would just say in closing, really to my colleagues as much as anyone, I cited three companies earlier, IBM, GE and Dupont as companies that have decided to reduce CO_2 emissions rather significantly. It is really part of their business plan as a company. They are not doing it to lose money. They believe you can do good and do well at the same time.

I think they are onto something. I think they are onto something. Again, our thanks to each of you. Thanks so much for being here today, and Mr. Chairman, thanks for that extra 2 minutes.

Senator INHOFE. Take another two.

Senator CARPER. I yield my extra 2 minutes to Mr. Isakson.

Senator INHOFE. All right, thank you, Senator Carper, very much.

Senator ISAKSON. Thank you, Senator Carper, I appreciate it.

Dr. Thorning, what does emission intensity mean? What is a good definition for emission intensity?

Dr. THORNING. The definition, as I understand it, it's the amount of energy used to produce a dollar of output or a euro of output.

Senator ISAKSON. On your chart that you showed us earlier that's in your printed materials, those countries in the United Kingdom, have all of them ratified and signed the Kyoto Protocol?

Dr. THORNING. As I understand it, it's the government that would sign the treaty, not——

Senator ISAKSON. But are all of them attempting to meet the 2010 standards under the Protocol?

Dr. THORNING. In the United Kingdom?

Senator ISAKSON. Yes. In the EU.

Dr. THORNING. In the EU, they all are attempting to meet these targets, yes.

Senator ISAKSON. The reason I ask the question is you said, I think, and please correct me if I am wrong, that the United States has reduced emission intensity by 17 percent and over the same period of time the EU had reduced it by 7 percent, is that correct?

Dr. THORNING. Over the 1992 to 2002 period, our energy information data shows that the United States has reduced emissions intensity almost 17 percent compared to about 7 percent in the EU.

Senator ISAKSON. So I guess my point, I am sorry Senator Carper left, because it was kind of going to ratify something he said, so

is it reasonable for me to presume then that the United States that has not ratified the treaty is exceeding what would be the goals of the treaty, I guess in part, at a faster rate than are those that are signers to the treaty?

Dr. THORNING. We are reducing our rate of growth, as Dr. Watson testified. Our emissions are still growing, but the emissions intensity per dollar of output is being reduced very much faster than is the case in Europe. Given our much faster population growth, it would be difficult for us right now to absolutely stop growth and emissions. But we are certainly doing a credible job in terms of energy intensity, and as Dr. Watson said, are on track to meet the Administration's goal.

Senator ISAKSON. I am going to give Dr. Grubb—he either has to leave or he really wants to chime in here, one of the two, but before I recognize him, back to Senator Carper's statement, and I would add that in my State, Southern Company has established the same self-imposed goals in terms of reductions, that obviously if that analogy is a correct analogy, which I'm sure it is, the U.S. companies on their own, I think because of our Congress and our country's emphasis on clean air, is doing a pretty good job of lowering that.

Now, with that said, Professor Grubb?

Dr. GRUBB. Thank you very much. I should say I very rarely venture to question a number when I don't have the exact data in front of me. I don't know that——

Senator ISAKSON. We do it all the time, so you just feel free.

[Laughter.]

Dr. GRUBB. I simply do not understand how the 7 percent figure can possibly be true. EU emissions were more or less static, declined slightly over the period considered. I can assure you the European economy grew by more than 7 percent during that period. Therefore, I just do not see how only a 7 percent reduction in emissions intensity would be possible.

Senator ISAKSON. I think her statement was the emission intensity in the United States was 17 and in Europe, the EU, it was 7.

Dr. THORNING. Reduction in emissions intensity per dollar of output.

Senator ISAKSON. Per dollar of output, right.

One night I would love to take the two of you to dinner and watch you debate that subject. It would be interesting.

Dr. THORNING. I'll send you the spreadsheet we used.

Senator ISAKSON. Good.

Professor, let me ask you a question. I love your all's accents——

[Laughter.]

Senator ISAKSON. I guess I gave away where I'm from when I said you all, but Lord Lawson and Professor Grubb have beautiful accents. The only problem with them is, sometimes you start listening more to what it sounds like they are saying than what they are saying.

[Laughter.]

Senator ISAKSON. So let me ask you a question. It sounded like to me that you were saying, in part of your testimony, you were saying that you greatly preferred market-based solutions to really

solve the problems of carbon emissions, clean air, all of that. Is that correct?

Dr. GRUBB. Yes. I think an appropriate mix of policies is needed, but market-based solutions are very much the grounding of an efficient policy.

Senator ISAKSON. You referred to Maggie Thatcher's period of privatization and private enterprise empowerment, I guess is what it was, as being a part of that. Then I thought I heard you say, a reference to doing that through impositions of targets and penalties. Did I hear that right? What did you say?

Dr. GRUBB. To an economist, a market-based solution to an environmental is using an economic instrument to address the pollution, so that rather than, say, mandating the technology that companies have to use, you say, either we're going to tax this pollution so it becomes more expensive and you, the company, choose how best to respond to that, or you say we're going to cap the emissions and set up a trading market in the allowed emissions, so that we will reach an equilibrium price and the companies who think they can do it more efficiently can do more and sell the allowances to others. That's what I mean by market-based solutions.

Senator ISAKSON. Thank you. What do you have to say about that, Lord Lawson?

Lord LAWSON. I would differ slightly, Senator. I think that a system which begins by setting arbitrary caps, and advocating the different countries, is not a market-based system. You can't call that a market-based system, because the setting of the caps is entirely an arbitrary fiat.

The second thing I would say is that there is no question in any recommendation in the House of Lords report, nor any recommendation I would make, that we should mandate what technologies businesses and companies use. What I suggested, what the report suggested, is so far from that, which the government in the United Kingdom has hitherto done, by going bingo for wind energy, is to have a research budget which will allow companies to investigate all forms of reductions in carbon in the production of energy, whether it's cleaner conventional energy, whether it's unconventional energy, whatever.

Explore them all and decide which they feel makes the most business sense, is the most likely to become profitable within a reasonable period of time. That is much closer, I think, to a genuine market approach.

The only other thing that I would say if I may is that believing as I do in the marketplace, I hope that the United States will not go along the road of a protectionist energy policy, which one of your colleagues suggested might be wise. I think it would be profoundly unwise, it would not be in the interest of the United States. I think it would certainly not be in the interest of the world economy, where globalization, the extinction of the market across borders to a greater extent than has ever happened before has proved to be extremely beneficial. We don't want to roll back from that, in my judgment, in any way.

Senator ISAKSON. Thank you very much. Thanks to all the panelists.

Senator INHOFE. Thank you, Senator Isakson.

I noticed during the very articulate and somewhat lengthy answer, Professor Grubb, that you had to Senator Carper's question, that Dr. Thorning, you were making a lot of notes. Is there anything you would like to share with us from the notes you were taking?

Dr. THORNING. Yes, thank you very much, Senator. I would like to correct a possible misinterpretation of the testimony I submitted. What our results show when we analyzed economic impact of the Kyoto Protocol on Germany, United Kingdom, Netherlands, Spain, Italy is that those particular countries, if they actually imposed the taxes high enough to force down energy, would experience GDP levels of, in the case of Spain, 4.8 percent less in 2010 than under the baseline forecast.

Now, in these simulations we did recycle the revenue in terms of personal tax cuts, so the money didn't go into a black hole. These simulations, which were done in 2002 and 2003, assumed the United States was not participating. So there was obviously some leakage of jobs outside the EU.

But the numbers were not for the global economy, as Senator Carper said. It was simply for the five countries we modeled. Perhaps I might submit this paper for the record, which is a document with the detailed country results.

Senator INHOFE. Without objection, that will be made a part of the record.

[The referenced document follows:]

THE KYOTO PROTOCOL: IMPACT ON EU EMISSIONS AND COMPETITIVENESS BY MARGO THORNING, PH.D.

EXECUTIVE SUMMARY

EU Not Meeting Emission Targets: The original 15 members of the European Union are projected to be 7 percent above the 1990 emission levels by 2010. Data from the European Environmental Agency show that only Sweden and the United Kingdom are likely to meet their Kyoto targets. Spain, Denmark and Portugal are projected to be 25 percent to 35 percent above their targets in 2010. EU policymakers are beginning to worry about the additional steps required to meet the targets, including impact of emission trading schemes on industry.

GDP and Employment Effects of Emission Reduction Targets: An accurate portrayal of the costs of complying with GHG emissions reduction targets depends largely on choosing an economic model that captures all the short- and medium-term costs of adjusting to higher energy prices or regulatory mandates on the economy as a whole. When macroeconomic models are used to measure Kyoto's effects on the EU, the impacts are greater 0.5 to 5 percent less GDP in 2010 than under the baseline forecast. The Global Insight simulations also show job losses in 2010 ranging from 51,000 in Italy to 800,000 in Spain.

The Impact of the Emission Trading System on EU Electricity Prices: Although the ETS has only been in operation for a short time, electricity prices in the EU are rising. EU electricity prices are closely tracking the cost of the emissions trading permits. While some of the increases in electricity prices are doubtless due to rising global energy prices, part of the 31 percent rise in power can be attributed to higher prices for the right to emit a ton of CO_2.

Effectiveness of an International Emission Trading System: Emission trading will work only if all the relevant markets exist and operate effectively; all the important actions by the private sector have to be motivated by price expectations far in the future. The international framework for climate policy that has been created under the UNFCCC and the Kyoto Protocol cannot create confidence for investors because sovereign nations have different needs and values.

Conclusion: Near-term GHG emission reductions in the developed countries should not take priority over maintaining the strong economic growth necessary to keeping the United States one of the key engines for global economic growth.

Dr. THORNING. Second, the number that DG Environment has used for many years, Margo Walstrom, the previous commissioner of DG Environment, often was publicly quoted as saying that their models showed that imposing the Kyoto Protocol on the EU would cost only .12 percent of GDP. That's using their primus model which is an industry sector model.

I think that's one reason EU policymakers did not ask questions the real cost of these policies that they signed up to, because they were given information that was not based on an appropriate model, appropriate to answer the question of what does it cost to force down energy use.

Another study which I cited in my testimony was done by DG Research for DG Environment in Brussels about 2 years ago, and their simulations showed that if the EU got on track to reduce emissions, the Kyoto Protocol and then a tighter target in a post-2012 period, their own numbers showed a reduction in EU GDP of 1.3 percent a year by 2030. So they too are beginning to in some of their work show rather significant costs for emission reduction targets.

Finally, the point that Michael Grubb made about the U.S. numbers, the EIA numbers of 3.8 percent, or 4.0, 3.8 percent reduction in GDP by 2010, if the United States had signed up to the Kyoto Protocol, the EIA did another study which hasn't been so much noted showing that the cost to the United States would have been even greater had we started earlier. So starting earlier would not have, according to EIA, have materially, it would have actually made our situation worse, because our economy would have been less strong and we would have slowed our growth even sooner.

So I just wanted to mention that there is, there would have been no bonus to us had we embarked quickly in, say, 2000 on forcing energy taxes up high enough to reduce emissions.

Senator INHOFE. When you mentioned Margo Walstrom, I was reminded of a quite I use quite often, I have that on the easel up there, you might glance at it.

Senator Isakson, do you have any other questions for the panel, since it's down to you and me?

Senator ISAKSON. No, thank you, Mr. Chairman.

Senator INHOFE. All right. Why don't I do this. I would like to, I don't think we've ever, since I've chaired this committee, had a more distinguished panel, and that includes panel one, I might also say, Dr. Watson. If there is anything that you would like to say as a last parting thought, we will start with you, Professor Grubb. I would also include you, Dr. Watson, if there is any other last comment you would like to make also, feel free to do so.

Professor Grubb?

Dr. GRUBB. Thank you for the opportunity.

Perhaps the only other thing that I would add in relating to some comments that have come up during the whole session, since the session is about Kyoto and compliance and what you are doing, etc., I did just want to underline the distinction that as set out, I think also in the European Commission's letter, European countries are in varied states and are taking varied strategies toward Kyoto compliance.

Some, like the United Kingdom, intend to deliver virtually the whole lot domestically. The majority intend to actually make a significant contribution through the use of the flexibility mechanisms as very much designed and built into the treaty that involves foreign investment. But I still don't see that any EU country or the EU as a whole is not going to comply.

With respect to the references to Tony Blair and his comments, the British government has made it very clear, including a ministerial statement, that does not represent a backing away from Kyoto or the United Kingdom's commitment to Kyoto. It is simply saying, this is a big and complicated problem. We are willing to look at all kinds of options going forward in the next round.

But Tony Blair himself in that very same address referred to the need to build markets for these technologies. That is really what this whole process, I think, needs to be about.

Senator INHOFE. Thank you, Professor Grubb.

Dr. Thorning.

Dr. THORNING. I would just like to say that climate change is obviously, as we all recognize, a global problem and there will be many ways to approach emission reductions and alterative technologies. But we have to keep in mind climate change is not the world's worst problem. There are many others, as obviously the Copenhagen Consensus came up with. Governments have need for strong economic growth to fund a variety of programs, not the least of which is fighting terrorism, I think.

So we need to balance how we spend our money. If we slow our economic growth here in the United States unnecessarily through near term targets, we will certainly be less able to be a powerhouse for economic growth and for leadership in a variety of areas. So I think the approach the Administration is advocating is the only practical, sensible approach to move forward.

Senator INHOFE. Thank you. I know your council, you said something that I thought was interesting in your opening remarks, when you talked about capital recovery being so low in the United States, mostly due to our taxation system. I would like to see any paper you have on that. That might be helpful to us.

Dr. THORNING. I would be delighted to submit that to you.

Senator INHOFE. Please do, for the record.

Lord Lawson.

Lord LAWSON. I will say very little, I am extremely grateful to you, I must say again, for your having given me the opportunity to come here and meet you and answer some of your questions to the best of my ability.

I would just first of all echo one of the things that Dr. Thorning said, and that is, we must not be obsessed with this problem. Not because there isn't a problem, but because as she said, there are a number of other more, certainly arguably more imminent problems, which the world has to grapple with. Nuclear proliferation is one. International terrorism is another, and these two of course can lead to a very ugly way.

The question also of humanitarian aid to the world's poorest is another important matter for the world's economy. I think that there is a real danger in Europe, it's not the case in the United States, but there's a real danger in Europe of there being, for var-

ious reasons, an obsession with this particular issue, which, as I tried to suggest, can be more sensibly be met and dealt with in a different way which is more cost effective and which is likely to give more time for technologies to develop.

Because technology doesn't stand still. We can't predict how it's going to develop. But I think all history shows that it is going to develop in some areas faster than others, and we don't know which.

Therefore, tackling in a more cost-effective way at the present time, developing measures to adapt, adaptation is tremendously important. It will buy time and enable us both better to meet these other threats as the world as a whole and also better to develop the sort of technological means of mitigating that I think everybody in this room accepts is of first importance.

Senator INHOFE. Thank you, Lord Lawson. Both you and Dr. Thorning mentioned how obsessed we are. Well, this is Washington, DC. We live obsession every day. I have made some speeches on the floor and reflected that many of those who are so obsessed with global warming today were equally obsessed with the new ice age that was coming in 1978. So that was a point well made.

Dr. Watson, did you have anything final comments to make?

Dr. WATSON. I just wanted to thank you, Mr. Chairman, express my appreciation for appearing before the committee. I think you did an outstanding job, and the members of the committee, on airing the issues. I think we've had a very good exchange here.

I obviously would like to echo, the comments by Lord Lawson and Dr. Thorning, about the importance of keeping things in perspective. Once again emphasize, again, we believe that the way to engage developing countries is to put climate change in a broader context so that we're addressing multiple issues that are of importance to them—economic growth, reducing poverty, etc., as I said. I believe that's the only sensible way you're really going to engage them.

Thank you, sir.

Senator INHOFE. Thank you very much, Dr. Watson and thank all of you for coming. I know you've come a long way. It was immensely helpful and I thank you so much for being here.

We are adjourned.

[Whereupon, at 5:18 p.m., the subcommittee was adjourned.]

[Additional statements submitted for the record follow:]

STATEMENT OF HARLAN L. WATSON, PH.D., SENIOR CLIMATE NEGOTIATOR AND SPECIAL REPRESENTATIVE, BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, U.S. DEPARTMENT OF STATE

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear before you today to discuss the Kyoto Protocol and assess efforts to reduce greenhouse gases. I would like to begin with a discussion of the Bush Administration's overall climate change policy, including a description of our broad international engagement in carrying this policy forward. Finally, I would like to touch upon U.S. expectations at the Eleventh Session of the Conference of the Parties (COP 11) to the UN Framework Convention on Climate Change (UNFCCC).

PRESIDENT BUSH'S CLIMATE CHANGE POLICY

As a Party to the UNFCCC, the United States shares with many other countries its ultimate objective: stabilization of greenhouse gas concentrations in the atmosphere at a level that prevents dangerous human-induced interference with the climate system. In February 2002, President Bush reaffirmed America's commitment

to the Framework Convention and its central goal, while also making clear that he could not commit the United States to the Kyoto Protocol that would have cost the U.S. economy up to $400 billion dollars and 4.9 million jobs.[1]

Addressing the challenge of global climate change will require a sustained, long-term commitment by all nations over many generations. To this end, the President has established a robust and flexible climate change policy that harnesses the power of markets and technological innovation, maintains economic growth, and encourages global participation. Major elements of this approach include implementing near-term policies and measures to slow the growth in greenhouse gas emissions, advancing climate change science, accelerating climate change technology development, and promoting international collaboration.

Near-Term Policies and Measures to Slow the Growth in Greenhouse Gas Emissions

Although climate change is a complex and long-term challenge, the Bush administration recognizes that there are cost-effective steps we can take now. In February 2002, President Bush set an ambitious national goal to reduce the greenhouse gas intensity (emissions per unit of economic output) of the U.S. economy by 18 percent by 2012, which represents about a 29 percent improvement in the "business-as-usual" rate of change of 14 percent projected by the Energy Information Administration (EIA) over this period.[2] The Administration estimated that its 18 percent intensity improvement goal will reduce cumulative emissions by more than 1,833 million metric tons of carbon dioxide equivalent by 2012,[3] and recent EIA projections suggest that achieving the 18 percent goal will reduce emissions by 366 million metric tons of carbon dioxide equivalent in 2012 alone.[2]

A hallmark of the intensity approach is flexibility, an especially important consideration when confronted with the many uncertainties surrounding climate change. These uncertainties suggest that a measured response is required that concentrates first on slowing emissions growth before trying to stop and eventually reverse it. A greenhouse gas emissions intensity goal can encourage reductions without risking economic consequences that could jeopardize our ability to invest in long-run scientific and technological solutions.

To this end, the Administration has developed an array of policy measures, including voluntary programs and financial incentives.

In setting the 18 percent decade goal, President Bush issued a challenge to the private sector to do its part. The President's call resonated with business, which has responded positively through its participation in a number of new voluntary programs, including DOE's Climate VISION program and EPA's Climate Leaders and SmartWay Transport Partnership programs:

• Climate VISION (Voluntary Innovative Sector Initiatives: Opportunities Now)[4]: In February 2003, the Federal Government and industry organizations representing thousands of companies from 12 energy-intensive economic sectors (since expanded to 14) and The Business Roundtable also joined in a voluntary partnership known as Climate VISION. Climate VISION is unique in that it focuses on economic sectors, not specific companies, with each industry association making a commitment on behalf of its members to reduce greenhouse gas emissions intensity. These Climate VISION partners, which include some of the largest companies in America, represent a broad range of industry sectors—oil and gas, electricity generation, coal and mineral production and mining, manufacturing (automobiles, cement, iron and steel, magnesium, aluminum, chemicals, and semiconductors), railroads, and forestry products—accounting for about 40 to 45 percent of total U.S. greenhouse gas emissions. Four Federal agencies participate in the program: DOE (lead), Department of Agriculture (USDA), Department of Transportation (DOT), and the Environmental Protection Agency (EPA).

• Climate Leaders[5]: Climate Leaders, established in February 2002, is an EPA partnership encouraging individual companies to develop long-term, comprehensive climate change strategies. Under this program, partners set corporate-wide greenhouse gas reduction goals and inventory their emissions to measure progress. By reporting inventory data to EPA, partners create a lasting record of their accomplishments and also identify themselves as corporate environmental leaders, strategically positioned to address climate change policy issues. Seventy-one major companies

[1] http://www.whitehouse.gov/news/releases/2002/02/20020214-5.html.

[2] Energy Information Administration (EIA). 2005. Annual energy outlook 2005: with projections to 2025, DOE/EIA-0383(2005). Washington, DC: U.S. Department of Energy, p. 55. (http://www.eia.doe.gov/oiaf/aeo/index.html)

[3] http://www.whitehouse.gov/news/releases/2002/02/20020214.html.

[4] http://www.climatevision.gov/.

[5] http://www.epa.gov/climateleaders/.

from diverse industries representing 8 percent of U.S. emissions are now participating.

• SmartWay Transport Partnership[6]: Launched in February 2004, the SmartWay Transport Partnership is designed to reduce fuel consumption and emissions by encouraging shippers and carriers to improve the overall environmental performance of the freight delivery system. Currently, 225 companies have joined SmartWay, including 170 Trucking Carriers, 25 Shippers, 7 Shipper/Carriers, 8 Railroads, 7 logistics companies and 8 Affiliates. Based on the actions taken by these partners to date, EPA projects savings of at least 175 million gallons of fuel by the year 2007.

Further, the USDA is using its conservation programs to provide an incentive for actions that increase carbon sequestration. Under the Farm Security and Rural Investment Act of 2002, the United States will invest about $40 billion over 10 years for conservation measures on its farms and forest lands—including measures that will enhance the natural storage of carbon.

DOE is also pursuing many energy supply technologies with comparatively low or zero carbon dioxide emissions profiles, such as solar, wind, bioenergy, and combined heat and power. In addition, the Bush Administration also has increased fuel economy standards for new light trucks and sport utility vehicles by 1.5 miles per gallon over the next three model years, and a new round of standards was proposed on August 23.[7]

These and other initiatives may be contributing to greenhouse gas emission intensity reductions that we have seen already. The President's 18 percent 10-year goal represents an average annual rate of 1.8 percent. According to Energy Information Administration's (EIA) *Emissions of Greenhouse Gases in the United States 2003* report[8], the greenhouse gas intensity was 2.3 percent lower in 2003 than in 2002, and a June 2005 EIA flash estimate of energy-related carbon emissions—which account for over four fifths of total greenhouse gas emissions—suggests an improvement in carbon dioxide emissions intensity of 2.6 percent in 2004[9]. Overall, then, the Nation appears to be ahead of schedule in meeting the President's goal.

Advancing Climate Change Science

In May 2001, President Bush commissioned the National Academies National Research Council (NRC) to examine the state of our knowledge and understanding of climate change science. The NRC's report makes clear that there are still important gaps in our knowledge.[10]

Based on the resulting NRC report and the Administration's ongoing climate science planning activity, President Bush created a new cabinet-level management committee (the Committee on Climate Change Science and Technology Integration) in February 2002 to oversee climate change science and technology activities. The President's direction resulted in the creation of the U.S. Climate Change Science Program (CCSP), combining the existing U.S. Global Change Research Program (USGCRP) and the Climate Change Research Initiative (CCRI), as well as the creation of the Climate Change Technology Program (CCTP).

The Climate Change Science Program (CCSP)[11] integrates the federal research on global change and climate change across thirteen federal agencies (the National Science Foundation (NSF), the Department of Commerce, the DOE, EPA, the National Aeronautics and Space Administration (NASA), the Department of State, the Department of Interior, the Department of Agriculture, the Department of Health and Human Services, the Department of Transportation, the Department of Defense, U.S. Agency for International Development, and the Smithsonian Institution) and overseen by the Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget. The Administration requested $1.9 billion for CCSP in FY 2006.

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[6] http://www.epa.gov/smartway/.

[7] http://www.nhtsa.gov/portal/site/nhtsa/template.MAXIMIZE/menuitem.f2217bee37fb302f6d7c121046108a0c/?javax.portlet.tpst=1e51531b2220b0f8ea14201046108a0c__ws__MX&javax.portlet.prp__1e51531b2220b0f8ea14201046108a0c__viewID=detail__view&javax.portlet.begCacheTok=token&javax.portlet.endCacheTok=token&itemID=d674acd2593e5010VgnVCM1000002c567798RCRD&overrideViewName=PressRelease.

[8] http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/057303.pdf, p. 15.

[9] http://www.eia.doe.gov/neic/press/press257.html.

[10] National Research Council. 2001. Climate Change Science: An Analysis of Some Key Questions, Committee on the Science of Climate Change, National Research Council, National Academy Press, Washington, DC. (http://www.nap.edu/catalog/10139.html).

[11] http://www.climatescience.gov.

In July 2003, CCSP released its *Strategic Plan for the U.S. Climate Change Science Program*[12], the first comprehensive update of a national plan for climate and global change research since the original U.S. Global Change Research Program strategy was issued at the inception of the program in 1990. The plan is organized around five goals: (1) improving our knowledge of climate history and variability; (2) improving our ability to quantify factors that affect climate; (3) reducing uncertainty in climate projections; (4) improving our understanding of the sensitivity and adaptability of ecosystems and human systems to climate change; and (5) exploring uses and identifying limits of knowledge to manage risks and opportunities. A review of the CCSP plan by the NRC, which concluded that it "articulates a guiding vision, is appropriately ambitious, and is broad in scope," shows the Administration is on the right track.[13]

Twenty-one Synthesis and Assessment Products are identified in the Strategic Plan in fulfillment of Section 106 of the 1990 Global Research Act to be produced through 2007. These reports are designed to address a full range of science questions and evaluate options for response that are of the greatest relevance to decision and policy makers and planners. The products are intended to provide the best possible state of science information, developed by a diverse group of climate experts, for the decision community.

Since CCSP was created in 2002, the program has successfully integrated a wide range of research, climate science priorities of the thirteen CCSP agencies. CCSP has taken on some of the most challenging questions in climate science and is developing products to convey the most advanced state of knowledge to be used by federal, state and local decision makers, resource managers, the science community, the media, and the general public.

CCSP will hold a public workshop on November 14–16 in Arlington, VA. The CCSP Workshop will address the capability of climate science to inform decision-making and will serve as a forum to address the progress and future plans regarding CCSP's three decision-support deliverables as described above. The Workshop will provide an opportunity for scientists and user communities to discuss decision-maker needs and future application of scientific information on climate variability and change, as well as discussion on expected outcomes of CCSP's research and assessment activities that are necessary for sound resource management, adaptive planning and policy.

Accelerating Climate Change Technology Development

While acting to slow the pace of greenhouse gas emissions intensity in the near term, the Administration is laying a strong technological foundation to develop realistic mitigation options to meet energy security and climate change objectives.

The Bush administration is moving ahead on advanced technology options that have the potential to substantially reduce, avoid, or sequester future greenhouse gas emissions. Over 80 percent of current global anthropogenic greenhouse gas emissions are energy related, and although projections vary considerably, a tripling of global energy demand by 2100 is not unimaginable. Therefore, to provide the energy necessary for continued economic growth while we reduce greenhouse gas emissions, we may have to develop and deploy cost-effective technologies that alter the way we produce and use energy.

The Climate Change Technology Program (CCTP)[14] was created to coordinate and prioritize the Federal Government's climate-related technology research, development, demonstration, and deployment (RDD&D) activities, for which the Administration has requested $2.865 billion in FY 2006. Title XVI of the Energy Policy Act of 2005 authorizes CCTP within the Department of Energy (DOE).

Using various analytical tools, CCTP is assessing different technology options and their potential contributions to reducing greenhouse gas emissions. Given the tremendous capital investment in existing energy systems, the desired transformation of our global energy system may take decades or more to implement fully. A robust RDD&D effort can make advanced technologies available sooner rather than later and can accelerate modernization of capital stock at lower cost and with greater flexibility.

On August 5, Energy Secretary Bodman, who currently chairs the President's Cabinet Committee on Climate Change Science and Technology Integration, re-

[12] http://www.climatescience.gov/Library/stratplan2003/final/default.htm.

[13] National Research Council. 2004. Implementing Climate and Global Change Research: A Review of the Final U.S. Climate Change Science Program Strategic Plan, Committee to Review the U.S. Climate Change Science Program Strategic Plan, National Research Council, National Academy Press, Washington, D.C., p. 1 (http://books.nap.edu/catalog/10635.html).

[14] http://www.climatetechnology.gov/.

leased the CCTP *Vision and Framework* for our forthcoming draft *Strategic Plan*.[15] CCTP's strategic vision has six complementary goals: (1) reducing emissions from energy use and infrastructure; (2) reducing emissions from energy supply; (3) capturing and sequestering carbon dioxide; (4) reducing emissions of other greenhouse gases; (5) measuring and monitoring emissions; and (6) bolstering the contributions of basic science. The DOE also released for public review and comment the larger CCTP *Strategic Plan* on September 22.[16]

The Administration continues strong investment in many strategic technology areas. As the President's National Energy Policy requires, the strategic technology efforts with respect to energy production and distribution focus on ensuring environmental soundness, as well as dependability and affordability.

• Energy Efficiency and Renewable Energy: Energy efficiency is the single largest investment area under CCTP and it provides tremendous short-term potential to reduce energy use and greenhouse gas emissions. Renewable energy includes a range of different technologies that can play an important role in reducing greenhouse gas emissions. The United States invests significant resources in wind, solar photovoltaics, geothermal, and biomass technologies. Many of these technologies have made considerable progress in price competitiveness, but there remain opportunities to reduce manufacturing, operating, and maintenance costs of many of these technologies.

• Hydrogen: President Bush announced his Hydrogen Fuel Initiative[17] in his 2003 State of the Union Address. The goal is to work closely with the private sector to accelerate our transition to a hydrogen economy, on both the technology of hydrogen fuel cells and a fueling infrastructure. The President's Hydrogen Fuel Initiative and the FreedomCAR Partnership[18] which was launched in 2002 will provide $1.7 billion through 2008 to develop hydrogen-powered fuel cells, hydrogen production and infrastructure technologies, and advanced automotive technologies, with the goal of commercializing fuel-cell vehicles by 2020.[19]

• Carbon Sequestration: Carbon capture and sequestration is a central element of CCTP's strategy because for the foreseeable future, fossil fuels will continue to be the world's most reliable and lowest-cost form of energy. A realistic approach is to find ways to capture and store the carbon dioxide produced when these fuels are used. DOE's core Carbon Sequestration Program[20] emphasizes technologies that capture carbon dioxide from large point sources and store it in geologic formations. In 2003, DOE launched a nationwide network of seven Regional Carbon Sequestration Partnerships[21], involving State agencies, universities, and the private sector, to determine the best approaches for sequestration in each geographic region represented and to examine regulatory and infrastructure needs. On June 9th of this year, Secretary of Energy Bodman announced a major expansion of the Regional Partnerships program[22].

• Coal-Fired, Near-Zero-Emissions Power Generation: The United States has vast reserves of coal, and about half of its electricity is generated from this fuel. Advanced coal-based power and fuels, therefore, is an area of special interest from both an energy security and climate change perspective. The Coal Research Initiative (CRI) consists of research, development, and demonstration of coal-related technologies that will improve coal's competitiveness in future energy supply markets. The Clean Coal Power Initiative (CCPI)[23], within the CRI, is a cost-shared program between the government and industry to demonstrate emerging technologies in coal-based power generation and to accelerate their commercialization. A major initiative under CCPI is the FutureGen project[24], a 10-year, $1 billion government industry cost-shared effort to design, build, and operate the world's first near-zero atmospheric emissions coal-fired power plant. This project, which cuts across many CCTP strategic areas, will incorporate the latest technologies in carbon sequestration, oxygen and hydrogen separation membranes, turbines, fuel cells, and coal-to-hydrogen

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[15] http://www.climatetechnology.gov/vision2005/index.htm.
[16] http://www.climatetechnology.gov/stratplan/draft/index.htm.
[17] http://www.hydrogen.gov/president.html.
[18] http://www.eere.energy.gov/vehiclesandfuels/.
[19] Much of the funding dedicated to the Hydrogen Fuel Initiative is accounted for within other technology areas here.
[20] http://www.fe.doe.gov/programs/sequestration/index.html.
[21] http://www.fe.doe.gov/programs/sequestration/partnerships/.
[22] http://www.energy.gov/engine/content.do?PUBLIC__ID=18031&BT__CODE=PR__PRESSRELEASES&TT__CODE=PRESSRELEASE.
[23] http://www.fe.doe.gov/programs/powersystems/cleancoal/index.html.
[24] http://www.fe.doe.gov/programs/powersystems/futuregen/index.html.

gasification. Through the CRI, clean coal can remain part of a diverse, secure energy portfolio well into the future.

• Nuclear Fission: Concerns over resource availability, energy security, and air quality as well as climate change suggest a larger role for nuclear power as an energy supply choice. While current generations of nuclear energy systems are adequate in many markets today, new construction of advanced light-water reactors in the near term and of even more advanced systems in the longer term can broaden opportunities for nuclear energy, both in industrialized and developing countries. The Nuclear Power 2010 program[25] is working with industry to demonstrate the Nuclear Regulatory Commission's new licensing process, while the Generation IV Nuclear Energy Systems Initiative[26] is investigating the more advanced reactor and fuel cycle systems that represent a significant leap in economic performance, safety, and proliferation-resistance. One promising system being developed under the Nuclear Hydrogen Initiative[27] would pair very-high-temperature reactor technology with advanced hydrogen production capabilities that could produce both electricity and hydrogen on a scale to meet transportation needs. Complementing these programs is the Advanced Fuel Cycle Initiative[28], which is developing advanced, proliferation resistant nuclear fuel technologies that can improve the fuel cycle, reduce costs, and increase the safety of handling nuclear wastes.

• Fusion: Fusion energy is a potential major new source of energy that, if successfully developed, could be used to produce electricity and possibly hydrogen. Fusion has features that make it is an attractive option from both an environmental and safety perspective. However, the technical hurdles of fusion energy are very high, and with a commercialization objective of 2050, its impact would not be felt until the second half of the century, if at all. Nevertheless, the promise of fusion energy is simply too great to ignore.

Advances in these and other technology areas in the CCTP portfolio could put us on a path to ensuring access to clean, affordable energy supplies while dramatically reducing the greenhouse gas profile of our economy over the long term. Moreover, the deployment of cleaner energy technologies in developing economies like China and India can make a huge difference in altering the future global energy picture.

Promoting International Collaboration

President Bush—in both his June 2001 and February 2002 climate change policy speeches—highlighted the importance of international cooperation in developing an effective and efficient global response to the complex and long-term challenge of climate change.[29]

Any effective international response to climate change requires developing country participation, which includes both near-term efforts to slow the growth in emissions and longer-term efforts to build capacity for future cooperation. Central to achieving global cooperation to address climate change will be the participation of developing countries.

The Bush administration believes that the most effective way to engage developing countries is to focus not solely on greenhouse gas emissions, but rather on a broader development agenda that promotes economic growth, reduces poverty, provides access to modern sanitation, enhances agricultural productivity, provides energy security, reduces pollution, *and* mitigates greenhouse gas emissions.

The Administration also believes that well-designed multilateral collaborations focused on achieving practical results can accelerate development and commercialization of new technologies and advance climate change science. In particular, under President Bush's leadership, the United States has brought together key nations to tackle jointly some tough energy challenges. These multilateral collaborations mirror the main strategic thrusts of our domestic technology research programs, and they address a number of complementary energy concerns, such as energy security, climate change, and environmental stewardship. Another characteristic of the collaborations is that they include as partners Kyoto countries, non-Kyoto countries, industrialized countries, developing countries, and countries with economies in transition.

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[25] http://www.ne.doe.gov/NucPwr2010/NucPwr2010.html.
[26] http://www.ne.doe.gov/infosheets/geni.pdf.
[27] http://www.ne.doe.gov/infosheets/hydrogen.pdf.
[28] http://www.ne.doe.gov/infosheets/afci.pdf.
[29] http://www.whitehouse.gov/news/releases/2001/06/20010611-2.html and http://www.whitehouse.gov/news/releases/2002/02/20020214-5.html.

• Asia-Pacific Partnership for Clean Development and Climate[30]: In July 2005, Deputy Secretary of State Zoellick announced plans to create the Asia-Pacific Partnership for Clean Development and Climate to focus on voluntary practical measures to create new investment opportunities, build local capacity, and remove barriers to the introduction of clean, more efficient technologies.[31] The partnership is designed to help each country meet nationally designed strategies for improving energy security, reducing pollution, and addressing the long-term challenge of climate change. We view the partnership as a complement, not an alternative, to the UN Framework Convention on Climate Change. It is critically important to be able to build on mutual interests and incentives to tackle global challenges effectively. The six countries that currently comprise this partnership represent about half of the world's economy, population, energy use and greenhouse gas emissions. We are actively engaging with our Partners toward a formal launch early next year.

• Methane to Markets Partnership[32]: Launched in November of last year, the Methane to Markets Partnership, led on the U.S. side by EPA, now includes 16 partner countries. This Partnership is an international initiative that focuses on advancing cost-effective, near-term methane recovery and use as a clean energy source to enhance economic growth, promote energy security, improve the environment, and reduce greenhouse gases. Initially, the Partnership will target three major methane sources: landfills, underground coal mines, and natural gas and oil systems. The Partnership has the potential to deliver by 2015 annual reductions in methane emissions of up to 50 million metric tons of carbon equivalent or recovery of 500 billion cubic feet of natural gas. When fully achieved, these results could lead to stabilized or even declining levels of global atmospheric concentrations of methane.

• International Partnership for the Hydrogen Economy (IPHE)[33]: Recognizing the common interest in hydrogen research that many countries share, the United States called for an international hydrogen partnership in April 2003, and in November 2003, representatives from 15 national governments and the European Commission gathered in Washington to launch IPHE. IPHE provides a vehicle to organize, coordinate, and leverage multinational hydrogen research programs that advance the transition to a global hydrogen economy. It reviews the progress of collaborative projects, identifies promising directions for research, and provides technical assessments for policy decisions. IPHE also will develop common recommendations for internationally-recognized standards and safety protocols to speed market penetration of hydrogen technologies. Through IPHE, the United States has assisted Brazil and China in developing hydrogen roadmaps.

• Carbon Sequestration Leadership Forum (CSLF)[34]: CSLF is a U.S.-launched initiative that was established formally at a ministerial meeting held in Washington, D.C., in June 2003. CSLF is a multilateral initiative that provides a framework for international collaboration on sequestration technologies. The Forum's main focus is assisting the development of technologies to separate, capture, transport, and store carbon dioxide safely over the long term, making carbon sequestration technologies broadly available internationally, and addressing wider issues, such as regulation and policy, relating to carbon capture and storage. In addition to these activities, CSLF members and other interested nations are invited to participate in the FutureGen clean coal project.

• Generation IV International Forum (GIF)[35]: In 2002, nine countries and Euratom joined together with the United States to charter GIF, a multilateral collaboration whose goal is to develop the fourth generation of advanced, economical,

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[30] Partners include Australia, China, India, Japan and South Korea and the United States. Fact sheet at http://www.whitehouse.gov/news/releases/2005/07/20050727-11.html.

[31] http://www.state.gov/s/d/rem/50326.htm.

[32] http://www.epa.gov/methanetomarkets/ and http://www.methanetomarkets.org/. Founding Methane to Markets member governments include the United States, Argentina, Australia, Brazil, China, Colombia, India, Italy, Japan, Mexico, Nigeria, Russian Federation, Ukraine, and the United Kingdom. The Republic of Korea became the 15th member in June and Canada the 16th member in July.

[33] http://www.iphe.net/. Founding IPHE members include the United States, Australia, Brazil, Canada, China, European Commission, France, Germany, Iceland, India, Italy, Japan, Norway, Republic of Korea, Russia, and the United Kingdom. New Zealand became the 17th member in January 2005.

[34] http://www.cslforum.org/. CSLF members include the United States, Australia, Brazil, Canada, China, Colombia, Denmark, European Commission, France, Germany, India, Italy, Japan, Mexico, Netherlands, Norway, Republic of Korea, Russian Federation, South Africa, and the United Kingdom.

[35] http://gen-iv.ne.doe.gov/. GIF members include the United States, Argentina, Brazil, Canada, Euratom, France, Japan, Republic of Korea, South Africa, Switzerland, and the United Kingdom.

safe, and proliferation-resistant nuclear systems that can be adopted commercially no later than 2030. A technology roadmap developed by the GIF and DOE's Nuclear Energy Research Advisory Committee in 2003 identified six technologies as candidates for future designs. Based on the *Roadmap*, GIF countries are jointly preparing a collaborative research program to develop and demonstrate the projects.

• ITER[36]: In January 2003, President Bush announced that the United States was joining the negotiations for the construction and operation of the international fusion experiment known as ITER.[37] If successful, this multi-billion-dollar research project will advance progress toward producing clean, renewable, commercially—available fusion energy by the middle of the century. It was recently agreed that the experimental reactor will be sited in Cadarache, France.

Regional and Bilateral Activities: Since 2001, the United States has established 15 climate partnerships with key countries and regional organizations that, together with the United States, account for almost 80 percent of global greenhouse gas emissions.[38] These partnerships encompass over 400 individual activities, and successful joint projects have been initiated in areas such as climate change research and science, climate observation systems, clean and advanced energy technologies, carbon capture, storage and sequestration, and policy approaches to reducing greenhouse gas emissions.

• Clean Energy Initiative[39]: At the 2002 World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa, the United States launched a "Clean Energy Initiative," whose mission is to bring together governments, international organizations, industry and civil society in partnerships to alleviate poverty and spur economic growth in the developing world by modernizing energy services. The Initiative consists of four market-oriented, performance-based partnerships:

- Global Village Energy Partnership (GVEP)[40] is an international partnership with over 700 public and private sector partners including the World Bank, UNDP, and leading energy companies. The U.S. implementation of GVEP, led by the U.S. Agency for International Development, is a 10-year initiative that seeks to increase access to modern energy services for those in developing countries in a manner that enhances economic and social development and reduces poverty.
- Partnership for Clean Indoor Air[41], led by EPA, which is addressing the increased environmental health risk faced by more than 2 billion people in the developing world who burn traditional biomass fuels indoors for cooking and heating.
- Partnership for Clean Fuels and Vehicles[42], which is helping to reduce vehicular air pollution in developing countries by promoting the elimination of lead in gasoline and encouraging the adoption of cleaner vehicle technologies; and
- Efficient Energy for Sustainable Development (EESD)[43], led by DOE, which aims to improve the productivity and efficiency of energy systems, while reducing pollution and waste, saving money and improving reliability through less energy intensive products, more energy efficient processes and production modernization.

• Renewable Energy and Energy Efficiency Partnership (REEEP): Also formed at the 2002 WSSD, the Renewable Energy and Energy Efficiency Partnership (REEEP) seeks to accelerate and expand the global market for renewable energy and energy efficiency technologies. As the world's largest producer and consumer of renewable energy, and with more renewable energy generation capacity than Germany, Denmark, Sweden, France, Italy, and the United Kingdom combined, the United States is one of 17 countries who are partners in REEEP. The United States also actively participated in the Renewables 2004 conference sponsored by the German Government in June 2004, and submitted five action items intended to provide specific technology plans and cost targets for renewable energy technologies using solar, biomass, wind, and geothermal resources.

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[36] ITER member countries include the United States, China, European Union, Japan, Russian Federation, and the Republic of Korea.

[37] http://www.whitehouse.gov/news/releases/2003/01/20030130-18.html.

[38] Partners include Australia, Brazil, Canada, China, Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama), European Union, Germany, India, Italy, Japan, Mexico, New Zealand, Republic of Korea, Russian Federation, and South Africa.

[39] http://www.sdp.gov/sdp/initiative/cei/28304.htm.

[40] http://www.sdp.gov/sdp/initiative/cei/44949.htm.

[41] http://www.sdp.gov/sdp/initiative/cei/29808.htm and http://www.pciaonline.org/.

[42] http://www.sdp.gov/sdp/initiative/cei/29809.htm and http://www.unep.org/pcfv/main/main.htm.

[43] http://www.sdp.gov/sdp/initiative/cei/28304.htm.

• Renewable Energy Policy Network for the 21st Century (REN21)[44]: REN21 is a global policy network, which connects governments, international institutions and organizations, partnerships and initiatives and other stakeholders on the political level with those "on the ground," aimed at providing a forum for international leadership on renewable energy. Its goal is to allow the rapid expansion of renewable energies in developing and industrial countries by bolstering policy development and decisionmaking on sub-national, national and international levels. The United States serves as one of the 11 governments serving on REN2l's Steering Committee.

• Group on Earth Observations[45]: Of particular importance is the need for a broad global observation system to support measurements of climate variables. On July 31, 2003, the United States hosted 33 nations—including many developing nations—at the inaugural Earth Observation Summit (EOS), out of which came a commitment to establish an intergovernmental, comprehensive, coordinated, and sustained Earth observation system. While the use and benefits of these observations are extensive, the climate applications of the data collected by the system include the use of the data to create better climate models, to improve our knowledge of the behavior of carbon dioxide and aerosols in the atmosphere, and to develop strategies for carbon sequestration. The United States was instrumental in drafting a ten-year implementation plan for a Global Earth Observation System of Systems, which was approved by 55 nations and the European Commission at the 3rd EOS summit in Brussels in February 2005. The United States also released its contribution through the Strategic Plan for the U.S. Integrated Earth Observing System in April 2005.[46] The plan will help coordinate a wide range of environmental monitoring platforms, resources, and networks.

Other examples of our engagement across the globe in advancing climate change science and addressing greenhouse gas emissions include our participation in the Intergovernmental Panel on Climate Change (IPCC), the Global Environment Facility (GEF) and activities under the Tropical Forest Conservation Act.

• Intergovernmental Panel on Climate Change (IPCC)[47]: The IPCC was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988 to assess scientific, technical and socioeconomic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. It is open to all Members of the United Nations and of WMO. The United States has played an active role in the IPCC since its establishment and has provided more of its funding than any other nation. Dr. Susan Solomon, a senior scientist at the National Oceanic and Atmospheric Administration's Aeronomy Laboratory in Boulder, Colorado, serves as co-chair of the IPCC Working Group I, which is assessing the scientific basis of climate change. The United States hosts the Working Group's Technical Support Unit and hundreds of U.S. scientists are participating in the preparation of the IPCC's Fourth Assessment Report, which is due to be completed in 2007.

• Global Environment Facility (GEF)[48]: The GEF is the financial mechanism under the UN Framework Convention on Climate Change. It focuses on innovative and generally small scale projects and funds only the incremental costs involved in producing global environmental benefits. The GEF has committed about $5.4 billion to date, leveraging over $17 billion from other sources, including the private sector, international development banks and organizations, governments, NGOs and bilateral agencies. It has designed and initiated nearly 1,600 investment and capacity building projects that are now being implemented by developing countries with the help of ten agencies, including the UN Development Program and the International Fund for Agricultural Development. The GEF has also provided nearly 5,000 small grants directly to NGOs and community groups in over 70 countries. U.S. contributions will fund solely technology transfer and capacity building in developing countries.

• Tropical Forest Conservation Act[49]: Many of our international activities also help to promote the biological sequestration of carbon dioxide, an important tool for addressing climate change that can have benefits both for conservation and climate change. The Tropical Forest Conservation Act (TFCA) offers eligible developing countries opportunities to reduce concessional debt owed to the United States while

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[44] http://www.ren21.net/.
[45] http://earthobservations.org/.
[46] http://iwgeo.sse.nasa.gov/docs/EOCStrategic__Plan.pdf.
[47] http://www.ipcc.ch/.
[48] http://www.gefweb.org/.
[49] http://www.usaid.gov/our__work/environment/forestry/intro__tfca.html. TFCA agreements have been concluded with Bangladesh, Belize, Colombia, El Salvador, Jamaica, Panama (two agreements), Peru and the Philippines.

generating local currency funds to support programs to conserve tropical forests. Since 1998, the United States has concluded nine TFCA agreements with eight countries that will generate more than $95 million for tropical forest conservation over the next 10–25 years. Three U.S.-based international NGOs (The Nature Conservancy, the World Wildlife Fund and Conservation International) contributed approximately $7.5 million to six of the nine agreements, thereby increasing the amount of debt we were able to treat. In FY 2006, the Administration has requested a total of approximately $100 million for certain debt restructuring programs. These programs include bilateral Heavily Indebted Poor Countries (HIPC) and poorest country debt reduction, contributions to the HIPC Trust Fund and TFCA debt reduction.

ELEVENTH SESSION OF THE CONFERENCE OF THE PARTIES (COP 11) TO THE UNFCCC

The Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change will hold its 11th Session in Montreal from November 28 to December 9, 2005. Under Secretary of State for Democracy and Global Affairs Paula J. Dobriansky will head the U.S. delegation to this meeting. As the Kyoto Protocol entered into force on February 16 of this year, the Montreal meeting will also be the first "meeting of the Parties (MOP)" under that instrument.

While the COP and the MOP will take separate decisions, reflecting the different legal instruments involved and the different membership in these two bodies, there will be a joint "High Level Segment" from December 7–9. It is likely that statements of ministers and other heads of delegation will take up a good portion of the time, rather than the more interactive and successful roundtables that characterized the High Level Segments of COP 9 in Milan in 2003 and COP 10 in Buenos Aires in 2004. In addition, there will be a heavy workload under the MOP as the Parties to that instrument seek to adopt the "Marrakech Accords" and other decisions to begin implementing the Kyoto Protocol.

We intend to work constructively within the COP framework and to carry forward our positive message, as we have in the last two COPs, and anticipate that it will have increased resonance as a result of the positive G-8 outcomes and the positive response to the approach of our Asia Pacific Partnership. At those previous COPs, we have highlighted all that the United States is doing with respect to science and technology, and with respect to our domestic actions and international partnerships related to climate change.

CONCLUDING REMARKS

Mr. Chairman and Members of the Committee, I hope that my testimony this afternoon conveys a sense of the vast extent to which the United States is working to reduce greenhouse gas intensity, promote energy efficient technologies and advance climate science, while also placing primary importance on supporting economic growth and prosperity.

We see economic growth, reducing poverty, providing access to modern sanitation, enhancing agricultural productivity, providing energy security, reducing pollution, and addressing the climate change problem, as integrally related. Meeting the challenge of the expected future growth in global energy demand and reducing greenhouse gas emissions will require a transformation in the way the world produces and consumes energy over the next generation and beyond. This is why we are leading global efforts to develop and deploy breakthrough technologies for both the developed and developing world.

I thank you for this opportunity to testify before this Committee. I look forward to responding to any questions you may have.

RESPONSE BY HARLAN WATSON, PH.D., TO AN ADDITIONAL QUESTION FROM SENATOR LAUTENBERG

Question. What historical evidence leads you to believe that reliance on a voluntary approach to reducing greenhouse emissions will result in reductions sufficient to forestall continued global warming?

Response. Given that the global warming experienced since the beginning of the industrial age is a combination of natural and human-induced factors, it is not clear any approach—whether mandatory or voluntary—will result in reductions sufficient to forestall continued global warming.

However, given the U.S. experience with a large number of voluntary programs, such as EPA's Climate Leaders and DOE's Climate VISION programs, which covers some 40–45 percent of total U.S. emissions, we are optimistic that these can result

in substantial reductions in the growth of greenhouse gas emissions—and in many cases to absolute reductions in such emissions—while maintaining economic growth. The EPA Climate Leaders website at http://www.epa.gov/climateleaders/ and the Climate VISION website at http://www.climatevision.gov/ and the accompanying links contain a wealth of information on the actions of individual companies and sectors and the progress they are making. EPA's voluntary methane partnership programs—the AgSTAR (see http://www.epa.gov/agstar/), Coalbed Methane Outreach (see http://www.epa.gov/cmop/), Natural Gas STAR (see http://www.epa.gov/gasstar/), and Landfill Methane Outreach (see http://www.epa.gov/lmop/)—helped achieve absolute reductions in U.S. methane emissions of 10.0 percent below 1990 levels in 2003.

RESPONSES BY HARLAN WATSON, PH.D., TO ADDITIONAL QUESTIONS FROM SENATOR OBAMA

Question 1. Next winter, in 2006, the world will discuss the next steps beyond the 2012 Kyoto deadline. If either China or India indicates a willingness to negotiate commitments would the Administration consider signing a future treaty?

Response. Under Article 9.3 of the Kyoto Protocol, Kyoto Parties are obligated to begin discussions this year on the second phase of the Protocol after the first compliance period ends in 2012. China and India, like the vast majority of Parties to the Kyoto Protocol, are classified as developing countries and thus are exempt from all emissions reductions requirements. Whether or not China or India might indicate a willingness in these new negotiations to take on emissions reduction commitments for themselves, is, of course, hypothetical. For the United States, we oppose any policy that would achieve reductions by putting Americans out of work, or by simply shifting emissions from one state to another, or from the United States to another country. Like us, developing countries are unlikely to join in approaches that foreclose their own economic growth and development.

We would note that to date China and India have been resolute and crystal clear in indicating that they do not support applying to themselves a target-and-timetable approach to greenhouse gas emissions imposed through the UN process—an approach they consider to be a threat to the economic growth that is crucial in solving their more immediate problems of poverty alleviation and development. Pushing for these countries to take on binding emissions reductions under a new climate change agreement would undermine U.S. efforts to engage them in cooperative approaches that are consistent with their aspirations to achieve prosperity and well-being for their people.

Outside the context of targets, we have found through our bilateral and regional partnerships, countries like China and India are willing and even eager to address these issues, especially where meeting climate change goals also advances more immediate social and economic objectives, such as economic development, poverty reduction, access to modern sanitation, enhanced agricultural productivity, energy security, pollution reduction, and greenhouse gas emissions mitigation.

Question 2. Under the Protocol, countries can achieve their commitments through means other than reducing their own emissions. For example, they can partner with developing countries to transfer environmentally friendly technology. With regard to developing countries, what options are most promising for curtailing future emissions?

Response. Because developing countries have different national resource endowments there is no single option that addresses their needs. In the last three years, the United States has launched a series of bilateral and multilateral initiatives—such as the Carbon Sequestration Leadership Forum, the International Partnership for a Hydrogen Economy, the Methane to Markets Partnership, and the World Summit on Sustainable Development Partnerships—to help developing countries adopt new energy sources, from cleaner use of coal to hydrogen vehicles, to solar and wind power, to the production of clean-burning methane, to less-polluting power plants. And we continue to look for more opportunities to deepen our partnerships with developing nations, and will soon be launching our most ambitious partnership agreement yet, the Asia Pacific Partnership for Clean Development and Climate. The countries that make up this Partnership—Australia, China, India, Japan, South Korea, and the United States—account for about half of the world's population, economic output, energy use, and greenhouse gas emissions. The whole world benefits when developing nations have the best and latest energy technologies.

Question 3. When calculating whether the United States should ratify the Kyoto Protocol, did the Administration factor in the costs of increased droughts, wildfires, and flooding, as well as the corresponding crop and property losses?

Response. No. The Energy Information Agency, an independent statistical and analytical agency in the U.S. Department of Energy, conducted the most extensive analyses of the cost to the United States of meeting a Kyoto target in an October 1998 study entitled *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*.[1] That study analyzed impacts of the Protocol on U.S. energy use, prices, and the general economy in the 2008–2012 time frame, when the United States under the Kyoto Protocol was to reach an average level of net greenhouse gas emissions 7 percent lower than they were in 1990. It is not possible to link specific droughts, etc. to climate change, and thereby to estimate costs avoided from specific emissions reduction policies.

Question 4. If not, should these costs be calculated in any future decision of whether the United States should be involved in similar international protocols in the future?

Response. A cost-benefit analysis of any similar international protocol should take into account both the costs of meeting the requirements of the protocol as well as the value of the benefits that will be derived from the protocol—similar to a cost-benefit analysis that might be applied to any government program.

The standard criterion for deciding whether a government program can be justified on economic principles is *net present value*—the discounted monetized value of expected net benefits (*i.e.*, benefits minus costs). Net present value is computed by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. Programs with positive net present value increase social resources and are generally preferred. Programs with negative net present value should generally be avoided.

Question 5. During the question and answer period following your testimony, you stated that the President believes global climate change is an important issue and that human actions are contributing to an increase in greenhouse gas concentrations in the atmosphere. What steps is the Administration willing to take to convince the skeptics here in Congress that the problem is real and that mankind, including the United States, must take action to reduce greenhouse gas levels?

Response. President Bush has addressed the important issue of global climate change on many occasions—including, most recently in his November 16, 2005 speech in Kyoto, Japan, in his June 30, 2005 speech just prior to the G8 meeting in Gleneagles, Scotland, in his February 21, 2005 speech in Brussels and in two major climate change policy addresses on June 11, 2001 and February 14, 2002, when the President set a national goal of reducing the greenhouse gas intensity of the U.S. economy 18 percent 2012.

The U.S. budget devoted to climate change—more than $5 billion annually and by far the largest in the world—as well as the many actions we are taking both domestically and internationally, which were elaborated in my written testimony of October 5, 2005 to the Committee demonstrate our resolve.

[1] A copy of the complete study is available at http://www.eia.doe.gov/oiaf/kyoto/pdf/sroiaf9803.pdf.

Table 1

Summary of Federal Climate Change Expenditures

Programs and Tax Proposals Related to Climate Change
FY 2006 President's Budget

(Discretionary budget authority and tax proposals in millions of dollars)

	FY 2004 Actual	FY 2005 Enacted	FY 2006 Proposed	$ Change 2006-2005
Climate Change Science Program (CCSP)				
U.S. Global Change Research Program	1,803	1,700	1,711	11
Climate Change Research Initiative	173	217	181	-36
Subtotal – CCSP[1]	**1,976**	**1,918**	**1,892**	**-26**
Climate Change Technology Program (CCTP)				
Department of Agriculture	45	48	35	-13
Department of Commerce	28	30	7	-22
Department of Defense	51	75	60	-15
Department of Energy	2,390	2,505	2,506	1
Department of the Interior	1	2	2	0
Department of Transportation	5	1	2	1
Environmental Protection Agency	110	109	113	4
National Aeronautics and Space Administration	227	208	128	-80
National Science Foundation	11	11	11	1
Subtotal – CCTP[1]	**2,868**	**2,989**	**2,865**	**-124**
International Assistance				
U.S. Agency for International Development	195	189	162	-27
Department of State	5	6	11	5
Department of the Treasury[2]	52	45	25	-20
Subtotal – International Assistance[1]	**252**	**240**	**198**	**-42**
Energy Tax Incentive Proposals That Reduce Greenhouse Gases[3]	**0**	**83**	**524**	**441**
Total[1,4]	**5,090**	**5,223**	**5,473**	**250**

[1] Subtotals and table total may not add due to rounding. Subtotals and totals supersede numbers released with the President's 2006 Budget. Discrepancies resulted from rounding and improved estimates.

[2] The FY 2004 and FY 2005 enacted level for the Tropical Forestry Conservation Act (TFCA) is $20 million each year. In FY 2006, the Administration has requested a total of $99.8 million for debt restructuring programs to be available for: bilateral Heavily Indebted Poor Countries (HIPC) and poorest country debt reduction, contributions to the HIPC Trust Fund, and TFCA debt reduction. The Budget provides the Treasury Department flexibility in determining the amount for each program. The FY 2006 funding level for TFCA has not been determined yet.

[3] The cost of the four energy tax incentives related to climate change included in the President's FY 2006 Budget is $3.6 billion over five years (2006-2010).

[4] The International Assistance subtotal contains funds that are also counted in the Climate Change Science Program subtotal. Table total line excludes this double-count.

EEA Report No 5/2004

Greenhouse gas emission trends and projections in Europe 2004

Progress by the EU and its Member States towards achieving their Kyoto Protocol targets

European Environment Agency

Cover design: EEA
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Denmark
Tel. +45 33 36 71 00
Fax +45 33 36 71 99
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Key messages

Greenhouse gas emissions in the pre-2004 EU Member States (EU-15) in 2002 were 2.9 % below base-year level ([1]). This means the EU-15 was little more than a third of the way towards achieving the 8 % emissions reduction from base-year levels required by 2008–12 under the Kyoto Protocol ([2]). On the basis of their emissions in 2002 nine of the EU-15 (Austria, Belgium, Denmark, Finland, Greece, Ireland, Italy, Portugal and Spain) were not on track to meet their individual greenhouse gas limitation or reduction targets in 2010.

From 1990 to 2002 EU-15 greenhouse gas emissions decreased from most sectors (energy supply, industry, agriculture, waste management); however emissions from transport increased by nearly 22 % in the same period ([3]).

The latest projections for 2010 show that neither existing domestic policies and measures by Member States to reduce emissions, nor planned additional domestic policies and measures, will be sufficient for the EU-15 to reach its Kyoto target.

Existing domestic policies and measures will reduce total EU-15 greenhouse gas emissions by only 1.0 % from base-year levels by 2010. This projection has improved a little compared to last year's estimate due to positive updates of individual projections from seven Member States. Sweden and the United Kingdom project that existing domestic policies and measures will be sufficient to meet their burden-sharing targets and they may even over-deliver on their targets. The Netherlands project to meet the target with a combination of domestic policies and measures and emission allowances from the use of Kyoto mechanisms ([4]). If Sweden and the United Kingdom do no more than meet their agreed targets, the EU-15 reduction will be just 0.6 %.

When the additional domestic policies and measures being planned by Member States are taken into account, an EU-15 emissions reduction of 7.7 % is projected. However, this relies on several Member States cutting emissions by more than is required to meet their national targets, which cannot be taken for granted. If no over-delivery by these Member States is included, the EU-15 will achieve a 5.4 % reduction with additional policies and measures.

The use of Kyoto mechanisms, which are in a stage of implementation by Austria, Belgium, Denmark, Ireland, Luxembourg and the Netherlands, will reduce the gap between projected emissions with planned domestic policies and measures by 2010 and the EU-15 target by 1.1 % additionally. This would bring the total reduction to – 8.8 % and thus the Kyoto target for EU-15 would be achieved.

Six countries (Austria, Belgium, Denmark, Finland, the Netherlands and Sweden) have allocated financial resources for using the Kyoto mechanisms with a total amount of about EUR 1 300 million over the whole

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([1]) Base-year level of greenhouse gas emissions for EU-15 is calculated by using 1990 emissions for carbon dioxide, methane and nitrous oxide from all Member States and 1990 or 1995 emissions for fluorinated gases depending on which the Member State has chosen.

([2]) The pre-2004 EU-15 Member States are covered by the 'EU burden-sharing' agreement which lays down differentiated emission limits for each of these 15 Member States with the aim of ensuring that the EU-15 meets its overall 8 % reduction commitment under the Protocol. The commitment period 2008–2012 is referred to as the year 2010 in this report.

([3]) All data in this report on past and projected trends exclude emissions and removals from land-use change and forestry, unless explicitly mentioned.

([4]) Joint Implementation and Clean Development Mechanism according to the Kyoto Protocol, Art. 6 and Art. 12.

5-year Kyoto Protocol commitment period. The same countries and Spain have started to prepare legal and operational frameworks and bilateral agreements for using the Kyoto mechanisms.

Domestic policies and measures in EU-15 Member States that are projected to help most in achieving the targets include promotion of electricity from renewable energy, promotion of combined heat and power (CHP), improvements in energy performance of buildings and energy efficiency in large industrial installations, and promotion of the use of energy-efficient appliances. However, the EU renewable energy target (22 % of gross electricity consumption) and the indicative EU target for CHP (18 % share in total electricity production) for 2010 are unlikely to be met with current trends. Other key policies and measures include promotion of biofuels in transport and reducing the average carbon dioxide emissions of new passenger cars, recovery of gases from landfills and reduction of fluorinated gases. The adopted emissions trading directive is expected to create a market for carbon dioxide allowances from 2005 onwards and aims to ensure that emissions reductions can be made where it is most economically efficient.

Emissions have declined substantially in almost all new Member States. In 2002 emissions were 33 % below the base-year level, mainly due to the introduction of market economies and the consequent restructuring or closure of heavily polluting and energy-intensive industries. Greenhouse gas emissions from transport decreased by 12 % between 1990 and 1995 but increased afterwards and in 2002 exceeded 1990 levels by 9 %.

With existing domestic policies and measures, all new Member States, except Slovenia, were on track to meet their Kyoto targets on the basis of their emissions in 2002. Seven new Member States project to meet or even over-comply their Kyoto targets by 2010 with existing domestic policies and measures. However, in most countries emissions will increase between 2002 and 2010. Slovenia projects to meet its Kyoto target with additional policies and measures including CO_2 removals from land-use change and forestry.

1 Introduction

This report presents an assessment of the actual (1990 to 2002) and projected progress (by 2010) of the European Community (EC) and its Member States and of EEA countries ([5]) towards achieving their emission targets under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

The report also serves to support and complement the annual evaluation report of the European Commission to the Council and European Parliament, which is required under Council Decision 2004/280/EC concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

In this report, the assessment of whether Member States are on track to reach their targets is based mainly on an analysis of domestic policies and measures. The use by Member States of the flexible mechanisms of the Kyoto Protocol to fulfil their commitments is only included to a limited extent. Activities concerning land-use change and forestry ('carbon sinks') are not included, except where explicitly noted. This assessment contains information on 23 EU Member States, but is most detailed for the pre-2004 EU-15 Member States. These are covered by the 'EU burden-sharing agreement' which lays down differentiated emission limits for each of the 15 Member States with the aim of ensuring that the EU-15 meets its overall reduction commitment under the Protocol.

This year (2004) the report is published for the third time. The most recent information submitted by Member States up to April 2004 is included. Updates were available on emission inventories by all Member States and on emission projections and national programmes by nine of the EU-15 Member States and two of the new Member States. Detailed information on national greenhouse gas emission trends, projections, policies and measures and methodologies is presented in a separate EEA technical report.

([5]) This report covers 23 EU Member States and six additional EEA member countries, which include EU candidate countries (Bulgaria, Croatia and Romania) and Norway, Iceland and Liechtenstein. The report does not cover Cyprus and Turkey due to lack of data and because they do not have targets under the Kyoto Protocol. Also Malta does not have a target under the Kyoto Protocol, but the limited available data is presented.

2 The Kyoto Protocol targets

- The EU, its Member States, all candidate countries (except Turkey), and all additional EEA member countries, have ratified the Kyoto Protocol.
- The Kyoto Protocol will enter into force early 2005, because, due to Russia's recent ratification, the limit of a minimum of 55 % of carbon dioxide emissions of all these industrialised countries that have ratified, is now covered.

Combating climate change and minimising its potential consequences are key objectives of the UN Framework Convention on Climate Change (UNFCCC) and represent a high priority for the EU.

Achieving stabilisation of atmospheric greenhouse gas concentrations, avoiding dangerous interference with the climate system, is a key objective of the UNFCCC and the EU which would require substantial (50 to 70 %) reductions in global greenhouse gas emissions. As a first step, Parties to the UNFCCC in 1997 adopted the Kyoto Protocol. This requires developed countries, as a whole, to reduce their emissions of a basket of six greenhouse gases to 5.2 % below their levels in a given base-year (1990 in most cases) by the period 2008–12.

For EU-15 the Kyoto Protocol sets the target of an 8 % emissions reduction from the base-year level by the 2008–12 commitment period. Within this overall target, differentiated emission limitation or reduction targets have been agreed for each of the pre-2004 EU-15 Member States under an EU accord known as the 'burden-sharing agreement'.

The new Member States have different targets under the Kyoto Protocol. The Czech Republic, Estonia, Latvia, Lithuania, Slovakia and Slovenia have reduction targets of 8 % from the base-year, while Hungary and Poland have reduction targets of 6 %. Cyprus and Malta have no Kyoto target. The candidate countries Bulgaria, Croatia and Romania have reduction targets of 8 %. Turkey has ratified the UNFCCC, but not the Kyoto Protocol. The additional EEA member countries Norway and Iceland are allowed to increase emissions under the Kyoto Protocol, by 1 % and 10 % respectively, from their base-year emissions. Liechtenstein, with a target of – 8 %, has signed the Kyoto Protocol, but not ratified.

Figure 2.1 **Greenhouse gas emission targets of EU-15 Member States for 2008–12 relative to base-year emissions under the EU burden-sharing decision ([6])**

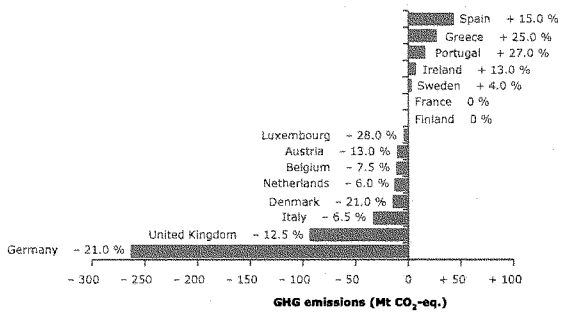
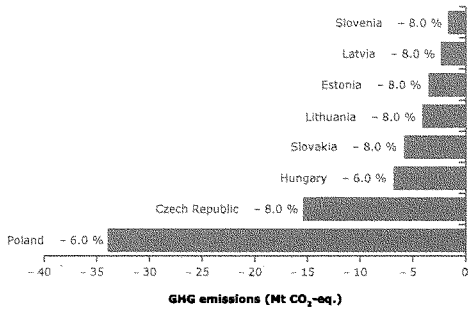


Figure 2.2 **Greenhouse gas emission targets of new EU Member States and acceding countries for 2008–12 relative to base-year emissions under the Kyoto Protocol**



Note: Countries with base-years other than 1990 are Hungary (average 1985–87) and Poland (1988). Cyprus and Malta have no targets and Turkey is a Party to UNFCCC, but not to the Kyoto Protocol.

([6]) In the Council decision (2002/358/EC) on the approval by the EU of the Kyoto Protocol the various commitments of the Member States are expressed as percentage changes from the base-year. In 2006 the respective emission levels will be expressed in terms of tonnes of CO_2-equivalent. In this connection, the Council of Environment Ministers and the Commission have, in a joint statement, agreed to take into account inter alia the assumptions in Denmark's statement to the Council Conclusions of 16–17 June 1998 relating to base-year emissions.

3 Greenhouse gas emissions in EU-23

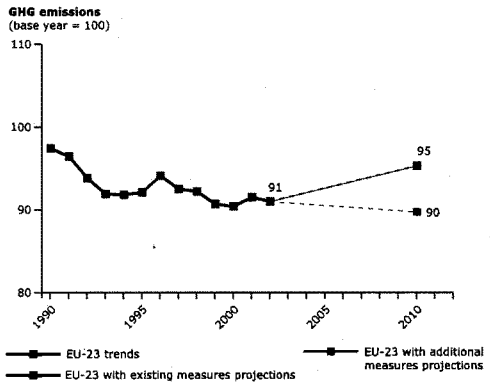
[illegible]

Total EU-23 greenhouse gas emissions declined in 2002 by 1 % compared to 2001 and were 7 % below 1990 levels and 9 % below the theoretical EU-23 base-year emissions (7). The new Member States share was 15 % of the total 2002 emissions (Figure 3.1).

By 2010, total EU-23 greenhouse gas emissions are projected to be about 5 % below the theoretical EU-23 base-year levels based on Member States' own estimates taking into account all existing domestic policies and measures. The projected decline is 10 % with additional domestic policies and measures. However, emissions are expected to increase between 2002 and 2010 with existing domestic policies and measures.

In the EU-15, greenhouse gas emissions per capita decreased by 6 % from 1990 to

Figure 3.1 Greenhouse gas emission trends and projections for EU-23

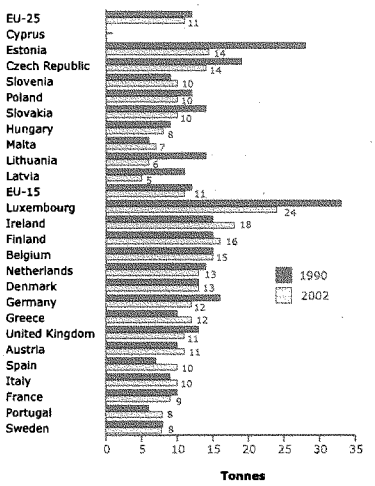


Note: Data exclude emissions and removals from land-use change and forestry. The figure refers to a theoretical EU-23 base-year as 100 in order to allow a consistent analysis of greenhouse gas emission trends and projections. This base-year for EU-23 has no legal status. Cyprus and Malta are not included due to lack of data and because they do not have targets under the Kyoto Protocol.

(7) The theoretical EU-23 base-year emission is calculated by adding base-year emissions of all EU-23 Member States included in this report for analytical purposes; it has no legal status.

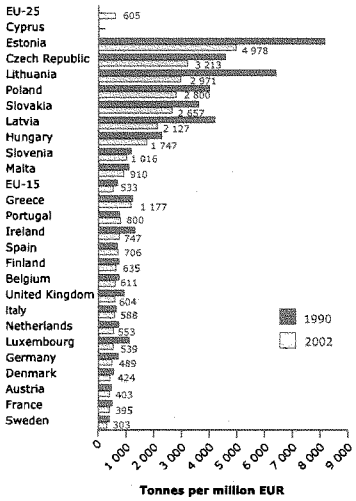
2002 largely due to decreases in Germany and the UK. The new EU Member States have lower per capita emissions on average than the EU-15 Member States. All of the new Member States, except Malta and Slovenia decreased per capita emissions substantially in the 1990s (Figure 3.2). In the EU-15, greenhouse gas emissions per GDP decreased by 23 % from 1990 to 2002. Despite substantial decreases between 1990 and 2002, per GDP emissions of the new EU Member States are well above the EU-15 average (Figure 3.3).

Figure 3.2 Greenhouse gas emissions per capita of EU-25 Member States for 1990–2002



Note: For Poland, the 2002 value refers to the latest available data (2001). Cyprus is not included due to lack of data.

Figure 3.3 Greenhouse gas emissions per GDP of EU-25 Member States for 1990–2002



Note: Due to lack of data, 1990 values refer to 1995 for Estonia, Hungary, Poland and Slovakia. For Poland, the 2002 value refers to the latest available data (2001). Cyprus is not included due to lack of data.

4 Progress of EU-15 Member States in limiting greenhouse gas emissions

EU-15 assessment

- In 2002, greenhouse gas emissions of the EU-15 were 2.9 % below the base-year level, taking the EU-15 little more than a third of the way towards its greenhouse gas emission target under the Kyoto Protocol of 8 % reduction.
- With existing domestic policies and measures, projections for 2010 show the EU-15 total greenhouse gas emissions decreasing only slightly by 1.0 % relative to the base year. This leaves a shortfall of 7.0 % in reaching the EU-15 target. The use of Kyoto mechanisms, currently foreseen by six countries, would reduce this shortfall by an additional 1.1 %.
- Savings from additional domestic policies and measures being planned by Member States would result in emission reductions of 1.7 %, almost sufficient to meet the EU-15 target, but this would rely on slow delivery by some Member States. Combined with the use of Kyoto mechanisms the reduction would be 4.4 %, enough to achieve the EU-15 target.

Member States assessment

- Emission trends until 2002 and projections for 2010 on the basis of existing domestic policies and measures indicate that two Member States (Sweden, United Kingdom) are on track to achieve their burden-sharing targets in 2010, while Germany was on track in 2002 and projects it will be close to its target with existing domestic policies and measures.
- France was also on track in 2002, and projects it will reach its target in 2010 using additional domestic policies and measures currently being planned.
- Finland, Greece and Ireland were not on track in 2002, but project that with additional domestic policies and measures they can meet their targets.
- Luxembourg and the Netherlands project achieving their targets by 2010 by a combination of domestic policies and measures and use of the Kyoto mechanisms.
- Austria and Belgium were not on track in 2002, but project achieving their targets by 2010 by a combination of additional domestic policies and measures and use of the Kyoto mechanisms.
- The other four Member States (Denmark, Italy, Portugal and Spain) were not on track in 2002 and do not project to reach their targets with a combination of additional domestic policies and measures and use of the Kyoto mechanisms.

In 2002, the aggregate greenhouse gas emissions of EU-15 Member States were 2.9 % below base-year level with a decrease by 0.5 % from 2001 to 2002 (Figure 4.1). This latter decrease was mainly due to a relatively warm winter and low economic growth. After the lapse of more than half of period between 1990 and the first commitment period (2008–2012) under the Kyoto Protocol, the reduction by 2002 is little more than a third of that needed to reach the EU-15 greenhouse gas emission target of an 8 % reduction.

Greenhouse gas emission reductions from domestic policies and measures up to 2002 were not sufficient for many EU-15 Member States to be on a path towards achieving their targets. Greenhouse gas emissions in 2002 of most Member States are well above their hypothetical target paths from their base-year emissions to their targets in 2010 ([8]) (Figure 4.2).

The emission reductions in the early 1990s were largely a result of increasing efficiency in power and heating plants, the economic restructuring in the five new federal states in Germany, the liberalisation of the energy market and subsequent changes in the choice of fuel used in electricity production from oil and coal to gas in the United Kingdom and significant reductions in nitrous oxide emissions in the chemical industry in France, Germany and the United Kingdom (see Section 8).

CO_2 emissions from electricity production has increased since 1999 in EU-15. Only Denmark, Germany, Ireland, the United Kingdom and Belgium increased their share of renewable energy sources in electricity production and therefore helped to limit the emission increase in that sector (see Section 8). Greenhouse gas emissions from transport have increased every year since 1990 in most Member States. However transport emissions decreased in 2001 and 2002 in Germany and the United Kingdom.

For 2010, the aggregate projections for EU-15 of greenhouse gas emissions based on existing domestic policies and measures show a small fall to 1.0 % below base-year levels (Figure 4.1). This means that most of the current emission reduction of 2.9 % achieved by 2002 from the base-year level is projected to be lost by 2010. This development leads to a shortfall of 7.0 %, assuming only existing domestic policies and measures, in meeting the EU-15 Kyoto commitment. Compared to last year's analysis, the gap between the target and the projection based on existing domestic policies and measures for the EU-15 has narrowed slightly due to positive updates of projections from seven Member States.

Only two Member States — Sweden and the United Kingdom — project that only existing domestic policies and measures will be sufficient to meet or even exceed their burden-sharing targets (Figure 4.3). Germany is close to its burden-sharing target while all others are projected to be significantly above their commitments with their existing domestic policies and measures.

Under the Kyoto Protocol, Member States can use flexible mechanisms (Kyoto mechanisms: Joint Implementation (JI) and Clean Development Mechanism (CDM)) to help meet their targets. Several countries have intentions to use these instruments, but only a few are in an advanced stage of implementing Kyoto mechanisms (see Section 5). Contributions from the use of Kyoto mechanisms by Austria, Belgium, Denmark, Ireland, Luxembourg and the Netherlands ([9]) reduce the gap between projected emissions by 2010 and the target

([8]) The evaluation of greenhouse gas emissions in this section is mainly based on domestic policies and measures. Several countries, including Austria, Belgium, Denmark, Ireland, Luxembourg and the Netherlands, have put in place measures and financial commitments to make use of the Kyoto mechanisms and thus project they will achieve their burden-sharing targets.

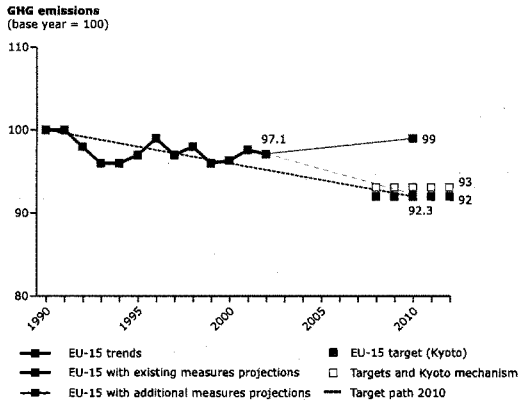
([9]) These Member States have reported substantiated information on their intended use of Kyoto mechanisms in their National allocation plans under the EU emission trading by end of October 2004.

by an additional 1.1 %. This would reduce the above mentioned shortfall of EU-15 greenhouse gas projections in 2010 of 7 % with only existing domestic policies and measures to 6 %, including use of Kyoto mechanisms. Combining planned policies and measures with the use of Kyoto mechanisms the reduction would be 8.8 %, enough to achieve the EU-15 target.

Luxembourg and the Netherlands project to achieve their targets with a combination of domestic policies and measures and emission allowances bought through the use of Kyoto mechanisms.

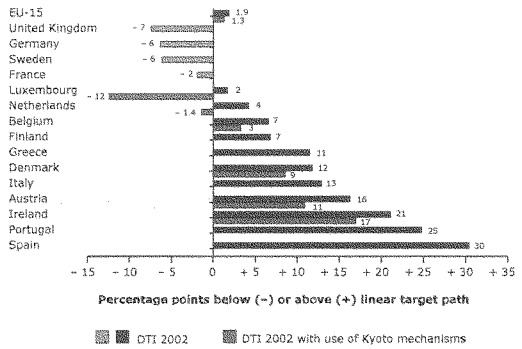
Additional domestic policies and measures planned by several Member States would almost close the gap to the EU-15 target, assuming over-delivery by several Member States (Finland, France, Greece, Ireland, Sweden and the United Kingdom) compared with their burden-sharing targets. This over-delivery cannot be taken for granted.

Figure 4.1 Actual and projected EU-15 greenhouse gas emissions compared with Kyoto target for 2008–12



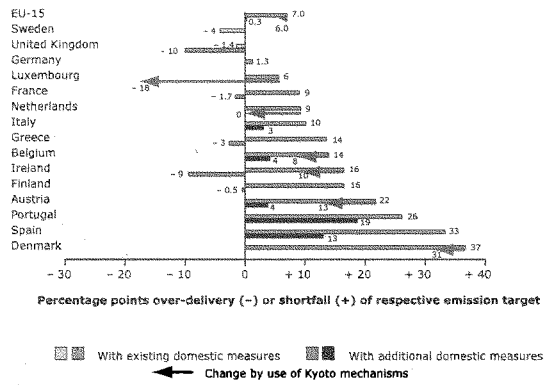
Note: The target path is used to analyse how close 2002 emissions were to a (hypothetical) linear path of emission reductions or allowed increases from the base-year to the Kyoto Protocol target, assuming domestic policies and measures are used. Data exclude emissions and removals from land-use change and forestry.

Figure 4.2 Distance-to-target (burden-sharing targets) for EU-15 Member States in 2002



Note: The distance-to-target indicator (DTI) measures the deviation of actual emissions in 2002 from a (hypothetical) linear path between base-year emissions and the burden-sharing target for 2010. A positive value suggests an under-achievement and a negative value an over-achievement by 2002. The DTI is used as an early indication of progress towards the Kyoto and Member States' burden-sharing targets. It assumes that the Member States meet their targets entirely on the basis of domestic policies and measures. Therefore, for those Member States in an advanced stage of implementing Kyoto mechanisms a second DTI estimate is presented, showing the additional effects of the use of these mechanisms in 2002.

Figure 4.3 Relative gap (over-delivery or shortfall) between greenhouse gas projections based on domestic policies and measures and 2010 targets and additional changes by the use of Kyoto mechanisms for EU-15 Member States



Note: All EU-15 Member States provided projections assuming existing domestic policies and measures. Several countries provided projections with additional domestic policies and measures. Only for those countries that provided quantitative information on their projected use of Kyoto mechanisms the effect of these mechanisms is presented (Austria, Belgium, Denmark, Ireland, Luxembourg and the Netherlands). For EU-15 the effect of use of Kyoto mechanisms is calculated based on information from these six countries. For more information see Section 5.

5 Use of Kyoto mechanisms

- The projected use of Kyoto mechanisms by Austria, Belgium, Denmark, Ireland, Luxembourg and the Netherlands to help achieve the EU-15 target amounts to 45.6 Mt CO_2 equiv. per year of the commitment period or about 1 % of the EU target of – 8 %.
- Six countries have allocated financial resources for using the Kyoto mechanisms (Austria, Belgium, Denmark, Finland, the Netherlands and Sweden) with a total amount of about EUR 1 300 million over the whole 5-year commitment period. The same countries and Spain have started to prepare legal and organisational frameworks and bilateral agreements for using the Kyoto mechanisms.

Twelve Member States — Austria, Belgium, Denmark, Finland, Ireland, Italy, the Netherlands, Portugal, Slovenia, Spain, Sweden and the United Kingdom — have provided information on their intended use of the flexible mechanisms of the Kyoto Protocol (Kyoto mechanisms: Joint Implementation (JI) and Clean Development Mechanism (CDM)) to achieve their targets for the commitment period 2008–12 ([10]). JI enables industrialised countries to work together to meet their emission targets by means of project activities. The CDM enables an industrialised country to meet its target, while project activities must be hosted by a developing country.

The information available is limited so far ([11]). Only Austria, Denmark and the Netherlands provided substantial amounts of information on the intended use of Kyoto mechanisms in their national allocation plans submitted to the European Commission under the EU Emission trading scheme. Belgium, Ireland and Luxembourg gave limited information to the European Commission to substantiate their indications on the amounts of their intended use of Kyoto mechanisms. Based on information from these six Member States the projected use of Kyoto mechanisms for achieving the burden-sharing target would amount to about 45.6 Mt CO_2-equiv. per year in the commitment period. This would represent about 13 % of the total EU-15 emission reduction required or almost one percentage point of the 8 % Kyoto target (Figure 4.3).

Sweden and the United Kingdom indicate that they will reach their burden-sharing targets without using the Kyoto mechanisms.

So far only Austria, Belgium, Denmark, Finland, the Netherlands and Sweden have allocated financial resources for the purchase of Kyoto units over the whole 5-year commitment period. The largest resources were as follows: Austria EUR 288 million, Belgium EUR 120 million, Denmark EUR 126 million and the Netherlands EUR 736 million. Finland allocated EUR 8.5 million and Sweden EUR 23 million. However, Finland and Sweden have not yet decided whether to use Kyoto mechanisms or not. The same six countries and Spain have started to implement legal and organisational arrangements or bilateral/multilateral agreements for JI/CDM programmes for the purchase of project based Kyoto units.

([10]) Kyoto Protocol Art. 6 and 12 in connection with Art. 3, para 10, 11, 12.

([11]) Information is taken from a questionnaire sent out in 2002 and 2003 under the greenhouse gas monitoring mechanisms (280/2004/EC), 3rd National communications under UNFCCC and National allocation plans of the EU Emission trading scheme (2003/87/EC). During the phase of Commission decisions on national allocation plans information on the intended use of Kyoto mechanisms is changing quite rapidly. The assessment in this report is as of 30 October 2004.

6 Progress of new Member States in limiting greenhouse gas emissions

- In 2002 total greenhouse gas emissions in the new Member States were about 11 % below the theoretical base-year level. Emission trends until 2002 and projections for 2010 on the base of existing domestic policies and measures show that all new Member States except Slovenia are on track in 2002 to meet their Kyoto targets. Slovenia projects to meet its Kyoto target with additional policies and measures and by including CO_2 removals from land-use change and forestry.
- Greenhouse gas emissions from transport decreased by 9 % between the base-year level and 1999 but increased afterwards and in 2002 exceeded base-year levels by 12 %.

All new Member States that joined the EU on 1 May 2004 have to reach their Kyoto targets individually (except Cyprus and Malta, who have no Kyoto targets). This section shows the overall aggregated trends in the (eight) new Member States with targets to facilitate comparison with the EU-15.

Since 1990 total emissions have declined substantially in almost all new Member States, mainly due to the introduction of market economies and the consequent restructuring or closure of heavily polluting and energy-intensive industries (Figure 6.1). Emissions of almost all new Member States were well below their linear target paths meaning that they were on track to meet their Kyoto targets (Figure 6.2).

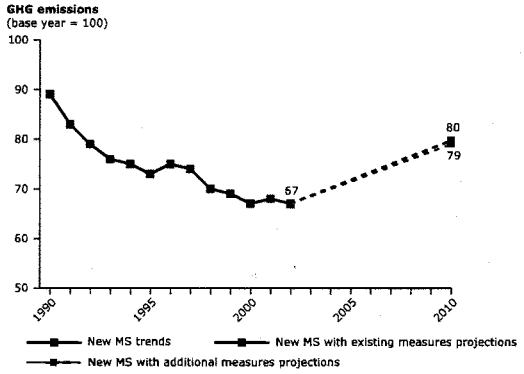
Emissions from transport increased in the second half of the 1990s, exceeded the 1990 level in 1999 and were increasing further in 2002. The new Member States seem to be repeating the experience of Greece, Ireland, Portugal and Spain in that, starting from relatively low transport levels, high economic growth leads to strong growth in transport and its greenhouse gas emissions.

Greenhouse gas emissions in seven new Member States are projected to meet or even over-comply with their Kyoto targets by 2010 with existing domestic policies and measures. Slovenia projects to meet its Kyoto target with additional policies and measures and by including carbon dioxide removals from land-use change and forestry (Figure 6.3).

Emissions aggregated from all new Member States are projected to increase after 2002 but will still in 2010 be 20 % below the base-year level. Only the Czech Republic, Estonia and Slovenia project decreasing emissions between 2002 and 2010. In Hungary and Poland greenhouse gas emissions for 2010 are projected to be significantly above 2002 emission levels (Figure 6.1).

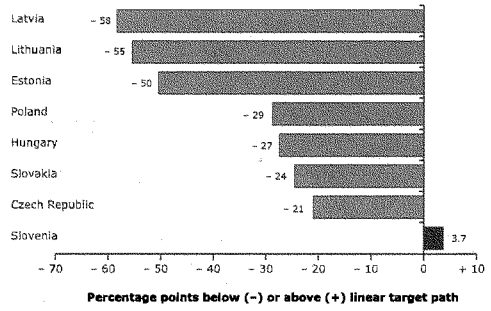
All countries have policies and measures in place to reduce greenhouse gas emissions and two countries have identified additional policies and measures.

Figure 6.1 **Actual and projected greenhouse gas emissions aggregated for new Member States**



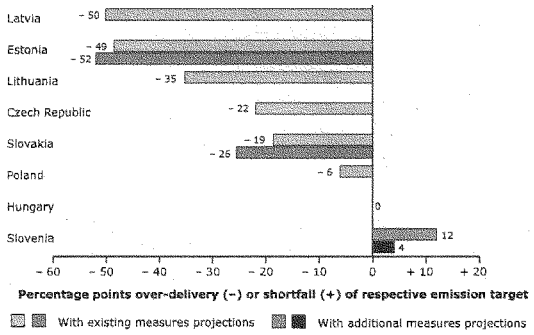
Note: Data exclude emissions and removals from land-use change and forestry. The figure refers to a theoretical 'aggregated new EU Member States base-year' as 100 in order to allow a consistent analysis of greenhouse gas emission trends and projections. This base-year has no legal status. Due to lack of data Cyprus and Malta are not included.

Figure 6.2 **Distance-to-target (Kyoto Protocol) for new Member States countries in 2002**



Note: The distance-to-target indicator (DTI) measures the deviation of actual emissions in 2002 from a (hypothetical) linear target path between 1990 and 2010. A positive value suggests an under-achievement by 2002 and a negative value an over-achievement in 2002. The DTI is used as an early indication of progress towards the Kyoto targets. It assumes that the countries meet their targets entirely on the basis of domestic policies and measures. Countries with base-years other than 1990 are Hungary (average 1985–87), Poland (1988) and Slovenia (1986). Due to lack of more recent data, for Poland the DTI refers to 2001.

Figure 6.3 Relative gap (over-delivery or shortfall) between projections and targets for 2010 for new Member States



Note: Projections for Poland include only the energy sector.

7 Progress of EU candidate countries and EEA countries in limiting greenhouse gas emissions

- All EU candidate countries and Iceland were on track, based on both their 2002 emissions and their projected 2010 emissions, to meet or even over-achieve their Kyoto targets.
- Liechtenstein and Norway project falling short of their Kyoto target with existing policies and measures. Information on possible additional measures was not available.

Analyses for Bulgaria, Croatia and Romania, candidates to join the EU, are presented in this section, as well as analyses for the countries Iceland, Liechtenstein and Norway, which are members of the European Environment Agency.

In 2002, greenhouse gas emissions of all candidate countries were well below their linear target paths meaning that they were on track to meet their Kyoto targets (Figure 7.1). Also Iceland was on track to achieve its emission limitation of + 10 % under the Kyoto Protocol. Liechtenstein and Norway fall short of their Kyoto targets of – 8 % and + 1 % according to their distance to target emissions indicator in 2002.

For 2010, projections taking into account domestic policies and measures show that Bulgaria, Romania and Iceland will over-achieve their Kyoto targets while Liechtenstein and Norway will fall short with existing domestic policies and measures (Figure 7.2).

Figure 7.1 Distance to target (Kyoto Protocol) for candidate and other EEA countries in 2002

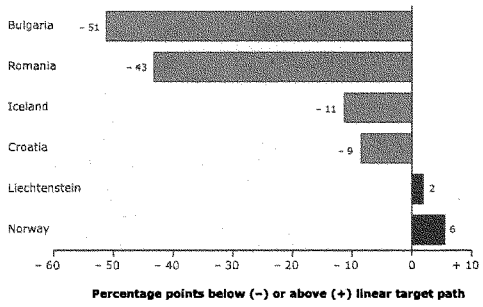
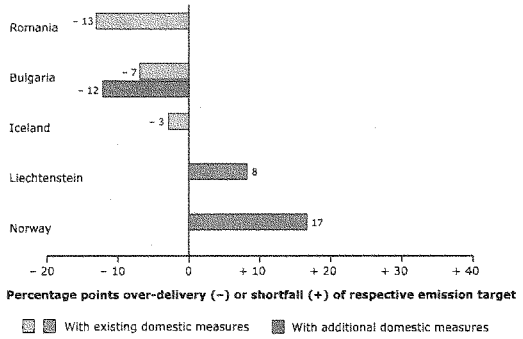


Figure 7.2 Relative gap (over-delivery or shortfall) between projections and targets for 2010 for candidate and other EEA countries



8 Effects of domestic policies and measures in the EU

Overview of policies and measures

The Commission has proposed additional common and coordinated policies and measures – some of which the EU has already adopted – which would result in additional emission reductions potentially sufficient to bridge the gap between projected emissions with existing domestic policies and measures and the EU target.

The European Commission has identified EU-wide common and coordinated policies and measures through the European Climate Change Programme (ECCP). The potential for greenhouse gas emission reduction of the ECCP as a whole has been estimated to be about 300 Mt CO_2-equivalents which is of a similar magnitude as the reduction needed to achieve the EU-15 Kyoto target. However, this early estimate is uncertain and the actual effects of policies and measures after their implementation must be evaluated.

A few policies and measures had already been adopted before the ECCP started. A second report on the progress of the ECCP was published in May 2003 and since then a number of the policies and measures have been adopted or are at an advanced stage of preparation. Several are also included in the Member States' reporting on policies and measures. In several Member States similar national policies and measures had already been in place and the EU-wide policies and measures enhance these. Furthermore many Member States have specific national policies and measures in place, which are not directly related to the EU-wide common and coordinated policies and measures. These national policies and measures are presented in detail in the separate EEA technical report on analysis of trends and projections.

Here a summary is provided of the most important common and coordinated policies and measures. All of them have been agreed already, but most of them will only start to deliver substantial emission reductions in future years.

Energy supply and use (energy industries, industry and households):

- EU CO_2 emissions trading scheme (Directive 203/87/EC, to start 1 January 2005);
- Directive linking the EU CO_2 emissions trading scheme with the Kyoto mechanisms (COM (2003) 403 final, agreed upon by Council and Parliament and to be adopted second half of 2004);
- Directive on the promotion of electricity from renewable energy sources (2001/77EC, adopted by Council and Parliament in 2001, to be transposed by Member States by October 2003);
- Directive on Combined Heat and Power to promote high efficiency cogeneration (2004/8/EC, adopted by Council and Parliament in February 2004, to be transposed by Member States by February 2006);
- Directive on the Energy Performance of Buildings (2002/91/EC, adopted by Council and Parliament January 2003, to be transposed by Member States by January 2006),
- Directive restructuring the Community framework for the taxation of energy products and electricity (2003/96/EC, adopted the Council October 2003, to be transposed by Member States by 2005).

Transport:

- Reduction in the average CO_2 emissions of new passenger cars (agreements between the Commission and car manufacturers in EU, Japan and Korea; 1998/1999);
- Directive on use of biofuels in transport (2003/30/EC, adopted by Council and Parliament May 2003, to be transposed by Member States by 2005).

Agriculture:

- Common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers (carbon credit for energy crops) (Regulation 1782/2003).

Waste management:

- Recovery of methane from biodegradable waste in landfills (Landfill directive 1999/31/EC, transposed by Member States July 2001).

Further proposals are currently under development targeting energy efficiency improvements, tax regulations, infrastructure use and charging in transport, and emissions reductions of certain fluorinated gases.

The emissions trading directive is expected to create a market for CO_2 allowances from 2005 onwards and to ensure that emissions reductions can be made where it is most economically efficient. The linking of the EU emissions trading scheme to the Kyoto mechanisms is aimed at reducing costs for those companies participating and promoting the transfer of environmentally sound technology to countries with economies in transition (e.g. Russia) and to developing countries.

Based on information from Member States key national policies and measures are in the areas of: renewable energy, combined heat and power (CHP), energy efficient appliances and building standards, implementing the EU-wide agreement on CO_2 emissions from passenger cars and the landfill directive. The largest emission savings for EU-15 are projected to be from renewable energy policies, followed by the landfill directive. All EU-15 Member States apply energy taxes, but the scope of them is still limited. A prominent example is the ecological tax reform in Germany, aiming at incentives for energy saving, energy efficiency and promotion of renewable energy sources.

Sectoral emission trends and projections

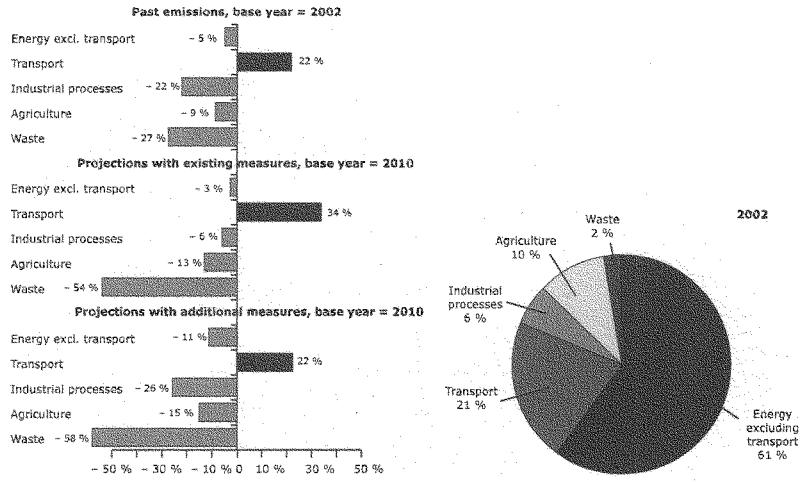
- From 1990 to 2002, EU-15 greenhouse gas emissions decreased in most sectors (waste management, industrial processes, agriculture, least in energy supply and use, excluding transport).
- EU-15 greenhouse gas emissions from transport increased by nearly 22 % in the same period and are projected to increase further by 34 % above 1990 levels by 2010 in the projection, with existing policies and measures.
- EU-15 greenhouse gas emissions from energy supply and use excluding transport were 5 % below 1990 levels in 2002, but are projected to increase again to 7 % above 1990 levels by 2010 in the projection, with existing policies and measures.
- With additional domestic policies and measures, EU-15 greenhouse gas emissions in most sectors are projected to decline further by 2010 compared to 2002 levels, except for transport emissions which are expected at least to be stabilised.

The common and coordinated policies and measures of the EU and domestic policies and measures implemented by Member States have influence on the past and projected greenhouse gas emissions. For EU-15 the emission shares and changes for the main sectors are presented in Figure 8.1.

The most important gases and main emission sources are:

- *energy supply and use excluding transport*: CO_2 from fossil fuel combustion in electricity and heat production, refineries, manufacturing industries, households and services;
- *transport*: CO_2 from fossil fuel combustion, but also N_2O from catalytic converters;
- *industrial processes*: CO_2 from cement production, N_2O from chemical industry, HFCs from replacing CFCs in cooling appliances and from production of thermal insulation foams;
- *agriculture*: CH_4 from enteric fermentation and manure management and N_2O from soils and manure management; and
- *waste management*: CH_4 from waste disposal sites.

Figure 8.1 Changes in EU-15 greenhouse gas emissions by sector between the base-year and 2002 and projected for 1990–2010 with existing and additional domestic policies and measures and contribution of sectors in 2002



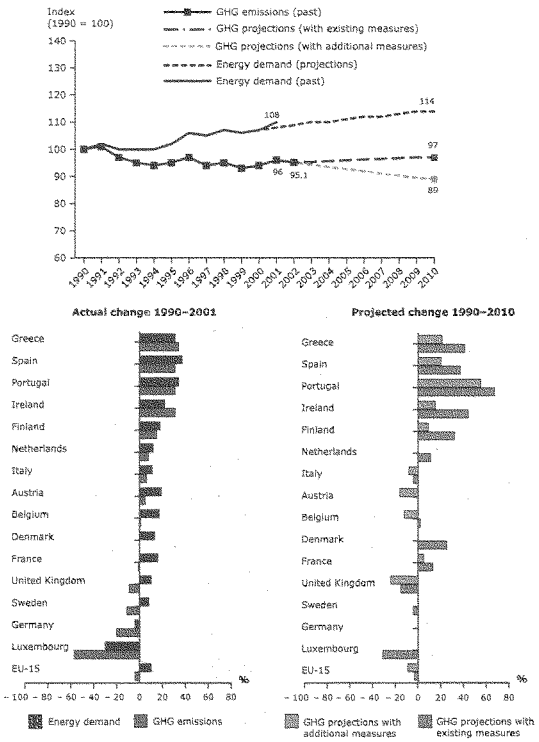
Energy supply and use excluding transport

- Between 1990 and 2002, CO_2 emissions from electricity and heat production increased by 3 % due to an increase in electricity production in thermal power plants by more than 20 %. In 2010, a further increase of electricity production up to 40 % is projected.
- Relatively small increases in CO_2 emissions compared to the large increases in electricity production show a decoupling in all Member States.
- Renewable energy targets for the EU-15 (22 % of gross electricity consumption) and Member States for 2010 are unlikely to be met on current trends. In order to meet the target large increases in renewable energy are therefore required.
- In the EU, the current rate of increase in combined heat and power (CHP) is not sufficient to achieve the indicative (previous) EU target of an 18 % share of CHP in total electricity production by 2010.
- CO_2 emissions from households increased by 1 % from 1990 to 2002, while the number of dwellings increased by 12 %, showing some decoupling. For 2010, the number of dwellings is projected to grow still further.

The main sectors covered by energy supply and use, excluding transport, are public electricity and heat production, refineries, manufacturing industries and households. The decline of greenhouse gas emissions in the early 1990s is primarily the result of reductions in Germany (efficiency improvements in electricity and heat production and restructuring of the industry) and the United Kingdom (fuel switch in electricity and heat production). In 2001 (the most recent year for which data on energy demand are available), greenhouse gas emissions decreased by 4 % relative to 1990 while energy demand increased by 8 % in the same period (Figure 8.2). The decrease of emissions between 2001 and 2002 by 0.9 % was mainly due to warm outdoor temperatures in the winter season. Almost all Member States decoupled greenhouse gas emissions from energy consumption at least to a certain extent; only in Ireland and Greece did emissions grow more rapidly than energy consumption.

For 2010 the decoupling of emissions from energy demand during the 1990s is projected to weaken. Emissions in EU-15 are projected to increase by 1 % while energy demand increases by 4 % compared to 2001 with existing domestic policies and measures. Denmark, Finland, Greece, Ireland, Luxembourg, Portugal and Spain project higher greenhouse emissions than in 2001.

Figure 8.2 EU-15 greenhouse gas emissions from energy supply and use (excluding transport) compared with energy demand



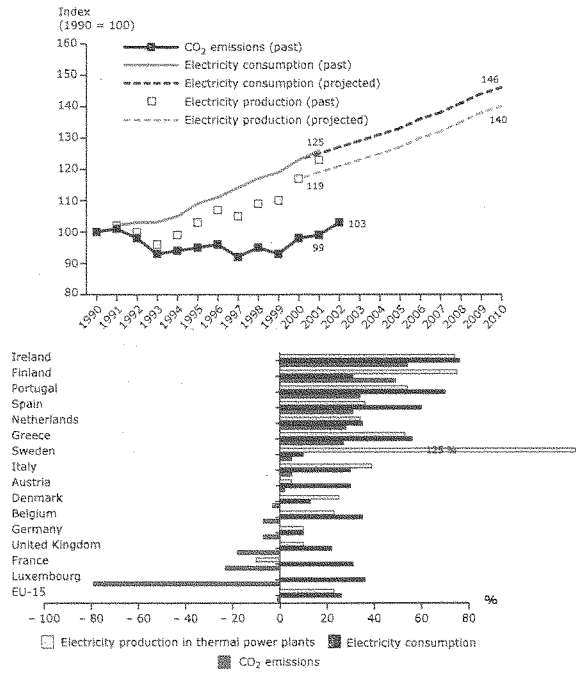
On the supply side *public electricity and heat production* is the most important source of greenhouse gas emissions, mainly CO_2. Increasing CO_2 emissions in recent years have more than offset an 8 % reduction achieved in the early 1990s and result in emissions 3 % above 1990 levels in 2002 (Figure 8.3). This trend is not projected to improve for 2010, as the electricity production in thermal power plants is projected to increase further.

The share of *renewable energy* (wind energy, solar energy, biomass and hydropower) in the EU's electricity consumption grew slightly from 13.4 % to 13.6 % between 1990 and 2002. In 2002, Austria and Sweden were by far the largest users of renewables for their national electricity production with shares of about 66 % and 47 %, respectively.

The EU-15 has experienced a drop in the share of electricity produced from renewables as the share in 2001 was 15.2 % compared to 13.6 % in 2002. This decrease is due to a reduction in generation from large hydropower resulting in the share of output declining from 11.3 % in 2001 to 9.0 % in 2002 for large hydropower, while the share of electricity generation from all other renewable energy sources increased. Only Belgium, Denmark, Germany, Ireland and the United Kingdom increased their share of total renewable energy sources in electricity production in 2002.

Increase in wind power (increasing by a factor of 46 in the EU during the period 1990–2002) was driven mostly by Denmark, Germany and Spain, with policies and measures including 'feed-in' arrangements

Figure 8.3 EU-15 CO_2 emissions from public electricity and heat production compared with electricity production in thermal power plants

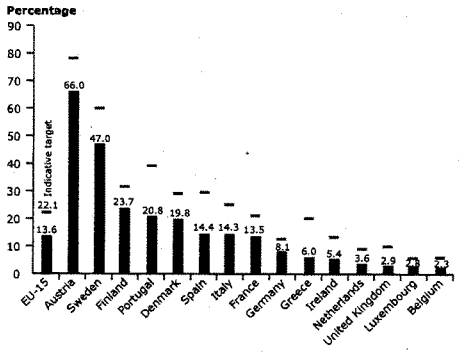


that guarantee a fixed favourable price for renewable electricity producers. Solar (photovoltaic) electricity increase was driven by Germany and Spain, mainly as a result of a combination of 'feed-in' arrangements and high subsidies. Biomass/waste resources have also expanded rapidly (almost 200 % increase between 1990 and 2002). The absolute change in electricity produced from biomass and waste was largest for Finland, Germany and the UK. In absolute values, the amount of electricity produced from wood/waste was highest in Finland, followed by Sweden. Both countries provided considerable research and development support and subsidies to the biomass power industry. In Sweden, the introduction of CO_2 and energy taxes from which biomass is exempt also helped the expansion of biomass power plants.

For 2010, the EU has proposed indicative targets for Member States and agreed to an overall indicative target of 22.1 % for the EU-15 for the contribution of renewable energy sources to gross electricity consumption (Figure 8.4). That target is unlikely to be met under current trends because renewable electricity was dominated by large hydropower (66 % share of output in 2002, compared to biomass/waste 13 % and wind power 10 %) and its capacity is not expected to increase substantially because of concerns about its impact on the environment through the loss of land and resulting destruction of natural habitats and ecosystems. In order to meet the target large increases in other renewables are therefore required.

Additional policies and measures to support the further expansion of the use of renewables include the EU Directive on the use of biofuels in transport. Austria, Finland, France, Greece, Ireland, Italy and Portugal have reported additional domestic policies and measures. Those which have been assessed quantitatively provide a reduction potential of almost 30 Mt CO_2-equiv., additional to the about 80 Mt CO_2-equiv. assessed for existing policies and measures. Germany has recently amended its Renewable energy act ([12]) in order to achieve its 12.5 % target for the share of renewables in electricity consumption under the EU indicative target mentioned above.

Figure 8.4 Targets for 2010 and share of electricity production met by renewable energy sources in 2002



Note: National indicative targets shown are reference values that Member States agreed to take into account when setting their indicative targets by October 2002, according to the EU renewable electricity directive.

([12]) Decision of Federal Council of Germany, 9 July 2004, http://www.bmu.de/de/1024/js/sachthemen/erneuerbar/eeg_nov/

New national goals for the increased use of renewables have been laid down at the international conference Renewables 2004 in Bonn. The main outcome of the conference is an action list of commitments made by governments, including fourteen EU Member States, to promote the use of renewable energy sources ([13]).

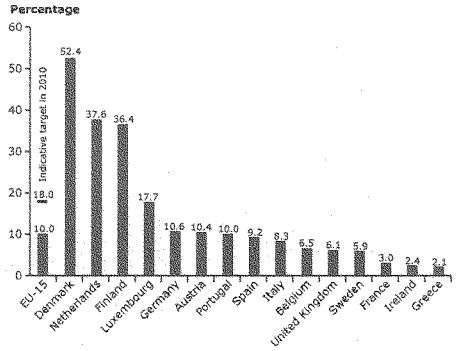
Combined heat and power (CHP) technology uses fossil fuels, biomass or waste to supply end-users with heat as well as electricity. CHP utilises over 85 % of the energy in the fuel rather than the average of about 35 to 45 % in current plants producing only electricity. In the EU-15, CHP increased its share in electricity production to about 10 % in 2000 (Figure 8.5). Tax incentives and subsidies stimulated investment in CHP. In recent years, however, many Member States have had problems with intensification of CHP use, in particular Germany, the Netherlands and the United Kingdom.

Rising natural gas prices, falling electricity prices and uncertainty over the evolution of the liberalisation of the electricity markets make companies reluctant to invest in CHP.

For 2010, the EU had set, before the adoption of the new CHP Directive, an indicative target of doubling electricity production from CHP from the 1994 level (from 9 % to 18 %). The current rate of increase is not sufficient to achieve this indicative EU target of 18 % by 2010. The new EU directive on CHP adopted in 2004 and the EU CO_2 Emission Trading Scheme, which will start working in 2005, will promote the use of CHP but have not set a target for the share of electricity from CHP.

Energy use in *manufacturing industries* consists of fossil fuel combustion for heat and electricity produced for own use. CO_2 emissions from fossil fuel combustion fell by 11 % between 1990 and 2002 towards a

Figure 8.5 EU-15 target for 2010 and share of gross electricity production met from combined heat and power production in 2000



Note: The data include combined heat and power production from public electricity and heat producers as well as from autoproducers (at specific industrial sites). Eurostat has adopted a new methodology to calculate the share of CHP in gross electricity production designed to better identify electricity production from combined heat and power. This revision has resulted in different (lower) figures for some countries. The 18 % indicative target for 2010 was set by the European Commission in 1997 on the basis of a previous methodology and may therefore not be directly comparable with the new methodology. The directive on CHP (2004) does not contain an indicative target.

([13]) International Conference for Renewable Energies — renewables 2004, Bonn, June 2004, http://www.renewables2004.de/

share of 14 % of total EU-15 greenhouse gas emissions. Emission reductions were already achieved in 1993, and were mainly due to efficiency improvements and structural change in Germany after reunification and the relatively small economic growth in the EU-15. Additionally a fuel shift from carbon intensive solid fuels to less carbon intensive gaseous fuels took place. Between 1990 and 2000, industrial output — the main driving force for emissions from the industry sector — in terms of gross value added increased by 13 % and is projected to increase further to 45 % above the 1990 level by 2010. Past developments show that all EU-15 Member States except Spain have decoupled their CO_2 emissions from manufacturing industries from gross value added.

CO_2 emissions from energy use in *households* accounted for 10 % of total EU-15 greenhouse gas emissions in 2002 and fluctuated mainly in line with outdoor temperature in the winter season. The 2002 emissions were 1 % above 1990 levels in 2002. The energy demand is mainly driven by the number and size of dwellings, the standard of the building stock and the appliances for heating and warm water production. Over the period 1990–2002 the number of households increased by 12 %. The decoupling of emissions from growth in households seen until 2000 results from energy efficiency improvements due to thermal insulation, fuel switching to natural gas and an increase in district heating using biomass. For 2010, the number of dwellings is projected to grow by 23 % relative to 1990 levels.

Transport

- Between 1990 and 2002, EU-15 greenhouse gas emissions from domestic transport (mainly road) increased by 22 %.
- EU carbon dioxide emissions from international aviation and navigation (not addressed under the Kyoto Protocol) made up 6 % of total emissions in 2002, and increased by 64 % from 1990 levels.
- EU-15 greenhouse gas emissions from domestic transport are projected to increase by 34 % from 1990 levels by 2010 even with existing domestic policies and measures (PM).
- Strong increases in freight transport by road occurred in the past and are projected to continue, if no additional policies and measures are taken.
- The average carbon dioxide emissions of new passenger cars were reduced by about 11 % from 1995 to 2002, but the significant decrease in previous years has stopped in 2002. In order to meet the EU target additional efforts are necessary.
- Past and projected increases in passenger transport by road will make it difficult to meet overall carbon dioxide emissions from passenger cars by 2010.

The transport sector gives rise to carbon dioxide emissions through fossil fuel combustion in road transportation, national civil aviation, railways, national navigation and other transportation. Transport caused the largest increase in greenhouse gas emissions between 1990 and 2002 (+ 22 %), with road transport being by far the biggest transport emission source (93 % share). Emissions increased continuously due to high growth in both passenger and freight transport by road (by 18 % and 40 %,

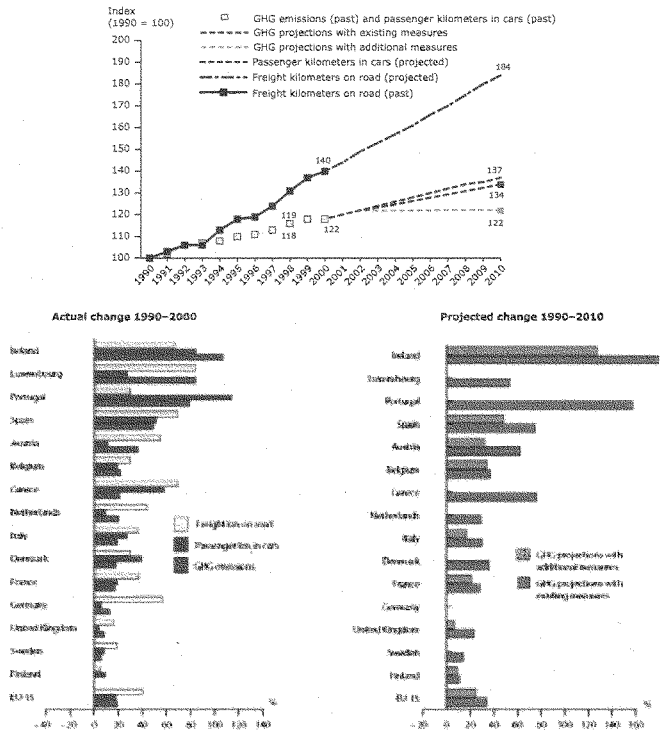
(14) EU-15 greenhouse gas emission projections from transport are calculated on basis of projections reported by 14 Member States. Sectoral emission projections are missing for Germany.

respectively, between 1990 and 2000) (Figure 8.6). Only Germany and the United Kingdom show decreasing emissions in recent years.

For 2010, the current emissions increase is projected to continue up to 37 % above 1990 levels with existing domestic policies and measures ([14]). Passenger and freight transport on road is then expected to be at 34 % and 84 %, respectively, compared to 1990. Additional policies and measures are projected to stabilise the growth of emissions at about 2002 levels.

Greenhouse gas emissions from transport are mainly carbon dioxide emissions accounting for 20 % of total EU emissions. Carbon dioxide emissions from international aviation and navigation are growing

Figure 8.6 EU greenhouse gas emissions from transport compared with transport volumes (passenger transport by car and freight transport by road)



Note: Greenhouse gas emission projections for EU-15 are calculated on the basis of projections reported by 14 Member States. Sectoral emission projections are missing for Germany.

([14]) EU-15 greenhouse gas emission projections from transport are calculated on basis of projections reported by 14 Member States. Sectoral emission projections are missing for Germany.

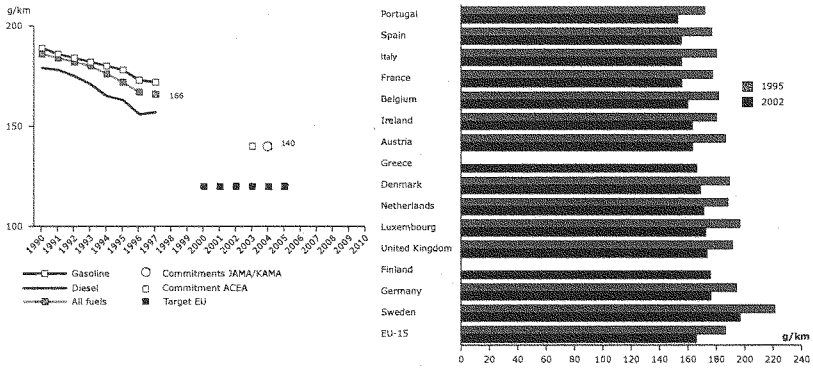
faster (a 44 % increase from 1990 to 2002 of emissions from international aviation), but these are currently not addressed in the Kyoto Protocol or in EU policies and measures.

Nitrous oxide emissions from transport account for only a small part of total EU greenhouse gas emissions but they increased after the introduction of catalytic converters for petrol-driven cars, which reduce emissions of air pollutants but also emit nitrous oxide as an unintended side effect. The introduction of catalytic converters has helped to improve air quality and the importance of the unintended side effect is diminishing as catalytic converters have improved in recent years.

All reporting Member States project growing transport emissions, indicating that existing policies and measures are not sufficient to decouple emissions from activity growth. Austria, Ireland, Italy, Spain and the United Kingdom expect that additional policies and measures will significantly reduce the projected growth in transport emissions.

Emissions from transport are projected to increase up to 2010 due to continued increases in both passenger and freight transport by road, despite policies and measures aimed at achieving the EU objective of shifting traffic from road to rail and inland waterways. A key EU policy is the agreement between the European Commission and the European, Japanese and Korean car industries to reduce average carbon dioxide emissions from new passenger cars, by setting a target for 2008 (European industries) and 2009 (Japanese and Korean industries). Carbon dioxide emissions were reduced between 1995 and 2001, but did not fall significantly in 2002 (Figure 8.7). The main reasons for the reductions since 1995 are fuel efficiency improvements, mainly in diesel, and a shift in fleet composition from petrol to diesel passenger cars, which are more energy efficient but emit more air pollutants than petrol-fuelled cars. In order to meet the EU's final target of 120 g CO_2/km, additional efforts are needed. Additionally, the continuous increase in passenger transport by road will make it difficult to limit its absolute emissions.

Figure 8.7 Average specific CO_2 emissions of new passenger cars per fuel type and targets



Note: Targets for the average carbon dioxide emissions of new passenger cars in 2008/2009 have been agreed between the European Commission and the European Automobile Manufacturers Association (ACEA) and similarly with Japanese (JAMA) and Korean (KAMA) automobile manufacturing industries.

Industry (non-energy related)

- Between 1990 and 2002 EU-15 nitrous oxide emissions from chemical industries decreased by 58 %.
- Between 1990 (base-year for fluorinated gases) and 2002, EU hydrofluorocarbon emissions, currently accounting for 1 % of total EU greenhouse gas emissions, increased by a factor of seven.
- EU-15 greenhouse gas emissions from industrial processes (carbon dioxide, nitrous oxide and fluorinated gases) were reduced by 22 % from 1990 to 2002, are projected to cut again by 6 % below 1990 levels with existing domestic policies and measures and could fall to 26 % below 1990 levels with additional domestic measures (15).

The trends in emissions in the 1990s show a reduction in carbon dioxide emissions from cement production due to lower economic activity and increased imports in the early 1990s, and in nitrous oxide emissions through emission reduction measures in the adipic acid production industry in France, Germany and the United Kingdom. Very large increases in emissions of hydrofluorocarbons occurred as they replaced chlorofluorocarbons, which have been and will continue to be phased out because of the damage they cause to the ozone layer. In 2002, total greenhouse gas emissions from industrial processes (carbon dioxide, nitrous oxide and fluorinated gases) were 22 % below 1990 levels.

For 2010, EU-15 emissions from industrial processes are projected with existing domestic policies and measures to achieve only a 6 % cut relative to 1990 levels (15). The significant abatement of nitrous oxide emissions in the manufacture of adipic acid in a few Member States is to a large extent offset by increases in emissions of fluorinated gases which are projected to almost double from the base-year to 2010, and expected increases in cement production of 11 %.

With additional domestic regulatory policies and measures, which a few Member States are planning, the actual decline of greenhouse gas emissions from industrial processes is projected to continue further to 26 % below 1990 levels (15).

Agriculture

- Between 1990 and 2002, EU-15 greenhouse gas emissions from agriculture fell by 9 %. Nitrous oxide emissions from agricultural soils fell by 8 % and methane emissions from enteric fermentation (from cattle) by 9 %.
- Based on existing domestic policies and measures, EU-15 greenhouse gas emissions from agriculture are projected to decrease to 13 % below the 1990 level in 2010 (16).

(15) EU-15 greenhouse gas emission projections from industrial processes are calculated on basis of projections reported by ten Member States. Sectoral emission projections are missing for Germany, Ireland, Luxembourg, the Netherlands and Spain.

(16) EU-15 greenhouse gas emission projections from agriculture are calculated on basis of projections reported by 12 Member States. Sectoral emission projections are missing for Germany, Luxembourg and Spain.

Between 1990 and 2002 nitrous oxide emissions from agricultural soils fell mainly because of a decrease in the use of nitrogen fertiliser and manure. This was a consequence of the reform of the EU's common agricultural policy (CAP) and the implementation of the nitrate directive, aimed at reducing water pollution. Methane emissions from enteric fermentation (by cattle) also fell, mainly due to a drop in the number of cattle, also a result of CAP reform.

For 2010, emissions from agriculture are projected to decrease further, mainly due to the continuing effect of the CAP reform and the EU nitrate directive.

Waste management

- Between 1990 and 2002, EU methane emissions from landfills fell by 27 %.
- EU greenhouse gas emissions from the waste sector are projected to be more than 50 % below 1990 levels in 2010 (with existing policies and measures) [17].

Since 1990 methane emissions from landfills have fallen. The decrease is mainly due to the (early) implementation of the landfill waste directive and similar national legislation intended to reduce the amount of untreated biodegradable waste disposed of in landfills and to ensure the installation of landfill gas recovery at all new sites.

EU greenhouse gas emissions from the waste sector are projected to decrease further up to 2010, mainly due to further implementation of the landfill directive.

(17) EU-15 greenhouse gas emission projections from waste management are calculated on basis of projections reported by eleven Member States. Sectoral emission projections are missing for Germany, Luxembourg, the Netherlands and Spain.

9 Use of carbon sinks

The projected use of carbon sinks for achieving the EU Kyoto target is at the relatively small, with an estimated removal by forestry and agricultural activities of 23 and 5 Mt CO_2 per year respectively or in total about 0.7 % in relation to the EU target of - 8 %.

In addition to policies and measures targeting at sources of greenhouse gas emissions (see Section 8), Member States can make use of CO_2 removals by land-use change and forestry activities (carbon sinks). Nine Member States have provided quantitative information on their intended use of carbon sinks to achieve their burden-sharing targets (Austria, Denmark, Ireland, Italy, the Netherlands, Portugal, Slovenia, Spain and the United Kingdom). This limited information shows for EU-15 that so far there are plans to remove, by 2008–2012, around 23 million tonnes CO_2 per year through forestry activities ([18]) and an additional almost 5 million tonnes CO_2 per year through agricultural activities ([19]). These removal estimates represent almost 8 % of the total EU-15 reduction required. This means that 0.7 % could be delivered by using carbon sinks to help closing the gap of 7.0 % between projected greenhouse gas emissions with existing domestic policies and measures and the EU-15-target (see Section 4). The European climate change programme estimates that potentially 93–103 million tonnes CO_2 could be sequestered through the enhancement of sink activities in the agricultural and forestry sectors.

([18]) Afforestation, reforestation and deforestation under Article 3.3 of the Kyoto Protocol.

([19]) Only forest management; no data available for other activities under Article 3.4 (cropland management, grazing land management and revegetation).

10 The reporting scheme

- Under the EU monitoring mechanism all Member States provided greenhouse gas inventory data for 1990 to 2002 for all gases. Three Member States have gaps for a few years or gases (Greece, Ireland, Luxembourg).
- Most new Member States provided greenhouse gas inventory data for 1990 to 2002. For many, gaps exist in reporting on fluorinated gases.
- The quality of emission projections and policies and measures has improved for those Member States that reported this information under the Monitoring Mechanism or through National Communications under UNFCCC.
- Further improvements in reporting of inventories, projections and policies and measures are still needed.

Reporting of greenhouse gas inventories has improved, but needs to be more complete and include all gases, especially for new Member States. Reporting on additional information required under the Kyoto Protocol, including information on emissions and removals from land-use change and forestry has taken a small step forward but is still only available for eleven Member States and in many cases not complete. The quality of reporting of emission projections and policies and measures has improved, but further improvements are needed regarding completeness, comparability, consistency and transparency. Information on the use of flexible mechanisms under the Kyoto Protocol was available in substantiated detail for six Member States. It is expected that use of the new implementing provisions, adopted under the EU monitoring mechanism by end of 2004, will help to improve the quality of reporting.

STATEMENT OF HON. JOHNNY ISAKSON, U.S. SENATOR FROM THE STATE OF GEORGIA

Thank you Mr. Chairman:

Thank you for holding this hearing. This is an opportunity for us to discuss the progress, if any, that has been made by the countries that have ratified Kyoto.

I have found that some are reconsidering their early ardent advocacy for the Kyoto Protocol. In fact, at this year's Association of South East Asian Nations regional summit, the Asia-Pacific Partnership on Clean Development and Climate was announced. It brings together Australia, China, India, Japan, South Korea and the United States, which together account for nearly half of the world's greenhouse gas emissions.

The partnership's vision statement speaks of:

- developing, deploying and transferring existing and emerging clean technology
- exploring technologies such as clean coal, nuclear power and carbon capture
- involving the private sector.

Missing, in stark contrast to the Kyoto Protocol, is any mention of mandatory reduction targets for greenhouse gas emissions. Although the statement says the partnership would not replace the Kyoto process, the implication at the July announcement was clear in my mind: here was an alternative model through which countries could combat climate change without risking the economic pain that is inflicted on them by the onerous Kyoto protocol.

Even just last month, British Prime Minister Tony Blair who has in the past supported the Kyoto concept, indicated a possible change of mind. To quote him: "Probably I'm changing my thinking about this in the past two or three years." He further went on to extol the importance of technology in curbing emissions.

I look forward to hearing from our witnesses their views on the international community's progress on Kyoto.

Thank you, Mr. Chairman.

STATEMENT OF LORD NIGEL LAWSON OF BLABY, HOUSE OF LORDS, UNITED KINGDOM

Ladies and Gentlemen of the Committee,

I am grateful for your invitation to testify before you today. I am aware that you have been provided with the Report of the House of Lords Select Committee on Economic Affairs on The Economics of Climate Change in advance of these proceedings, so I intend simply to summarise our key findings and to provide some commentary of my own.

By way of background, the Economic Affairs Committee is one of the four permanent investigative committees of the House of Lords, and fulfils one of the major roles of our second chamber as a forum of independent expertise and review of all UK government activity. It is composed of members of all three main political parties. Its climate change report, which was agreed unanimously, was published on 6 July 2005, just ahead of the G8 summit at Gleneagles in Scotland.

In summary, the Committee concluded that:

- The Government should give the UK Treasury a more extensive role, both in examining the costs and benefits of climate change policy and presenting them to the public, and also in the work of the Intergovernmental Panel on Climate Change (IPCC);
- There are concerns about the objectivity of the IPCC process, and the influence of political considerations in its findings;
- There are significant doubts about the IPCC's scenarios, in particular the high emissions scenarios, and the Government should press it to change its approach;
- Positive aspects of global warming have been played down in the IPCC reports: the IPCC needs to reflect in a more balanced way the costs and benefits of climate change;
- The Government should press the IPCC for better estimates of the monetary costs of global warming damage and for explicit monetary comparisons between the costs of measures to control warming and their benefits;
- A more balanced approach to the relative merits of adaptation and mitigation is needed, with far more attention paid to adaptation measures;
- UK energy and climate change policy appears to be based on dubious assumptions about the roles of renewable energy and energy efficiency, and the costs to the UK of achieving its objectives have been poorly documented, and the Government, with much stronger Treasury involvement, should review and substantiate the cost estimates involved and convey them in transparent form to the public;

• Current UK nuclear power capacity should be retained;

• International negotiations on climate change reduction will prove ineffective because of the preoccupation with setting emissions targets. The Kyoto Protocol makes little difference to rates of warming, and has a naive compliance mechanism which can only deter countries from signing up to subsequent tighter emissions targets. Any future Protocols might be more fruitfully based on agreements on technology and its diffusion.

I cannot of course speak for the Committee as a whole, but my own understanding of the issue is clear:

• The IPCC's consistent refusal to entertain any dissent, however well researched, which challenges its assumptions, is profoundly unscientific;

• Although its now famous "hockey stick" chart of temperatures over the last millennium, which inter alia featured prominently in the UK Government's 2003 Energy White Paper, is almost certainly a myth, the IPCC refuses to entertain any challenge to it;

• The IPCC's scenarios exercise, which incidentally incorporates a demonstrably fallacious method of inter-country economic comparisons, manifests a persistent upward bias in the likely amount of carbon dioxide emissions over the next hundred years. For example, a combination of steadily increasing energy efficiency and the growth of the less energy-intensive service economy has led to a steadily declining rate of growth of carbon dioxide emissions over the past 40 years: all the IPCC's scenarios unaccountably assume an abrupt reversal of this established trend.

So why is the IPCC so adamant that it will not revisit its conclusions?

It may be that they are so profoundly concerned about the perils of global warming that the darkest possible picture is painted in order to secure urgent action.

There may also be the inevitable institutional characteristic of making the problem more serious than it is in order to command greater attention. This too may be a consequence of the way research funding is administered—it is a cold, isolated world for the climate change contrarian in the modern scientific community.

Whichever reason—and I suspect it may be both—the IPCC's absolutist position is unhelpful. The world faces a number of other, and arguably more imminent, challenges and competing claims on resources: the threats from nuclear proliferation and international terrorism, and the need for humanitarian aid for the world's poorest, are obvious examples. Choices always have to be made, and they need to be based on rational assessment.

So far as climate change is concerned, I am not qualified to pronounce on the science. While it seems clear to me, as a layman, that—other things being equal—increasing carbon dioxide emissions will, in time, warm the planet, I note that the science of climate change is uncertain and that reputable scientists hold greatly differing views about the rate at which such warming is likely to occur—which in any case is not simply a matter of the science: it depends just as much on the likely rate of future economic growth and the pattern and nature of that growth.

The key question, which is not a matter for scientists at all, is what should be done about such global warming as may occur.

• There are two possible approaches, which are not of course mutually exclusive: mitigation, that is, seeking to stabilize and if possible reduce the amount of carbon dioxide in the atmosphere, and adaptation, that is to accept that the climate may well be warming, and to take action to counter any harmful consequences that may flow from this.

• The IPCC and its acolytes make only the most perfunctory acknowledgment of adaptation. Their estimates of the damage from global warming are based on the assumption that very little adaptation occurs, and focus almost exclusively on the need for mitigation. In my view, however, the most important conclusion of the House of Lords report is that adaptation needs to take centre stage.

• Numerous studies have shown that adaptation is the more cost-effective option, which is hardly surprising. Not only is that the way in which we normally come to terms with climatic vagaries, but there are benefits as well as costs from global warming. There are, of course, regional variations: in northern Europe, for example, including Britain, for the rest of this century the benefits are likely to exceed the costs, whereas for the tropics the reverse is the case. But adaptation, which implies pocketing the benefits while acting to diminish the costs, has obvious attractions.

• The four principal costs potentially involved in global warming are damage to agriculture and food production, water shortage, coastal flooding (as sea levels rise), and—allegedly—malaria:

  • In the case of agriculture, adaptation, much of which will occur autonomously, that is, without the need for government action, would consist of cultivating

areas which have hitherto been too cold to be economic and, in other cases, switching to crops better suited to warmer climates.

• In the case of water shortage, there is massive wastage of water at the present time, and ample scope for water conservation measures which incidentally would also help on the farming front.

• The most serious likely cost is that caused by coastal flooding of low-lying areas, where government action is clearly required, in the form of the construction of effective sea defences—as the Dutch, incidentally, put in place more than 500 years ago. With modern technology this becomes an admittedly expensive but nonetheless highly cost-effective option.

• Finally, as to malaria—which leading malaria experts, whom the IPCC was careful to exclude from its deliberations, argue is in any event unrelated to temperature, noting that the disease was endemic in Europe until the 17th century—the means of combating if not eradicating this scourge are well established.

• By contrast, the Kyoto and emissions caps and targets approach seems a most unattractive option:

• Even if the existing Kyoto targets were attained they would make little if any difference to the predicted rate of global warming. Kyoto's importance is presented as a first step to other, stiffer future agreements. But this is pie in the sky.

• The developing countries, including major contributors to future carbon dioxide emissions such as China and India are—and are determined to remain—outside the process.

• Since the only sanction against non-compliance with Kyoto (which is likely to be widespread) is even stricter targets in any successor agreement, the realism of this approach is even harder to detect.

• In addition, even if targets were achievable, the cost of reaching them would be horrendous. Essentially, it would work by raising the cost of carbon-based energy to the point where carbon-free energy sources, and other carbon saving measures, become economic. For Kyoto-style mitigation to be seriously effective, it would involve a substantially greater rise in energy prices than anything we have yet seen despite recent spikes.

• The real cost of this approach is not so much dearer energy as the reduced rate of world economic growth which this would imply. It is far from self evident, not least for the developing countries, that over the next hundred years a poorer but cooler world is to be preferred to a richer but warmer one. Nor should it be overlooked that the Kyoto strategy requires the present and next generation to sacrifice their living standards in order to benefit more distant generations who are projected in any event to be considerably better off.

• Mitigation can however, be a desirable complement to adaptation. Far better than the Kyoto approach is additional support for research into reduced carbon technologies of all kinds, thus bringing forward the time when at least some of these technologies may become economic. A nation which performs relatively well in terms of cutting back emissions is bound to lose out competitively whereas a nation which achieves a technological breakthrough is likely to benefit competitively.

In conclusion, I believe that the IPCC process is so flawed, and the institution, it has to be said, so closed to reason, that it would be far better to thank it for the work it has done, close it down, and transfer all future international collaboration on the issue of climate change, where the economic dimension is clearly of the first importance, to the established Bretton Woods institutions.

It is profoundly important that all governments, most importantly their Treasury departments, make their own independent and rigorous economic analysis of the issue. At the time the Lords committee was taking evidence this, for whatever reason, had not happened in the UK. I very much hope that, following our report, it will.

We appear to have entered a new age of unreason, which threatens to be as economically harmful as it is profoundly disquieting. It must not be allowed to prevail.

RESPONSES BY LORD NIGEL LAWSON TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. To make clear for the record, did you appear before the Committee to testify on behalf of the British government? If not, in what capacity did you appear?

Response. I no more testified on behalf of the British government than Senator Jeffords represented the United States administration. I appeared before the Committee because I was invited to do so, and it would have been discourteous to have declined. As I made clear in my opening statement at the hearing on 5 October, I did so in my capacity as a member of the House of Lords Select Committee on Economic Affairs, which published its Report on The Economics of Climate Change on 5 July. This is an all-party committee, and its Report was unanimous. The Committee's members bring to bear a wide range of experience and expertise; and, as I told your Committee on 5 July, my own includes a decade as a senior British government Minister, from 1979 to 1989—to be precise, as Financial Secretary to the Treasury 1979–1981, Energy Secretary 1981–1983, and Chancellor of the Exchequer (equivalent to your Treasury Secretary) 1983–1989.

Question 2. You are critical of the Intergovernmental Panel on Climate Change for not looking at how nations might work together to prepare for adaptation and mitigation of the inevitability of climate change. What steps are you recommending the IPCC take?

Response. Chapter 9 of the House of Lords Committee's report, which I submitted as a background document to my own written testimony, contains its unanimously agreed conclusions and recommendations. Those which concern the IPCC may be found in particular in paragraphs 145, 154, 158, 159, 161, 162, 168, 169, 170, and 174. In my opinion these are the minimum steps the IPCC needs to take; and, if it does not do so, it would—as I submitted in my written testimony to your committee—"be far better to thank it for the work it has done, close it down, and transfer all future international collaboration on the issue of climate change, where the economic dimension is clearly of the first importance, to the established Bretton Woods institution".

Question 3. The House of Lords July Report says that it is "far better that government sets the goal and the price signals to achieve that goal, leaving the market to select the technologies and their rate of diffusion through the economy." Isn't that what the Kyoto Protocol sets out to do? Does not the cap and trade program move those participating countries in that direction? If not, what other policy would be effective at sending a clear signal to the private sector?

Response. The House of Lords Report's criticism of governments selecting which technologies to back was explicitly aimed at the UK's approach in its White Paper on energy policy of picking winners—basically wind power and energy efficiency. That is quite different from a possible international agreement on the development of low-carbon technologies and their diffusion, which would be based on supporting those low carbon technologies the energy industry was prepared to back with its own money in the light of market criteria. I set out the severe drawbacks of the Kyoto/cap and trade approach in my written testimony, and it would be otiose to repeat them here.

Question 4. Developed nations have benefited the most from the burning of fossil fuels but the low-lying areas likely to be flooded as a result of climate change are likely to be poor communities and the developing world. You advocate construction as an effective defense. Who should bear the costs of this construction and why?

Response. The cost should be borne partly by the developing countries themselves (whose GDP per head of population by the end of this century will, according to the IPCC's scenarios, be higher than that of the developed world today) and partly by the developed nations, through earmarking a significant proportion of their overseas aid budgets to this specific purpose. The relative size of these two components should vary according to the specific circumstances of each developing country concerned.

Question 5. You refer to numerous studies showing adaptation is a more cost-effective option. Are these peer-reviewed studies? Will you provide copies of these studies for the record?

Response. I would refer the Committee to the substantial paper by Dr. Indur Goklany, entitled *"A Climate Policy for the Short and Medium Term: Stabilization or Adaptation"*, published in the journal *Energy & Environment*, volume 16, no 3 & 4, 2005.

POSITION PAPER, PIECE ON CLIMATE CHANGE FOR PROSPECT,
BY LORD NIGEL LAWSON

Nothing could better illustrate the intellectual bankruptcy of what might be termed the climate change establishment than Dr. Michael Grubb's September *Pros-*

pect essay "Stick to the Target". He is clearly outraged by the fact that, in July, the House of Lords Select Committee on Economic Affairs published a report, "The Economics of Climate Change", which had the temerity to express considerable scepticism about both the reliability of the IPCC process—the Intergovernmental Panel on Climate Change, set up under the auspices of the United Nations to inform and advise governments on what is clearly a global issue—and the desirability of the Kyoto/emissions targets approach to tackling the problem.

Although a member of that Committee, whose report was agreed unanimously (those who are interested in it would do better to read it than rely on Dr. Grubb's travesty), I cannot speak for the Committee as a whole. But my own understanding of the issue is clear.

The IPCC story, which appears to have been swallowed hook, line and sinker by most governments, not least our own, is essentially as follows. Over the past millennium, from 1000 AD, the world's mean temperature scarcely changed at all until around 1860, when direct records first began. Since then it has risen (not steadily, in fact: there was a period of cooling between 1945 and 1965) by an unprecedented 0.6 degrees centigrade. This can only be due to the simultaneous growth in the amount of carbon dioxide in the atmosphere as a result of industrialisation, which warms the planet by the so-called greenhouse effect. Unless something is done about it, this warming is set to continue, and probably to accelerate, as world economic growth continues apace, and with it carbon dioxide emissions. On this basis, a range of possible scenarios can be produced, showing further increases in world temperature ranging from 1.7 degrees to 6.1 degrees by the end of the present century, with dire consequences on a number of fronts. The only solution is to cut back on carbon dioxide emissions as much and as soon as possible, and the best way to do this is by the Kyoto process of internationally agreed emissions targets.

While there is little doubt that carbon dioxide emissions, other things being equal, do warm the atmosphere—although reputable climate scientists differ over how much they warm it—every other aspect of the IPCC story is seriously flawed.

First, the history. The "hockey-stick" chart of temperatures over the past millennium (so-called because the constant temperature over the long period up to 1860 resembles the straight handle and the subsequent rise the curved blade), which featured prominently in the Government's 2003 energy white paper, is almost certainly a myth. There is, for example, ample evidence of a warm period—warmer than today—in the middle ages and of a very cold period around 1800. Historical treeline studies—showing how far up mountains trees are able to grow at different times, which is clearly correlated with climate change—confirm this variation. This would not matter very much, merely indicating that the climate fluctuates all the time and that the present warming phase is by no means without precedent, were it not for the IPCC's consistent refusal to entertain any dissent, however well-reseached, over the issue since it first published the "hockey-stick" chart in 2001—a profoundly unscientific attitude which is all too characteristic of that body.

Next, the scenarios. It is of course hard, to say the least, to form a view of the likely rate of world economic growth over the next hundred years; but it is striking that all the IPCC scenarios—which incidentally are based on a demonstrably fallacious method of inter-country economic comparisons—incorporate a heart-warmingly rapid rate of growth in the developing world, so that by the end of the century income per head in the developing world is well above what it is in the rich world today. This may happen—I hope it does—but it is clear that the IPCC scenarios do not capture the true range of realistically possible outcomes.

This upward bias is further compounded by the translation from economic growth to growth in carbon dioxide emissions. The recent historical record shows a steady decline in this rate of growth, from 2.3 percent a year over the past 40 years, to 1.6 percent a year over the past 30 years, to 1.3 percent a year over the past 20 years, to 1.2 percent a year over the past 10 years. This should not be surprising. In the first place, economic progress is a story of increasing efficiency in the use of all factors of production. In the case of labour this is customarily referred to as growth in productivity, but precisely the same applies to land and energy. Secondly, the pattern of world economic growth has been changing, with services, which are less energy-intensive, growing faster than manufacturing, which is more so.

What is surprising, however, is the IPCC's assumption, without offering any evidence, that this trend will now be reversed. Its six scenarios for the 21st century are based on an annual rate of growth in carbon dioxide emissions ranging from 1.4 percent a year (appreciably greater, rather than less, than in the recent past) to 2.3 percent a year (almost double the rate of the recent past). Once again, although the future is inevitably uncertain, it is clear that the IPCC scenarios do not capture the true range of plausible futures. And of course this upward bias feeds directly into an upward bias in projected climate change.

There are two possible reasons why this should be so, and why the IPCC is so adamant that it will not revisit its assumptions; and they are not incompatible: both may be true. The first is that those involved in the exercise are so profoundly concerned about the perils of global warming, and the risk of governments deferring the action they believe is needed, that the scarier the outlook they can produce the better. The second is a characteristic of any institution looking into any problem: the more serious the problem can be made to appear, the more important the institution and its personnel become and the more attention they can command.

But however understandable, this is not helpful in a world of limited resources where there are many other problems jostling for attention and the devotion of additional resources: to take just two examples, dealing with the more imminent dangers posed by Islamic terrorism and by nuclear proliferation—and by the possible interaction between them. Humanitarian aid to the world's poorest is another obvious candidate for more resources.

At the margin, choices have to be made, and it is essential they are made on the basis of the most rational assessments we can achieve.

Which brings us to the question of what is to be done about such global warming as is likely to occur. There are two possible approaches, which are not of course mutually exclusive: mitigation, that is, seeking to stabilize and if possible reduce the amount of carbon dioxide in the atmosphere, and adaptation, that is to accept that the climate may well be warming, and to take action to counter any harmful consequences that may flow from this. The IPCC and its acolytes make only the most perfunctory acknowledgment of adaptation, base their estimates of the damage from global warming on the assumption that very little adaptation occurs, and focus almost exclusively on the need for mitigation. By contrast, perhaps the most important conclusion of the House of Lords report (a conclusion not even addressed by Dr. Grubb in his Prospect attack) is that adaptation needs to take centre stage.

Numerous studies have shown that adaptation is the more cost-effective option, which is hardly surprising. Not only is that the way in which we normally come to terms with climatic vagaries, but (a fact which the IPCC does its best to play down) there are benefits as well as costs from global warming. There are, of course, regional variations: in northern Europe, for example, including Britain, for the rest of this century the benefits are likely to exceed the costs, whereas for the tropics the reverse is the case. But adaptation, which implies pocketing the benefits while acting to diminish the costs, has obvious attractions.

The four principal costs potentially involved in global warming are damage to agriculture and food production, water shortage, coastal flooding (as sea levels rise), and—allegedly—malaria. In the case of agriculture, adaptation, much of which will occur autonomously, that is, without the need for government action, would consist of cultivating areas which have hitherto been too cold to be economic and, in other cases, switching to crops better suited to warmer climates. In the case of water shortage, there is massive wastage of water at the present time, and ample scope for water conservation measures—which incidentally would also help on the farming front.

The most serious likely cost is that caused by coastal flooding of low-lying areas, where government action is clearly required, in the form of the construction of effective sea defences—as the Dutch, incidentally, put in place more than 500 years ago. With modem technology this becomes an admittedly expensive but nonetheless highly cost-effective option. Finally, as to malaria—which leading malaria experts, whom the IPCC was careful to exclude from its deliberations, argue is in any event unrelated to temperature, noting that the disease was endemic in Europe until the 17th century—the means of combating if not eradicating this scourge are well established.

By contrast, the Kyoto/emissions targets approach seems a most unattractive option. Even Dr. Grubb admitted, in his evidence to the House of Lords committee, that even if the existing Kyoto targets were attained they would make little if any difference to the rate of global warming: Kyoto's importance for him was as a first step to other, stiffer, such agreements. But this is pie in the sky. The developing countries, including major contributors to future carbon dioxide emissions such as China and India are—and are determined to remain—outside the process, while the United States, the biggest emitter of all, has declined to ratify the treaty. Moreover, since the only sanction against non-compliance with Kyoto (which is likely to be widespread) is even stricter targets in any successor agreement, the realism of this approach is even harder to detect.

This is no bad thing, since the cost of going the emissions targets route, if it were effective, would be horrendous. Essentially, it would work by raising the cost of carbon-based energy to the point where carbon-free energy sources, and other carbon saving measures, become economic. Given that only last month the present Chan-

cellor of the Exchequer told the annual TUC Conference that the recent rise in oil prices was a global problem requiring a global solution, and called on the oil-producing nations to reduce their prices, there seems to be some lack of coherence in the Government's approach. For Kyoto-style mitigation, to be seriously effective, involves a substantially greater rise in energy prices than anything we have yet seen—although the Government's energy white paper was curiously silent about this.

But the real cost of this approach is not so much dearer energy as the reduced rate of world economic growth which this would imply. It is far from self evident, not least for the developing countries, that over the next hundred years a poorer but cooler world is to be preferred to a richer but warmer one. Nor should be overlooked that the Kyoto strategy requires the present and next generation to sacrifice their living standards in order to benefit more distant generations who are projected in any event to be considerably better off.

To the extent that mitigation is a desirable complement to adaptation, far better than the Kyoto approach is additional support for research into reduced carbon technologies of all kinds, thus bringing forward the time when at least some of these technologies may become economic. At least this goes with the grain. Whereas a nation which performs relatively well in terms of cutting back emissions is bound to lose out competitively, a nation which achieves a technological breakthrough is likely to benefit competitively.

The IPCC process is so flawed, and the institution, it has to be said, so closed to reason, that it would be far better to thank it for the work it has done, close it down, and transfer all future international collaboration on the issue of climate change, where the economic dimension is clearly of the first importance, to the established Bretton Woods institutions. Meanwhile, whether this happens or not, it is imperative that in this country the Treasury becomes fully involved in all this. In my time as Chancellor, it would have been unthinkable, on a matter as important as climate change, for the Treasury not to have made its own independent and rigorous economic analysis of the issue. At the time the Lords committee was taking evidence this, for whatever reason, had not happened. I very much hope that, following our report, it will.

But the IPCC's apparent determination to suppress or ignore dissenting views and reasoned criticism, which has become little short of a scandal, is part of a wider problem.

It is, I suspect, no accident that it is in Europe that climate change absolutism has found the most fertile soil. In part this no doubt reflects the widespread European distaste for President Bush—the great Kyoto non-signer—and all he stands for. But much more fundamental, I believe, is the fact that it is Europe that has become the most secular society in the world, where the traditional religions have the weakest popular hold. Yet people still feel the need for the comfort and higher values that the transcendent certainties of religion can provide; and it is what might be termed the quasi-religion of greenery in general and the climate change issue in particular which has filled the vacuum, with reasoned questioning of its mantras regarded as a form of blasphemy.

We have recently seen a further example of this in the widespread assumption that the Mexican gulf coast hurricanes, Katrina and Rita, are a consequence of global warming—a punishment, it is implied, for our heedless materialism and disregard of the planet. One wonders, in that case, what caused the region's worst recorded hurricane, which devastated Galveston in 1900. In fact, the balance of scientific opinion is that there is no convincing evidence that the further climate change which is feared might occur over the coming decades will lead to an increased incidence and severity of hurricanes, let alone the modest degree of warming that we have seen so far.

In primitive societies it was customary for extreme weather events to be explained as punishment from the gods for the sins of the people. Little, it seems, has changed.

As Dick Taverne has pointed out, we appear to have entered a new age of unreason, which threatens to be as economically harmful as it is profoundly disquieting. It must not be allowed to prevail.

HOUSE OF LORDS

Select Committee on Economic Affairs

2nd Report of Session 2005-06

The Economics of Climate Change

Volume I: Report

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Contact Details

All correspondence should be addressed to the Clerk of the Economic Affairs Committee.
Committee Office, House of Lords, London SW1A 0PW
The telephone number for general inquiries is 020 7219 6968
The Committee's email address is economicaffairs@parliament.uk

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NOTE:

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ABSTRACT

The Committee, having considered various aspects of the economics of climate change, calls on the Government to give HM Treasury a more extensive role, both in examining the costs and benefits of climate change policy and presenting them to the United Kingdom public, and in the work of the Intergovernmental Panel on Climate Change (IPCC).

We have some concerns about the objectivity of the IPCC process, with some of its emissions scenarios and summary documentation apparently influenced by political considerations.

There are significant doubts about some aspects of the IPCC's emissions scenario exercise, in particular, the high emissions scenarios. The Government should press the IPCC to change their approach.

There are some positive aspects to global warming and these appear to have been played down in the IPCC reports; the Government should press the IPCC to reflect in a more balanced way the costs and benefits of climate change.

The Government should press the IPCC for better estimates of the monetary costs of global warming damage and for explicit monetary comparisons between the costs of measures to control warming and their benefits.

Since warming will continue, regardless of action now, due to the lengthy time lags in climate systems, and since there is a risk that international negotiations will not secure large-scale and effective mitigation action, a more balanced approach to the relative merits of adaptation and mitigation is needed, with far more attention paid to adaptation measures.

We are concerned that UK energy and climate policy appears to be based on dubious assumptions about the roles of renewable energy and energy efficiency and that the costs to the UK of achieving its objectives have been poorly documented. We look to the Government, with much stronger Treasury involvement, to review and substantiate the cost estimates and to convey them in transparent form to the public.

We think that current nuclear power capacity, before further decommissioning occurs, should be retained.

We urge the Government to replace the present Climate Change Levy with a carbon tax as soon as possible.

We are concerned that the international negotiations on climate change reduction will be ineffective because of the preoccupation with setting emissions targets. The Kyoto Protocol makes little difference to rates of warming, and has a naïve compliance mechanism which can only deter countries from signing up to subsequent tighter emissions targets. We urge the Government to take a lead in exploring alternative "architectures" for future Protocols, based perhaps on agreements on technology and its diffusion.

The Economics of Climate Change

CHAPTER 1: INTRODUCTION

1. Sir David King, the Government's Chief Scientific Adviser, has stated that "climate change is the most severe problem that we are facing today—more serious even than the threat of terrorism"[1]. Much of the debate about global warming—its reality, causes and the urgency of finding solutions—has been driven by the science of climate change. Despite a huge literature on the economic implications of warming, the costs of tackling it, and the role of economic policy instruments in the control of greenhouse gas emissions, economic arguments have not been to the fore in the public presentations on the issue. Many people may, therefore, be ignorant of key issues highlighted by an economic perspective—for example: the close linkages between world economic performance, the man-made forces influencing climate change, and the role of technological change in reducing greenhouse gas emissions; the considerable time lags between taking action and the effects of those actions; the costs that must be borne now for benefits that will not accrue to this generation; and the cost in terms of opportunities forgone by spending resources on climate change control rather than on, for example, addressing issues of global poverty now.

2. The economics is important. Indeed, the Chancellor of the Exchequer has declared that "climate change is an issue for finance and economic ministries as much as for energy and environmental ones"[2]. **We welcome this recognition of the central role of economics. It is the driving force behind our inquiry. But we believe that the Chancellor needs to broaden the scope of the Government's interests, and the Treasury's interests in particular, in aspects of the climate change debate that we feel have not yet been given sufficient emphasis.** Both the science and the economics of climate change are explored in the publications of the Intergovernmental Panel on Climate Change (IPCC). **We are concerned that the links between projected economic change in the world economy and climate change have not been as rigorously explored as they should have been by the IPCC. We believe the complex interactions between world economic growth and climate change need additional scrutiny at the international level, and that the United Kingdom Government has a role to play in ensuring that this happens. We are also concerned that clearer messages should be conveyed to the public about the likely costs and benefits of climate change control, who will bear those costs and benefits, and when.** Since the science of human-induced warming remains uncertain, the issue is how to behave in the face of that uncertainty. Uncertainty does not dictate doing nothing: none of the concerns we raise constitutes a reason for not tackling climate change. Rather, uncertainty dictates caution and the taking

[1] Sir David King, Climate change science: Adapt, mitigate, or ignore? *Science*. 303. 176-7, 2004.

[2] Speech by The Rt Hon Gordon Brown, Energy and Environment Ministerial Roundtable, 15 March 2005.

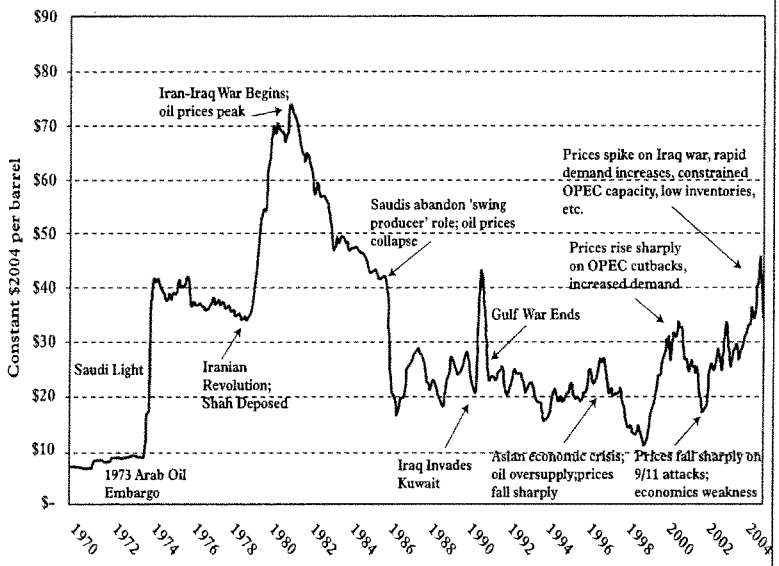
out of insurance against the worst risks. But, like insurance against any other risk, insurance costs money. It is important that the costs of such precaution are better understood, and the risk-cost trade-offs are better appreciated.

3. We believe there is an educative role to be played by a more frank and open discussion of the economic issues involved in tackling climate change, and that the public deserves to be better informed about them. We do not believe, for example, that many people are aware that the international efforts made so far—The Framework Convention on Climate Change (1992) and its first Protocol, the Kyoto Protocol (negotiated in 1997 and brought into force in 2005)—will make little difference to future rates of warming, even if implemented in full. It must be emphasised that these international agreements will have to be supplemented with far more telling initiatives if climate change is to be tackled in any significant way. Ultimately, a public that is not adequately informed may react adversely to the discovery that more and more cost burdens will fall on them, and on their children, in the name of warming control. The fuel protests of 1999-2000 are testimony to the sensitivity of the public to even modestly rising energy prices. Substantial increases in energy prices must be an integral part of any policy for reducing carbon emissions. Box 1 shows the time-profile of oil prices from 1970 to the present day. In real terms, oil prices today are about half of their peak price in 1981 at the time of the Iran-Iraq war. In nominal terms, prices are about the same. To encourage reductions in carbon emissions, real prices need to rise further, and by significant amounts. **We are not convinced that there is sufficient public awareness of this issue. Any public misperception on these issues could threaten the political feasibility of getting plans of action put into effect. If climate change is as serious as most scientists claim, and as the Government accepts, then it is important to convey the complementary message that the action to tackle it will also have to be serious and potentially life-changing. It is better to be honest now than to shield the public from the economic realities inherent in the more pessimistic forecasts.**

BOX 1

The path of oil prices 1970 to the present

The chart shows the evolution of real oil prices (i.e. oil prices with inflation netted out) expressed in constant 2005 US dollars. While nominal prices (inclusive of inflation) are about the same today as they were at the peak of oil prices in 1981, the real price is about one-half. If there is to be a major reduction in carbon emissions, energy prices, as typified by the price of oil, will have to rise significantly in real terms.



Source: US Department of Energy

4. The Committee decided to restrict the scope of its investigation to certain aspects of the economics of climate change. We have done so because we are aware that the subject is potentially very wide-ranging. In addition, other Parliamentary committees have also investigated some of the issues[3]. The Committee decided to focus on (a) the way in which scenarios of the future changes in the world economy affect the projections of warming; (b) issues relating to the costs and benefits of tackling climate change; and (c) the profile of economics in the governmental and inter-governmental processes relating to climate change science and control. We have not systematically investigated the important issues of choosing policy instruments for tackling climate change—the role of carbon and energy taxes, the EU emissions trading scheme and other measures. Nonetheless, our inquiry strayed into these areas and we have some comments to make.

[3] For example, the House of Commons Environmental Audit Committee has looked at the international agreements and the role of the UK in international negotiations: *The International Challenge of Climate Change: UK Leadership in the G8 and EU.* (2004-05, HC 105). See also House of Lords European Union Committee: *The EU and Climate Change.* (2003-04, HL 179).

BOX 2

The greenhouse gases

The main greenhouse gases are carbon dioxide (CO_2) which is emitted by the use of fossil fuels and by the burning of forests; methane (CH_4) which comes from decaying degradable matter, e.g. in landfill sites, and from livestock; nitrous oxides (N_2O) from fertilisers, industrial processes, and fossil fuel burning; and a group of other gases, such as perfluoromethane (CF_4) and perfluoroethane (C_2F_6) used in aluminium production, and sulphur hexafluoride (SF_6) from dielectric fluids. Other gases, such as carbon monoxide (CO) and nitrogen oxides (NO_X), have indirect effects on greenhouse warming through various chemical reactions.

The power of the main greenhouse gases to "force" temperature rises varies substantially. The conventional way of expressing these forcings is the "Global Warming Potential" (GWP). The GWP for carbon dioxide is set equal to 1. Then the other forcings are as follows:

Carbon dioxide	= 1
Methane	= 23
Nitrous oxide	= 296
Hydroflurocarbons	= 12 to 12000 depending on the gas
Perfluorocarbons	= 5000 to 12000
Sulphur hexafluoride	= 22200

However, CO_2 remains the most important gas because of the quantities in which it is emitted.

7. It is not this natural greenhouse effect that gives rise to concern. It is the fact that the relatively short period in the world's history since the Industrial Revolution has seen significant increases in the emissions of the greenhouse gases, especially carbon dioxide and methane. These greenhouse gases add to the concentrations already in the atmosphere. Moreover, they accumulate and stay in the atmosphere for decades (their "atmospheric residence time"). While they get generally mixed in the atmosphere, it is common in pictorial terms to show these increased concentrations as a "blanket" that traps the outgoing long-wave radiation and returns it to Earth. It is this accelerated or enhanced greenhouse effect that causes the concern, since the effect is to warm the Earth's surface even more than the level achieved naturally. In effect, what is happening is that the greenhouse gases are upsetting the natural energy balance in such a way that "something has to give" to restore the balance, and it is surface warming that is bringing about the adjustment.

CHAPTER 2: THE UNCERTAIN SCIENCE OF CLIMATE CHANGE

The greenhouse effect

5. Our dominant concern is with certain aspects of the economics of climate change, but clearly, any investigation must begin with the underlying science.

6. The Earth's surface is warmed by the sun. This incoming solar radiation is fairly constant—it does not vary with time. The Earth's temperature is controlled by the balancing between this incoming short-wave radiation, which warms the Earth, and the loss of this energy as it is bounced back into space. The re-radiated energy cools the Earth. Energy-out balances energy-in, and the Earth maintains a constant global temperature. Without this balance, the Earth would become steadily hotter and life would cease. Of the incoming solar radiation, roughly 30% bounces back into space from clouds, atmospheric aerosols and bright, reflective areas of the Earth's surface, such as deserts. That leaves 70% of the incoming radiation to be absorbed, mostly by land areas and the oceans. But even this 70% cannot stay permanently absorbed, otherwise the Earth would again continually warm up and life would not be possible. It is re-emitted primarily as long-wave, infra-red radiation back into space. But some of this re-radiated energy is absorbed by water vapour and by "greenhouse gases" which exist in the atmosphere. The principal greenhouse gas is carbon dioxide, but the principal absorbing agent is overwhelmingly water vapour. The effect of this absorption of the re-radiated energy is to produce another round of re-radiation, this time back to the Earth's surface, where it is absorbed once again. This is the "greenhouse effect". This re-absorption process is natural: it is what maintains the Earth's average temperature at +15°C rather than at levels below freezing[4].

[4] The effect is actually to warm the Earth by around 35°C, i.e. to +15°C rather than the approximate -20°C that would otherwise prevail.

8. Evidence from Antarctic ice cores suggests that atmospheric concentrations of CO_2 were fairly constant over 1000 years until the Industrial Revolution[5]. In the year 1000 (measured by ice core samples), concentrations were 280 ppm (parts per million), and the concentrations were the same around 1800, whereas today they are some 375 ppm. Currently, concentrations are growing at some 1.5 ppm every year, as recorded by the Mauna Loa observatory in Hawaii, which has been monitoring concentrations since 1959. A similar picture, but with more variability over time, emerges for N_2O, at around 270 ppb (parts per billion) between 1000 and 1700, rising to 310 ppb in 2000. Methane, CH_4, is also fairly constant between 1000 and 1750 at 750 ppb, rising to over 1600 ppb in 2000[6]. Longer historical records from ice cores also suggest that carbon dioxide and methane concentrations are now at their highest levels for the past 400,000 years[7].

Negative forcing

9. Not all greenhouse gases—gases that contribute in some way to the enhanced greenhouse effect—create "positive forcing", i.e. warm the atmosphere[8]. Some have a cooling effect. Aerosols—tiny particles of liquid or dust in the atmosphere, such as soot, volcanic ash and dust—give rise to cooling effects. Clouds can have a cooling effect as well, reflecting radiation back into space. The level of understanding of the behaviour of clouds and aerosols is unfortunately far less than the level of understanding for the main warming greenhouse gases. An important cooling aerosol is sulphate which comes from sulphur dioxide (when mixed with oxygen), which in turn comes from sulphur-bearing fossil fuels such as coal. These sulphate aerosols reflect sunlight and hence produce a cooling or "dimming" effect. In the rich world, substantial controls exist over sulphur emissions because of damage caused by local air pollution and transboundary acid rain. As a result, sulphur emissions are declining. But in the poorer world, there are still considerable pressures to burn fuels such as coal and lignite, and sulphur emissions are rising. The scenarios of future warming therefore depend in part on what happens to this balance of sulphur emissions.

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[5] Sir John Houghton, *Global Warming: the Complete Briefing*. Cambridge University Press. 3rd Edition. 2005, p32. Ice cores can also be used to construct temperature and CO_2 records going back over 400,000 years (and, most recently, cores have been extracted that go back 900,000 years). As snow fell, the air in the snow became trapped in the ice that subsequently formed, so that greenhouse gas concentrations in the trapped air bubbles can be measured. This gives the CO_2 record for the whole period. Examination of the oxygen and hydrogen isotopes in the ice core also permits temperature readings. The two time-series—temperature and CO_2—appear to show a very close correlation, suggesting that the two are closely linked. Ice ages had low levels of CO_2 (about 210 ppm) and warm periods had high levels of CO_2 (around 270 ppm). See J. Petit et al. Climate and atmospheric history in the past 420,000 years from the Vostok ice core in Antarctica. *Nature*, 399, June 3, 429-436, 1999. While correlation is not causation, and there remains some dispute over the nature of the linkage, there is also evidence that CO_2 concentrations "lead" temperature rather than the other way round. See M. Maslin, *Global Warming: A Very Short Introduction*. Oxford University Press, 2004, p.60.

[6] R. Watson et al., op.cit. p.47.

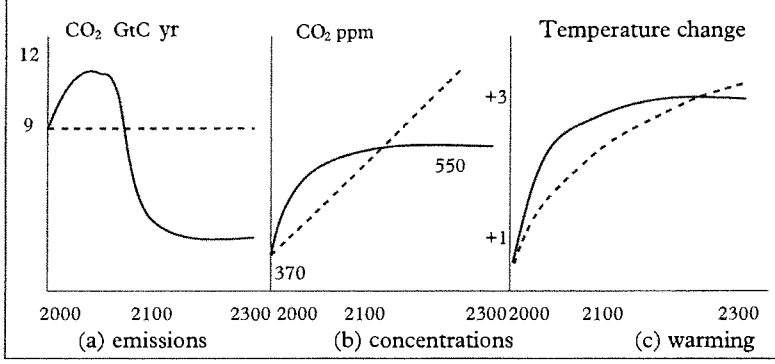
[7] J. Weier, *Global Warming*, Earth Observatory, NASA, Washington DC. 8 April 2002.

[8] "Radiative forcing" refers to the amount of energy trapped by the atmosphere and is measured in watts per metre squared (Wm^{-2}).

BOX 3

The basic linkages in climate change

Emissions of greenhouse gases (GHGs) cumulate in the atmosphere because the rate at which they diffuse in the atmosphere exceeds the rate at which they decay naturally, allowing also for the fact that they reside for various "lifetimes" in the atmosphere. Thus atmospheric concentrations of GHGs have risen steadily over time. In turn, because of the accelerated greenhouse effects, the increasing concentrations translate into radiative forcing which raises the mean surface temperature of the Earth. The exact relationships between emissions, concentrations, forcing and temperature change are not known with certainty. The diagrams below show a stylised picture of a situation in which global annual CO_2 emissions (the main GHG) stay constant at current levels for the next 300 years (the dashed lines), and an alternative scenario in which emissions grow from now until 2050 and then decline dramatically (the continuous line). Panel (a) shows the emissions trajectories. Panel (b) shows the resulting atmospheric concentrations, and panel (c) shows the resulting temperature profiles. While the dashed line is unrealistic—it assumes immediate cessation of the growth in CO_2 emissions—it serves to show that such a cessation would still result in steadily rising temperatures over the next few hundred years, illustrating the time lags and non-linearities in the climate system. The continuous line is consistent with radical action now, but emissions would nonetheless continue to rise for around 50 years, after which actions taken now and in the near future would dramatically cut emissions. The radical scenario achieves a 550 ppm concentration target by around 2100, a target that is widely being regarded as the long-term goal that might realistically be achieved. Again because of the lags in the system, stabilisation at this level in 2100 still results in rising temperatures thereafter, but temperature is stabilised at around +2.5°C in 2300. In practice, CO_2 emissions are still rising, although they are currently rising at a decreasing rate. The dashed line is therefore increasing rather than staying constant, underlining what many climate scientists regard as the urgency of early action.



Temperature change

10. Box 3 shows that the growth of emissions of greenhouse gases is linked to global temperature changes after some considerable time-lags. Since

greenhouse gas emissions, especially carbon dioxide, increased with the onset of the Industrial Revolution, current temperatures should have responded to these past emissions. The recent historical record of global temperature change is not disputed. Instrumental records (using thermometers) for temperatures in the Earth's Northern Hemisphere do not really begin until around 1860[9]. "Global" (i.e. Northern Hemisphere) average temperatures show marked fluctuations around a rising trend[10]. The (approximate) observed cycles are upwards for 1860 to 1875, downwards to 1890, up to 1900, down to 1915, up to 1942, down to 1970 and upwards since then. A more "smoothed" series would suggest a reasonably constant temperature to 1920, upwards to around 1940, downwards to 1970 and upwards since then. Since 1860, the mean temperature change has been around 0.6°C.

11. Any test of the link between temperature change and greenhouse gases must therefore account for these cycles. Mathematical models that try to explain temperature change are known as general circulation models (GCMs). These models attempt to mimic the forces at work that change the Earth's climate. If they can "explain the past", then they can be used to predict the future, assuming we have a reasonable idea of how the various determining factors (e.g. the greenhouse gases themselves) will behave in the future. GCMs tend to be very complex and have to run on powerful computers.

Scientific consensus and scientific doubt

12. Testing the validity of climate models is obviously difficult. In so far as the models predict climate change, the predictions can easily be in error and only the passage of time can validate the predictions. But if the science of climate change as embodied in IPCC reports is correct, the option of "waiting and seeing" may be risky because of the manner in which current emissions of greenhouse gases add to the stock of gases in the atmosphere. Once cumulated, the decay processes are very long term and hence the gases cannot be "decumulated" in short periods of time. Other tests are therefore needed. These tend to comprise (a) ensuring the internal consistency of the models—i.e. the extent to which they are consistent with received theory, and (b) the extent to which they "predict the past". In case (b) two historical tests are used. The first looks at the detailed temperature record since the mid-19th century, when instrumental records become widespread, and the second looks at the extremely long run record embodied in ice cores, tree rings and other "proxy" data going back hundreds of thousands of years.

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[9] A unique series exists for Central England from 1659 and can be accessed at www.met-office.gov.uk/research/hadleycentre/CR_data/Annual/cet.gif.

[10] It is important to understand how temperature changes are computed and portrayed. Temperature can obviously be measured daily and even hourly, so there are huge numbers of observations from the instrumental record. These are made more manageable by a process of averaging through time. A "moving average" of, say, 5 years, would take the average over the first 5 years 1 to 5, then the average of the 5 year period from years 2 to 6, and so on. The larger the averaging period, say 50 years instead of 5 years, the "smoother" the resulting trend line becomes. Turning points in this moving average therefore tend to change with the averaging period. In the climate science literature the difference between this moving average trend line and the actual temperature is known as an "anomaly". To test whether temperature and a greenhouse gas like CO_2 are correlated, it is the anomalies in temperature that are compared to CO_2 concentrations. This allows the correlation not to be unduly influenced by the time trends in the series.

BOX 4

The main IPCC publications

THE FIRST ASSESSMENT				
Year	**Working Group 1**	**Working Group 2**	**Working Group 3**	**Other**
1991	Volume 1 The IPCC Climate Assessment	Volume 2 The IPCC Impacts Assessment	Volume 3 The IPCC Response Assessment	Emission Scenarios
1992	Supplementary Report to the Scientific Assessment	Supplementary Report to the Impacts Assessment		Climate Change: The IPCC 1990 and 1992 Assessments
1995				Climate Change 1994 – Radiative Forcing of Climate Change and the Evaluation of the IS92 Emission Scenarios
THE SECOND ASSESSMENT				
1996	Climate change 1995 – The Science of Climate Change	Climate Change 1995 – Impacts, Adaptations and Mitigation of Climate Change	Climate Change 1995 – Economic and Social Dimensions of Climate Change	Climate Change 1995 – IPCC Second Assessment Synthesis of Scientific-Technical Information
2000				Emission Scenarios – IPCC Special Report
THE THIRD ASSESSMENT				
2002	Climate Change – The Scientific Basis	Climate Change 2001 – Impacts, Adaptation and Vulnerability Climate Change 2001 - Mitigation		Climate Change 2001 – Synthesis Report
2007	THE FOURTH ASSESSMENT			

13. The Committee heard from several scientific witnesses on the theory. No one disputes the fact of temperature rise in the last 100 years or so. No one disputes that carbon dioxide is a greenhouse gas and few dispute that it has an enhanced "greenhouse effect". What is disputed, albeit by a minority of scientists, is the scale of this effect. In the view of Professor Richard Lindzen of MIT, current climate models would have predicted a substantially greater increase in the past temperature than has been observed in the past 150 years, perhaps +3°C compared to the +0.6°C we have witnessed. In his view, this suggests that the models are biased upwards and that, while warming will occur, it is the lower end of the IPCC spectrum that is relevant, not the upper limits, which he regarded as "alarmist"[11]. Our understanding of the scientific response to this apparent anomaly is that (a) cooling effects, including those from sulphates, have masked the expected rise in warming,

[11] Evidence from R. Lindzen (Vol II, pp 44-55)

and (b) only climate models that combine natural variability and anthropogenic forcings "fit" the past data[12], as outlined in paragraph 15.

14. We recognise that there is a strong majority view on climate change. Majorities do not necessarily embody the truth, but we note that major associations of scientists have adopted similar positions. The IPCC tends to be the focus of the majority view which has been confirmed by the Royal Society[13], and by the US National Academy of Sciences, the American Meteorological Society, the American Geophysical Union and the American Association for the Advancement of Science. Despite this, it is a concern that the IPCC has not always sought to ensure that dissenting voices are given a full hearing. We document these concerns later in the Report.

15. As far as the recent temperature record is concerned, as noted above, the temperature record is not one of consistent warming. Indeed, there was a distinct "cooling period" in the 1960s and 1970s—see Box 5. The conventional explanation of this phenomenon is, first, that this period was associated with substantial sulphur emissions in North America and Europe, with sulphates having a cooling effect. As sulphur emissions came to be controlled, the underlying upward trend in warming resumed. Second, there was a natural variation in temperature in this cooling period due to changed sunspot activity. The IPCC is clear that GCMs that contain only anthropogenic temperature forcing predict more temperature change than has been observed in the 20th century. It claims that GCMs that embody only natural variation understate the temperature rise of the past 30 years or so. Only when anthropogenic and natural forcings are combined is the temperature record accurately simulated[14].

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[12] On (a) see Sir John Houghton, *Global Warming: The Complete Briefing*. Cambridge University Press, 2005. p.103. On (b) see R. Watson et al., op.cit., p.198.

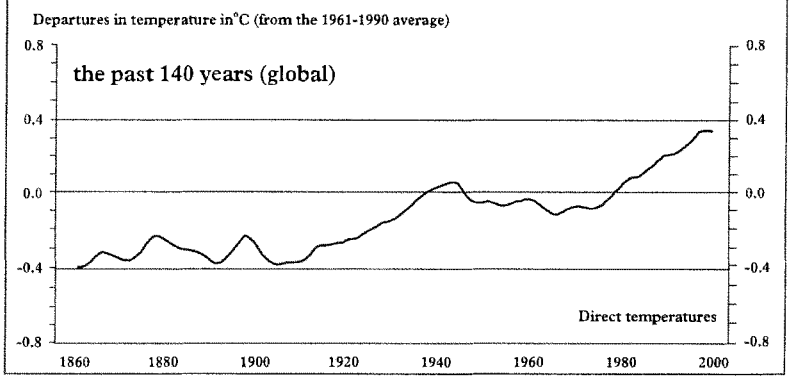
[13] Evidence from the Royal Society (Vol II, pp 293-306)

[14] R. Watson et al., op.cit. p.198

BOX 5

Recent temperature change

It is customary to show temperature in terms of deviations from the average of 1961-1990 temperatures. "Decomposing" the chart into approximate time periods, there is roughly a 0.6°C increase from 1860 to 2000. There appears to be no trend increase or decrease, i.e. temperature is fairly constant, in the period 1860 to 1920. There is continuous warming from 1920 to 1945, followed by a period of "cooling" from 1945 to 1965, in turn followed by continuous warming from 1965 to the present.



16. In his evidence to us, Sir David King drew attention to recent research which, it is claimed, shows that changes in ocean temperatures have been accurately predicted by the GCMs, further validating the models[15].

17. Apart from the issue of explaining the divergence between actual and expected recent past warming, we heard doubts expressed about other features of the accepted science. These include:

- concerns that changes in ice-core record CO_2 concentrations might have followed temperature rise rather than the other way round;
- the poor nature of the data used to compute the long run historical record, or alleged misinterpretation of the long-run historical temperature record;
- the GCMs fail to "reconstruct" the long term historical record;
- the view of some that the relative importance of the natural factors affecting climate variability, e.g. variation in solar output, is underplayed in the IPCC assessments;
- apparent divergences between land-based temperature records and satellite-based measurements, the latter showing some cooling rather than warming in recent years;
- the manner in which the GCMs are adjusted until they align with the observed data;

[15] Evidence from Sir D. King (Vol II, pp 96-106)

- the uncertain role of cloud cover. Professor Lindzen argued that clouds generate a negative feedback effect (cooling) rather than the positive feedback effect assumed in the GCMs; and that
- the models fail to predict sudden weather events.

18. We do not propose to evaluate these doubts, nor are we qualified to do so. We are also aware that climate scientists who adhere to the human-induced warming hypothesis have responses to most of these sources of doubt[16]. But the science of climate change remains debatable. We heard from witnesses who seemed in no doubt at all about the science, while others expressed one or more of the above concerns. **That makes it clear that the scientific context is one of uncertainty, although as the science progresses these uncertainties might be expected to diminish and be resolved, one way or the other. Hence it is important that the Government continues to take a leading role in supporting climate science, and encourages a dispassionate evidence-based approach to debate and decision making.**

19. In terms of policy on climate mitigation and adaptation, the issue becomes one of how to behave in the face of uncertainty. Given this uncertainty, the effective irreversibility of climate change, and the potential for large-scale damage, a precautionary approach is called for. But precaution cannot be the right option at any cost. We return to this issue later.

A note on the "hockey stick" debate

20. While we have not entered into the scientific debate in any detail, we received a significant amount of evidence on the so-called "hockey stick" debate and hence feel we should comment on this issue.

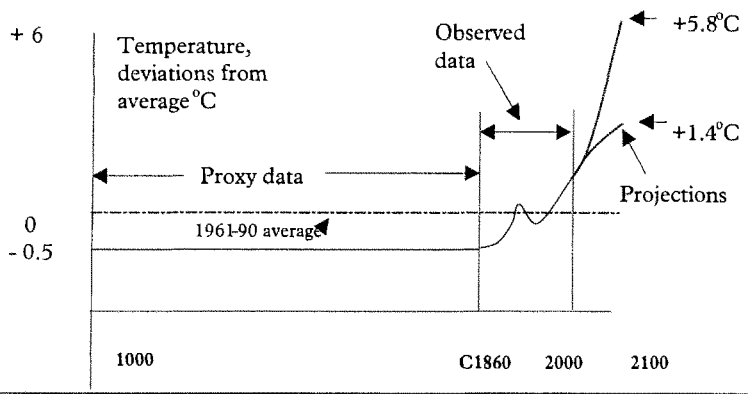
21. The hockey stick refers to the shape of the long-run time series curve of temperature change—see Box 6. This appears to show gently declining global (actually Northern Hemisphere) temperature from at least 1000 until about 1700, with a rise from then until the present. Most importantly, the recent past shows a sharp upturn such that the later part of the 20th century is warmer than any previous period. Thus the series resembles a hockey stick with the blade facing upwards—see Box 6. We noted earlier that a similar graph is suggested for carbon dioxide concentrations. The importance of the hockey stick shape is that the upturns in both temperature and CO_2 coincide and both are relatively recent phenomena, i.e. in the last 150 years or so. The hockey stick thus appears to be persuasive visual evidence that the recent temperature change is human-induced.

[16] An excellent description of most of these debates is to be found in M. Maslin, *Global Warming: A Very Short Introduction*. Oxford: Oxford University Press, 2004.

BOX 6

The "hockey stick"

According to the hockey stick literature, the time-profile of temperature in the Northern Hemisphere has the shape shown in the stylised diagram below. Temperatures before the mid-19th century tend to be inferred from ice-core and tree-ring data ("proxy" data). The implication is that natural climate variability has not generated temperature variations that compare with the temperature change witnessed since the onset of industrial times. Hence the temperature change of the last few centuries must be due to human-induced factors. The historical evidence is debated. Several studies have found fairly long periods in the last millennium in which variations of up to +1°C may have occurred[17]. In their evidence to us, the Royal Society drew attention to these papers but argued that natural variation alone cannot explain recent warming[18]. In a separate critique, Dr McIntyre and Professor McKitrick of Canada argue that one of the prominent hockey stick series is consistent with marked increases in temperatures between 1400 and 1500.



Source: P. Jones and M. Mann, Climate over past millennia. *Reviews of Geophysics*, 2004. 42: 1-42.

22. Some critics argue that the experience of the last few hundred years is too short a period for the climate models to determine the balance of natural and man-made factors in temperature change. This is why considerable attention has been paid to the longer run temperatures and the "hockey stick". One attempt to reconstruct a long-term temperature record is that of Professor Michael Mann of the University of Virginia[19]. The picture that emerged for

[17] H. von Storch et al. Reconstructing past climate from noisy data. *Science*. 2004.306:679-682; A. Moberg et al. Highly variable Northern Hemisphere temperatures reconstructed from low-and-high resolution proxy data. *Nature*. 2005. 433: 613-7.

[18] Evidence from the Royal Society (Vol II, pp 293-306).

[19] M. Mann, R. Bradley and M. Hughes. Global-scale temperature patterns and climate forcing over the past six centuries. *Nature*. 392, 1998. 779-787. 1999. M. Mann, R. Bradley and M. Hughes. Northern hemisphere temperatures during the past millennium: inferences, uncertainties and limitations. *Geophysical Research Letters*. 26. 1999. 759-762. M. Mann, R. Bradley and M. Hughes. Global-scale temperature patterns and climate forcing over the past six centuries: Corrigendum. *Nature*. 430. 2004. 105. The 1998 paper by Mann et al. is for the period 1400-1980. The 1999 paper expands the historical coverage back to 1000.

the period 1000–1980 is very much the hockey stick shape. The Mann hockey stick appeared in the IPCC Climate Change Assessment of 2001, thus achieving, as one journalist put it, "iconic status"[20]. In an analysis of Mann's et al data, Dr Stephen McIntyre and Professor Ross McKitrick of the University of Guelph in Canada claim that the analysis involves "collation errors, unjustifiable truncation or extrapolation of source data, obsolete data, geographical location errors" and other defects[21]. Their reconstructed series shows close correlation with Mann's series from 1550 to 1980 but shows temperatures higher between 1400 and 1500 than any of the 20th century temperatures. If correct, the late 20th century is no longer historically unprecedented and the "hockey stick" does not exist. We sought evidence that refuted the claims of McIntyre and McKitrick, but have not come across any detailed rebuttal. One curious feature of the debate over Professor Mann's time series is that the critics appear to ignore other studies which secure similar hockey stick pictures[22].

23. We are in no position to determine who is right and who is wrong in the growing debate on the hockey stick. If there are historical periods of marked temperature increase, it seems to us it is important to know why these occurred. Overall, we can only urge that the issue is pursued in the next IPCC Assessment.

On past scares

24. Some of our witnesses drew attention to previous environmental and resource exhaustion scares. The implication is that since these scares did not materialise, neither might accelerated global warming. While forecasters do seem to indulge periodically in "end of the world" stories, there is no guarantee that if they were wrong before they will be wrong again. More importantly, the science of global warming has advanced following substantial expenditures on research. Previous alarms, such as the 1970's *Limits to Growth* debates (which have not, in any event, gone away), earlier fears of global cooling (rather than warming), and even the fear in the 19th century over exhaustion of coal supplies, were based on more limited scientific investigation. **We do not believe that today's scientists are "crying wolf": they may turn out to have been wrong in some respects, but the arguments on which they base their case are better researched than in earlier cases. That said, this Chapter has sought to highlight some pressing issues which we believe deserve a further response from the scientific community in order to enhance understanding and resolve current controversies.**

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20 D. Appell. Behind the hockey stick. *Scientific American*. March 2005.

21 Evidence from R. McKitrick (Vol II, pp 262-266). See also S. McIntyre and R. McKitrick. Corrections to the Manne et al. (1998) proxy data base and Northern Hemisphere average temperature series. *Energy and Environment*. 14. 6.2003. 751-771. S. McIntyre and R. McKitrick. *The IPCC, the Hockey Stick Curve and the Illusion of Experience*. Washington DC: The George C Marshall Institute. S. McIntyre and R. McKitrick. Verification of multi-proxy paleoclimatic studies: a case study. Accepted Abstract. American Geophysical Union Meetings, Paper PP53A-1580, December 2004.

22 K. Briffa et al. Low frequency temperature variations from a northern tree ring density network. *Journal of Geophysical Research*, 106, (D3), 2001, 2929-41.

CHAPTER 3: THE FUTURE IMPACTS OF THE ENHANCED GREENHOUSE EFFECT

The nature of temperature change

25. Much of the global warming literature suggests that warming will be associated with many detrimental, and some positive, effects on human wellbeing and natural environments[23]. By and large, the greater the temperature rise, the larger the effects are likely to be. The IPCC's 2001 Report suggests a range of mean temperature changes of 1.4°C to 5.8°C by 2100[24]. We consider shortly how realistic this range is. These are mean global temperatures. Temperature changes in different continents will vary around this mean, some will be markedly higher, some lower. There will therefore be a spatial variation in temperature change. The lower end of the IPCC global temperature range appears modest. The problem arises because not only is there a problem arising from the trend increase in global temperature, but that trend rate masks substantial increased variability in temperature and probably in precipitation and weather events generally.

26. Measuring the impacts of global warming is obviously fraught with difficulty. Indeed, one of the Committee's witnesses went as far as to question whether predicting impacts 100 years and more hence has any value at all[25]. There are certainly profound problems involved in peering so far into the future. Nonetheless, it is hard to see the alternative. The problem lies in the time-lags that are endemic in the climate system. Present emissions of greenhouse gases do not have immediate impacts. Warming now is caused by greenhouse gases, emitted decades ago. This is because the emissions cumulate in the atmosphere and what damage is done arises from this concentration of gases, not from the current emissions themselves. Each greenhouse gas resides in the atmosphere before decaying naturally: CO_2 persists for 2 to 200 years, methane for 12 years, nitrous oxide for 114 years, and in the case of perfluoromethane upwards of 50,000 years[26]. It follows that action now to reduce emissions will have no immediate short-run effects. Any beneficial results will not accrue for decades to come[27]. By implication, climate policy is about reducing impacts in the decades and centuries to come; therefore, if impacts in 2100 are to be mitigated, action has to be taken sooner rather than later.

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[23] Detailed assessments of the likely impacts can be found in Inter Governmental Panel on Climate Change, *Climate Change 2001: Impacts, Adaptation, and Vulnerability.* Cambridge: Cambridge University Press, 2001.

[24] J. Houghton et al. *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press. 2001. The benchmark for these temperature increases is not always clear, but is usually the "pre-industrial" period, i.e. around 1750. Thus, a projected rise of, say, 2.6°C would imply warming of about 2°C compared to the present day. Some of the scientific opinion at the conference convened in Exeter early in 2005 considered that the IPCC 2001 Assessment understates likely temperature change.

[25] Evidence of Professor Colin Robinson (Vol II, pp 1-14)

[26] R. Watson et al. op.cit. p.182

[27] In many cases, reducing greenhouse gas emissions also reduces other pollutants, such as particulate matter. For example, any reduced road transport would have this effect since particulates and CO_2 are emitted from vehicles. The benefits of reducing particulates would, however, be fairly immediate. This joint effect is known as "ancillary benefits" in the literature. However, if the pollutant reduced is sulphur, then reduced sulphur emissions may actually increase warming—see the section on "negative forcing".

Impacts: a thumbnail sketch

27. **Whatever the validity of the temperature projections, the science of measuring impacts remains speculative.** Arguably, the most certain effect is sea level rise (SLR) due, in the main, to the thermal expansion of the oceans. The IPCC projects a mean global SLR of 20 to 88 cms by 2100. There will be local variations around this range. SLR clearly threatens low lying islands and deltaic regions in countries such as Bangladesh and Egypt. Some of these regions have additional problems of sinking due to rapid extraction of freshwater or diverted sediments (which offset erosion). **Many of the adverse effects can be offset by adaptation and we believe that the economic and social returns from investing in adaptation should be properly weighed against the cost of mitigation.** A notable example of such adaptation is the discussion already taking place on plans to extend and enhance the flood defences for London. But we acknowledge that foresight of this kind is a luxury that many poor countries cannot today afford from their own resources. International assistance will be required to help finance the adaptation that is needed. However, in the timescale before major adjustment needs to occur, projected economic growth in the developing countries should enable them to finance greater shares of the measures needed.

28. Rapid warming, which is what the IPCC's central projections suggest is the case, may be associated with increased weather variability and hence with the incidence or severity of weather events such as storms and monsoons. Despite a popular literature suggesting that cyclones and hurricanes will also increase, the climate models appear to be undecided on these effects. Similarly, often-repeated graphs of rising money costs of extreme weather events can be misleading since money value of damage is partly a function of the intensity of property development (and hence financial value of the assets) in addition to the severity of the weather event. Put another way, weather events could be constant in their severity but damage costs would still rise. Nonetheless, the facts are that more property and more lives are now at risk from major weather events. The IPCC provides evidence that global insured and uninsured property losses currently amount to over $40 billion per annum compared to just $4 billion per annum (all in real terms) some 50 years ago[28].

29. Impacts on human health are also open to some debate. Deaths associated with abnormally high summertime temperatures may well rise. By contrast, deaths may be reduced due to warming winters. Several of the Committee's witnesses referred to the European heatwave of summer 2003 and it was suggested that current warming (due to past emissions of greenhouse gases) accounted for the abnormal number of premature deaths at that time. A carefully researched study in *Nature* concluded that:

    "It is an ill-posed question whether the 2003 heatwave was caused, in a simple deterministic sense, by a modification of the external influences on climate—for example, increasing concentrations of greenhouse gases in the atmosphere—because almost any such weather event might have occurred by chance in an unmodified climate"[29].

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[28] R. Watson et al. op.cit. p.256

[29] P. Stott, D. Stone and M. Allen, Human contribution to the European heatwave of 2003. *Nature*, 432, 2 December 2004, 610-613.

30. But the authors do conclude that, relative to a temperature threshold that was exceeded in 2003 but in no other year since records began in the mid-19th century, "it is very likely (confidence level > 90%) that human influence has at least doubled the risk of a heatwave exceeding this threshold magnitude". The experience of 2003 may therefore not augur well for the future, although we are conscious again of the need to be careful about the policy implications. It will be sensible to manage exposure of vulnerable people to such heatwaves—a relatively simple task—rather than focus solely on emissions reductions to reduce the chance that they will occur again with more regularity.

31. Mortality and morbidity due to changes in the availability of drinking water are more likely with future warming. Higher temperatures, coupled with rising population growth, and hence growing demand for water, will decrease water availability in some parts of the world. Saline intrusion will affect freshwater supplies in some coastal areas, and water pollution can be expected to increase. The same issues of adaptation versus mitigation arise: much water is wasted, even in poor countries, and better water management policies may be better investments than attempts to reduce warming. This will be especially true if policies to reduce emissions have a limited chance of success, an issue we return to later.

32. It is also widely argued that vector-borne diseases will increase as regions warm, especially malaria. **However, we noted evidence from Professor Paul Reiter of the Institut Pasteur in Paris, which strongly disputed the IPCC's arguments on the likely spread of malaria**[30]. Professor Reiter argues that malaria is not a "tropical" disease and that it was widespread during the "little ice age" from mid-15th century to mid-18th century when temperatures were lower than today. Warmth is a factor in the transmission of the disease, but a number of location-specific factors are more important. Professor Reiter's cautions underline the fact that even the IPCC conclusions, based on a scientific process with many hundreds of experts, still need to be treated with care. We return to Professor Reiter's evidence later when we consider the reliability of some of the IPCC evidence.

33. Global warming will bring about ecosystem change and hence changes in the populations of species. The IPCC cites particular ecosystems at risk: glaciers, coral reefs and atolls, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands and remnant native grasslands[31]. A case in point is the coral reefs where the evidence suggests that coral bleaching will increase as oceans become warmer, an effect already identified with El Niño events. Since the reefs embody a great deal of marine biodiversity, the diversity of species is itself under threat. The threats from warming need to be placed in context. There are many other threats to coral reefs: over-fishing, destructive fishing techniques, pollution run-off, oil spills, even tourism. Nonetheless, the impacts of warming cannot be controlled as readily as these other man-made threats. For example, in contrast to some other impacts, it is difficult to see what adaptive measures could be taken to protect reefs from ocean surface warming. There are some offsetting factors. Some species will "relocate": a warmer North Sea, for example, has already

[30] Evidence of P. Reiter: The IPCC and Technical Information. Example: Impacts on Human Health (Vol II pp 284-288)

[31] See R. Watson et al. op.cit. p.223. In his evidence to us (Vol II, pp 96-106), Sir David King was clear that current evidence suggests glaciers are in retreat for the first time in the current warming period.

experienced increases in a number of species, including large shoals of squid, followed by their predators—species of dolphins and whales that would normally be expected to inhabit more southerly waters[32]. But the available evidence suggests that any benefits to ecosystems are likely to be confined to the lower end of the projected temperature changes. Impacts on other vulnerable ecosystems will also be difficult, or impossible, to reverse, although, again, it has to be recognised that human influence over land use change, brought on by population growth and the extension of agriculture, is the major determinant of ecosystem and species loss.

34. Impacts of warming on agriculture are debated. The evidence suggests that some regions could gain from a warmer climate and the fact that higher levels of CO_2 enhance crop growth. But some regions, notably the poorer ones, will lose because of changes in precipitation and higher temperatures. Many other factors affect agricultural yields and IPCC concludes that it will be difficult to distinguish the impacts of modest climate change from the "noise" in these other factors. Moreover, at the lower end of the projected temperature increases there will be scope for adaptation. Provided the resources are available, farmers will not stand by and watch crops being ruined if there are alternatives available. But, to the extent that it is needed in the short term, adaptation in the poor regions of the world is clearly limited without outside help. At the higher end of the temperature increase spectrum the scope for adaptation is further reduced. Food security issues appear particularly problematic in Africa[33]. Dr Martin Parry has suggested that the positive effects of warming on crop yields would disappear at +1°C for India and perhaps 1.5°C for Southern Europe[34].

35. The impact literature also refers to "socially contingent impacts" which in turn relate mainly to the prospects of wholesale forced migrations of populations in seriously affected regions. The IPCC acknowledges that these effects, if they occur, must be uncertain.

Extreme events

36. The term extreme events tends to be reserved for weather events such as cyclones, hurricanes, tornadoes, ice storms, blizzards, rain storms, and heatwaves. The IPCC believes that many of these events will increase with warming. Sir John Houghton has declared that "these probably constitute the most important element in climate change impacts"[35]. For obvious reasons, the insurance industry tracks extreme events. Data from Munich Re indicate a more than five-fold increase in the number of weather-related extreme events in the 1990s compared to the 1950s. The economic losses from these events need to be distinguished from the number of events because economic damages will also be influenced by the scale of property at risk. These losses are estimated to have risen by a factor of 10 in the same period (at constant prices)[36]. Dr Madhav Khandekar, a Canadian consulting meteorologist, has

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[32] *The Guardian*, 2 April 2005, reporting evidence from Dove Marine Laboratory, Newcastle University.

[33] R. Watson et al. op.cit. p.231

[34] M. Parry et al. Viewpoint. Millions at risk: defining critical climate change threats and targets. *Global Environmental Change*. 11, 2001. 181-3

[35] Sir John Houghton, *Global Warming: The Complete Briefing*. Third Edition. 2005. Cambridge: Cambridge University Press. P179.

[36] R. Watson et al. op.cit. p256.

challenged the IPCC findings in work he submitted to us[37]. Dr Khandekar cites studies which find no increasing trends for thunderstorms, intense tornadoes, hurricanes or tropical cyclones in the USA, although extreme precipitation events have increased. He finds no evidence for increasing trends of extreme events elsewhere that could be associated with warming rather than natural events like the El Niño Southern Oscillation, which remain, in themselves, unpredictable.

37. We are in no position to evaluate these contrasting views. **We do draw attention to the fact that, if extreme events are indeed to be considered the most important impacts from climate change, there is uncertainty and controversy about the underlying data required to substantiate this claim.**

Large scale one-off changes

38. Some of our witnesses placed considerable emphasis on the role of global warming in generating "surprises", or what IPCC refers to as "large-scale singular events". The GCMs generate results which suggest that, as radiative forcing increases, so climatic change increases in a fairly orderly manner. This result is fairly reassuring in the context of policy since it implies that, while climate change continues unabated during the policy-making period, there is time to adjust and introduce the required changes in policy and practice. But if change is non-linear and abrupt, then that reassurance largely disappears, and there are many examples of non-linear behaviour and thresholds in Earth's climate system[38]. Several GCMs suggest that some of these major events could arise at high levels of warming. One reason for being concerned about surprises, apart from their potential for large scale impacts, is that evidence suggests that some past climate change has occurred within very short periods of time[39]. The kinds of surprises that are prominent in the discussion are:

- reversal (or "shut down") of the ocean thermohaline circulation (THC). The THC refers to deep-ocean currents that move heat and freshwater between the world's oceans. A major influence on these currents in the past has been the freshwater released from ice melts in the North Atlantic. The Gulf Stream brings warm surface water from the Gulf of Mexico to the North East Atlantic and returns cold deep water to the South Atlantic. The Gulf Stream maintains Europe's temperatures at about 8°C higher than they would otherwise be. It relies on salty and cooling surface water sinking downwards, and the fear is that additions of substantial amounts of fresh surface water will reverse or "switch off" this vertical change in the ocean's waters. Such fresh water additions could come from melting ice in the Arctic and Greenland. European summers would heat up and winters would become very much colder[40];

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[37] M. Khandekar . Are climate model projections reliable enough for climate policy? *Energy and Environment*, 15 March 2004

[38] For an overview of these features see J. Rial et al. Nonlinearities, feedbacks and critical thresholds within the Earth's climate system. *Climatic Change*. 65. 2004. 11-38.

[39] See M. Maslin, *Global Warming: a Very Short Introduction*. Oxford: Oxford University Press. 2004.

[40] In his evidence to us (Vol II, pp 96-106), Sir David King thought this shut-down process might take only a decade and that the temperature fall might be -20°C.

- disintegration of the West Antarctic ice caps which would alter the South Atlantic ocean circulation and produce sea level rise on a more dramatic scale than the increase due solely to thermal expansion, with increases of several metres;
- melting of the permafrost. Methane gas mixed with water, in solidified form, exists in very large quantities in soils beneath the permafrost[41]. High levels of temperature change could release the methane, a powerful greenhouse gas, producing a "runaway" acceleration of warming, in addition to considerable destruction of property that is built on top of these soils;
- acidification of the oceans, changing ocean life dramatically; and
- major regional effects that are likely to have global consequences. These include: a lengthening of the dry season in Amazonia, destroying the balance of wet (long) and dry (short) seasons that maintain the Amazon rainforest as we know it today; desertification of large parts of Africa; and major changes to the Indian monsoon.

39. **How such catastrophic threats should influence decision-making depends on the scale of the effects, their probability of occurrence, and when they might occur. The scale of these events is clearly very large.** The probability of their occurrence appears not to be known. Changes in the THC are not at all likely to occur, as we understand it, in the next 100 years, but might thereafter. Sir David King suggested to us that the important time benchmark is the point at which the Greenland ice sheet begins to melt. He told us that some of the GCMs suggest this could happen with +2°C, well below his own personal belief that, without serious action, the world would be heading for +3°C.

40. How seriously these risks should be taken clearly depends on many factors, at the very least on the commitment of the current generation to future generations, the degree of credibility in forecasts and projections hundreds of years ahead, and the speed at which technology will change. We recognise that the ways in which these risks can be integrated into decision-making procedures are only now being advanced. **If cataclysmic events which threaten the viability of existing societies are even remote possibilities, it is important that policy makers construct frameworks for analysing and debating probability and risks, since the threats associated with such "doomsday" scenarios are fundamental elements in driving the international discourse.** We acknowledge that the evidence on all these risks is continually being monitored and it is clearly important to reappraise the risks at regular intervals. There is a balance to be struck.

Summary indicators of warming damage

41. The detrimental impacts of climate change are likely to manifest many different types of effect. Moreover, the size of the global temperature change matters: low levels of temperature increase may be associated with some beneficial effects on agricultural yields and even ecosystem productivity. For

[41] These gas hydrates also exist in vast reserves below the world's oceans. There is a scientific debate about the extent to which high warming levels could also begin to release these hydrates, something that does appear to have happened many millions of years ago.

this reason, the Committee sought firmer guidance on the likelihood of the different temperature projections made by IPCC, since IPCC does not currently attach any probabilities to the temperatures within the range they suggest. Of course, even if low temperature increases are benign, doing nothing about climate change may still not be an option: warming does not stop automatically once a given temperature increase has been experienced. But if the lower projections are more likely, there could be more time to devise better strategies for mitigating and adapting to climate change. **We think it is a matter of some importance that IPCC moves towards clearer judgements on the probabilities of the projected temperature increases.** We return to this issue in Chapter 4.

42. Getting a concise picture of warming impacts is difficult, not least because the science of impact assessment is uncertain, probably more uncertain than the science of climate change itself. It is for this reason that the Committee sought evidence on summary indicators of climate change damage. Two presented themselves: (a) some indication of global and regional populations at risk now and in the future, and (b) monetary measures of damage which can be benchmarked on world and regional Gross Domestic Product (GDP). Dr Martin Parry has produced estimates of the former[42]. These are summarised in Box 7. (We defer consideration of the measures of economic damage to Chapter 6.) We acknowledge, however, that neither measure accounts adequately for large scale singular events.

[42] M. Parry et al. op.cit.

BOX 7

Populations at risk from global warming

We note and agree with the view that, while listing the many potential impacts of climate change is important, the end result is a confusing mix of effects, some of which may be very important and others far less so. There is a need for a "reductionist" measure of impact that can be readily understood. In Chapter 6 we look at the available monetary measures of impact. Dr Martin Parry and his colleagues have suggested a measure of climate change impact based on the numbers of people at risk. The measures are located in time in the 2050s and the 2080s. The results are summarised in broad terms below. They vary according to the level of temperature increase which, in turn, corresponds to atmospheric concentrations. Here we show how the impacts vary with temperature increase. The study estimates those at risk from hunger, malaria, coastal flooding and water shortage. We illustrate the malaria and water impacts only, for ease of presentation. (Since the source shows charts only, some error may also be involved in inferring absolute magnitude.)

Temperature increase	Additional people (millions) at risk from Malaria (M) and water shortage (W)			
	2050s		2080s	
	M	W	M	W
+1°C	160-230	1250-2250	-	-
+2°C	200-260	2100-3000	225-280	2750-3250
+3°C	-	-	270-340	3000-3500

The more alarming numbers relate to water shortages, the suggestion being that an additional three billion people would face water problems, or perhaps 40%of the world's population at the time. These are "business as usual" estimates, i.e. there is no climate mitigation and no adaptation. The latter is obviously very questionable, as we argue in this report. We also draw attention in the main body of this report to some serious questions about the estimates for malaria.

Source: M. Parry et al. op.cit.

Positive effects of warming

43. The Committee noted that the scientific literature tended to focus on the negative impacts of climate change. This is understandable given that some of these effects are thought to be catastrophic, and because individuals tend to be more averse to a loss than they are in favour of an equivalent gain[43]. But a rigorous appraisal of climate change does need to include positive effects. The beneficial effects of CO_2 "fertilisation" on crops was noted above. But there will also be gains in amenity across large areas. Several studies were presented to us which indicated the nature of some of these amenity gains: increased opportunities for tourism, for example, but also the fact that many people simply prefer to live in mild climates. In his evidence, Professor Mendelsohn of Yale University argued that regions have "optimal" climates: regions that are "too cold" gain from warming, while those that are

[43] This phenomenon of "loss aversion" is well documented in the psychological and economics literature.

"too hot" will lose[44]. Dr David Maddison of University College London and Ms Katrin Rehdanz of Hamburg University argue that impacts at the level of the household will be the most profound, yet little is known about how households perceive climate change. Like Professor Mendelsohn, they invoke the notion of an optimal climate but at the household level, with households moving towards or away from that optimum as climate change occurs[45]. The research suggests that people will accept lower wages to work in areas of "better" climate typified by lower rainfall, lower mid-summer temperatures (in countries such as Italy) and lower cloud cover. Similarly, house prices tend to be higher in regions with preferred climates. Household expenditures also change with climate. Finally, individuals' own ratings of their "happiness" have been shown to vary directly with income and climate[46]. Overall, there appear to be distinct amenity gains for the countries of Northern Europe, with generally neutral effects in Southern Europe. Once the focus moves to Asia there are serious household losses, confirming the general picture that it is the poorer parts of the world that suffer most from warming. **We are clear that fuller consideration needs to be given to the literature on the positive effects of warming.**

44. We draw attention to this literature for several reasons. First, we heard little about the positive effects of warming from the scientific witnesses. Second, we observe that this category of benefit is mentioned only in passing in the IPCC Working Group II assessment of impacts, where it is noted that economic impact studies "may have overlooked" positive impacts[47]. **We conclude that there are weaknesses in the way the scientific community, and the IPCC in particular, treats the impacts of climate change. We call for a more balanced approach and look to the Government to take an active role in securing that balance of research and appraisal.**

Adaptation versus mitigation

45. The IPCC 2001 Reports make explicit reference to adaptation to climate change. Adaptation can take various forms. The IPCC reports distinguish "autonomous" and "planned" adaptation. First, market forces and natural behaviour will lead to some "natural" adaptation to climate change, e.g. by changing crop strains so that crops are more tolerant of dry conditions. Second, conscious and deliberate policies and investments will also be needed to encourage further adaptation. We understand the IPCC cautions on adaptation: it is easy to see that reliance on adaptation alone would be risky since it may not be possible to adapt to major risks. But it also seems to us that nearly all of the public debate on global warming is about mitigation—reducing emissions—rather than about adapting to climate change and, assisting the most vulnerable societies in the world to adapt to the risk they may face.

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[44] Evidence from R. Mendelsohn (Vol II, pp 266-269). See also R. Mendelsohn and M. Schlesinger, Climate response functions. *Ambio*, 28, 1999, 362-6

[45] Evidence from D. Maddison (Vol II, pp 256-262).

[46] K. Rehdanz and D. Maddison. Climate change and happiness. *Ecological Economics*. 52. 2005. 111-125.

[47] There is no chapter or sub-section of the IPCC Working Group II 2001 Report dealing with positive impacts. Chapter 19 lists positive effects in the agricultural sector and possible reductions in winter mortality but makes no mention of amenity effects.

46. In evidence to us, Dr Indur Goklany of the US Department of the Interior argued that mitigation can do little to reduce many of the impacts from warming, whereas investment in adaptation now would both reduce the baseline risks that will occur even without any warming, and the warming impacts as well. His estimates suggest that warming could add substantially to the population at risk, notably from hunger, water shortage and coastal flooding. Those at risk from additional water shortage could, however, be offset by those who benefit because of warming-induced water gains[48].

47. **The issue is clearly one of balance. Most adaptation expenditures would be local, while mitigation requires action on a global scale. Few would suggest doing nothing by way of mitigation, and few would suggest no adaptation expenditures at all. But the policy literature seems to us to be overly focussed on mitigation. We therefore urge the Government to ensure that greater efforts are made to understand the relative costs and benefits of adaptation compared to those of mitigation.**

[48] Evidence from I. Goklany (Vol II, pp 217-225).

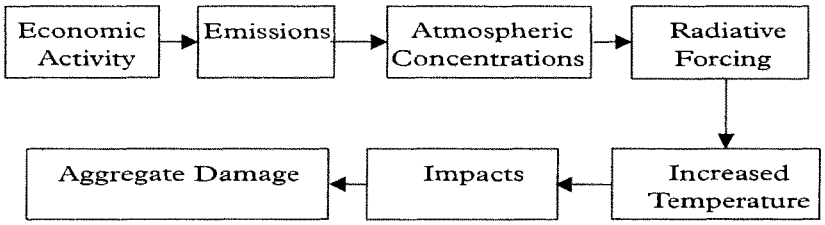
CHAPTER 4: FORECASTING GREENHOUSE GAS EMISSIONS AND TEMPERATURE CHANGE

The climate—economics linkages

48. This chapter focuses on an issue that was instrumental in launching our inquiry: the IPCC emissions scenarios. The IPCC has a separate set of experts whose task it is to develop greenhouse gas emissions scenarios. There are 40 such scenarios and six separate models are used to quantify them. The IPCC is concerned to argue that these scenarios are not forecasts as such, but "pictures" of "what would happen if" certain driving forces were in place. But once the scenarios are translated into the policy context, the distinction between "scenario outcomes", "projections" and "forecasts" seems to us to be fuzzy. Denying that the scenarios embody forecasts may have the effect of avoiding criticism of their realism, but the fact is that the resulting temperature projections are presented as conditional forecasts, changes that will come about if a certain combination of circumstances prevails.

49. Box 8 summarises the scenarios as they are described in the 2000 Special Report on Emissions Scenarios (SRES). The earliest reports on the scenarios were issued in 1990. They were revised in 1992, and the latest is dated 2000[49].

50. The role that emissions projections play in projections of warming and hence damage is, inescapably, complex. The sequence is as follows:



51. Each of the linkages between the components of the diagram above involve complex factors. For example, the link between economic activity and emissions involves population change, rates of economic growth, the stage of economic development (e.g. reliant on heavy industry versus a service-based economy), the type of energy used to "fuel" the economy, energy efficiency (the amount of energy used to produce a unit of GNP changes as economies develop), and technology. In addition, it is affected by the way global incomes are added up across countries—the "aggregation" debate (see below). Hence, emissions do not have any simple proportional relationship to economic activity. As far as the links from emissions to atmospheric concentrations of greenhouse gases and from concentrations to temperature change are concerned, what matters is the stock of greenhouse gases in the atmosphere. Annual emissions do not therefore have any simple proportional

[49] They can be found on-line at http://sres.ciesin.org. 52 people are listed as the SRES "Writing Team"

link to concentrations. Annual emissions add to the stock and the stored emissions (the atmospheric concentration) also "decay" at various rates. Most importantly, it is the stock that helps to determine temperature change. Even here the link is complex because the change in "radiative forcing" is not proportional to concentrations. The link from temperature change to economic damage depends on a further set of factors: how economies adapt to temperature change, how vulnerable some economies are, how rapid warming is and whether there are abrupt changes in temperature and weather events.

BOX 8

The IPCC emissions scenarios

The IPCC *Special Report on Emissions Scenarios* (SRES) for 2000 groups "alternative futures" into four "families", A1, A2, B1 and B2. Within these families there are variations in assumptions about the underlying driving forces, especially technological change, so that, in all, there are 40 scenarios. While they are given different names, the basic differentiating features are:

- A1 has rapid economic growth and rapid technological change, with population peaking in the mid-21st century and declining thereafter. There is strong convergence of per capita incomes between rich and poor countries.
- A2 has slower economic growth and technological change.
- B1 has the same population assumptions as A1, strong convergence, and strong reductions in energy and materials intensity.
- B2 has rising population growth, "intermediate" economic growth, and slower technological change than A1 and B1.

The scenarios are associated with a range of temperature changes: each sub-scenario within the A1 scenarios, for example, has a range of temperature changes, and the range across the sub-scenarios tends to be quite wide, especially for A1 scenarios.

None of the scenarios includes explicit policies directed at controlling climate change. Summary statistics for the scenarios are given below:

Scenario	Population 2050 (billion)	Population 2100	World GDP 2050 trillion $ 1990	World GDP 2100 trillion $ 1990	Convergence rich/poor 2100 (1990 = 16.1)	GDP growth rate 1990 - 2100 (% p.a.)	Cumulative Emissions 1990 - 2100 (GtC)
A1	8.7	7.0-7.1	164/ 187	525/ 550	1.5 – 1.6	3.0	1068-2189
A2	11.3	15.1	82	243	4.2	2.2	1862
B1	8.7	7.0	136	328	1.8	2.5	983
B2	9.3	10.4	110	235	3.0	2.2	1164

The range of temperature increases corresponding to these scenarios is 2.1 to 6.1°C for A1 by 2100, 3.0 to 5.2 °C for A2, 1.7 to 3.0 °C for B1 and 2.1 to 3.9 °C for B2

Source: adapted from data in N. Nakicenovic et el. *Emissions Scenarios.* Cambridge: Cambridge University Press. 2000. Note: these ratios are computed using MERs, not PPPs.

The Henderson—Castles critique

52. Professor David Henderson and Mr Ian Castles have published several critiques of the IPCC SRES[50]. Essentially, their criticism is that the IPCC scenarios are built on projections of economic change that involve adding up economic activity across countries using market exchange rates (MER). If, instead, one uses the "purchasing power parity" (PPP) approach, the projected economic growth rates for developing countries (LDCs) will be lower[51]. The reason it may matter is that the IPCC SRES assumes there will be a substantial degree of convergence of real per capita incomes between rich and poor countries by about 2100. Hence economic growth rates in developing countries are assumed to be higher than in rich countries. Current PPP comparisons of incomes per capita show a ratio of rich to poor incomes of about 7, compared to 16 with the MER. But if the gap between rich and poor now is narrower, then LDCs have less "catching up" to do. Their growth rates will be lower (compared to what would happen with the MER assumption) and hence emissions growth will be lower, other things being equal. But if emissions are exaggerated in the IPCC SRES, then so may rates of warming be exaggerated. As noted above, there is no simple relationship between emissions and warming—the linkage is not a linear one—so it cannot be assumed that an error of X% in emissions translates into an error of X% in warming. Nonetheless, the Henderson-Castles critique pointed to a potentially significant source of error in the IPCC work, led to a somewhat heated exchange with the IPCC[52], and attracted both academic and media attention[53].

53. While the IPCC SRES does indeed make some use of PPP conversions, the IPCC acknowledges that it has used MER conversions in its main work, and it insists on the "methodological soundness of the use of MER for developing long-term emissions scenarios"[54]. We found no support for the use of MER

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[50] See evidence from P.D. Henderson (Vol II, pp 36-44) and I. Castles (Vol II, pp 207-211) See also I. Castles and P.D. Henderson. The IPCC emissions scenarios: an economic-statistical critique. *Energy and Environment*. 14:2 and 3. 2003. 159-186. I. Castles and P.D. Henderson, Economics, emissions scenarios and the work of the IPCC. *Energy and Environment*, 14: 4, 2003, 415-435. I. Castles and P.D. Henderson, International comparisons of GDP: Issues of theory and practice, *World Economics* (forthcoming). P.D. Henderson, The Treatment of Economic Issues by the Intergovernmental Panel on Climate Change (*mimeo*). P.D. Henderson, *SRES and IPCC: The Treatment of Economic issues*. Address to Joint Meeting of the American Enterprise Institute and The Economist, Washington DC, November 2004.

[51] Market exchange rates are the exchange rates we are all familiar with when changing foreign currency. PPP, on the other hand, compares the values of a given bundle of goods across countries allowing for the ratios of the actual prices of each component of the bundle. The "purchasing power equivalent" for any one good is the ratio of the price of that good in country A divided by the price of that good in country B. These price ratios are applied to average quantities of the selected goods to build up a picture for the purchasing power equivalent for the whole bundle of goods which usually amounts to extending it to GDP as a whole. Extending the analysis to many countries is far more complex. The most widely used procedure is to compute world prices so that each country's prices are expressed relative to these world prices. Even this procedure can involve error.

[52] See N. Nakicenovic et al. IPCC SRES revisited: A response. *Energy and Environment*. 14:2 and 3. 2003, 187-214, and A. Grübler et al. Emissions scenarios: A final response. *Energy and Environment*.

[53] The academic debate has only partially appeared in the journals. See especially J. Ryten, MERs, PPPs and IPCCs: Illusions and reality, *Energy and Environment*. 15:3. 2004, 363-367; W. McKibbin et al. Can the IPCC SRES be improved? *Energy and Environment*. 15:3. 2004, 351-362. We refer to other important contributions in the rest of this chapter. On the media attention see *The Economist*, 15 February 2003 and November 2003. W. McKibbin, Flaws in climate-change research need fixing. *Weekend Australian Financial Review*, July 24-5, 2004.

[54] A. Grubler et al. Emissions scenarios: A final response. *Energy and Environment*, 15 (1), 2004, 11-24.

in such exercises, other than from Dr Nakicenovic of the IPCC. We consider that Professor Henderson and Mr Castles were right to raise the issue. In so doing, they have helped to generate a valuable literature that calls into question a whole series of issues relating to the IPCC SRES, not just the issue of MER versus PPP. It has emerged that the PPP versus MER issue is far more complex than perhaps anyone thought initially. Indeed, Professor Henderson has modified his own position, whilst retaining his very firm view that the IPCC SRES process embodies many confusions.[55] It seems unlikely that the debate over the emissions scenarios would have occurred at all had Professor Henderson and Mr Castles not persisted in their views. We consider that they have performed a public service.

54. The issues that have now emerged are:

- the credibility of IPCC's insistence that no one scenario is any more likely than any other;
- the compatibility of the economic growth assumptions embodied in the scenarios with historical experience, and the credibility of the world economic growth rates embodied in the scenarios in a resource-limited world;
- the assumption in the IPCC scenarios of "convergence" or, more strictly, "conditional convergence" of per capita incomes between rich and poor countries;
- the MER versus PPP debate itself;
- the compatibility of IPCC's overall emissions and concentration trajectories with past experience;
- the credibility of the population projections in the scenarios; and
- the role played by sulphur emissions (which have a cooling effect) in the scenarios.

We take each issue in turn.

Are the IPCC emissions scenarios equally plausible?

55. The IPCC takes the view that its emissions scenarios "reflect a wide range of future possibilities that characterize our current understanding of the uncertainties of the drivers of future emissions patterns". They say that "The SRES was designed to provide insights on uncertainty from a range of plausible scenarios, and not to assign likelihood to any of the alternative futures described by the set of 40 scenarios"[56]. This is indeed the standard procedure in scenario building, as it is practised in the world of business. But, while this may have been the purpose of the scenario exercise, the reasonableness of constraining the exercise in this way must be brought into question. Whatever the intent of the IPCC, the public perception of the scenario exercise is often that each scenario is equally plausible: by not assigning levels of significance—quantitative or qualitative—to the scenarios, the impression given is that each has the same probability of occurrence. One of the salient features of the Henderson-Castles critique was that the high-

[55] P.D. Henderson, SRES, IPCC and the treatment of economic issues: what has emerged? Westminster Business School, London. May 2005. *Mimeo.*

[56] A. Grübler et al. op.cit.

emission scenarios rest on assumptions that are not credible. We were therefore concerned to hear from Dr Nakicenovic that IPCC had no intention of undertaking any significant reappraisal of the SRES for the IPCC Fourth Assessment exercise (AR4) for 2007[57]. It seems to us that there is an urgent need for a wholesale reappraisal of the emissions scenario exercise.

56. One of our witnesses, Professor Richard Tol of Hamburg University, has assessed the relative likelihood of each of the IPCC scenarios[58]. One important feature of Professor Tol's work is that he has sought to validate the scenarios using long term historical data, something that the SRES did not do, and an issue raised in the original Henderson-Castles critique. On the underlying assumptions, Professor Tol finds: (a) the population projections are credible, although the A1 and B1 scenarios unaccountably have the same populations; (b) the per capita income growth for developed economies is credible; (c) the per capita income growth for the developing countries diverges from long-term (though not more recent) historical precedent, and for Africa there is a clear break with the past; (d) the assumption of convergence of per capita incomes is not consistent with much of the longer term past record; (e) projections of energy intensity are only partially confirmed by history. Professor Tol concludes on scenario assumptions that:

"The [previous observations] suggest that the SRES modellers know a lot about the supply side of the energy system, but less about the demand for energy. Their knowledge of economic development is lacking".

57. As to which scenarios are more likely, Professor Tol argues that the A2 scenario "is by far the most realistic" and

"The SRES scenarios do not accord with past trends. On the one hand, this makes for interesting scenarios. On the other hand, it is odd that all SRES scenarios break with past trends at the same time, and that this trend break is sometimes at the point where data end and scenarios start".

58. The A2 scenario is, however, one of the scenarios with high cumulative CO_2 emissions—see Box 4. The high emissions result from the population projection of 15 billion people in 2100, a projection not borne out by any of the population forecasts made elsewhere.

59. We find Professor Tol's analysis telling. He suggests that many of the likely errors in the scenarios cancel out, and he suggests that the scenarios do result in emissions that are within the range of "not implausible" futures. But the shortcomings in the scenarios identified by Professor Tol do further underline our call for their thorough reassessment.

60. **In short, serious questions have been raised about the IPCC emissions scenarios, and—as we have already noted—a reappraisal of the scenarios exercise is urgently needed.**

Are the economic growth assumptions credible?

61. Table 1 indicates that world GDP is expected to grow at 2.2 to 3.0% p.a. in the IPCC scenarios. In his evidence to us, Professor Angus Maddison, a

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[57] Evidence from N. Nakicenovic (Vol II, pp 131-137)

[58] Evidence from R. Tol (Vol II, pp 66-77). See also R. Tol. *How Likely are the SRES Scenarios?* Hamburg University, 15 January 2005, mimeo.

leading expert on the historical record of the world economy, produced estimates of expected growth in the world economy up to 2030 which are consistent with a 3% growth rate. and with the historical record from 1900 to 1990[59]. However, we were interested to hear from Paul Johnson of HM Treasury that he found the high economic growth scenarios "relatively unlikely" and that "the 3% a year growth for 100 years is certainly extremely unprecedented"[60]. Table 1 shows data for historical growth rates taken from the work of Professor Maddison.

TABLE 1

Past economic growth rates for world and world regions

	1500 - 1820	1820 - 1870	1870 - 1913	1913 - 1950	1950 - 1973	1973 - 1998
W. Europe	0.4	1.6	2.1	1.2	4.8	2.1
USA	0.9	4.2	3.9	2.8	3.9	3.0
Japan	0.3	0.4	2.4	2.2	9.3	3.0
World	0.3	0.9	2.1	1.8	4.9	3.0
World	**1820 – 1998**		**2.2**			
World	**1870 – 1998**		**2.7**			
World	**1913 – 1998**		**3.0**			

Source: A. Maddison. The World Economy: A Millennial Perspective. Paris: OECD, P. 262

The issue of convergence

62. Convergence refers to the process whereby real per capita incomes in currently rich and poor countries are assumed gradually to converge over time. For this to happen, economic growth rates in the developing world must be faster than growth rates in the developed world. The greater the divergence in growth rates, the faster convergence occurs. Convergence matters for the emissions scenarios because it implies more rapid growth in the developing world, thus increasing emissions, at least in the first instance. The IPCC SRES aggregates national outputs using market exchange rates (MER), which we have already observed is incorrect. But, taking their own MER-based data, a 1990 ratio of 16.1 reduces to a maximum of 4.2 in 2100 (the A2 scenario) and a minimum of 1.5 (the A1FI scenario which is fossil-fuel intensive and with a near 3% growth rate). In other words, rapid convergence is assumed in all of the scenarios. In the A2 scenario, for example, incomes per capita rise at about 1% per annum for the OECD countries, but 2.3% in the developing world. In the A1B scenario, the respective rates are 1.6% and 4%[61]. In all scenarios, income per head in the developing world is well above income per head in the OECD countries today.

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[59] Evidence from A. Maddison (Vol II, pp 249-256). Professor Maddison's estimates suggest a world GDP of some $27 trillion in 1990 would grow to nearly $90 trillion in 2030. 1900 GDP was some $2 trillion, all at 1990 prices.

[60] Evidence from P. Johnson (Vol II, pp 151-156)

[61] N. Nakicenovic et al. *Special Report on Emissions Scenarios*. Cambridge: Cambridge University Press, 2000, p33.

63. **We consider the convergence assumptions in the IPCC sc narios to be open to some question.** In no case do they consider future ratios of income of currently rich to poor countries to be greater than four. Unfortunately, in the SRES these ratios are expressed in market exchange rate terms, so comparisons with the recent evidence shown in Table 2, which uses purchasing power parity exchange rates, cannot be made. Nonetheless, Table 2 does show recent convergence between Western Europe/USA and Asia. But for a scenario exercise to capture feasible futures, at least one scenario should explore the result of assuming that significantly less convergence occurs. In his evidence to us, Professor Tol suggested that scenarios in which limited convergence took place would be politically difficult for IPCC to contemplate, but the scenarios are meant to be based on reasonable scientific assumptions and should encompass realistic possibilities. **In our view, political factors should not be allowed to influence the scenarios, whether over the issue of convergence or indeed in any other context.**

TABLE 2

The historical record on convergence

	1870	1913	1950	1998
W. Europe/ Asia	3.8	5.8	7.9	**6.4**
USA/Asia	4.5	8.3	15.0	**9.3**
W. Europe/ Africa	4.7	6.3	**5.9**	13.7
USA/Africa	5.5	9.1	11.2	20.0
W. Europe/ L. America	3.0	2.4	**2.0**	3.2
USA/ L. America	3.5	3.5	3.7	4.7

Source: Computed from data in A. Maddison. *The World Economy: A Millennial Perspective.* Paris: OECD, p.264. W. Europe here excludes Portugal and Spain. Asia excludes Japan. Bold figures indicate an endpoint where some convergence has occurred.

PPP versus MER

64. As we noted above, much of the debate over the realism of the IPCC scenarios was stimulated by the original critiques of Professor Henderson and Mr Castles which focussed mainly, but not exclusively, on the choice of the proper exchange rates for aggregating world output ("Gross World Product"), and for expressing economic growth rates. Since these critiques, further contributions to the debate have appeared. We note in particular papers by Professor Richard Tol, Professors Alan Manne and Rich Richels,

Drs Alfsen and Holtsmark, and Professor Nordhaus[62]. We are encouraged to see that IPCC itself recognised the need to open the scenario exercise to more scrutiny by co-sponsoring an Expert Meeting on the scenarios in January 2005 in Washington DC. Several of the contributions we cite appeared at that conference.

65. Professor Nordhaus's paper to that conference seems to us to be especially important.

- First, he shows why using MERs is categorically the wrong procedure for aggregating world income. He remarks: "estimates of output or income at MER are simply wrong—they are constructed on an economically incorrect basis", and, "Incomes estimated at MER are fundamentally wrong because they use the price of a non-representative bundle of goods to compare the different countries"[63].
- Second, using a simple example of two countries, one with high prices of non-traded goods and one with low prices of non-traded goods[64], Professor Nordhaus demonstrates that the error in using MER can be very large compared to the use of correct PPP measures.
- Third, economic growth rates should also be computed using PPP data.
- Fourth, while PPP approaches are conceptually superior, there are some significant data problems with their use, but "it is likely that the PPP imprecision is small relative to the MER bias".
- How far the IPCC emissions scenarios are in error is an empirical issue because other factors influence the emission levels, notably what is assumed about carbon-intensity trends. In reviewing the available corrections to the IPCC scenarios, Professor Nordhaus finds some of them arguing for significant changes in emissions projections and other suggesting very little difference. In his view: "The jury is out on how much using PPP as compared to MER will affect aggregate emissions".
- Other potential errors in emission projection models, such as population and technological change assumptions, may be at least as important as the MER/PPP issue, and perhaps more so. We consider some of these other issues here.

66. We cannot of course infer that errors in the emissions projections translate into comparable errors in the projections of greenhouse gas concentrations and rates of warming. **In general, any change in emissions due to changed economic assumptions will translate into a smaller effect on**

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[62] R. Tol, Exchange rates and climate change: An application of FUND. *Climate Change*, forthcoming; K. Alfsen and B. Holtsmark. PPP correction of the IPCC emissions scenarios: Does it matter? *Climate Change*, forthcoming; A. Manne, R. Richels and J. Edmonds. Market exchange rates or purchasing power parity: does the choice make any difference to the climate debate? *Climate Change*, forthcoming. (This paper supersedes an earlier one: Market exchange rates or purchasing power parity: does the choice make a difference in the climate debate? www.stanford.edu/group/MERGE/marketEx.pdf.). W.Nordhaus, *Alternative Measures of Output in Global Economic-Environmental Models: Purchasing Power Parity or Market Exchange Rates?* Paper presented to IPCC Expert Meeting on Emission Scenarios, US Environmental Protection Agency, Washington DC, January 2005.

[63] W. Nordhaus, *Alternative Measures of Output in Global Economic-Environmental Models: Purchasing Power Parity or Market Exchange Rates?* Paper presented to IPCC Expert Meeting on Emission Scenarios, US Environmental Protection Agency, Washington DC, January 2005.

[64] "Non-traded" goods are goods that do not enter into international trade and hence do not have very similar prices.

concentrations and an even smaller effect on temperature. This in no way excuses poor analysis in the emissions scenarios, but it may mean that projections of warming are not themselves greatly affected. This is borne out by the models. Table 5 shows the results from the model of Manne and Richels.

TABLE 3

Effects of MER and PPP on emissions, concentrations and rates of warming

Base case	Total Carbon emissions in 2100 (billion tonnes carbon)	CO_2 concentrations (ppm)	Temperature change 2000 to 2100, °C
MER	21	731	+2.5
PPP	18	678	+2.4

67. The use of PPP does make a difference in emissions, by about 15%. But the variation in temperature is only 5%.

Are the emissions and concentrations trajectories plausible?

68. Many factors affect greenhouse gas emissions and atmospheric concentrations. Thus, even if the underlying assumptions about economic growth were correct in the IPCC SRES, a further test of reasonableness would be to compare projected and past emissions and atmospheric concentrations. In her evidence to us, Ms Rosemary Righter, Associate Editor of *The Times*, drew attention to the divergence between recent historical trends in CO_2 per capita emissions and CO_2 and CH_4 concentrations, and the high emission scenarios[65]. A similar point was made by Mr Martin Ågerup of the International Policy Network in his evidence[66]. Table 6 shows historical data on emissions. The table shows that, while emissions of CO_2 are increasing, the rate of global increase has fallen steadily since 1960. Similarly, per capita emissions are falling, not rising, and "carbon intensity"—carbon emissions divided by GDP—is also falling at a fairly constant rate. These changes in the past 30 years or so can be compared with the IPCC emissions scenario projections for 1990-2020. Table 4 shows that even the low emissions scenario (B1) has rates of growth of carbon emissions higher than the recent historical rates of change. **This suggests that the IPCC scenarios are not capturing recent experience in their short term projections.**

[65] Evidence from R. Righter (Vol II, pp 290-293). Ms Righter's evidence was partly based on an article she wrote in *The Times* of 15 February 2005. Ms Righter remarks in her evidence that she received no correspondence at all about this article, despite the fact that it showed the disparity between the IPCC high emission scenarios and historical evidence.

[66] Evidence from M. Ågerup (International Policy Network) (Vol II, pp 238-249)

TABLE 4

World emission trends and the IPCC scenario trends

	Average annual growth in CO2 emissions (excluding land-use change) % p.a.		Average annual growth in CO2 emissions per capita % p.a.	Average annual growth
1960-2000	2.3		+0.2	- 1.3
1970-2000	1.6		- 0.1	- 1.5
1980-2000	1.3		- 0.3	- 1.6
1990-2000	1.2		- 0.2	- 1.4
IPCC projections 1990 – 2020	A1F1 AIB A1T A2 B1 B2	2.1 2.4 1.7 2.0 1.7 1.4		

Note: The final row refers to the different scenarios produced by the IPCC.

69. Our simple analysis in Table 4 is borne out by more sophisticated work submitted to us by Professor Ross McKitrick of Guelph University in Canada[67]. Their analysis shows per capita emissions as a stationary constant at around 1.1 tonnes C per person on a global basis. They compute the implied per capita emission levels in the 40 IPCC scenarios and find that only seven of these scenarios remain in 2050 within even a wide margin of error relative to this current average emission level. Of course, assumptions about very rapid growth in emissions in developing economies could change this, i.e. scenarios can be constructed that assume a break between the time series for the past decades and the coming 100 years. But what cannot be justified is an assumption whereby most of the scenarios assume that break will happen. The work of McKitrick and his colleague Dr Mark Strazicich seems to us to point, once again, to the failure of the IPCC scenarios to be rooted in historical precedent.

The population projections

70. Table 5 compares the IPCC's assumption about population change in the main scenarios with historical growth rates and with the United Nations projections of world population. While the A1, B1 and B2 scenarios are seen to be consistent with official estimates, scenario A2 has a population growth rate more than 50% higher than the UN's medium variant population projection.

[67] Evidence from R. McKitrick (Vol II, pp 262-266)

TABLE 5

Population projections

	IPCC projections by scenario, billions			United Nations Projections, billions
	A1, B1	B2	A2	
World Population 2050	8.7	9.3	11.3	9.1 (range 7.7 to 10.3)
World Population 2100	7.0 - 7.1	10.4	15.1	9.1 (medium variant)
Implied growth rate, % p.a. 1990 – 2050 (1990 = 5.3 billion)	0.8	0.9	1.2	0.9 (range 0.6 to 1.1)

Source: IPCC projections from N. Nakicenovic et al. *Special Report on Emissions Scenarios.* Cambridge: Cambridge University Press, 2000, statistical annex. UN projections from www.unpopulation.org

Projecting global cooling effects

71. In discussing the science of global warming we noted that there are several agents with "negative forcing", i.e. factors which produce cooling rather than warming. A significant cooling agent is sulphate produced from sulphur dioxide emissions. The IPCC scenarios include these cooling effects. If the world cuts back on sulphur emissions in order to protect local environments and human health, then this reduces the extent to which these emissions inhibit warming. Hence warming scenarios are partly dependent on the assumed efforts the world makes in controlling such emissions. Our attention was drawn to a literature which debates this issue. One prominent study suggests that the IPCC SRES has an upwards bias in its upper-range temperature changes[68]. Much of this bias is due to the IPCC's optimistic assumption (from the point of view of local pollution control) about the extent to which sulphur emissions will be controlled.

Conclusions on the high emissions scenarios

72. **We received a significant amount of evidence on the realism of the IPCC emissions scenarios, and doubts were raised, particularly about the high emissions scenarios. The balance of this evidence suggests to us that the high emissions scenarios contained some questionable assumptions and outcomes.** First, they may not be consistent with trends over the past 25 years. Total emissions are indeed increasing, but the rates of increase have slowed significantly, as has the carbon-intensity of the world economy. Second, it also seems wrong to attach equal credibility to the scenarios in general and we believe the IPCC is now working on this issue. Third, high economic growth of around 3% per annum for the world economy is not unprecedented, but the Treasury indicated in their evidence to us that they thought growth of this magnitude over the next 100 years is unlikely[69]. Fourth, the assumptions made by IPCC about the rate of convergence in per capita incomes, which affect the projections of greenhouse gas emissions, should at least embody less optimistic

[68] M. Webster et al. Uncertainty in emissions projections for climate models. *Atmospheric Environment*, 36, 2002, 3059-3670.

[69] Evidence from P. Johnson (Vol II, pp 151-156)

assumptions. Political considerations should not be allowed to cloud what should be a scientific procedure in constructing the scenarios. Fifth, population projections in some of the high emission scenarios seem to us to be unrealistic. Sixth, there may also be some questions about underestimating the cooling effects of sulphur. Finally, while we acknowledge Professor Nordhaus's judgement that "the jury is still out" on the extent to which PPP conversion rather than MER conversions will affect emissions predictions, several critiques show that predictions could be significantly affected by the use of PPP exchange rates. PPP is the right procedure, as Professor Nordhaus's study amply clarifies. **While such errors do not translate into equal magnitude errors in concentrations or warming, it seems to us important that the IPCC emissions modellers give serious attention to adopting the correct procedures.**

CHAPTER 5: THE COSTS OF TACKLING CLIMATE CHANGE

73. If the costs of tackling climate change are small, then a cautious approach to decision-making in the face of uncertainty would dictate that those costs should be incurred as an insurance against the chances of the worst effects of global warming occurring. But the costs of tackling global warming may be large. Moreover, those costs will largely be borne by the current generations, while the benefits will accrue to generations yet to come, who are projected to be significantly wealthier and technologically more advanced. **Hence it is very important that a realistic picture of the likely costs be conveyed to, and understood by, people today who will have to pay them. We note the considerable efforts that the IPCC has made in constructing likely cost estimates for the world as a whole. We are far less satisfied with the data currently available on the costs to the United Kingdom, and we call for a significantly greater effort to clarify and estimate those costs.**

74. We heard evidence on costs and we were interested to note the different ways in which this cost information was conveyed. We therefore outline below our own understanding of the cost data.

Global costs

75. We acknowledge that estimating abatement (or "mitigation") costs is very complex. First, costs are lower if the world in general adopts the lowest cost emission-reduction technologies first and the highest cost technologies last—but we have no guarantee the world will behave that way. Costs are estimated in different ways. Usually they are based on the direct costs of the technologies, e.g. the cost of building a nuclear power station. But many other kinds of costs are involved and technology costs do not necessarily correspond with the correct concept of cost which is measured by the "welfare" losses incurred to consumers and producers. Costs can vary considerably, depending on how compliance policies are introduced. For example, market-based instruments, such as carbon taxes and tradable permits, are thought to have lower compliance costs than simply telling emitters what technology to use ("command and control"). It is for this reason that so much emphasis is being placed on the newer policies such as permit trading systems. Many economists believe that costs will be lower than anticipated because emitters will find new technologies and the cheaper ways of overcoming compliance problems: climate regulation may "force" innovation[70]. But others believe that there are many hidden costs in regulation, so that actual costs may prove to be higher than estimated. For all these reasons, and others, we would expect wide variations in the estimates of the costs of control.

76. Integrated Assessment Models (IAMs), in which simplified climate models are combined with economic models of the world economy, produce estimates of costs. As one would expect, as the target for atmospheric CO_2-equivalent concentrations gets tougher and tougher, so not only the total costs of meeting those targets rise, but so do the incremental costs (the "marginal" cost). In a very interesting diagram, the IPCC *Synthesis Report*

[70] In the business literature this tends to be known as the "Porter hypothesis", after Professor Michael Porter.

2001 tries to bring together the cost estimates of several of the IAMs, and links them with emissions reductions and atmospheric concentrations. Table 6 shows the IPCC estimates converted to an "annual" form and with some adjustments to current year prices and using a lower discount rate than that used by IPCC.

TABLE 6

Costs to the world of achieving the 550 ppm target, expressed in annual terms, $2005 prices, per annum

Present value of cost $2005 prices, trillion	Annual cost at 3%, borne in first 50 years, billion	Annual cost at 3%, borne in first 20 years, billion
2	78	134
17	661	1141

Notes: For 50 years at 3% divide the present value by 25.7. For 20 years, divide by 14.9. The above figures are therefore annuities derived from the present values. Present values taken from R. Watson et al. *Climate Change 2001: Synthesis Report.* Cambridge: Cambridge University Press. 2001. Figure 7.3

77. Table 6 suggests that getting to the 550 ppm level may cost the equivalent of $2 trillion to $17 trillion in present value terms, i.e. equivalent of spending this sum of money once and for all today[71]. Expressed, more meaningfully, as an annual flow, the sums are $78 billion to $1141 billion per annum. To get some idea of these sums, the world's annual GNP is currently about $35 trillion. Annual expenditures would therefore be 0.2 to 3.2% of annual current income. Unless "Kyoto plus" agreements extend to developing countries, these costs would be borne by the richer nations of the world alone, suggesting that the burden would rise to 0.3 to 4.5% of their annual current income. However, in both cases, world income would be growing. For example, if the world economy grows at 2% per annum, then the "worst case" level of costs (assuming all costs are borne in the next 20 years) would fall to some 2.3% of world income in 2035. If the costs are spread out over 50 years, the fraction would fall to 1.3% of world income.

World costs per tonne carbon

78. While Table 6 shows costs in formats that convey an overall picture of the likely cost burden to current generations, expressing these costs as an average cost of removing carbon is also useful. Indeed, we show in Chapter 6 why such figures are needed for a comparison with the damage done by carbon emissions in a cost-benefit framework. Table 7 shows our attempt to translate the figures into costs per tonne of carbon. While the IPCC *Synthesis Report* shows these costs as rising at an increasing rate per unit of change in CO_2 concentrations, the resulting figures in terms of costs per tonne of carbon emissions reduced do not show this pattern[72].

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[71] For comparison, Professor Nordhaus of Yale University has suggested that the cost of achieving the Kyoto Protocol targets (inclusive of US participation), and assuming the emissions levels in 2010 are sustained through 2100, would be some $3 trillion (in 2005 prices). See W. Nordhaus, Global warming economics. *Science,* 294, 9 November 2001, 1283-4

[72] This is rather counter-intuitive and we have been unable to determine why. There is a question arising as to why the incremental costs first go down and then up.

TABLE 7

World costs expressed in $ per tonne carbon

Concentration target (ppm)	Cumulative emissions, billion tC	Incremental reduction in emissions billion tC	Incremental cost at 3% discount rate $2005, trillion		Incremental cost per tC $2005	
			MERGE	FUND	MERGE	FUND
750	1348	-	0.7	0.0	-	-
650	1239	109	2.0	8.7	18.3	79.8
550	1043	196	3.5	8.7	18.3	44.4
450	714	329	4.3	19.5	13.1	59.3

Column 1 shows the various concentration targets. Column 2 shows the cumulative emissions corresponding to those targets. Column 3 shows the change in emissions, i.e. the emission reductions, needed to secure targets of 650 ppm or less. Column 4 shows the total worldwide cost of achieving these reductions, according to two different Integrated Assessment Models – MERGE and FUND. The final column shows this cost expressed per tonne of carbon reduced.

79. The "cost per tonne of carbon" for the 550 ppm target is thus embraced by figures like $18 to $80 tC, or about £10 to £44 tC.

Conclusions on world costs

80. We conclude that there are several ways of presenting global costs of controlling emissions so as to achieve a long run goal of atmospheric concentrations of 550 ppm. In present value terms—akin to a "one off" payment—the sums are anything from $2 trillion to $17 trillion. In annuitised form—the present value expressed as an annual payment—the range is $80 billion to $1100 billion per annum, assuming these costs are borne in the first 20 to 50 years. In terms of cost per tonne of carbon removed or avoided, the figures range from $18 to $80 tC.

The technologies to tackle climate change

81. A key issue is the range of the technologies that are available to tackle climate change. It is clear to us that there is no shortage of innovations available. The more important issue is their cost and the capacity to diffuse them at a rapid rate in the world economy. Professor Dennis Anderson of Imperial College London was especially helpful in providing cost information on the likely candidates[73]. His data are presented in Table 8.

[73] Supplementary evidence from D. Anderson (Vol II, pp 147-150)

TABLE 8

Illustrative costs of emissions-reducing technologies

Technology	Marker	Cost unit	Cost of Marker	Cost of Substitute	Net cost
Near term estimate (10 years time)					
Nuclear	NG/CC	c/kWh	3.5	6.0	2.5
Hydrogen from coal or gas + CCS	NG	$/GJ	4.0	8.0	4.0
Electricity from fossil fuels + CCS	NG/CC	c/kWh	3.5	5.0	1.5
Wind	NG/CC	c/kWh	3.5	5.0	1.5
Photovoltaic (solar input = 2000kWh/m^2)	Grid electy.	c/kWh	10.0	15.0	5.0
Biofuels	Petrol	$/GJ	12.0	15.0	3.0
Distributed generation	Grid electy.	c/kWh	10.0	15.0	5.0
Long term estimate:					
Nuclear	NG/CC	c/kWh	4.0	5.0	1.0
Hydrogen from coal or gas + CCS	NG	$/GJ	5.0	10.0	5.0
Electrolytic Hydrogen (onsite & distributed)	NG (distributed)	$/GJ	10.0	30.0	20.0
Electricity from fossil fuels + CCS	NG/CC	c/kWh	4.0	6.0	2.0
Wind	NG/CC	c/kWh	4.0	6.0	2.0
Photovoltaic (solar input = 2000kWh/m^2) [b/]	Grid electy.	c/kWh	10.0	8.0	-2.0
Biofuels	Petrol	$/GJ	12.0	15.0	3.0
Distributed generation	Grid electy.	c/kWh	10.0	10.0	0.0

Source: Professor Dennis Anderson, Imperial College London. Notes: NG = natural gas; NG/CC is natural gas - combined cycle power plant; CCS is carbon capture and geological storage; GJ = gigajoule; kWh = kilowatt hour; c = US cents

82. Table 8 expresses the costs of carbon-reducing technologies relative to a "marker", i.e. the technology that would be displaced by the "new" technology. In the longer term, the costs remain above the marker technologies by the same margin other than for solar photovoltaic in regions where there is fairly high levels of sunlight. The fact that the costs of most of these technologies remain above the current technologies means that the present free (or, rather, quasi-regulated) market will not bring about their natural substitution. That substitution must be managed, first by judging whether the extra costs of these technologies is smaller or greater than the money value of the environmental benefits they bring, and second, by designing incentive systems to accelerate the diffusion of these technologies.

The former is an exercise in cost-benefit analysis, the second is an exercise in designing market-based environmental policies such as carbon taxes and tradable permit schemes, or of government directly sponsoring the required R & D. Professor Anderson also argued that, once incentives are in place, they will in turn accelerate the process whereby unit costs are reduced[74].

83. **Given the wide array of potential technologies in Professor Anderson's list, we are surprised that the Government's *Energy White Paper*[75] should place such emphasis on just one technology, wind energy.** (There is also a debatable assumption about the likelihood of pervasive energy efficiency gains.) It is one of the technologies with a low excess cost burden over the marker technologies. Also, Professor Anderson's table relates to the global picture, not just the United Kingdom. Nonetheless, we would have preferred a wider vision in the White Paper. Dr Dieter Helm of Oxford University noted that, whereas the R & D budget in the US embraced the "big" technologies such as linked coal and hydrogen, the UK research programme has been "captured" by certain renewable technology interests[76].

84. Finally, we note the position of (conventional) nuclear power in Table 8. It is well known that nuclear power carries an excess cost penalty at the moment. Indeed, this is why British Energy has experienced such financial difficulties with the current electricity market. But Table 8 suggests that this excess penalty will be reduced significantly over time. **In our view, it would be unwise to close the nuclear energy option. It is prudent to maintain as wide an energy portfolio as possible. We argue that the current capacity of nuclear power, before further decommissioning occurs, should be retained.**

85. Additionally, there are serious doubts about the extent to which energy efficiency and wind energy can get the country on to a trajectory of emissions consistent with the 60% target. As Dr Helm indicated to us, such a policy is heavily reliant on "picking winners" among the technology options. We are not confident that the Government, indeed any government, can be so sure of the effectiveness of the technologies they choose to back. It is far better that government sets the goal and the price signals to achieve that goal, leaving the market to select the technologies and their rate of diffusion through the economy.

Costs to the United Kingdom

86. Estimating the costs to the United Kingdom for the UK's own programme is not straightforward. Indeed, this appears to us to be a point of criticism—government estimates of cost are unhelpfully vague for something as important as climate control. However, the Government's long run target of 60% reduction in CO_2 emissions by 2050 is supposed to be geared to the 550 ppm target since it assumes that "others" act likewise. According to the Department of Trade and Industry, the cost of this target is assumed to be between £10 billion and £42 billion in 2050, with an assumption that costs

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[74] Evidence from D. Anderson (Vol II, pp 137-150)

[75] Our energy future—creating a low carbon economy, February 2003

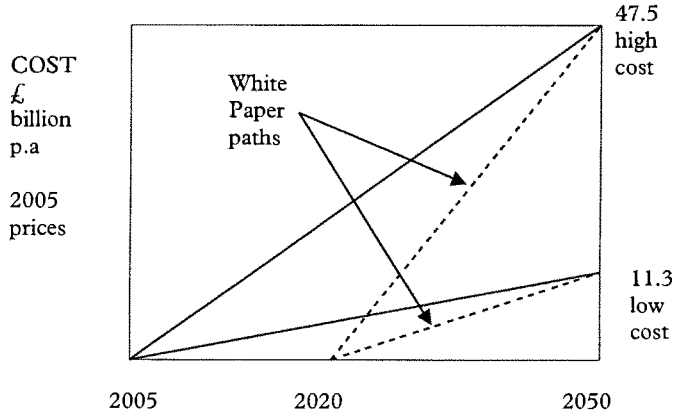
[76] Evidence from D. Helm (Vol II, pp 87-95). In his evidence (Vol II, pp 96-106), Sir David King was particularly keen on the development of nuclear fusion. However, it seems to us that this technology remains a distant prospect and we have discounted it in our analysis.

up to 2020 are "negligible" because the emission reductions are secured by energy efficiency. The evidence presented to us by Dr Dieter Helm suggests that this latter assumption is wildly optimistic. Indeed, we detect signs that the Government is aware that its *Energy White Paper* embodies very optimistic assumptions about the exclusive roles afforded to energy efficiency and renewable energy to achieve this long run target[77]. In an effort to prompt better and clearer estimates from the Government, Table 9 below presents our best guesses of the costs to the UK.

87. Figure 1 presents a very stylised picture of our assumptions. The dashed lines represent the DTI's assumption of zero cost to 2020 and rising costs thereafter. The continuous lines represent our assumption that costs begin now, as indeed they must have done through the current climate action programme.

FIGURE 1

Stylised cost trajectories for the UK



88. The trajectories encompass the DTI's optimistic assumptions about energy efficiency and a more pessimistic scenario (not subscribed to by the Government) in which the costs are incurred immediately, i.e. before 2020 which is when the White Paper assumes costs begin to rise.

[77] Our energy future—creating a low carbon economy, February 2003

TABLE 9

Possible costs for UK 60% target, present values and annuities

End point costs in 2050 p.a. £ billion, 2005 prices	Present value of costs at 3% discount rate, 2005 prices, £ billion	
	DTI path, positive costs starting in 2020	Pessimistic case, positive costs start in 2005
11.3	63	94
47.5	265	398
	Annualised costs 2005-2050 at 3% discount rate, 2005 prices, £ billion	
11.3	2.6	3.8
47.5	10.8	16.2

Source: EAC estimates

89. Table 9 suggests that the UK faces "one-off" costs equal to £60 to £400 billion, or an annual cost burden of £3 to £16 billion per year for nearly the next 50 years. This annual cost would be higher still if we assumed the cost burden has to be met in the next 20 years. In supplementary evidence, Defra advised us that the marginal control costs (the costs of reducing additional tonnes of greenhouse gases[78]) for the UK might lie in the range £25 - £150 tC in 2030, and £300 - £600 tC in 2050[79]. However, even the 2030 estimates could be understatements if energy efficiency does not progress as fast as assumed. Equally, widespread emissions trading schemes for greenhouse gases could lower these costs.

90. We acknowledge the rough and ready nature of our cost estimates for the UK's long term target of 60% reduction in CO_2 emissions by 2050, but the fact that we can only produce such figures arises from the poor information embodied in the *Energy White Paper* and elsewhere. We urge the DTI and the Treasury to produce more detailed estimates of these costs. Moreover, the cost trajectories should show sensitivity to the serious doubts over the White Paper assumptions about the roles of renewable energy and energy efficiency.

Costs of meeting UK goals as a percentage of GNP

91. Several of our witnesses conveyed their view that the costs of control to the United Kingdom are trivial. They expressed costs as a fraction of anticipated GNP. For example, if GNP grows at 2% for the next 45 years, it would be 2.4 times the current GNP in 2050. Currently, UK GNP is £1.16 trillion. In 2050 it would therefore be £2.8 trillion. If we take the "high" DTI figure of £47.5 billion climate change control cost in 2050, this is 1.7% of GNP. If we take the low figure, it is 0.4% of 2050 GNP. We doubt if this way of expressing cost will convey information in a comprehensible manner to more than an expert audience, but we accept that "benchmarking" costs on GNP is useful. However, fractions like 0.4 to 1.7% of GNP are not trivial. If this benchmarking approach is to be used, it is appropriate to relate it to other costs. For example, even the lower end of the range exceeds the current international development budget in the UK.

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[78] The cost estimates in Table 9 are annual averages, not marginal costs.

[79] Evidence from Defra (Vol II, pp 107-130)

92. Other witnesses adopted a variant of the GNP benchmarking approach and asked what climate change controls will do by way of reducing UK economic growth rates. It was put to us that instead of growing at an average of 2% per annum for the next 45 years, the UK would grow at 1.95% to 1.99%, a barely perceptible difference. The temptation is to conclude that such changes in growth rates are trivial compared to the rewards of avoiding the worst impacts of climate change. But we regard this manner of presenting cost data as sleight of hand. It has to be recalled first that the UK climate target only has meaning if all other countries adopt the same course. If they do not, then the UK will have undertaken unilateral action to no purpose. Hence the "return" secured by the UK from pursuing its long run target is highly uncertain. But, in any case, no other item of government expenditure is treated this way. If it was, it would be easy to justify almost any large scale item of public expenditure. We were therefore surprised to see this approach being quoted by Defra in their supplementary evidence to us on costs. We think it important to avoid the deception embodied in the "change in the rate of growth" approach.

93. Finally, we note that the Government uses the MARKAL model to estimate the costs of meeting various emission targets. The use of this model was noted approvingly by Professor Paul Ekins of the Policy Studies Institute[80]. But Dr Dieter Helm of Oxford University was scathing in his criticism of the model which he characterised as "garbage in, garbage out"[81]. Dr Helm's criticisms centre on both the nature of the model and the assumptions built into it about the costs of energy efficiency and the costs of renewable energy. He argued that both these costs are understated by the Government and hence MARKAL produces the answer that the costs to the UK of meeting the 60% target are similarly low. If Dr Helm is right, then even our estimates in Table 9 are likely to be understatements of the true cost.

94. **We are concerned that UK energy and climate policy appears to rest on a very debatable model of the energy-economic system and on dubious assumptions about the costs of meeting the long run 60% target. We call on DTI and the Treasury to improve substantially (a) the cost estimates being conveyed to the public and (b) the manner of their presentation.** Without these improvements we do not see how the Government can argue that it has adequately appraised its long-term climate targets in terms of likely costs and benefits. Indeed, in our examination of the witness from the Treasury, it was clear to us that no such cost-benefit analysis exists in substantial form. **We believe that the Treasury should be more active in scrutinising and publicising these costs and benefits, in association with Defra and DTI.**

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80 Evidence from P. Ekins (Vol II, pp 178-196)

81 Evidence from D. Helm (Vol II, pp 87-95)

CHAPTER 6: THE BENEFITS OF CLIMATE CHANGE CONTROL

95. In Chapter 3 we outlined the likely impacts of climate change. We noted that there is considerable uncertainty about these impacts and when they might occur. We also noted that some of them will be reduced in terms of impact because of automatic ("autonomous") and managed adaptation. We urged that more attention be given to adaptation strategies in the face of realistic risks that the world will not act fast enough or on a sufficient scale to prevent impacts occurring. But other impacts are not subject to adaptation and this will be especially true for the low probability but singular irreversible events such as reversal of the thermohaline current. While impacts can be expressed in terms of individual events and their probable magnitude, it remains the case that some overall summary indicator is needed. Chapter 3 briefly investigated the estimates of "population at risk". But, ideally from a policy standpoint, the relevant indicator should bear comparison with the costs of control. This is why the monetised benefits of control are attractive indicators, however difficult they are to produce. We turn to the evidence on monetised benefits.

Estimates of monetised damage from warming

96. Economists have estimated the monetary impact of global warming. These estimates are very uncertain, but uncertainty cannot be an argument for ignoring the estimates, since the same uncertainty exists for any other "metric" that might be used to measure these damages. Moreover, if a money metric is not used, it is possible only to conduct cost-effectiveness analysis rather than cost-benefit analysis. In cost-effectiveness analysis the measures of impact reduction arising from warming control are expressed in diverse units or in units such as change in population-at-risk. If the units of damage reduction (i.e. benefit) are not the same as the units for cost, it is not possible to say if a given level of expenditure on warming control is justified.

97. Table 10 summarises available estimates of the money value of the damage done by global warming. Care has to be taken to interpret the numbers. The Integrated Assessment Models used to get these estimates use different assumptions about the level of temperature change, so one has to be careful to compare like with like. The models vary according to the level of adaptation to warming that they assume. The estimates of Professor Mendelsohn, for example, contain a lot of adaptation. The early IPCC estimates (which date from 1995) assume hardly any adaptation. The figures are "benchmark" estimates. If the science of warming is correct, warming does not stop at the temperature increases used in the models. So one would see damages carrying on rising. The convention in the studies is that damages are expressed as a percentage of current world GNP. So long as GNP keeps growing, those same damages expressed as a percentage of future GNP would be much lower. Only the Mendelsohn estimates relate damage to future GNP. Damages can be expressed in different ways. For example, to get a global figure, one might weight the damages in each region by regional output or population. Similarly, damages might be "equity weighted" as explained to us by Professor Richard Tol of Hamburg University[82] and

[82] Evidence from R. Tol (Vol II, pp 66-77)

Dr Chris Hope of Cambridge University[83]. Equity weighting attaches a higher weight to damages borne by low income countries in order to reflect that these damages will assume a bigger proportion of their incomes than will damages to richer people.

98. So, if we take, say, the Nordhaus estimates, these tell us that for a +2.5°C warming one might expect to see global damage amounting to 1.5-1.9% of world GNP. However, in Africa that impact might be closer to 4% and in India 5%. The scale of the aggregate impacts reflects (a) the geographical incidence of warming and associated weather events, (b) the variable vulnerability of the economies of developing nations to these impacts, and (c) the smaller GNP of the relevant countries. Finally, Table 10 shows estimates for damages only. Controlling climate change will avoid some (not all) of these damages, but it may also bring other benefits known as "ancillary benefits". For example, if CO_2 emissions are controlled through traffic restraint, then congestion might ease and there will be benefits from the reduced congestion, better local air quality, and so on. It is generally accepted, though not by all economists, that these ancillary benefits can be added to the reduced global warming damages when conducting a cost-benefit analysis. Moreover, there will be some additional costs too, due to the dynamic effects of diverting expenditures towards climate control and away from other uses of resources.

99. **Table 10 suggests that, in terms of percentages of world GNP, damage is relatively low, even for +2.5°C. The damages are not evenly spread. In general, developing countries lose more than developed economies. Some models suggest no real net damage to rich countries.**

[83] Evidence from C. Hope (Vol II, pp 24-35)

TABLE 10

Damages as % of regional and world GNP

Region	IPCC 1995 +2.5°C	Mendelsohn et al 2000 +2.5°C	Nordhaus and Boyer 2000 +2.5°C	Tol 1999 +1.0°C
N America USA		- 0.3	+ 0.5	-3.4
W Europe EU			+ 2.8	-3.7
OECD Pacific Japan		+ 0.1	+ 0.5	-1.0
FSU E. Europe Russia		-11.1	+ 0.7 - 0.7	-2.0
Mid East			+ 2.0	-1.1
L America Brazil		+ 1.4		+ 0.1
S Asia India		+ 2.0	+ 4.9	+ 1.7
China		-1.8	+ 0.2	-2.1
Africa			+ 3.9	+ 4.1
All developed countries		0.0		
All developing counties		+ 0.2		
World – output Weighted	+1.5 to + 2.0	- 0.1	+ 1.5	- 2.3
World – population weighted			+ 1.9	+ 2.7
World – equity weighted				- 0.2

100. The monetised estimates do not seem to be consistent with the more alarming pictures of global warming damage painted in much of the scientific literature. However, only crude efforts are made in some of the models to account for impacts such as thermohaline reversal etc. Most of the models make no effort to account for large-scale singular events. The estimates are also benchmarked on a doubling of CO_2 concentrations relative to pre-industrial levels, i.e. on approximately 550 ppm. Damages will be larger if concentrations are permitted to go beyond this level. Finally, average world damages conceal the bias in the damages towards developing countries. Rich countries may still wish to act to prevent damage to these countries even if they might suffer little damage themselves.

101. **The evidence presented to us indicates that these estimates of monetised damage are highly controversial within IPCC deliberations.** Indeed, we note that in the 1995 Second Assessment Report, damages and benefits were afforded a separate chapter in the report of Working Group III. In the Third Assessment Report of 2001 the monetary estimates are confined to a sub-section of Chapter 19 of the report of Working Group II. That chapter is intended to be a summary of other chapters, but the monetary damage estimates are introduced there for the

first time. Moreover, there is no discussion at all of the estimates in the 2001 IPCC *Synthesis Report*. It appears to us that the IPCC has made a conscious effort to downplay the economic approach to measuring damages. We acknowledge, as does IPCC, that these estimates are uncertain. But it is hard to justify the minimal discussion of the estimates on this basis since all the IPCC Reports contain detailed discussions of various non-monetised impacts that must be equally uncertain. **We urge the Government to press the IPCC for a proper detailing of the estimates and a discussion of the uncertainties in the next IPCC Assessment Report in 2007.** Brief inspection of the plans for that report does not provide encouragement. According to the outline on the IPCC's website, there is to be no discussion at all in 2007 of the "integrated assessment" models and the estimates of damage costs are given even less space (in Chapter 20 of WGII and Chapter 2 of WGIII).

102. In his evidence to us, Dr Terry Barker of Cambridge University confirmed that some past controversies on monetary valuation have made the IPCC nervous of monetised damage estimates. In particular, he noted that monetised values of "human life"—more strictly, what people are willing to pay to reduce risks to life and limb—were widely criticised[84]. We can see why such procedures would appear controversial, especially as "willingness to pay" will be constrained by income, making the life of someone in a poor country appear less "important" than a life in a rich country. But placing money values on life risks is in fact commonplace, and is part of the Government's approach to cost-benefit appraisal of regulations and of major investments in transport and in health and safety. No government treats life risks as if they should be zero. Hence costs and risks are traded off on a regular basis. If the argument is not about monetising the risks but about the inequality of the valuations used, then it is possible to have more sympathy. But the procedures for "equity weighting" described above go a long way to correct this basis in the use of a willingness-to-pay metric. Whatever the rights and wrongs of these arguments, we are concerned that, by trying to avoid controversy, the IPCC is not facing up to the realities of making choices. If nothing else, economics forces those choices into the open.

The social cost of carbon

103. A very convenient way of summarising the money value of the damage done by warming is to compute the extra damage done to the world as a whole from one extra tonne of carbon released now. In the economist's language, this is the "marginal damage" from emissions. It has also come to be known as the "social cost of carbon" (SCC). Defra currently has an "official" guide value for SCC of £70 tC, but with a range of £35-140 tC. This was based on an earlier review of the integrated assessment models. In 2004 Defra instituted a review of these estimates, culminating in two consultancy reports in 2005 which have yet to be finally reviewed and released. Since these estimates of the SCC are derived from the monetised values of damages, they are just as subject to issues of uncertainty, equity weighting, discounting, and so on.

104. We applaud Defra and the Treasury for pursuing a consensus view of the size of the SCC. Failure to arrive at such a number (or range of numbers)

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[84] Evidence from T. Barker (Vol II, pp 78-86).

encourages misallocation of resources between government departments, and this has been the driving force behind finding an agreed SCC. Moreover, SCC estimates can be compared directly with the marginal costs of abatement discussed in Chapter 5[85]. If the SCC exceeds the marginal costs of control, then, *prima facie*, the climate target being considered is too strict. If the SCC is less than the marginal cost of control, there is scope for making the target stricter. Effectively, these comparisons amount to conducting a cost-benefit analysis[86]. It seems to us that this is exactly the kind of exercise that Defra and the Treasury should be conducting in their climate policy appraisal, whether it is the Kyoto Protocol targets, the long-term 60% target, or any of the mechanisms being used to meet these targets—such as the Renewables Obligation or adoption of windpower. Dr Helm made it clear that he thought these policies would not pass a cost-benefit test if this comparison was made[87].

Conclusions on benefit estimates

105. **While we agree with others that the monetised benefit estimates for controlling global warming are uncertain, we are concerned that the IPCC appears to be playing down these estimates in favour of often detailed descriptions of individual impacts that cannot be brought into comparison with the likely costs of control. Perhaps one reason for this lack of emphasis is that the economic measures of damage give the impression that the benefits of warming control are smaller relative to the costs.** But whatever the outcome of a comparison of costs and benefits, such a comparison needs to be made. Not providing it conveys the impression of a partial approach to the economics of climate change. It is imperative that the damages from greenhouse gas emissions be spelled out in monetary terms so that the public and government can better appreciate the trade-off between current sacrifices and future benefits from emissions control. **We urge that explicit comparisons be made between the monetary cost of adaptation measures and their benefits. While we were reassured by Defra that they would be pressing for a higher profile for the economics in the IPCC's Fourth Assessment Report, we consider that the Treasury has a duty to reinforce Defra's intent. Indeed, given the potential importance of this issue, both in terms of public expenditure and of overall economic cost, the Treasury should become directly involved itself, making its own economic assessment of the issue.**

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85 Marginal benefits are the same as the SCC avoided.

86 As noted previously, one might want to add the (marginal) ancillary benefits of control to the SCC to derive an overall marginal benefit of control. This would then be compared to the marginal cost of control.

87 Evidence from D. Helm (Vol II, pp 87-95)

CHAPTER 7: THE IPCC PROCESS

106. In the previous chapters we have several times referred to some limitations in the IPCC process. This process is an international one involving all governments and hundreds if not thousands of experts. Inevitably, in such a large-scale venture there will be weaknesses and errors. But the stakes are high and it is imperative that the process is an open one, capable of receiving criticism, and insistent on the highest standards of scientific and economic procedures. While HM Government and the many UK experts comprise just one collective player in the IPCC process, it is important that they are vigilant in ensuring that any errors and defects are brought to the attention of the IPCC and the scientific community in general. In this chapter we elaborate on our previous concerns and introduce some others.

The Special Report on Emissions Scenarios

107. In Chapter 4 we listed a number of criticisms of the IPCC Special Report on Emissions Scenarios (SRES). We noted that the original criticisms advanced by Professor David Henderson and Mr Ian Castles on the use of market exchange rates in aggregating world income has generated a much broader literature that questions (a) the credibility of the IPCC high emissions scenarios, and (b) the relevance of purchasing power parity exchange rate conversions. Whatever the resulting outcomes of making the scenario exercise more robust, it is clear to us that IPCC does need to reconsider its SRES exercise. This requires more than making allowance for new data, which Dr Nakicenovic told us would figure in the 2007 exercise[88]. We urge the IPCC to go beyond making adjustments for improved data. There is a need to reconsider the economic basis on which the scenarios are constructed.

108. In terms of process, we heard from several witnesses that the IPCC SRES exercise does not reflect the most appropriate expertise. While there are some national accounts statisticians involved in the exercise, it seems to us that a broader representation from the economics and statistics community is called for, along with a perspective from economic historians. The failure to take adequate account of the consistency between projections and past experience is a case in point, and an issue that was raised early on by Professor Henderson and Mr Castles, and again by Professor Tol and by Professor Ross McKitrick in their evidence to us[89].

The policy-makers' summaries

109. The IPCC main reports of Working Groups I to III consist of detailed technical chapters. Each chapter then has a "policy-makers summary" designed for those who need a fairly rapid guide to what the technical chapter has said. But there is a stark contrast in the way the technical chapter and the summary are written. The former is written by lead authors who in turn have a team of experts who make inputs to that chapter. The latter may be written by the same authors but is scrutinised in detail by government representatives to the IPCC meetings. As Dr Barker put it to us:

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[88] Evidence from N. Nakicenovic (Vol II, pp 131-137)

[89] See, for instance, evidence from R. Tol (Vol II, pp 69-77)

"governments...do have a say in the Summary for Policy Makers [which is] taken extremely seriously by governments, and it is a line-by-line acceptance, and each word can count, and the process can actually collapse if governments will not accept a particular phrasing, a particular word".

110. Dr Barker went on to say that government representatives can be very sensitive to some issues. For example, wording that suggests costs of control are large might upset governments whose policy stance is based on the view that costs are small and easily bearable. Dr Barker concluded that:

"...what happens is that there is a political process which uses words which can have different meanings for different people and the outcome is a Summary for Policy Makers that everybody will sign up to"[90].

111. **We can see no justification for this procedure. Indeed, it strikes us as opening the way for climate science and economics to be determined, at least in part, by political requirements rather than by the evidence. Sound science cannot emerge from an unsound process.**

112. We sought examples of the kind of problem that has arisen because of such interference in what should be a scientific process. Examples were not hard to find. In the 1995 Second Assessment Report, the Summary of Chapter 6 on *The Social Costs of Climate Change* bears little resemblance to the technical chapter it is supposed to summarise. Indeed, the lead authors of that chapter disowned the Summary. In the 2001 Working Group II Report our attention was drawn to the following statement in the *Summary for Policymakers* (p.8):

"Benefits and costs of climate change effects have been estimated in monetary terms and aggregated to national, regional and global scales. These estimates generally exclude the effects of changes in climate variability and extremes, do not account for the effects of different rates of change, and only partially account for impacts on goods and services that are not traded in markets. *These omissions are likely to result in underestimates of economic losses and overestimates of economic gains* [from climate change]"(our emphasis).

113. Chapter 19 (p.942), on which the Summary quotation above is supposedly based, actually says:

"Overall, the current generation of aggregate estimates may understate the true cost of climate change because they tend to ignore extreme weather events, underestimate the compounding effect of multiple stresses, and ignore the costs of transition and learning. *However, studies also may have overlooked positive impacts of climate change. Our current understanding of (future) adaptive capacity, particularly in developing countries, is too limited, and the treatment of adaptation in current studies is too varied, to allow a firm conclusion about the direction of the estimation bias*" (our emphasis).

114. **In short, the Summary says that economic studies underestimate damage, whereas the chapter says the direction of the bias is not known.**

IPCC and scientific expertise

115. Given the global scale of the IPCC process, it should be expected that it will attract the best experts. In his evidence to us, Professor Paul Reiter raised

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[90] Evidence from T. Barker (Vol II, pp 78-86)

doubts about the extent to which this is the case[91]. He refers to the Second Assessment Report of Working Group II in 1995, Chapter 18 of which is concerned with human health impacts of warming. A significant part of this chapter discussed malaria. Yet, according to Professor Reiter, none of the lead authors had ever written a paper on malaria, the chapter contained serious errors of fact, and at least one of the chapter's authors continues to make claims about warming and malaria that cannot be substantiated. Professor Reiter's concerns extend to the same chapter in the Third Assessment Report of 2001, where he was initially a contributory author. While he expresses far more confidence in this chapter than the equivalent one in the Second Assessment Report, Professor Reiter notes that "the dominant message was that climate change will result in a marked increase in vector-borne disease, and that this may already be happening". In Professor Reiter's view, no such conclusion is warranted by the evidence, and he speaks as a malaria specialist of more than thirty years' experience. While nominated by the US Government to serve on the comparable group for the Fourth Assessment Report, the next one that will appear from IPCC, Professor Reiter learned that his nomination had not been accepted by IPCC. Yet Professor Reiter tells us that of the two lead authors for that chapter, one had no publications at all and the other only five articles.

116. We cannot prove that Professor Reiter's nomination was rejected because of the likelihood that he would argue warming and malaria are not correlated in the manner the IPCC Reports suggest. But the suspicion must be there, and it is a suspicion that lingers precisely because the IPCC's procedures are not as open as they should be. It seems to us that there remains a risk that IPCC has become a "knowledge monopoly" in some respects, unwilling to listen to those who do not pursue the consensus line. We think Professor Reiter's remarks on "consensus" deserve repeating:

"Consensus is the stuff of politics, not science. Science proceeds by observation, hypothesis and experiment. Professional scientists rarely draw firm conclusions from a single article, but consider its contribution in the context of other publications and their own experience, knowledge and speculations".

We are concerned that there may be political interference in the nomination of scientists whose credentials should rest solely with their scientific qualifications for the tasks involved.

IPCC and economics expertise

117. In his evidence to us, Professor Ross McKitrick suggested that the IPCC no longer commanded the allegiance of mainstream economists[92]. In scrutinising the authorship of chapters, we believe his perception has arisen because some of the economics that was originally subsumed in Working Group III was moved in the 2001 Report to Working Group II. Working Group II is concerned with impacts, adaptation and vulnerability. Its authorship is dominated by impact specialists who tend not to be economists. The fact that the chapter that deals with monetised benefits of warming control now appears in that volume may explain its apparent downgrading, although we note that this is also consistent with IPCC's desire to avoid the

[91] Evidence from P. Reiter (Vol II, pp 284-288)

[92] Evidence from R. McKitrick (Vol II. Pp 262-266)

politically-inspired debates over the benefit estimates. Working Group III deals with the remaining economic issues and the amount of economic expertise is more significant.

Conclusion

118. **Overall, we are concerned that the IPCC process could be improved by rethinking the role that government-nominated representatives play in the procedures, and by ensuring that the appointment of authors is above reproach.** If scientists are charged with writing the main chapters, it seems to us they must be trusted to write the summaries of their chapters without intervention from others. Similarly, scientists should be appointed because of their scientific credentials, and not because they take one or other view in the climate debate. The IPCC publications as a whole contain some of the most valuable summary information available to the world on what we know about climate change. The standards employed are clearly very high. But this is all the more reason to ensure that procedures are unimpeachable. **At the moment, it seems to us that the emissions scenarios are influenced by political considerations and, more broadly, that the economics input into the IPCC is in some danger of being sidelined. We call on the Government to make every effort to ensure that these risks are minimised.**

CHAPTER 8: UNITED KINGDOM POLICY AND THE INTERNATIONAL NEGOTIATIONS ON CLIMATE CHANGE

119. Our inquiry was primarily concerned with the projections of economic activity that underline the IPCC forecasts of climate change, with the costs of tackling climate change and the benefits that would accrue to the world as a whole. Difficult and controversial though it is, we believe that conscious efforts must be made to weigh up the costs and benefits of climate change policy at every level. Because of this focus we spent less time in our inquiry on current UK policy on climate change. Moreover, as we noted in the introduction, other Parliamentary committees have been examining these issues. Nonetheless, we did take the opportunity to explore some issues of policy. These are documented in this chapter.

UK and EU policy

120. Boxes 9 and 10 summarise our understanding of the various climate targets that the United Kingdom and the European Union have signed up to. Some of these targets are legally binding and some are not. The original 1992 "Rio" target was a voluntary one and non-compliance carried with it no penalties. In the event, the United Kingdom was one of very few countries that complied with the Rio targets, though not through policy design—compliance was largely secured because of the choices of newly privatised electricity utilities to switch to natural gas and out of coal[93]. The UK "Kyoto" target is determined by the EU burden sharing agreement. In other words, it is the EU that has to comply with its overall target, compliance that is required in international law. Non-compliance by individual EU Member States with the burden sharing agreement is a matter for internal EU law. Targets that have no legal compliance requirements are the Government's 1997 Manifesto commitment of 20% reduction in CO_2 emissions (relative to 1990) by 2010, and its long-term 60% reduction target for around 2050. Moreover, while the 2050 target is frequently referred to as a unilateral target, close inspection of the language used to describe it makes it clear that it is conditional on other countries pursuing similar goals. Some other EU states have confirmed comparable targets, but most have not. Thus the targets vary substantially in the extent to which legal compliance is required.

[93] Germany also complied with the Rio targets because reunification led to wholesale economic restructuring and the closure of many heavily polluting plants.

BOX 9

United Kingdom Climate Targets

Year agreed	The gases covered	The target	Comment
1992 Framework Convention on Climate Change, Rio	CO_2 only	2000 emissions no greater than 1990 emissions: voluntary agreement	Incidentally achieved very largely via electricity privatisation introduced by Conservative Government
1997 Labour Manifesto	CO_2 only	2010 emissions 20% less than 1990 emissions	Language of commitment varies, e.g. Energy White Paper 2003 states it as "to move towards a 20% reduction".
1997 Kyoto Protocol, agreed in EU 1998	GHGs	2008-12 emissions 12.5% below 1990 emissions	UK's share under the EU burden sharing agreement for the Kyoto Protocol
2003 Energy White Paper	CO_2 only	c 2050 emissions 60% less than in 1990 "with real progress by 2020".	Commitment is to be "on a path towards" the target. In absolute terms it equals around 65 mtC in 2050. Also stated as a global goal for the "world's developed economies"

BOX 10

The EU Climate Targets

Year agreed	The gases covered	The target	Comment
1996, 1939th European Council Meeting, Luxembourg		Warming above pre-industrial level should not exceed +2°C: this is "an overall long-term objective to guide global efforts to reduce climate change risks". Conforms to CO_2 concentration goal of 550 ppm.	Note that this includes roughly 0.6°C warming in 20th century + additional warming already committed. Probably equivalent to +1°C compared to now.
1992 FCCC	CO_2	2000 emissions should be no greater than 1990 emissions	EU over-complied with target (-3% on 1990) due to UK, France and Germany, Sweden, Luxembourg over-complying
1997 Kyoto Protocol	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	2008-2012 emissions in EU-15 must be at least 8% below 1990 emissions. This target then allocated unequally between Member States.	Slight relaxation of these targets secured at Bonn and Marrakech

121. The absence of the United States from the ratified Kyoto Protocol is, of course, a serious deficiency and we are concerned that there are few signs to indicate how the ratifying countries intend to persuade the US to re-enter the negotiations. Just as important, the participation of Russia has been secured through political horse-trading in order to ensure the Protocol has the required minimum number of ratifiers. Yet Russia's emissions commitments constitute "hot air", that is, they do not correspond to any real reductions in greenhouse gases.

The Kyoto Protocol

122. **We also note that the compliance mechanisms in the Kyoto Protocol are very weak and even counter-productive.** Essentially, any signatory that fails to comply receives a penalty target in the context of any post-Kyoto agreement. Thus, a country not achieving the 2008-12 target must not only make up the shortfall in the second compliance period (yet to be negotiated), but must also achieve an additional 30% of this amount. The obvious problem is that anyone who does not comply is unlikely to sign up to this form of self-punishment in the later rounds. As Professor Scott Barrett of Johns Hopkins University has pointed out, if anything, the compliance

mechanism is a deterrent to further participation[94]. In large part, this kind of deficiency in the Kyoto Protocol arises from the international negotiators' preoccupation with agreements that set emission targets. Moreover, **we heard from several witnesses that the Kyoto targets themselves were going to make little difference to rates of warming** – see Table 11. In other words, Kyoto only begins to make environmental sense if it is the first of several, and maybe many, such future agreements. In his evidence to us, Professor Michael Grubb was insistent that this was always part of the design of Kyoto and that its own environmental ineffectiveness is not important since it is merely the first step in a longer run process[95].

TABLE 11

The environmental ineffectiveness of the Kyoto Protocol

	Business as Usual (BAU)	Kyoto Only = Kyoto + BAU 2010	Kyoto + constant emissions 2010	Kyoto + 1% p.a. emissions reduction 2010 to 2100
Concentrations:				
1990 ppm	350			
2100 ppm	700	680	660	625
Increase in temperature °C by 2100	2.1	2.0	1.9	1.8
Sea level rise cm	50	48.5	47.5	45.5

Source: adapted from T. Wigley The Kyoto Protocol: CO2, CH4 and climate implications. *Geophysical Research Letters*, 25 (13), 1998, 2285-2288.

Notes: scenarios assume Annex B countries only (i.e. those countries with emission reduction commitments), but including the US, take action. BAU = business as usual. "Kyoto only" is the effect of Kyoto assuming no further agreements, with some BAU scenario following. "Kyoto+constant emissions" assumes Annex B countries stay at their 2010 emission levels once the Kyoto targets are achieved. "Kyoto+ 1% reduction" assumes Annex B countries reduce emissions at 1% p.a. to 2100 after 2010. SLR = sea level rise. ppm = parts per million by volume. All figures approximate and assume 2.5°climate sensitivity – i.e. the temperature response to greenhouse gas forcing.

The analysis assumes that the US signs up to the Kyoto Protocol, so the estimates here overstate the effectiveness of the Kyoto Protocol if the US continues with its current policy of not ratifying the treaty.

123. But if Kyoto is simply the first step on a ladder of agreements, the issue of devising compliance incentives looms even larger. If there is widespread non-compliance, which is what many observers suggest will be the case, it means that participants have experienced difficulties in reaching the targets. Those difficulties may be economic, political or other. But if there are difficulties in meeting the Kyoto targets, there are likely to be even greater difficulties meeting yet stricter targets. Non-compliance with the first rung of the ladder

[94] S. Barrett, Kyoto plus. In D. Helm (ed.), *Climate Change Policy*, Oxford: Oxford University Press, 2005.

[95] Evidence from M. Grubb (Vol II, pp 165-177)

makes it far less likely that there will be participation in later agreements. Professors William McKibbin and Peter Wilcoxen have stated that "...the Kyoto Protocol is an impractical policy focused on achieving an unrealistic and inappropriate goal"[96]. Moreover, while China, India and Russia have ratified the Kyoto protocol, China and India do not have emission targets, and, as already noted, Russia's commitments constitute "hot air". **One of our observations, therefore, is that the "beyond Kyoto" negotiations, which start this year, will have to take a far more innovatory approach than simply assuming that the Kyoto targets will be tightened**[97].

Kyoto and the United States

124. The environmental effectiveness of any future international agreements on climate change will depend critically on both the United States and the developing world adopting active programmes to combat emissions growth. As we note above, this may not mean adopting agreements based on further emissions targets—an alternative approach will be required. But if the US remains outside future agreements, as they have done with respect to Kyoto, then their effect will be seriously limited. The US currently accounts for just over 20% of the entire world emissions of greenhouse gases, and closer to 25% for carbon emissions from fossil fuels. After Australia (which has also declined to ratify Kyoto), the US has the highest per capita greenhouse gas emissions of any country.

125. The developing world emitted roughly half the world's greenhouse gases in 2000. Whereas the developed world is likely to increase emissions by around 35% 2000-2025, the developing world's increase is likely to be over 80%[98]. It seems obvious to us that both the US and the developing world have to take on active programmes of reducing emissions with immediate effect, or the efforts of Europe and the rest of the world will be wasted.

126. With this in mind, we sought some explanation for the position of the United States. It seems to us that scrutiny of the costs and benefits to the US provides invaluable insights into the US position.

127. There are several elements to the cost burden that the US would bear if it ratified Kyoto. First, it would have its own domestic emissions reduction programme and the costs of that would fall on industry, transport and households. The US judged early on that these costs would be unacceptable, but had always maintained that the prospect of acceptability would exist if

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[96] W. McKibbin and P. Wilcoxen, The role of economics in climate change policy. *Journal of Economic Perspectives*, 16(2), 2002, 107-129.

[97] There is a growing literature on the limitations of the Kyoto Protocol and alternative means of achieving climate change goals. For example, see S. Barrett, Kyoto plus. In D. Helm (ed.), *Climate Change Policy*, Oxford: Oxford University Press, 2005; J. Aldy, S. Barrett and R. Stavins, *Thirteen Plus One: A Comparison of Global Climate Policy Architectures*, Working Paper RWP03-012, John F Kennedy School of Government, Harvard University, 2003; D. Bodansky, *International Climate Efforts Beyond 2012: A Survey of Approaches*, Washington DC: Pew Center for Climate Change.

[98] All of these data come from K. Baumert and J. Pershing, *Climate Data: Insights and Observations*. Washington DC: Pew Center for Climate Change, 2004.

there was widespread emissions trading[99]. In the event, the Kyoto Protocol enabled various forms of trading: trades between rich nations based on allocated permits (cap and trade), project-based trades between (roughly) OECD countries and East Europe and Former Soviet Union ("joint implementation"), and project-based trades between OECD countries and developing countries ("Clean Development Mechanism"—CDM). Moreover, the US had already sponsored major efforts at joint implementation in order to learn how to operate such projects. Arguably, the limited prospects for extensive cap and trade systems (which is what the EU has developed), and the comparatively small role playable by joint implementation and the CDM, persuaded the US government that compliance costs to the US would be higher than they hoped.

128. Second, the US has been insistent that developing countries must quickly assume targets of their own. We noted above that this is a rational position to take since rates of warming cannot be adequately affected without this happening. The developing countries have always maintained that warming was not their responsibility. If the rich countries want to bring the developing countries on board, they might therefore have to pay for developing country reductions as well as their own. The Kyoto Protocol does have "flexibility mechanisms" which permit reductions in developing countries to be credited to developed economies provided the latter pay for them. But what the US may have feared was the prospect that the developing countries would maintain their "you not us" stance and eventually the US would have to become a major contributor to the costs of reducing emissions in developing countries, without emission credits being secured.

129. Third, "relative" cost matters, i.e. the burden on the US relative to the burden borne by others. Apart from any feelings about "unfairness" if others did not appear to bear as big a burden, there are concerns about competitiveness, and about impacts on specific sectors of the economy—not least oil and coal producers.

130. A fourth factor relates to the Integrated Assessment Models (IAMs) that influenced the US government. These were primarily those that showed comparatively small global benefits from Kyoto (the work of Professors Nordhaus, Mendelsohn, Manne and Dr Richels). Thus the US was being asked to bear a "big" cost (as they saw it) for uncertain global benefit. The climate models themselves were showing little or no effect on rates of warming from Kyoto. However, a dominant feature of the minor impact of the Kyoto Protocol on warming is also the fact that developing country rates of growth of emissions are the fastest. President Bush clearly stated: "I oppose the Kyoto Protocol because it exempts 80% of the world, including major population centers such as China and India"[100].

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[99] Emissions trading works by having permits allocated to emitters. Those who find it easiest to abate will sell their permits and abate emissions. Those who find it hardest to abate will not abate but will buy permits instead. In this way, emissions trading minimises the compliance costs. Throughout all the negotiations leading to the Kyoto Protocol, the US insisted on the substantive role of trading precisely because it would reduce the costs of compliance to the US.

[100] This position somewhat reneges on the first President Bush's commitment to the Rio Framework Convention on Climate Change (of which Kyoto is the first Protocol) since that speaks of "differentiated responsibilities and respective capabilities" for combating climate change. Historically, the US accounts for around 30% of cumulative CO_2 emissions and, as the richest country in the world, has more capability to reduce emissions than other countries.

131. We offer this brief analysis of the position of the US not because we wish to defend that position, but in order to argue that there is an economic rationality to the stance taken. Failure to understand that rationality will misdirect efforts to bring the US into future negotiations in a more positive way. Again, we believe that if the "Kyoto plus" negotiations simply attempt to impose stricter emissions targets on the world—what Professor Scott Barrett of Johns Hopkins University has called "the Kyoto only" approach—the position of the US will not change[101]. Indeed, if the US has been unwilling to sign up to the Kyoto targets, we do not see how it will sign up to even stricter targets. In our view, there is a real risk that the international negotiators will render their own efforts fruitless if they persist in an exclusive adoption of the targets-based approach.

132. **Finally, the US has repeatedly stressed the role of technological change in securing greenhouse gas emission reductions. While the Kyoto Protocol should, in principle, encourage technological change, we are not convinced that it has sufficient focus on this central issue.** We return to this point when considering how the "Kyoto process" might be taken forward.

Alternative architectures for "Kyoto Plus"

133. **We argue above that the "more of the same" approach to emissions targets may not tackle the global warming threat. We urge the UK Government to help broaden the debate through its membership and current presidency of the G8 and using its position of being internationally respected in the scientific world.** While we have not investigated the alternative means of tackling warming in any detail, we draw attention to two alternative approaches to international negotiations.

134. Any "Kyoto plus" treaty has to provide incentives for long run emissions reductions. This means there must be changes in technology and/or behaviour that can be sustained through time and, importantly, that there must be effective compliance mechanisms. The Kyoto Protocol is essentially a legal regime that attempts to punish short-term non-compliance but, as noted above, does so with an enforcement mechanism that is so weak it is likely to be counter-productive, i.e. it will encourage reduced participation in the future, not the widening participation that is required. At the moment, it is hard to see how countries will sign up to a stricter target-based regime than already exists with the Kyoto Protocol. One possibility is that Kyoto-plus should adopt stricter targets but with much more effective enforcement. One of the few international environment treaties to be effective is the Montreal Protocol which controls ozone-depleting chemicals. This treaty can be enforced using trade sanctions. One possibility is that Kyoto-plus could introduce trade sanctions as a non-compliance penalty. However, the chances of this succeeding seem to us remote. Controlling climate change is not like controlling ozone depletion—in the latter case alternative technologies were already being advanced and the costs of "buying in" the developing countries were small. Taking ozone depleting chemicals out of economic systems is trivial compared to taking carbon out. In contrast, the benefits of reducing ozone depletion are enormous. It is a mistake, therefore,

[101] S. Barrett, Kyoto plus. In D. Helm (ed.), *Climate Change Policy*, Oxford: Oxford University Press, 2005.

to assume that any Kyoto-plus treaty should simply copy the format of the Montreal Protocol.

135. There are many proposals for a changed approach to Kyoto-plus[102]. These include harmonised national carbon taxes, more rapid progress to world-wide emissions trading, a more forceful agreement on adaptation measures than is contained in the Kyoto Protocol, and what to us seem more fanciful ideas about allocating carbon budgets between nations so that per capita emissions converge at some future date.

136. **It could be argued that it is late in the day to be suggesting a significant change of focus in the climate negotiations. But we fear that the present "more of the same" approach, focusing on targets for emissions reductions,** will fail. It is better to aim for cost-effective technologies, and the right balance between adaptation and mitigation.

Adaptation

137. We reiterate our concern that adaptation measures have become the "Cinderella" of the negotiating process. The chances that a politically feasible set of emissions reduction measures along current lines will significantly alter the rate of warming are, in our view, small. Hence it is vital to look urgently at what can be done to diffuse technologies on, for example, water conservation, new water supplies, avoidance of the worst impacts of weather extremes etc. A sensible strategy is to have a robust adaptation strategy in place as well. While we acknowledge that the Kyoto Protocol discusses adaptation, there is little evidence that adaptation is being pursued aggressively. To some extent, current decisions are already being modified to take adaptation "on board", as with flood control decisions in countries like the United Kingdom. But much more needs to be done and **climate adaptation should become one of the mainstream elements of investment decisions, particularly with respect to infrastructure, housing, coastal development and international development assistance.** Of course, adaptation has its limits—it is not obvious what it would mean to adapt to the large scale one-off events discussed earlier. But before those limits are reached, there seems to us to be enormous scope for a global adaptation strategy on a par with the mitigation strategies that preoccupy the IPCC process and the national debate.

International carbon taxes

138. One approach not based on setting further emissions targets would be an internationally harmonised carbon tax. The advantages of such a tax are:

- it raises the price of emissions;
- it could be introduced only after a per capita income threshold has been reached, avoiding any initial rejection of the measure by developing countries but gradually bringing them into the agreement as their development proceeds;
- it could be based on consumption;

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[102] Most of these are very conveniently summarised and reviewed in D. Bodansky, *International Climate Efforts Beyond 2012: A Survey of Approaches*, Washington DC: Pew Center for Climate Change.

- it avoids tariffs in relation to trade between parties to the agreement, but with border tax adjustments for trade between participating and non-participating countries; and
- it avoids potential large changes in permit prices which can have a detrimental effect on investment decisions. The tax remains constant, or rises steadily over time, and emissions adjust.

139. The arguments against international carbon taxes are well known. For example, taxes may fail to achieve quantitative goals if governments fail to estimate accurately the response of emitters. Varying the tax as information about such responses evolve is one option, but this may only reinforce the uncertainty that emitters face. However, the political prospects of a harmonised international tax may be remote. For example, the European Union was singularly unsuccessful in introducing an EU-wide energy/carbon tax. But this should not prevent unilateral action by individual nations or groups of nations.

140. We share the criticisms expressed by some of our witnesses that the UK's current "climate tax", the Climate Change Levy, is anything but a carbon tax. It is an energy tax and the tax rate does not vary directly with the carbon content of fuels. It is not applicable to transport or households, and it offers electricity generators no incentives to switch between low and high carbon fuels. Further, it is associated with numerous exemptions and links to Climate Change Agreements which themselves may have secured illusory emission reductions due to "hot air" trading. **We therefore urge a thorough review of the Climate Change Levy regime, with the aim of moving as fast as possible to replacing it by a carbon tax.**

International technology agreements

141. **There appears to be growing support for the idea that Kyoto-plus should focus on technology and research and development.** Professor Scott Barrett of Johns Hopkins University notes that such a technology-based approach has worked for ocean oil pollution where, after years of trying unsuccessful procedures, standards for ships to separate ballast water and oil were agreed[103]. These standards have been followed by others, such as double hulls for new tanker ships. The features of this approach are (a) that compliance is easily verified, (b) each state has an incentive to protect its own waters from pollution, and (c) as more countries ratified the agreement, the bigger the incentive tanker owners had to comply because of the need to have access to as many ports as possible. Professor Barrett asks if a similar approach cannot be adopted for Kyoto-plus. International agreement on R & D in low or zero-greenhouse gas technology might help to lower future costs of these technologies at a rapid rate. In the same vein, the bigger the scale of the technological innovation, the lower the costs of adopting it. In some cases, adoption of the technology by a major player, for example, the US or Europe, will provide major incentives for other countries to adopt the same technology in order to gain access to the markets of the US and Europe. Vehicle technology is a case in point. As major purchasers, technological standards set by large importers would require that those technologies are adopted in the exporting nations. Moreover, technology

[103] S. Barrett, *Environment and Statecraft.* Oxford, Oxford University Press. 2001.

standards are compliant with the WTO rules. Finally, incentives for technology transfer to the developing nations would be built into the agreement.

142. **The International Energy Agency (IEA) has estimated that the R & D expenditure needed, if carbon-free energy is to become economically viable through the use of solar photovoltaics, biomass and carbon sequestration, is around $400 billion[104]. This is a little over 1% of current global annual GDP. This might be compared to the costs of the 1963-72 US Apollo programme that put man on the moon. The Apollo programme cost around 2.5% of US GNP in about 1970, or 1% of then global annual GNP[105]. The IEA renewable energy programme would therefore cost about the same now as the Apollo programme did then—1% of world GNP.** Spread over 30 years, this $400 billion would amount to around 0.03% of world GNP each year. Moreover, such an R & D programme would be a true global public good: one in which everyone would have a share of the benefits. An agreement of this kind would have the potential to overcome the major obstacles that currently inhibit further progress on tackling climate change—the need to find incentives to get the United States and the developing countries to join others in the quest for low carbon energy futures. The US is already investing heavily in such technology. The developing world would gain substantially by acquiring it. **We offer these thoughts as an illustration of what international negotiators might now consider—an agreement on technology and its diffusion.**

143. We do not pretend to have worked through in any detail proposals of the kind outlined above. **The important issue is to wean the international negotiators away from excessive reliance on the "targets and penalties" approach embodied in Kyoto.** We acknowledge that this approach could work, provided there was a powerful enforcement mechanism. The problem is that countries are not going to agree to such an enforcement mechanism, as the compliance negotiations over the Kyoto Protocol have already shown. Existing international institutions such as the United Nations simply do not have credible threats for participants to secure compliance. **Hence there should be urgent progress towards thinking about wholly different, and more promising, approaches based on a careful analysis of the incentives that countries have to agree to any measures adopted.**

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[104] Evidence from M. Grubb (Vol II, pp 165-177)

[105] R.D. Launius, *Proceedings of the 41st Aerospace Engineers Meeting* 6-9 January 2003

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

Introduction

144. We welcome the Government's recognition of the central role of economics in considering climate change. But we believe that the Chancellor needs to broaden the scope of the Government's interests, and the Treasury's interests in particular, in aspects of the climate change debate that we feel have not yet been given sufficient emphasis (para 2).

145. We are concerned that the links between projected economic change in the world economy and climate change have not been as rigorously explored as they should have been by the IPCC. We believe the complex interactions between world economic growth and climate change need additional scrutiny at the international level, and that the UK Government has a role to play in ensuring that this happens. We are also concerned that clearer messages should be conveyed to the public about the likely costs and benefits of climate change control, who will bear those costs and benefits, and when (para 2).

146. We are not convinced that there is sufficient public awareness of the economics of climate change. Any public misperception on these issues could threaten the political feasibility of getting plans of action put into effect. If climate change is as serious as most scientists claim, and as the Government accepts, then it is important to convey the complementary message that the action to tackle it will also have to be serious and potentially life-changing. It is better to be honest now than to shield the public from the economic realities inherent in the more pessimistic forecasts (para 3).

The uncertain science of climate change

147. The scientific context is one of uncertainty, although as the science progresses these uncertainties might be expected to diminish and be resolved, one way or the other. Hence it is important that the Government continues to take a leading role in supporting climate science, and encourages a dispassionate evidence-based approach to debate and decision making (para 18).

148. We do not believe that today's scientists are "crying wolf" about climate change: they may turn out to have been wrong in some respects, but arguments on which they base their case are better researched than in earlier cases. That said, we have sought to highlight some pressing issues which we believe deserve a further response from the scientific community in order to enhance understanding and resolve current controversies (para 24).

The future impacts of the enhanced greenhouse effect

149. Whatever the validity of temperature projections, the science of measuring impacts remains speculative. Many of the adverse effects of warming can be offset by adaptation and we believe that the economic and social returns from investing in adaptation should be properly weighed against the cost of mitigation (para 27).

150. We noted evidence from Professor Paul Reiter of the Institut Pasteur in Paris, which strongly disputed the IPCC's arguments on the likely spread of malaria as a result of warming (para 32).

151. We draw attention to the fact that, if extreme events are indeed to be considered the most important impacts from climate change, there is uncertainty and controversy about the underlying data required to substantiate this claim (para 37).

152. How catastrophic threats such as disintegration of Antarctic ice caps should influence decision-making depends on the scale of the effects, their probability of occurrence, and when they might occur. The scale of these events is clearly very large (para 39).

153. If cataclysmic events which threaten the viability of existing societies are even remote possibilities, it is important that policy makers construct frameworks for analysing and debating probability and risks, since the threats associated with such "doomsday" scenarios are fundamental elements in driving the international discourse (para 40).

154. We think it important that the IPCC moves towards clearer judgements on the probabilities of the projected global temperature increases (para 41).

155. We are clear that fuller consideration needs to be given to the literature on the positive effects of warming (para 43).

156. We conclude that there are weaknesses in the way the scientific community, and the IPCC in particular, treats the impacts of climate change. We call for a more balanced approach and look to the Government to take an active role in securing that balance of research and appraisal (para 44).

157. The issue of adaptation verses mitigation is clearly one of balance. Most adaptation expenditures would be local, while mitigation requires action on a global scale. Few would suggest doing nothing by way of mitigation, and few would suggest no adaptation expenditures at all. But the policy literature seems to us to be overly focussed on mitigation. We therefore urge the Government to ensure that greater efforts are made to understand the relative costs and benefits of adaptation compared to those of mitigation (para 47).

Forecasting greenhouse emissions and temperature change

158. Serious questions have been raised about the IPCC emissions scenarios, and a reappraisal of the scenarios exercise is urgently needed (para 60).

159. We consider the convergence assumptions in the IPCC scenarios to be open to some question. In our view, political factors should not be allowed to influence the scenarios, whether over the issue of convergence or indeed in any other context (para 63).

160. In general, any change in emissions due to changed economic assumptions will translate into a smaller effect on concentrations and an even smaller effect on temperature. This in no way excuses poor analysis in the emissions scenarios, but it may mean that projections of warming are not themselves greatly affected (para 66).

161. It appears that the IPCC scenarios are not capturing recent emissions experience in their short term projections (para 68).

162. We received a significant amount of evidence on the realism of the IPCC emission scenarios, and doubts were raised, particularly about the high emission scenarios. The balance of this evidence suggests to us that the high emissions scenarios contained some questionable assumptions and outcomes. While errors do not translate into equal magnitude errors in concentrations or warming, it seems to us important that the IPCC emissions modellers give serious attention to adopting the correct procedures (para 72).

The costs of tackling climate change

163. It is very important that a realistic picture of the likely costs be conveyed to, and understood by, people today who will have to pay them. We note the considerable efforts that the IPCC has made in constructing likely cost estimates for the world as a whole. We are far less satisfied with the data currently available on the costs to the UK, and we call for a significantly greater effort to clarify and estimate those costs (para 73).

164. Given the wide array of potential technologies, we are surprised that the Government's *Energy White Paper* should place such emphasis on just one technology, wind energy (para 83).

165. In our view, it would be unwise to close the nuclear energy option. It is prudent to maintain as wide an energy portfolio as possible. We argue that the current capacity of nuclear power, before further decommissioning occurs, should be retained (para 84).

166. We are concerned that UK energy and climate policy appears to rest on a very debatable model of the energy-economic system and on dubious assumptions about the costs of meeting the long run target of 60% reduction in CO_2 emissions. We call on DTI and the Treasury to improve substantially (a) the cost estimates being conveyed to the public and (b) the manner of their presentation. We believe that the Treasury should be more active in scrutinising and publicising these costs and benefits, in association with Defra and DTI (para 94).

The benefits of climate change control

167. Research suggests that, in terms of percentages of world GNP, monetised damage is relatively low, even for warming of 2.5°C. The damages are not evenly spread. In general, developing countries lose more than developed economies. Some models suggest no real net damage to rich countries (para 99).

168. The evidence presented to us indicates that the estimates of monetised damage are highly controversial within IPCC deliberations (para 101). We urge the Government to press the IPCC for a proper detailing of the estimates and for a discussion of the uncertainties in the next IPCC Assessment Report in 2007 (para 101).

169. While we agree with others that the monetised benefit estimates for controlling global warming are uncertain, we are concerned that the IPCC appears to be playing down these estimates in favour of often detailed descriptions of individual impacts that cannot be brought into comparison with the likely costs of control. Perhaps one reason for this lack of emphasis is that the economic measures of damage give the impression that the benefits of warming control are smaller relative to the costs (para 105).

170. We urge that explicit comparisons be made between the monetary cost of adaptation measures and their benefits. While we were reassured by Defra that they would be pressing for a higher profile for the economics in the IPCC's Fourth Assessment Report, we consider that the Treasury has a duty to reinforce Defra's intent. Indeed, given the potential importance of this issue, both in terms of public expenditure and of overall economic cost, the Treasury should become directly involved itself, making its own economic assessment of the issue (para 105).

The IPCC process

171. We can see no justification for an IPCC procedure which strikes us as opening the way for climate science and economics to be determined, at least in part, by political requirements rather than by the evidence. Sound science cannot emerge from an unsound process (para 111).

172. The IPCC Summary for policy makers says that economic studies underestimate damage, whereas the chapter says the direction of the bias is not known (para 114).

173. We are concerned that there may be political interference in the nomination of scientists to the IPCC. Nominees' credentials should rest solely with their scientific qualifications for the tasks involved (para 116).

174. The IPCC process could be improved by rethinking the role that government-nominated representatives play in the procedures, and by ensuring that the appointment of authors is above reproach. At the moment, it seems to us that the emissions scenarios are influenced by political considerations and, more broadly, that the economics input into the IPCC is in some danger of being sidelined. We call on the Government to make every effort to ensure that these risks are minimised (para 118).

UK policy and the international negotiations on climate change

175. We note that the compliance mechanisms in the Kyoto Protocol are very weak and even counter-productive. We heard from several witnesses that the Kyoto targets themselves were going to make little difference to rates of warming (para 122).

176. We consider that the "beyond Kyoto" negotiations, which start this year, will have to take a far more innovatory approach than simply assuming that the Kyoto targets will be tightened (para 123).

177. The US has repeatedly stressed the role of technological change in securing greenhouse gas emission reductions. While the Kyoto Protocol should, in principle, encourage technological change, we are not convinced that it has sufficient focus on this central issue (para 132).

178. We argue that the present "more of the same" approach, relying exclusively on targets for emissions reductions, may not tackle the global warming threat. We urge the Government to help broaden the debate through its membership and current presidency of the G8 and using its position of being internationally respected in the scientific world (para 133).

179. It could be argued that it is late in the day to be suggesting a significant change of focus in the climate negotiations. But we fear that the "more of the same" approach, focusing on emissions targets, will fail (para 136).

180. Climate adaptation should become one of the mainstream elements of investment decisions, particularly with respect to infrastructure, housing, coastal development and international development assistance (para 137).

181. We urge a thorough review of the Climate Change Levy regime, with the aim of moving as fast as possible to replacing it by a carbon tax (para 140).

182. There appears to be growing support for the idea that Kyoto-plus should focus on technology and R & D (para 141).

183. The International Energy Agency has estimated that the R & D expenditure needed, if carbon-free energy is to become economically viable through the use of solar photovoltaics, biomass and carbon sequestration, is around $400 billion. The IEA programme would cost about the same now as the 1963-73 US Apollo programme that put man on the moon cost then—1% of world GNP. Such an R & D programme would be a true global public good: one in which everyone would have a share of the benefits. This is an illustration of what international negotiators might now consider—an agreement on technology and its diffusion (para 142).

184. The important issue is to wean the international negotiators away from excessive reliance on the "targets and penalties" approach embodied in Kyoto. Hence there should be urgent progress towards thinking about wholly different , and more promising, approaches based on a careful analysis of the incentives that countries have to agree to any measures adopted (para 143).

APPENDIX 1: ECONOMIC AFFAIRS COMMITTEE

The members of the Select Committee which conducted this inquiry were:

† Lord Elder
Lord Goodhart
Lord Kingsdown
Lord Lamont of Lerwick
Lord Lawson of Blaby
Lord Layard
Lord Macdonald of Tradeston
† Lord Marsh
* Lord Paul
* Lord Powell of Bayswater
Lord Sheldon
Lord Sheppard of Didgemere
Lord Skidelsky
Lord Vallance of Tummel
Lord Wakeham

† until 11 April 2005
* since 6 June 2005

The Committee records its appreciation to Professor David Pearce OBE, Emeritus Professor, University College London, for his work as Specialist Adviser for the inquiry.

Declaration of Interests

Lord Elder
Consultant, First Group plc
Consultant, Forth Ports Plc
Consultant, The Smith Institute
Adviser to Daval International Ltd
Chancellor, Al-Maktoum Institute for Arabic and Islamic Studies
Member of the Action Committee for the Scottish National Photography Centre

Lord Goodhart
Vice President, International Commission of Jurists
Trustee, Fair Trials Abroad
Vice Chair of Council, JUSTICE

Lord Kingsdown
38 acres of woodland in North Kent
President, Canterbury Cathedral Trust
Chairman, Canterbury Cathedral Council
President, Kent County Agricultural Society
Trustee, Leeds Castle, Maidstone, Kent
Honorary Trustee, Royal Agricultural Society of England
Trustee, East Malling Trust for Horticultural Research
Emeritus Trustee, Royal Academy of Arts

Lord Lamont of Lerwick

Consultant, Rotch Property Group
Consultant, Fintrade
Stanley Leisure plc
Chairman, East European Food Fund (Investment Fund)
Director, Anglo-Arabian Projects Limited
Director, Balli Group plc (steel and commodity trading house)
Director, Compagnie Internationale de Participations Bancaires et Financieres (Investment Company)
Director, European Growth and Income Trust (Investment Trust)
Director, Jupiter Finance and Income Trust (Investment Trust)
Director, Scottish Annuity and Life Holdings (Reinsurance Company)
Director, RAB Capital plc
Member of the Advisory Board, MerchantBridge & Co
Secretary and office at Balli plc (steel and commodity trading house)
(Secretary primarily business and personal but some parliamentary work)
Chairman, Le Cercle
Chairman, British Iranian Chamber of Commerce
President, British Romanian Chamber of Commerce
Co-Chairman, Bruges Group

Lord Lawson of Blaby

Chairman, Central Europe Trust Co Ltd (Advisory and private equity)
Shareholding in Central Europe Trust Company Limited
Member of Governing Body of Westminster School

Lord Layard

Non-executive Director, Firebird New Russia Fund Ltd
Director, Well-being Programme, Centre for Economic Performance, London School of Economics
House in Chalk Farm, London NW3 and house in Cornwall

Lord Macdonald of Tradeston

Senior Advisor, Macquarie Bank Ltd (which manages and invests in infrastructure assets across communications, transport and utility sectors, including renewable energy)
Member, Fabian Society

Lord Marsh

Senior European Consultant, Taisei Corporation, Tokyo, Japan
Chairman, The Income & Growth Trust (a quoted split capital investment trust)

Lord Paul

Chairman and Director, Caparo Group Ltd
Board Member, London Development Agency
Visit to Scotland (16-17 June 2004) to view various power facilities as a delegate with the Parliamentary Group for Energy Studies
Caparo Group Ltd (Lord Paul, Hon.Ambar Paul, Hon. Akash Paul and Hon. Angad Paul are jointly interested in the whole of the issued share capital of the Company through shareholdings registered in the name of Caparo International Corporation, a Company registered in the British Virgin Islands)
Caparo Group, through its subsidiary Caparo plc, has a 35.5% interest in Core Growth Capital LLP, which manages two venture capital trusts, Core VCTI and Core VCTII plc

Chancellor of the University of Wolverhampton
Member of the DTI Industrial Development Advisory Board
Member of the Corporation of the Hall of Arts and Sciences
Advisory Board Member, Foreign Policy Centre
Member of the Board of London 2012
Non-executive Director, London 2012 Ethics Advisory Group
Director, Parliamentary Broadcasting Unit Limit
Vice President, Engineering Employers' Federation
Co-Chairman, Associated Parliamentary Manufacturing Industry Group
Chairman of the Board of PiggyBankKids (a children's charity) and its trading subsidiary PiggyBankKids Projects Limited
Trustee, Ambika Paul Foundation
President, Family Service Units
Patron, Plan International
Patron, UK Youth

Lord Powell of Bayswater

Adviser to Eastern Star Publications
Adviser to the Chairman of BAe Systems
Chairman, LVMH (Moet-Hennessy Louis Vuitton) UK
Chairman, Sagitta Asset Management Limited
Director, British Mediterranean Airways
Director, Caterpillar Inc
Director, Financière Agache
Director, LVMH (Moet-Hennessy Louis Vuitton)
Director, Mandarin Oriental Hotel Group
Director, Matheson & Co
Director, Textron Corporation
Director, Yell Group Limited
Director, Schindler Holdings, Switzerland
Director, Northern Trust Global Services
Member, Barrick Gold International Advisory Board
Member, Diligence Advisory Board
Chairman, GEMS Private Equity Fund Advisory Board
Member, Rolls-Royce European Strategy Board
Member, Textron International Advisory Council
Member, Wingate Capital International Advisory Board
Member, International Advisory Board of Magna Corporation
Member, the Advisory Board of the European Advisory Group GMBH
Member, Advisory Board of Thales UK (15 September 2004)
Member, Advisory Board of Alfa Capital (15 September 2004)
Chairman, Trustees of the Said Business School Foundation, Oxford University
Trustee, Aspen Institute (USA)
Trustee, British Museum
Chairman, Atlantic Partnership
Director, Singapore Millennium Foundation
Director, UK-China Forum
President, China-Britain Business Council
Trustee, Karim Rida Said Foundation

Lord Sheldon

Tonrose Ltd (textile distribution)
Trustee, Sheldon Group Pension Fund

Lord Sheppard of Didgemere

Didgemere Consultants Ltd
Non-executive Chairman, McBride plc (household and personal care products)
Non-executive Chairman, Unipart Group (automotive, rail, telecommunication, logistics etc)
Non-executive Chairman, One-Click HR plc (HR software etc)
Non-executive Director, Nyne Ltd (investor group) (currently not directly remunerated)
Non-executive Chairman, Global Tote Ltd (Satellite transmission services to Russia and Eastern Europe)
Non-executive Chairman, Namibian Resources Ltd (Diamond Mining)
Didgemere Consultants Ltd (business Advisory service)
Didgemere Farms Ltd (farming)
McBride plc (household and personal care products) (shareholding with a nominal value of over £50,000)
One-ClickHR plc (human resources management systems) (shareholding of more than 5% of issued share capital of the company)
DeltaDot Limited (an unquoted biotechnology) (shareholding of more than 5% of issued share capital of the company)
Namibian Resources Ltd
Farmland in Essex
Chancellor, Middlesex University
Hon. Fellow, Governor, London School of Economics
President, London First
Director, East London Business Alliance
Director, Central London Partnership
Director, London Business Board (London First/London Chamber/London CBI)
Vice President, Beer and Pub Association (formerly Brewers Society)
Member of the Various Professional Bodies (accountants etc)
Hon. Doctorate/Hon Fellow of various universities
Member, Protection of Roydon and Area (PORA) Committee
Vice President (formerly Appeal Chairman for 'Sheppard House') of Blue Cross (animal/peoples charity for pets of those unable - for reasons of health, etc - to pay vet fees)
Vice President United Response (charity for people with learning difficulties)
Fellow, Animal Health Trust
Member, UK Cancer Research Charity
Vice President, (past Chairman) Business in the Community
Past Chairman, The Prince's Trust (and Prince's Youth Business Trust) (now only infrequently involved)
Chairman of Trustees, Civilians Remembered Trust (Trust developing memorial park, etc for 60,000-plus civilians killed by bombing in 1939-45 war)
Patron of Trees for Cities

Lord Skidelsky

Non-executive Director, Janus Capital Group
Director, Transnational Insights
Non-executive Director, Greater Europe Fund
Professor of Political Economy, Warwick University, Department of Economics
Transnational Insights Ltd (100% of stock)

Governing Body, Brighton College
Member, Advisory Council, Wilton Park
Chairman, The Centre for Global Studies
Director, Moscow School of Political Studies

Lord Vallance of Tummel

Vice Chairman, Royal Bank of Scotland Group (served on the board in the early stages of the inquiry)
Member, Supervisory Board Siemens AG (engineering and services)
Director (Chairman), Nations Healthcare Ltd
International Advisory Board, Allianz AG (insurance)
European Advisory Council, Rothschild et cie (investment banking
Advisor, Amsphere Ltd (computing services)
Advisor, Postmasternet Ltd (retail services for postmasters)
425,000 shares in De Facto 479 Ltd (family owned investment company)
Wife is a member of the Committee on Standards in Public Life
Honorary Governor, Glasgow Academy
Honorary Fellow, Brasenose College, Oxford
Honorary Fellow, London Business School
Chairman, European Services Forum
Vice President, Princess Royal Trust for Carers

Lord Wakeham

Advisory Board, LEK Consultancy
Chairman, Genner Holdings plc
Genner Holdings Ltd (Investment Company)
Genner Farms Ltd (small family company)
Chairman of Governors, Cothill House
Chairman, Alexandra Rose Day
Chancellor, Brunel University
Deputy Lieutenant for Hampshire
Governor, Sutton's Hospital, Charterhouse
Justice of the Peace, Inner London Commission (Non-active)
Member of Council, St. Swithun's School
President, Brendoncare Foundation
Trustee, H.M.S. Warrior 1860
Trustee, Carlton Club

APPENDIX 2: LIST OF WITNESSES

The following witnesses gave evidence. Those marked * also gave oral evidence.

* Professor Dennis Anderson, Imperial College
* Dr Terry Barker, Cambridge University
  Mr Christopher Beauman, former adviser, Cabinet Office
  BP
  Dr Leonard Brookes, Fellow of the Energy Institute
  Sir Ian Byatt
  Dr Ian Castles, Australian National University, Canberra
  CSERGE (the Centre for Social and Economic Research on the Global Environment)
* Department for Environment, Food and Rural Affairs (Defra)
* Professor Paul Ekins, Policy Studies Institute
  George C Marshall Institute, Washington DC
  Dr Indur M Goklany
* Professor Michael Grubb, Imperial College
* Dr Dieter Helm, New College, Oxford
  Dr Cameron Hepburn, St High's College, University of Oxford
* Professor David Henderson, Westminster Business School
  Mr David Holland, MIEE
* Dr Chris Hope, University of Cambridge
* Sir John Houghton
  International Council for Capital Formation (ICCF)
  International Policy Network
* Sir David King, Chief Scientific Adviser to the UK Government
* Professor Richard Lindzen, Massachusetts Institute of Technology
* Professor Bjorn Lomborg, University of Aarhus
  Professor Angus Maddison
  Dr David Maddison, University College London
  Professor Ross McKitrick, University of Guelph, Canada
  Professor Robert Mendelsohn, Yale University
  Professor Nils-Axel Morner, Stockholm University
  Professor Julian Morris, University of Buckingham
* Professor Nebojsa Nakicenovic, , IIASA and Vienna University
* Dr R Pachauri, Chairman, IPCC
  Dr Peter Read

Professor Paul Reiter, Institut Pasteur, Paris

Research Councils UK

* Professor Colin Robinson, University of Surrey

Ms Rosemary Righter, The Times

The Royal Society

Professor S Fred Singer, University of Virginia

* Professor Richard Tol, University of Hamburg

* Mr Paul Johnson, HM Treasury

* Mr Adair Turner

Tyndall Centre for Climate Change Research

Evidence received by the Committee but not printed can be inspected in the House of Lords Record Office (020-7219 2333), e-mail hlro@parliament.uk

APPENDIX 3: CALL FOR EVIDENCE

The Economic Affairs Committee has decided to conduct an inquiry into 'Aspects of the Economics of Climate Change'.

Evidence is invited by 31 March 2005. The Committee will welcome written submissions on any or all of the issues set out below.

Following the recent ratification of the Kyoto Protocol, the Committee has decided to inquire first into the ways in which the problem of climate change has been assessed.

- How are the current estimates of the scale of climate change damage derived?
- How far do the estimates of damage depend on assumptions about future global economic growth, and how valid are those growth assumptions?
- How does uncertainty about the scale of the problem and its impact affect the economics of climate change?

The Committee will also inquire into the key role of the Intergovernmental Panel on Climate Change in compiling and assessing technical information on climate change.

- What has been the approach within the IPCC to the economic aspects of climate change, and how satisfactory has it been?
- Is there sufficient collaboration between scientific and economic research?
- Could IPCC member governments, and the UK in particular, do more in future to contribute to the robustness of the economic analysis?

The Committee then plans to go on to consider the question of who bears the brunt of climate change and of the costs of controlling it.

- In monetary terms, the impact of change and the costs of control may be greater in rich countries than poor ones. But is this an adequate measure?
- What would be the relative costs and benefits of using resources, otherwise expected to be allocated to climate change control, instead to expand international development assistance?
- When are damages likely to occur and how satisfactory is the economic approach to dealing with costs and benefits that are distant in time?
- What other associated benefits might there be from reducing greenhouse gas emissions?

At this stage the Committee does not intend to investigate the comparative merits of different policies for the control of climate change.

APPENDIX 4: GLOSSARY

BAU	'business as usual' – usually of a scenario that involves no policy changes
Biofuels	fuels based on biomass, e.g. wood
C	carbon (one tonne carbon = 3.67 tonnes CO_2)
C_2F_6	perfluoroethane, a greenhouse gas
CCS	carbon capture and storage
CDM	Clean Development Mechanism: process under the Kyoto Protocol whereby one country can pay for emissions reductions in a developing country and collect the 'credit' for the reduction
CF_4	perfluoromethane, a greenhouse gas
CH_4	methane (natural gas), a greenhouse gas
c/kWh	(US) cents per kilowatt hour
Concentrations	Concentrations of greenhouse gases in the atmosphere
Convergence	View that per capita real incomes in rich and poor countries will converge to the same level at some time in the future
CO_2	carbon dioxide, the main greenhouse gas
Defra	Department of the Environment, Food and Rural Affairs
$/GJ	(US) dollars per gigajoule
DTI	Department of Trade and Industry
Emissions	Emissions of greenhouse gases, mainly from the combustion of fossil fuels and burning of forests
Equity weighting	Procedure for adjusting economic costs and benefits to reflect their relative importance to different income levels.
FSU	Former Soviet Union
GCM	global circulation model
GDP	Gross Domestic Product (measure of a nation's economic output)
GNP	Gross National Product (= GDP + net property income from abroad)
GHGs	greenhouse gases
GJ	gigajoule = one billion joules
GtC	gigatonnes of carbon (one gigatonne = 1 billion (10^9) tonnes of carbon
Hockey stick	figurative name for the suggested time-profile of temperature change over long periods of time – fairly constant until the 19th century with a sharp upturn thereafter (the blade of the stick).

IAM	Integrated Assessment Model – a model combining a simplified form of a climate model and a model of the global economic system
IEA	International Energy Agency
Insolation	incoming solar radiation
IPCC	(United Nations) Intergovernmental Panel on Climate Change
kWh	kilowatt hour
kWh/m^2	kilowatt hours per square metre
Kyoto Protocol	first protocol (1997 ratified 2005) to the UN Framework Convention on Climate Change (1992) setting GHG emission reduction targets for industrialised nations
Land use change	alteration of land uses such that carbon emissions (especially) are likely to change, e.g. conversion of forest to agriculture
MARKAL	a computerised model integrating energy and economic magnitudes
MER	market exchange rate
MtC	million tonnes of carbon
NG	natural gas
NG/CC	natural gas combined cycle
N_2O	nitrous oxide, a greenhouse gas
Nuclear fusion	possible future form of nuclear power, based on a nuclear reaction in which atomic nuclei of low atomic number fuse to form a heavier nucleus with the release of energy
ppm	parts per million (a measure of atmospheric concentration)
PPP	purchasing power parity exchange rate
Proxy measure	(in the current context) a measure of temperature that is not derived from direct observation via thermometers, e.g. tree rings, ice cores
PV	present discounted value
PV	photovoltaic
R & D	Research and Development
SF_6	sulphur hexafluoride, a greenhouse gas
SRES	(IPCC) Special Report on Emission Scenarios
tC	tonne of carbon
tCO_2	tonne of carbon dioxide
THC	ocean thermohaline circulation (deep ocean currents)
WTO	World Trade Organisation

Rt Hon the Lord Lawson of Blaby of Newnham

Lord Lawson is a Conservative Life Baron, raised to the peerage as Rt Hon the Lord Lawson of Blaby of Newnham in the County of Northamptonshire in 1992. he was born on 11 March 1932, and was educated at Westminster School and Christ Church, Oxford (Scholar, BA philosophy, politics and economics 1954). He married Vanessa Mary Salmon 1955 (1 son 2 daughters and 1 daughter deceased); they divorced in 1980. He married Thérèse Mary Maclear 1980 (1 son 1 daughter).

Former Chancellor of the Exchequer Nigel Lawson is an internationally esteemed economist and renowned statesman who played a key role in the development of European economic and monetary union. He is currently Chairman of the Central Europe Trust, a strategic and consulting firm specialising in Central and Eastern Europe. In addition he also serves as President of the British Institute of Energy Economics, is a member of the Board of Directors of the Institute for International Economics in Washington, and a member of the International Advisory Board of Total SA.

During his political career he was a key figure in shaping Britain's fiscal and economic policies. As Secretary of State for Energy he had responsibility for the privatisation of the energy sector until he was appointed Chancellor of the Exchequer, a post he held for six years.

Lord Lawson's widely acclaimed book: The View From No. 11 - Memoirs of a Tory Radical shares with the reader his political and economic views and also addresses the issues of the ERM, the single European currency, unemployment, Europe and the nature of modern democracy.

Career
- Served Royal Navy 1954-56
- Member, editorial staff, "Financial Times" 1956-60;
- City Editor, "Sunday Telegraph" 1961-63;
- Special Assistant to Sir Alec Douglas-Home, as Prime Minister 1963-64;
- "Financial Times" columnist and BBC broadcaster 1965;
- Editor, "The Spectator" 1966-70;
- Chair, Central Europe Trust (CET) 1990-;
- Director, Barclays Bank plc 1990-98
- President, British Insititute of Energy Economics 1995-

Publications
- Co-author "The Power Game", 1976;
- "The View from Number 11: Memoirs of a Tory Radical", 1992;
- Co-author "The Nigel Lawson Diet Book", 1996

Charities
- Member of Governing Body, Westminster School

Honours
- Privy Counsellor 1981
- Hon. Student, Christ Church, Oxford 1996

Commons
- Opposition Spokesperson for Treasury and Economic Affairs 1977-79
- Commons Whip
- Opposition Whip 1976-77
- Contested (Conservative) Eton and Slough 1970 general election;
- MP (Conservative) for Blaby February 1974-92;
- Financial Secretary to the Treasury 1979-81;
- Secretary of State for Energy 1981-83;
- Chancellor of the Exchequer 1983-89

STATEMENT OF MARGO THORNING, PH.D., SENIOR VICE PRESIDENT AND CHIEF ECONOMIST, AMERICAN COUNCIL FOR CAPITAL FORMATION

INTRODUCTION

Mr. Chairman and Members of the Committee, I appreciate the opportunity to present this testimony before the Senate Environment and Public Works Committee

The American Council for Capital Formation represents a broad cross-section of the American business community, including the manufacturing and financial sectors, Fortune 500 companies and smaller firms, investors, and associations from all sectors of the economy. Our distinguished board of directors includes cabinet members from prior Republican and Democratic Administrations, former Members of Congress, prominent business leaders, and public finance and environmental policy experts.

The ACCF is celebrating nearly 30 years of leadership in advocating tax, regulatory, environmental, and trade policies to increase U.S. economic growth and environmental quality.

BACKGROUND

The European Union has a target of an 8 percent reduction from the 1990 base-year level for the Kyoto Protocol's 2008–2012 commitment period. To assist in meeting its target, the EU has put in place an emissions cap and trade system (ETS) covering carbon dioxide emissions for selected large industry and utility sectors.

WHERE DOES EUROPE STAND ON ACTUALLY COMPLYING WITH KYOTO?

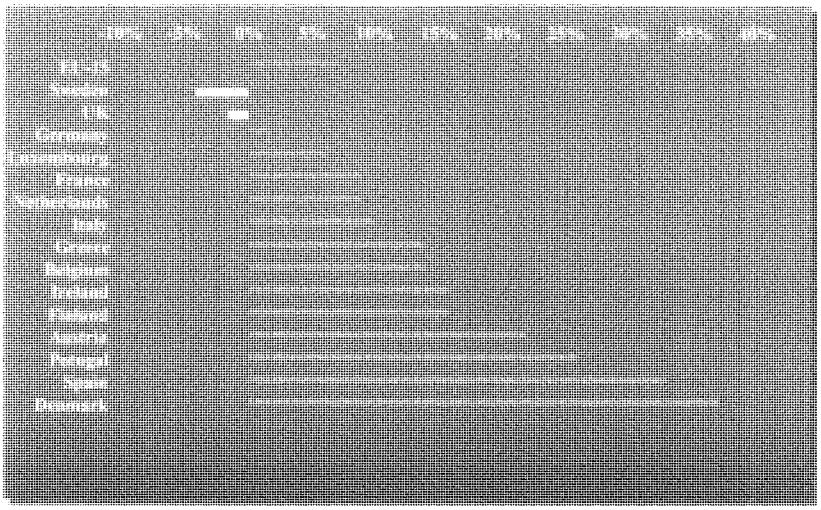
The original 15 members of the European Union are projected to be 7 percent above the 1990 emission levels by 2010. Data from the European Environmental Agency show that only Sweden and the UK are likely to meet their Kyoto targets. (See Figure 1.) Spain, Denmark and Portugal are projected to be 25 percent to 35 percent above their targets in 2010. EU policymakers are beginning to worry about the additional steps required to meet the targets, including impact of emission trading schemes on industry. They realize they cannot reconcile goals of increased EU industrial competitiveness as well as tighter future targets for GHG emission reductions. UK Prime Minister Terry Blair said on September 15, 2005 at the Clinton Global Initiative, "The truth is no country is going to cut its growth or consumption substantially in the light of a long-term environmental problem. To be honest, I don't think people are going, at least in the short term, to start negotiating another major treaty like Kyoto."

MEASURING THE ECONOMIC IMPACT OF THE KYOTO PROTOCOL ON THE EU:

GDP and Employment Effects

As studies by the International Council for Capital Formation (ICCF) illustrate, an accurate portrayal of the costs of complying with GHG emissions reduction targets depends largely on choosing an economic model that captures all the short- and medium-term costs of adjusting to higher energy prices or regulatory mandates on the economy as a whole. (See "Economic and Modeling of Climate Change Policy" at www.iccfglobal.org.)

Figure 1: Greenhouse Gas Emissions in the European Union Projected to Exceed Kyoto Targets in 2010

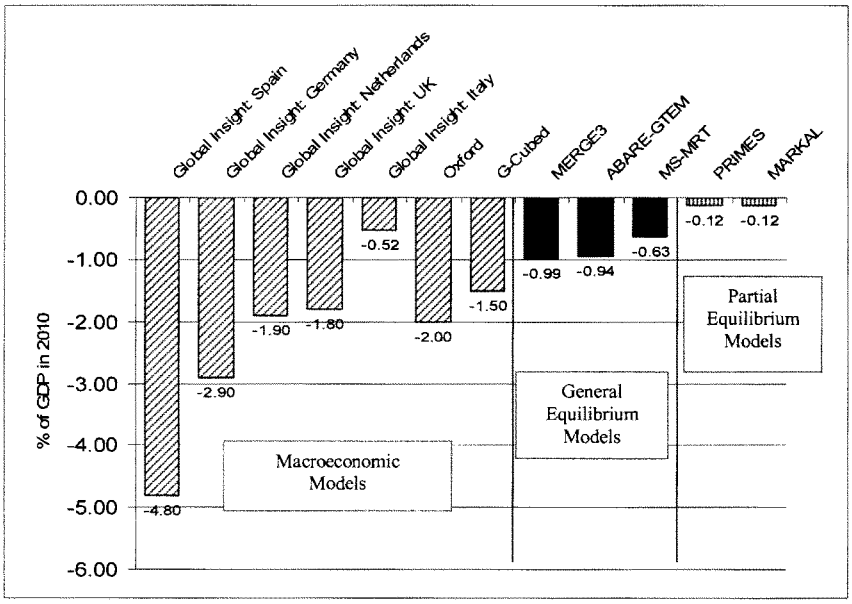


Source: European Environmental Agency, November 30, 2004

For example, some economic models such as the PRIMES model used by the EU environmental agencies are designed only for measuring sectoral effects, not economy wide effects. PRIMES is primarily designed to show the effect of policy changes on energy markets. It can calculate the direct cost implications of reduced energy use but not the economy-wide impact on gross domestic product (GDP), employment, investment, etc. Thus, the results of this model, which show a reduction of only 0.12 percent in GDP to the EU in 2010 from complying with the Kyoto Protocol, are not an accurate measure of the total costs to EU households, businesses, the economy, and government. (See Figure 2.) These sectoral models underestimate the negative economic effects by a factor of 10 to 15 times (0.12 vs. 1.5 to 2.0). Such reliance on results from PRIMES has led EU officials, industry, and households to believe that the costs of achieving the Kyoto Protocol's targets and the further cuts planned for the second and subsequent commitment periods will be relatively small. However, as the study "ACROPOLIS," released by DG Research of the European Commission in September 2003 noted, the tighter targets that are being discussed under the second commitment period could reduce GDP by 1.3 percent annually by 2030.

Even general equilibrium models, which measure "big picture" impacts on an economy after it has had time to adjust (over 30 to 40 years) to higher energy prices, show GDP losses of about 1 percent per year under Kyoto, which are an order of magnitude greater than PRIMES. (See Figure 2.) Even though general equilibrium models look at a period of time much longer than the Kyoto timetable, their results more accurately reflect the consequences of curbing emissions than does a sectoral model like PRIMES. General equilibrium models reflect the full economic impact of reducing emissions, not just the impact on the energy sector. Given their long time frame, general equilibrium models are unable to capture short-term adjustment costs and therefore probably underestimate near term impacts. Despite that fact, they still indicate that the economic impact of meeting Kyoto and post-Kyoto emissions targets will have an economic impact far greater than PRIMES.

Figure 2: Impact of Kyoto Protocol on GDP Levels in the EU in 2010 Alternative Model Forecasts



Source*: *International Council for Capital Formation "The Impact of EU Climate Change Policy on Economic Competitiveness" For presentation at a forum sponsored by Istituto Bruno Leoni, Milan, Italy November 29, 2003, Revised November 2004. (www.iccfglobal.org)

Macroeconomic models provide an assessment of the overall economic costs of meeting emission targets where the short-term, frictional cost of adjustment is included. These models, which U.S. scholars and climate policy modelers began using in the early 1990s to measure the impact of Kyoto on the U.S. economy, quantify the impact on employment, investment, budget receipts, and GDP growth when an economy is "shocked" by having to make quick changes in its capital stock, production processes, lifestyles, etc. Results of macroeconomic models show that Kyoto would have negative effects on the U.S. economy in the range of 1.5 percent to about 4 percent of GDP in 2010.

When macroeconomic models are used to measure Kyoto's effects on the EU, the impacts are greater 0.5 to 5 percent less GDP in 2010—than those derived from sectoral models like PRIMES. For some countries like Spain, the GDP loss due to reduced energy use will be severe Spanish GDP in 2010 is estimated to be about 4.8 percent smaller than under the baseline forecast. (See Figure 2.).

Employment in the EU would also be negatively affected by the imposition of an emission trading system with carbon prices high enough to force down energy use. The Global Insight simulations show job losses in 2010 ranging from 51,000 in Italy to 800,000 in Spain. (See www.iccfglobal.org.)

The Impact of the Emission Trading System: Impact on Electricity Prices

The European Union's Emission Trading System (ETS) was established in 2003. The goal was to implement a policy that was both cost-effective and operated in a similar way across the whole EU market, to reduce emissions of carbon dioxide and potentially other greenhouse gases, both to comply with the EU's commitments to 2012 under the Kyoto Protocol and to achieve further emission reductions thereafter.[1]

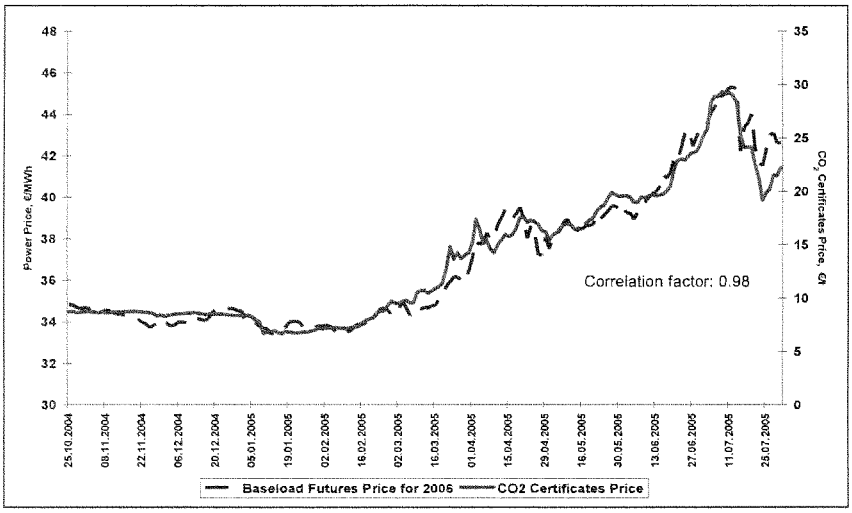
[1] Ofgem, "Emission Trading: Impacts on Electricity Consumers," February 2005.

The first Phase of the ETS will run from 2005–2007, and Phase 2 will coincide with the commitment period of the Kyoto Protocol, 2008–2012. Subsequent phases will be of 5 years duration.

The ETS applies to installations throughout the 25 Member States of the EU that engage in the following activities and are above a specified size: combustion installations (most importantly for power generation, but excluding municipal and hazardous waste incineration), mineral oil refineries, coke ovens, steel manufacturing, and production of cement, lime, glass and glass fibre, ceramics and pulp and paper. It has been estimated that the ETS will apply to 9,200 to 12,000 installations that are responsible for about 46 percent of EU carbon dioxide emissions. The Directive also provides for other sectors (perhaps chemicals, aluminum and aviation) and gases to be included in Phase 2 at the discretion of Member States.

Although the ETS has only been in operation for a short time, electricity prices in the EU are rising, as shown in Figure 3. EU electricity prices are closely tracking the cost of the emissions trading permits. While some of the increases in electricity prices are doubtless due to rising global energy prices, part of the 31 percent rise in power can be attributed to higher prices for the right to emit a ton of CO_2.

Figure 3: Power and CO_2 Certificates Prices' Developments



Source: "Correcting the failures in the EU-Emissions Trading Scheme", International Federation of Industrial Energy Consumers, June 28, 2005.

COULD AN INTERNATIONAL EMISSION TRADING SYSTEM FUNCTION EFFECTIVELY?

Many Kyoto proponents want to see the EU's ETS system spread to the rest of the world. However, as a new study by Dr. David Montgomery of CRA International shows, a global emission trading system is not workable.[2] Emission trading will work only if all the relevant markets exist and operate effectively; all the important actions by the private sector have to be motivated by price expectations far in the future. Creating that motivation requires that emission trading establish not only current but future prices, and create a confident expectation that those prices will be high enough to justify the current R&D and investment expenditures required to make a difference. This requires that clear, enforceable property rights in emissions be defined far into the future so that emission rates for 2030, for example, can be traded today in confidence that they will be valid and enforceable on that future date. The international framework for climate policy that has been created under the UNFCCC and the Kyoto Protocol cannot create that confidence for investors because sovereign nations have different needs and values. Therefore, it seems

[2] International Council for Capital Formation: Climate Change Policy And Economic Growth: A Way Forward to Ensure Both; page 65–79. April 2005 (see www.iccfglobal.org).

likely that the ETS system which the EU is trying to implement will fail to spread to other parts of the world and will eventually be replaced with a more practical approach to climate change policy. Several provisions of the 2005 Energy bill should have a positive impact on climate change. The new Asia-Pacific Partnership for Clean Development and Climate should also play a key role in transferring new technology to developing countries and help provide the practical assistance that is needed for a global approach to emission reduction.

CONCLUSIONS

There are many urgent global problems such as lack of food, sanitation and potable water that are daily imposing hardship and death on the world's least fortunate citizens. Energy use and economic growth go hand in hand, so helping the developing world improve access to cleaner, more abundant energy should be our focus. Near-term GHG emission reductions in the developed countries should not take priority over maintaining the strong economic growth necessary to keeping the U.S. one of the key engines for global economic growth. Establishing a mandatory cap and trade system in the United States would impede, not promote, U.S. progress in reducing emissions intensity. U.S. climate change policies should continue to strive to reduce energy intensity as the capital stock is replaced over the business cycle and to develop new, cost-effective technologies for alternative energy production and conservation and encourage the spread of economic freedom in the developing world. This approach is likely to be much more productive than having the U.S. adopt an ETS and thereby sacrifice economic well-being and job growth with little or no long-term impact on global GHG emissions.

RESPONSES BY MARGO THORNING TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. What would be the appropriate economic incentives for companies to develop cost-effective carbon capture technologies?

Response. The private sector is the United States is currently developing way to capture carbon. Some oil and gas companies, for example, are able to ship the CO_2 produced when oil and gas are extracted for injection in to old wells in order to enhance production. In this case, the market is providing the economic incentive to capture the carbon. Additional incentives to develop carbon capture technology could be provided by more favorable tax treatment for these investments. The U.S. lags behind many of its international competitors in capital cost recovery for energy and pollution control equipment. For example, after 5 years a U.S. investor recovers only 65.8 percent of his investment in a scrubber compared to 105 percent in China, 100 percent in Taiwan and 80 percent in Japan. Slow U.S. capital cost recovery raises the cost of capital and impedes investment in cleaner, more efficient energy equipment and hinders the achievement of environmental goals.

In addition to the ongoing efforts of the private sector to develop technologies to sequester and capture carbon, the U.S. government has budgeted about $3 billion per year for its Climate Change Technology Program, including research on carbon capture and sequestration. In 2003, DOE initiated a nationwide network of regional Carbon Sequestration Partnerships involving State agencies, universities, and the private sector.

Question 2. I know you have looked at the economics of the implementation of carbon control. What, in your view, are the most informative peer-reviewed studies that have been done on the economic impacts of a cap and trade program for CO_2?

Response. The most informative analyses make use of either macroeconomic models which are designed to capture the near term effects of curbing energy use or general equilibrium models which capture the long run (30–40 years) effects of policies to curb energy use. Other useful studies make use of cost-benefit analysis to evaluate the appropriate policy decisions to address climate change. Among the peer reviewed studies for the U.S. are those by Professors Willian Nordhaus, Thomas Rutherford, Alan Manne, and Dr. David Montgomery and Dr. Brian Fisher (see sources in my testimony of July 18, 2001 before the Governmental Affairs Committee of the U.S. Senate, the link is http://www.accf.org/pdf/TestSenFin701.pdf). Other useful analyses, while not peer-reviewed have been released by the U.S. Department of Energy's Energy Information Administration, and by the macroeconomic forecasting firm, Global Insight Inc. (formerly DRI-WEFA).

Question 3. I want to ask a question about the role the market can play in addressing climate change. If the increasing price of carbon intensive goods does not encourage manufacturers to seize market forces and develop less carbon intensive

goods, as we are now seeing, is there a role for government to see that the market does so?

Response. In my view, the policies put in place by the Bush Administration to encourage reductions in energy intensity (energy used per dollar of GDP) will be more effective than government mandates or a cap and trade system for reducing the growth in emissions. For example, most of the original 15 EU members are projected to substantially exceed their Kyoto Protocol targets in 2010. In contrast, U.S. emission intensity has fallen by 16.9 percent over the 1992–2002 period compared to only 9.3 percent in the EU. Our faster economic growth (over 3 percent per year compared to 1 percent in the EU) allows for faster replacement of the capital stock and faster reductions in emission intensity.

Question 4. If not by having developed nations, which reaped the benefits of carbon intensive energy for the last hundred years, lead the charge for developing new technologies to reduce carbon emissions, then how would you propose we as a nation encourage China, India and other developing nations reduce their carbon emissions?

Response. According to an analysis by the Canadian Fraser Institute, countries which rank high on their index of Economic Freedom also grow more rapidly. Economic freedom is defined as protection of property rights and contracts, openness of internal markets, overall share of output absorbed by government, political freedom and lack of import restrictions and lack of subsidies through state run enterprises. New research by David Montgomery of CRAI, Inc. shows that countries which rank high in terms of economic freedom use much less energy per dollar of output than countries ranking low on the index of economic freedom (see link to my power point presentation, slide #11 http://www.iccfglobal.org/pdf/ICCF-Slovenia-Oct2005.pdf).

Question 5. In your June 24th letter to the editor in the Washington Post, you wrote, "If economic freedom and economic growth could be accelerated in developing countries, emissions intensity would decline as countries get richer and able to adopt cleaner energy technologies." If wealthy developed nations fail to take action to curb greenhouse gases through use of innovative technologies, why would you think that developing nations would make such a different choice?

Response. Research shows that as countries grow and develop, environmental quality may at first decline. However as GDP per capita rises, gradually environmental quality rises, water and air become cleaner and other measures of environmental quality improve. As noted in my response to question number 3, emission intensity is slowing faster in the U.S. than in the EU. Developed country emission growth is slowing; in fact U.S. CO_2 emissions actually fell by 0.3 percent from 2000 to 2003 even though U.S. population grew by 8.6 million during that time. As developing countries grow, they are likely to choose less emitting, more energy efficient technologies so as to improve air quality. For example, China plans to build 40 new nuclear power plants over the next 20 years.

Question 6. You conclude that near-term greenhouse gas emissions reductions should not take priority over U.S. economic growth. Will there ever be a time when you think reducing greenhouse gases should take precedent? What peer reviewed scientific evidence do you have that limiting gas emissions today will have little or no long-term impact on global greenhouse gas emissions?

Response. Studies cited by Bjorn Lomborg in his book "The Skeptical Environmentalist (2001)" shows that even if Annex I countries met their Kyoto Protocol targets the temperature in the year 2100 would be only 0.5C lower than under a business as usual scenario. Because of the long life of CO_2 in the atmosphere and the projected growth of emission in developing countries it is not a cost-effective strategy to impose near term targets and timetables on developed countries. Instead the focus needs to be on promoting strong economic growth to enable countries to invest in less emitting energy and manufacturing and transport technologies. Promoting economic growth will also enable countries to adapt more easily to possible changes in temperature, no matter what the underlying cause.

Question 7. Specifically, which provisions of the Energy Policy Act of 2005 will lead to reduce carbon emissions?

Response. The tax incentives in the Energy Policy Act of 2005 (9.2 billion over the 2005–2015 period) for renewable energy, nuclear power, clean coal facilities, energy transmission, conservation and alternative motor vehicle and fuels would all help to reduce carbon emissions. In addition, provisions in Title XVI, Subtitle B will help DOE identify technology options which could reduce GHGs and are suitable for transfer to developing countries.

RESPONSE BY MARGO THORNING TO AN ADDITIONAL QUESTION FROM SENATOR OBAMA

Question. At the end of your written testimony, you conclude that rather than risk harm to the economy from reducing greenhouse gas emissions, it would be better to keep the U.S. as a key engine for global economic growth. That engine can then be used to spur development of clean energy in developing countries. If global climate change is having any hand in African drought and subsequent death from famine, does your view of U.S. responsibility for speeding up reductions in our greenhouse gas emissions change despite the possible risks to the economy?

Response. Adopting caps on U.S. carbon emission will do very little to reduce the growth in man made CO_2 emissions as developing country emissions from China, India, Brazil and other countries will soon outstrip those of the developed world. In addition, CO_2 stays in the atmosphere for approximately 100 years so reducing CO_2 concentrations is a very long term proposition. The tragedy of poverty and famine in Africa is best addressed through promoting economic freedom and reducing government corruption so that economic growth and improved living standards will occur. Policies which impose caps on U.S. carbon emissions will only slow our own economic growth, thus making it harder for the U.S. to provide funds and technical support for the world's poor.

STATEMENT OF MICHAEL GRUBB, PH.D., CHIEF ECONOMIST, THE CARBON TRUST, SENIOR RESEARCH ASSOCIATE, FACULTY OF ECONOMICS, CAMBRIDGE UNIVERSITY, AND VISITING PROFESSOR OF CLIMATE CHANGE AND ENERGY POLICY, IMPERIAL COLLEGE, LONDON

My name is Michael Grubb. I am Chief Economist of the UK Carbon Trust, an independent company funded by the UK government with turnover approaching US$150m/yr, established jointly between UK government and industry in 2001. The aim of the Carbon Trust is to help UK business and public sector implement CO_2 emission reductions cost-effectively and to develop a competitive low carbon industry technology sector.

My post is half time, which I combine with academic research through a post at the Faculty of Economics at Cambridge University, and a Visiting Professorship at Imperial College, where I was Professor of Climate Change and Energy Policy before joining the Carbon Trust. I am also editor-in-chief of the Climate Policy journal.

In this testimony I set out some key points in relation to the UK's delivery of its emission targets and the design of the Kyoto Protocol, and append a presentation that I gave yesterday to the Columbia University School of International and Public Affairs.

This submission contains the following components: key points about the emissions context for the Kyoto Protocol; implementation policies and prospects; observations about the economics of implementation of carbon management and low-carbon technology; and a concluding section that summarises my points in relation to what appear to some "common myths" about the Protocol.

1. The global emissions context

Policy on climate change is set in a context of large divergence of emissions between countries. This is illustrated in Chart 9 in the attached presentation, which shows the global distribution of CO_2 emissions in terms of three major indices: emissions per capita (height of each block); population (width of each block); and total emissions (product of population and emissions per capita = area of block).

Per capita emissions in the industrialized countries are typically as much as ten times the average in developing countries, particularly Africa and the Indian subcontinent. This is one of the reasons why industrialized countries accepted the responsibility for leading climate change efforts in the UNFCCC and subsequent Kyoto negotiations: unless they can control their own high emissions there is little prospect of controlling emissions from developing countries that start from a very much lower base.[1] There are also large differences among the industrialized coun-

[1] Article 4.2 of the UNFCCC commits industrialised countries to adopt 'policies and measures that will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention', with the initial 'aim' of returning their emissions of CO_2 and other greenhouse gases to 1990 levels. This became the focus of attention in the years immediately after the Convention and the failure of key industrialised countries to move in this direction was a principal reason why Kyoto moved to binding commitments focused on the industrialised countries.

tries, with per capita emissions in the EU and Japan at about half the levels in the United States and Australia.

The main aim of the Kyoto Protocol is to contain emissions of the main greenhouse gases in ways that reflect underlying national differences in emissions, wealth and capacity, following the main principles agreed in the UN Framework Convention on Climate Change (UNFCCC). These include the need for evolutionary approaches and the principle of 'common but differentiated' responsibilities, including leadership by the richer and higher emitting industrialised countries. Following the agreed negotiating mandate,[2] in Kyoto the countries that took on quantified commitments for the first period (2008–12) are the industrialised countries as listed in Annex I to the Treaty, which correspond roughly to those with per-capita emissions in 1990 of two tonnes Carbon per capita (2tC/cap) or higher—the 'Other EIT' [Economies in Transition] category and all to the left of it in the Chart.

At the same time, the currently low emissions and large population of the developing countries indicates the huge potential for global emissions growth, if and as their emissions climb towards anything like levels in the industrialized world. The Kyoto negotiations were marked by big tensions on this issue. In the final agreement, in addition to the provisions on national reporting and technology transfer, the Clean Development Mechanism is intended to provide a mechanism to start reigning in the rapid growth of developing country emissions without these countries themselves bearing the costs. The intent is that developing countries will engage more over time, in subsequent negotiation rounds, if and as the richer countries fulfil their commitments.

2. Current implementation policies and prospects

I shall speak in relation to policies principally in the UK, where a variety of instruments have been in place since about the year 2000 in the context of the UK Climate Change Programme (HMG, 2000), more recently complemented by the European Emissions Trading Scheme. At the core of the programme is a set of measures to encourage investment in established low carbon technologies, particularly relating to energy efficiency, combined with increased government expenditure along the 'innovation chain' of low carbon energy technologies. Already by FY 2002–3 these efforts amounted to a diverse set of instruments with a total incentive value for low carbon-related investments of around US$2bn.

The UK has generally found emissions reductions to be associated with positive economic developments. UK emissions reduced substantially during the 1990s as a result of privatisation in energy-consuming industries, that helped to boost their efficiency, and liberalisation of the UK electricity and gas systems that included a "dash for gas". It is estimated that this accounted for about half of the total observed reductions in UK CO_2 emissions. Sharply rising gas prices in the most recent years have reversed the trend towards natural gas in power production and resulted in a slight increase in CO_2 emissions.

A number of the measures indicated have continued to expand, and the government is currently conducting a major review. The Carbon Trust, for which I work half time, has steadily expanded its operations in relation to both energy efficiency and low carbon technology investments.

THE ECONOMICS OF ENERGY EFFICIENCY

Technical assessments systematically show a potential for reducing both emissions and costs; the UK Energy White Paper estimates that the UK economy could save several billion pounds through increased energy efficiency (see appended presentation). Many barriers impede corporate take-up of this potential (Charts 13–15).

Part of the Carbon Trust's remit is to help companies deliver these efficiency improvements, and our experience confirms the potential for reducing both emissions and costs. In FY 2004–5 the Carbon Trust spent L26m (c.US$40m) on its carbon management programmes, we estimate that our clients co-invested L80m–L130m (c.US$120–220m), and the value of the energy savings to these companies was L280m–L430m (c. US$400–US$700). [Chart 16] The Carbon Trust continues to get

[2] The COP 1 meeting agreed that the UNFCCC commitments were inadequate, and consequently to 'begin a process to enable it to take appropriate action for the period beyond 2000, including the strengthening of the commitments of Annex 1 Parties, i.e. the industrialized world', to (a) 'elaborate policies and measures'; and (b) 'set quantified limitation and reduction objectives within specified time-frames, such as 2005, 2010 and 2020. It was agreed that these negotiations 'should not introduce new commitments for developing countries', but should enhance the implementation of their existing commitments under the UNFCCC. Thus were launched the intensive negotiations that finally culminated in Kyoto.

strong and growing market interest and our budget is targeted to increase to about L110m (c. US$180m) annually over the next 3 years.

Companies in the Climate Change Agreements—the agreements with energy intensive sectors to deliver quantified emission reductions in return for rebates on the UK Climate Change Levy—have generally over-delivered on their targets, in part because they found more opportunities for cost-effective savings than originally anticipated.

These measures, together with other measures in the UK climate change programme and the introduction of the European Emissions Trading Scheme, mean that the UK is on track to over-achieve its Kyoto target of reducing greenhouse gas emissions to 12.5 percent below 1990 levels, and will profit from doing so.

TECHNOLOGY INVESTMENT

Low carbon technology and innovation are essential to delivering long term, deep emission reductions. Most of the technologies that competitively use and supply energy today have matured in the private sector, and this is likely to be true in the future.

Based on Carbon Trust experience and developments in the empirical economics innovation, I offer four broad observations about low carbon technology from a business perspective.

First, innovation, to business, is not a dream for future decades but a continuous process of constantly evolving, improving and selling new products. From this perspective, calls for massive government R&D and technology transfer programmes are inadequate answers to an ill-defined question about delivering "low carbon technology". The idea that low carbon technologies are all things for tomorrow is a myth that does not reflect reality. There are many products and services designed for efficiency that could bear the label "low carbon" right now. There are efficient cars, appliances, buildings and even renewable energy sources growing both their sales and market share. The challenge is to accelerate their uptake in a world where consumers are aware of climate change but not ready to buy something on the basis of it. This not only reduces emissions directly, but also gives confidence to the private sector that low-carbon innovations will more quickly find markets—and hence rewards. Energy efficiency standards, trading and fiscal schemes that reward the adoption of more efficient, lower-emitting technologies, are an important part of the technology story.

Second, measures that place a price on carbon, like the EU emissions trading system for implementing Kyoto, are an essential part of a low-carbon technology strategy. Robustly implemented, cap-and-trade systems provide the beacon for deeper private sector innovation and investment, and also deter investment in carbon-intensive innovation and capital stock which could prove extremely expensive to reverse as governments respond more strongly to the mounting impacts of climate change over time.

Third, although such measures are necessary they are not sufficient. The barriers to deeper innovation are large, particularly when the price signal is so uncertain partly because of the lack of international consensus even on the fact that it is needed. Technology innovation takes a long time as good research becomes a good idea, a proven concept and finally a commercial technology. These earlier stages do not require just R&D, but a whole chain of support to help build businesses out of bright ideas, so as to help technologies bridge the 'valley of death' that has previously impeded our countries from securing the fruits of R&D. Financial support, test centres, field trials and precommercial markets developed through a variety of policy mechanisms all have a role to play.

Fourth, for the crucial global dimension, it is important to recognise that most innovation occurs in a handful of major industrial powers and is diffused globally through investment by multinational companies. The calls for global R&D and technology transfer programmes thus miss the point. The key is to ensure that energy innovation in those major powerhouses—national and corporate—is supported by domestic market incentives, is in a low carbon direction, and is then projected internationally by incentive systems that reward low-carbon investors in developing countries. Kyoto's Clean Development Mechanism seeks to do just that (though much must be done to make the CDM more attractive to business), and future expansion of cap-and-trade type targets and associated domestic policies over time would do the job still better.

The world will spend many trillions of dollars on energy provision over the next few decades: expenditure that will determine both the scale of climate change and the energy technology systems that will dominate the rest of the Century. At present much of that investment is flowing towards new and innovative ways of

making the climate problem worse, by accessing ever more difficult sources of carbon and transforming them into useful energy. Low carbon technology offers the solution to climate change, but the question is about incentives. From a business perspective, it is wholly erroneous to suggest that the best way to deliver low carbon technologies is to avoid—or even abandon, where now adopted—the very policies that can make investing in them strategically worthwhile.

THE KYOTO PROTOCOL

The Kyoto Protocol has four main elements:

• it states that the way to solve the climate problem is for countries to negotiate quantified, binding limits on their overall greenhouse gas emissions, sequentially over time as the uncertainties reduce and they gain experience;
• these commitments are embedded in a variety of flexible market-based instruments like emissions trading, to make them as efficient as possible;
• the Treaty specifies the first round of limits, on emissions during 2008–12 for the industrialised countries that had already agreed in the original Convention to take the first specific steps;
• it has various provisions to bring in the rest of the world, including the 'Clean Development Mechanism' under which industrialised countries can gain emission credits for investments that reduce emissions in developing countries.

Like any agreement, it is far from perfect. But in defining commitments in terms of the outcome (emissions, on as wide a gas basis as practical, rather than trying to mandate specific technologies, policies, or measures); and in building in an unprecedented array of economics instruments with global reach, it is a Treaty probably more strongly influenced by economic reasoning than any other in history save those specifically related to trade and investment. Indeed, the Protocol's flexibility mechanisms were largely designed by US economists.

These flexibilities are crucial to understanding the compliance strategies of EU Member States. Most EU Member States do not intend to deliver all their targets domestically. The majority will fall short in domestic delivery, and will comply through use of the Protocol's flexibility mechanisms.

Most crucially, these mechanism include the Clean Development Mechanism, which generates emission reduction credits for investment in projects that help developing countries to adopt a cleaner course of development. The bigger the gap between domestic delivery and a country's Kyoto target, the more it will need to invest through the CDM and associated flexibility mechanisms in order to comply. To put it more bluntly, the Kyoto Protocol is only effective in helping developing countries to develop more cleanly to the extent that industrialised countries fall short of delivering their targets domestically; and this was built into the design of the Protocol and its first period targets. EU Member States have already set aside several billion Euros to help fund their compliance with the Kyoto Protocol in this way.

In effect, the design of the Kyoto Protocol ties countries to their targets with the elastic of international investment requirements to cover any gap. I have seen no evidence that any European country intends to defy international law by cutting this elastic.

To conclude, it appears to me that there are several misunderstandings about the nature of the Kyoto Protocol and I wish to close by setting out my perspective on these:

1. Environmental Effectiveness. The Kyoto Protocol provides the framework for a dynamic, evolving regime, with the current set of emission targets for the first commitment period being only the first step in a much longer term process of tackling climate change. The Protocol establishes a structure of rolling commitment periods, with agreement that negotiations on second period commitments (intended for 2013–2017) will start by 2005. The current first period emission targets are intended to meet the Convention requirement that industrialised countries should demonstrate that they are taking the lead by modifying their emission trends; they were never intended to provide the definitive solution to climate change. Much greater emission reductions will be needed to stabilize atmospheric concentrations of GHGs. The Protocol offers a structure through which to achieve this, by gradually "ratcheting up" the Protocol and its resulting environmental effectiveness. A similar approach was used in the ozone regime, where the Montreal Protocol's initial CFC emission target of a 50 percent cut was far from being environmentally effective, but was progressively tightened over time to greatly increase the treaty's environmental impact.

2. Developing country involvement. The Kyoto Protocol is very much a global agreement, and so is the Framework Convention on which it is based. All parties,

including developing countries, have a general commitment to adopt climate change mitigation policies and to report on the action they are taking. The Kyoto Protocol also establishes the Clean Development Mechanism (CDM) to promote globally sustainable development, especially through partnership with the private sector. By ratifying the Convention, its 185 parties agreed that establishing quantified commitments for countries in earlier stages of development would be premature and inequitable, as well as impractical, given the huge uncertainties in their emissions data, growth trends and governance. However, there is a clear understanding that, as industrialized countries take the lead in moving their economies onto a less carbon intensive path, the developing countries will follow. This understanding is built into the Protocol, which stipulates that its overall "adequacy" must be reviewed no more than two years after it enters into force. Along with the above-mentioned requirement for negotiations on second commitment period targets, the issue of deepening developing country commitments will be on the agenda.

3. Kyoto is a flexible agreement with feasible commitments. The Kyoto targets were negotiated as a package along with the various flexibilities in the agreement, including the market-based mechanisms of joint implementation, the CDM and emissions trading, as well as carbon sinks, multiple gases and a five-year commitment period, all of which the US fought hard to get agreed in the Protocol. These flexibilities make compliance feasible even for countries that have taken little domestic action so far and are facing a large gap between domestic emissions and their Kyoto 'assigned amounts', providing they undertake appropriate investments through the mechanisms.

4. The costs of meeting the Protocol's targets are modest. I have testified to UK experience. The IPCC reported results from global modeling studies of the costs for complying with Kyoto to be in the range 0.1 to 1.1 percent of GDP, with full emissions trading but without other Kyoto flexibilities (multiple gases, sinks, or CDM), which would further lower costs. This equates to between 0.01 and 0.1 percent reduced annual GDP growth rate in the richest countries of the world, far smaller than the standard uncertainties in economic growth projections that governments routinely use as the basis for policy making. The IPCC also notes that poor climate change policies to implement the Protocol's targets could raise costs, whilst smart implementation (e.g. that harnesses cost-effective efficiency improvements, co-benefits, and 'double dividends' from shifting taxation) would lower them; some European studies even show net economic benefits.

5. Kyoto is a carefully-crafted and integrated package developed over many years of global negotiations. As with any multilateral agreement, different parties place value on different provisions. Most developing countries were already unhappy with what they saw as weak targets in the Protocol; weaken them still further and the prospects for enticing developing countries into a global regime of quantified commitments will grow ever more distant. And as noted, it is the targets themselves that drive the Protocol's international mechanisms.

Kyoto is neither perfect, nor comprehensive; what global agreement ever is? But it offers a credible structure to solve the problem. It has survived because no-one has yet come up with an overall more plausible, or more efficient, basic approach to international agreement that can effectively limit emissions and expand over time as the seriousness of the problem becomes more apparent.

The economics of greenhouse gas mitigation

Presentation to Centre for Energy, Marine, Transportation and Public Policy
School of International and Public Affairs, Columbia University, 4 Oct 2005

Michael Grubb, Chief Economist, The Carbon Trust
Visiting Professor, Imperial College London, Faculty of Engineering
Senior Research Associate, University of Cambridge, Faculty of Economics

Imperial College
University of Cambridge
Applied Economics
CARBON TRUST

1.

Overview

- A few words on climate change impacts and evaluation
- A global view of the Stabilisation challenge
- The economics of energy efficiency: evidence and implications
- "Technology's the answer! (so what was the question?)":
  - The technology-push vs demand-pull debate
  - A closer look at energy-environmental innovation processes and policies
  - Strategic economics of innovation policy instruments
- Some brief observations on international strategies

2.

Evaluating climate change impacts:

Survey, stakeholder and revealed impact evidence all disagree with mainstream economic quantifications

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3.

Survey evidence

- … consistently shows that people care more about the long-term future, and about impacts on other people, than reflected in nation-state and traditional discounting economics
- Discount rate dominates quantification: increasing acceptance in economic theory of need for logarithmic or other forms of declining discount rates for long-period problems
- The economics of transboundary impacts still in its infancy …

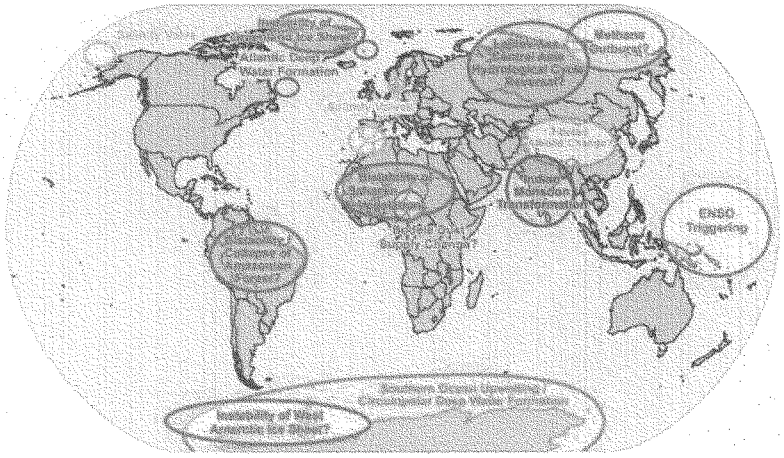
4.

Economic theory based upon 'willingness to pay to avoid damages' principles has never gained acceptance of the 'victims'

- Long-standing debate between willingness-to-pay vs willingness-to-accept (compensation) remains unresolved; latter yields higher numbers but former remains the main prop of monetization studies
- Sharp illustration in the debate about 'value of statistical life' in international climate damages
- The debate revealed deep theoretical confusion in the context of transboundary impacts: the stakeholder evidence demonstrated that global economics cannot escape directly addressing issues of procedural and substantive ethics

5.

Meanwhile, the scientists worry far more about instabilities than about incremental change …



6.

.. Whilst revealed impact evidence suggests a model of least-cost 'rational, optimal adaptation with foresight' is not necessarily appropriate

- The world is *not* undertaking least-cost measures to protect those in developing countries
- The current estimates of damage associated with Hurricane Katrina exceed the total damages from climate change projected by most economists for the entire US by mid Century
- There were extensive warnings ..
- .. And the political response is not the economically optimal policy of retreat

7.

A global view of the stabilisation challenge

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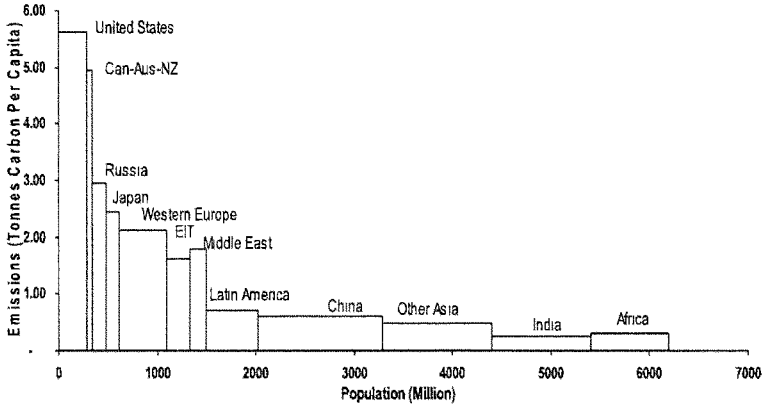
8.

From perspective of both global inequalities and pressures for growth, the challenge is huge

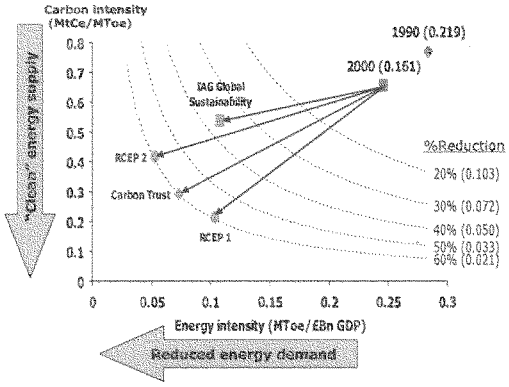
per-capita emissions vs population, 2000



9.

Global context implies need for deep emission reductions in industrialised countries

UK policy context (60% target by 2050), implies both much cleaner energy and big improvements in energy efficiency (x10 C.intensity)



The 2003 Energy White Paper set the UK on a path to reduce carbon emissions by 60% by 2050 through a combination of energy efficiency in the short term and renewables in the long term:

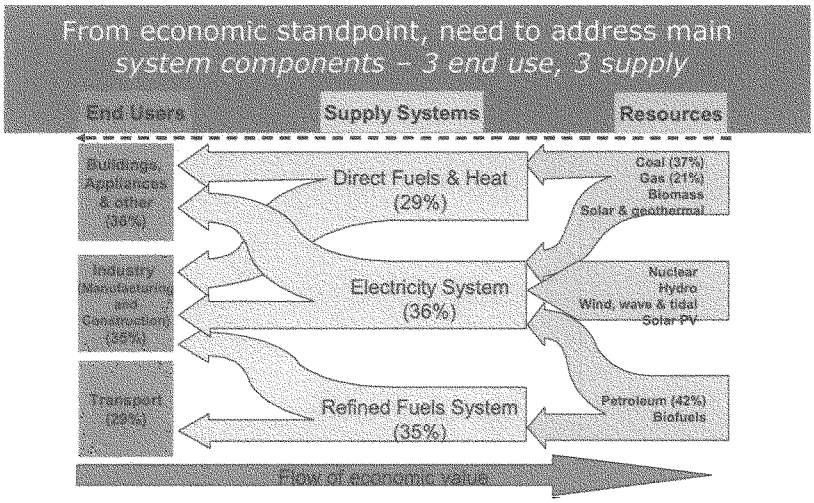
"[To achieve the required savings from energy efficiency] *would need roughly a doubling of the rate of energy efficiency improvement seen in the past thirty years"*

"Technology innovation will have a key part to play in underpinning all our goals and delivering a low carbon economy"

"To deliver these outcomes our aim will be to provide industry and investors with a clear and stable policy framework"

Note Figures in brackets show UK carbon intensity (MtC/£Bn), Scenarios show 2050 projections
Source RCEP 1998, DTI EP68 GDP growth forecasts, IAG "Long-term Reductions in GHG in the UK", Feb 2002

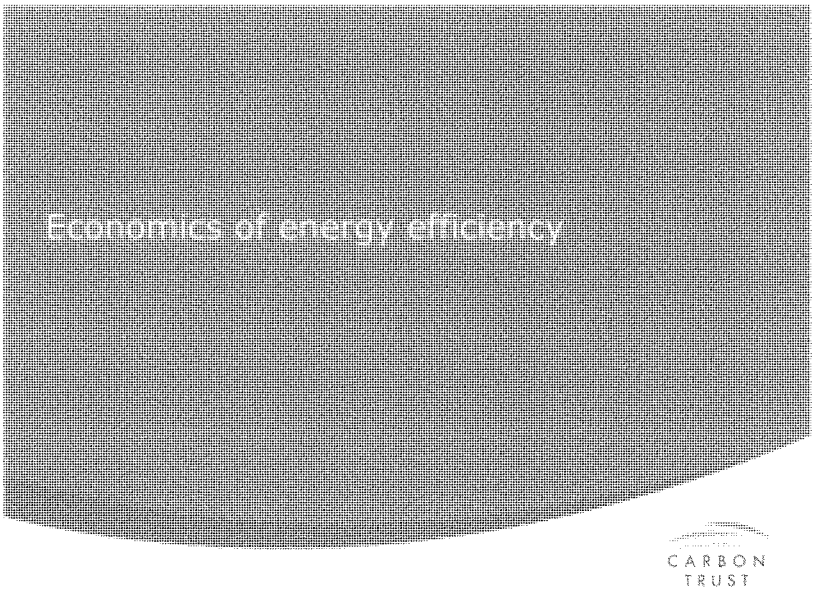
10.



The data show the % of global energy-related CO2 emissions associated with the different parts of the energy system (including emissions embodied in fuels and electricity). Note that patterns vary between regions (eg industry is lower and transport higher in developed economies), and the sectors are growing at different rates (over past 30 years, energy demand for buildings industry transport has grown at 2 6% 1.7% 2.5% annual average (LBNL ref)

Note: Some small flows that comprise under 1% of global energy flows (eg electricity and natural gas contributions to transport) are not shown **End Users:** Source IEA 'Non-electric energy industries' (emissions from refineries, gas etc) allocated 4 1 2 to transport industry buildings etc **Supply Systems:** Electricity System data IEA, Refined Fuels %CO2 assumed equal to Petroleum % CO2, direct fuels and heat is the residual **Resources** Source EIA

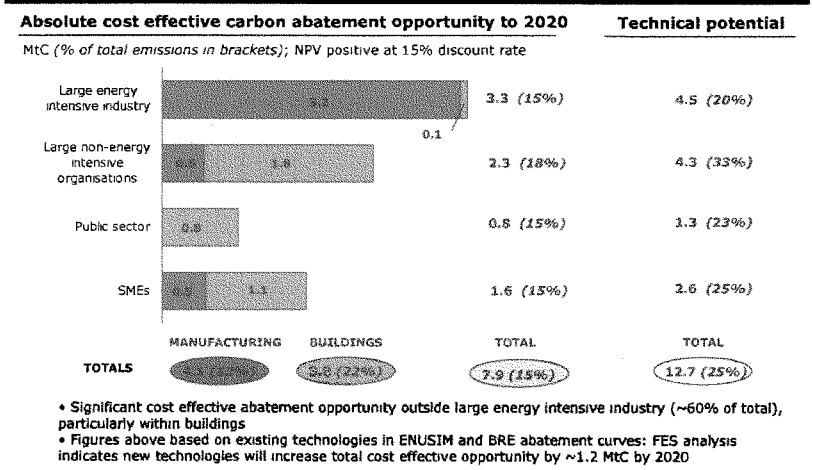
11.



12.

Technology and system studies all suggest significant *cost-effective* energy efficiency opportunity exists

Example of UK – CT policy review assessment @ 15% IRR



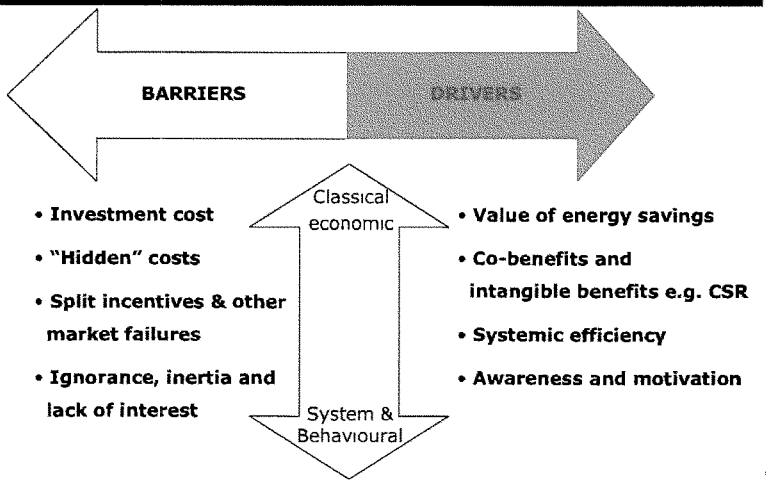
- Significant cost effective abatement opportunity outside large energy intensive industry (~60% of total), particularly within buildings
- Figures above based on existing technologies in ENUSIM and BRE abatement curves: FES analysis indicates new technologies will increase total cost effective opportunity by ~1.2 MtC by 2020

Source. Ecofys ENUSIM abatement curves, BRE buildings measures abatement curves

13.

Delivering energy efficiency requires addressing the barriers & drivers in organisational decision-making:

- if policy can address the non-financial dimensions there is good prospect for net economic gains



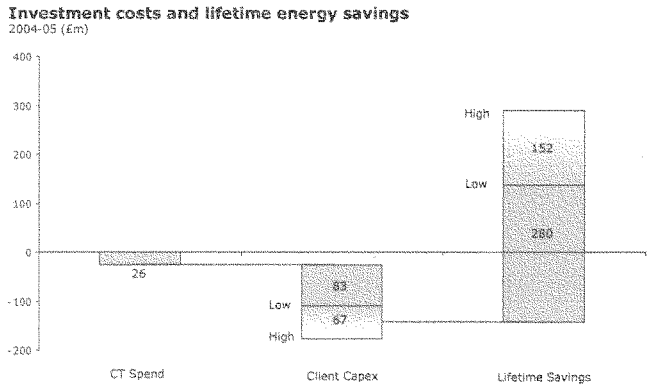
14.

The 'free lunch' requires economic explanation before policy appraisal can take it seriously:
- there are numerous barriers to energy efficiency that can be most usefully classified into three main non-financial categories

Issue	Definition	Examples	Policy options
Financial cost/benefit	Ratio of investment cost to value of energy savings	•More expensive but more efficient equipment	•Economic instruments that reduce equipment cost or finance cost, or increase energy prices •Direct legislative drivers on energy / emissions
Expanded cost/benefit (intangible, transaction and transition costs)	Cost or risk (real or perceived) of moving (or not moving) to more energy-efficient practices including managerial, information, risk and decision-making requirements, not captured under (a)	• **Costs & risks of change** Incompatability Performance risk Management time Other transaction costs • **Exposure of not changing** Higher emissions risk Equipment obselescence Customer & employee pressure	•Services providing information, technical support •Packaged energy service contracts •Standards requiring use of a particular technology/solution, e.g. product standards, etc. to avoid transaction costs
Market Misalignment (split incentives, system failures regulatory failures)	Market structure and constraints that prevent consistent tradeoff between specific energy efficient investment and the societal energy saving benefits	•Landlord / tenant split •Regulatory failures eg. in electricity •First-mover costs and risks •Externally-imposed budget constraints	•Contractual or market organisation solutions to split incentives between organisations •Standards •Capital market solutions (eg. Salix) •Socialisation of first-mover costs
Behaviour & motivation (inertia, awareness, materiality)	Internal issues of firm behaviour linked to awareness, motivation and internal organisation	•Organisational failures (eg. internal split incentives) •Inertia, rules of thumb •Tendency to ignore small opportunities	•Campaigns, sector learning networks •"Attention raising" instruments: e.g. trading; CCAs with sector targets and 'cliff' incentives (tax exemption) •ECA lists and low interest loans available to equipment purchasers in organisations

15.

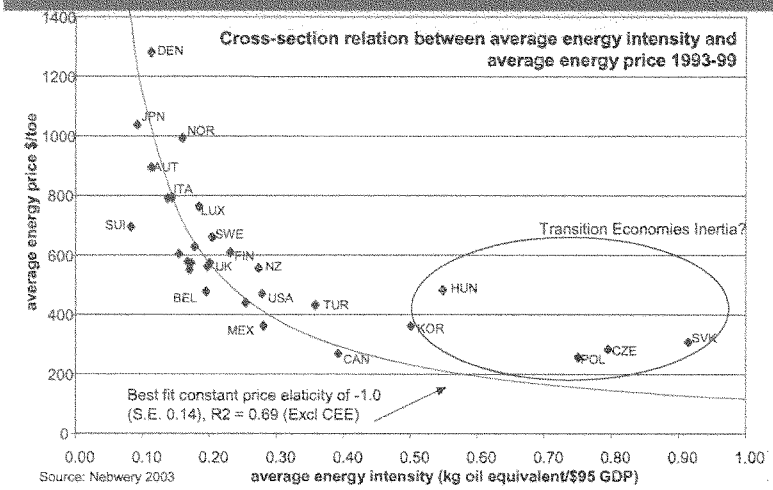
Exploiting this potential has enabled Carbon Trust programmes to deliver major lifetime cost savings
- assessed value of energy efficiency savings from 2004-5 programmes at least twice the cost of policy and co-investment



Source: Carbon Trust Impact Assessment

16.

Cross-country comparisons suggest final national energy expenditure per unit GDP is insensitive to price in long term (elasticity c.-1) ie. price increases offset by increased efficiency



Source: Nebwery 2003

17.

Significance of the technology-push vs demand-pull debate: evidence and implications

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18.

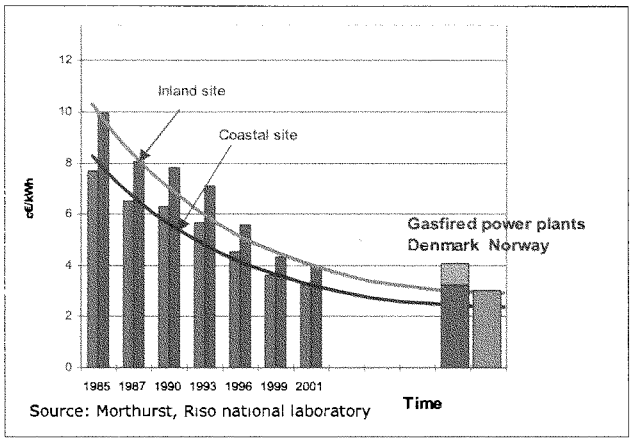
The basic issue

- Technology is the answer!
  - All studies agree that low carbon technology is central to addressing long-term climate change
  - Technologies adequate to stabilise the atmosphere are not yet commercially available
- But what was the question?
  - Is this a question of *R&D investment by governments* to develop the technologies that can solve the problem ('technology push' / exogenous technical change)?
  - Or a question of *market incentives* to promote private sector investment in emerging technologies and learning-by-doing ('demand pull' / induced technical change)
  - Or – combination reflecting a 'systems view' of innovation processes & markets

19.

Cost reductions - and pathways - in wind energy have been closely associated with buildup of the *industry* during the 1990s

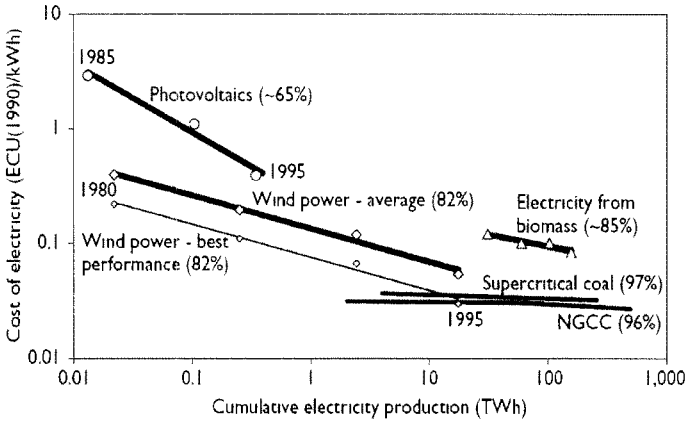
Example of wind energy costs in Denmark



Source: Morthurst, Riso national laboratory

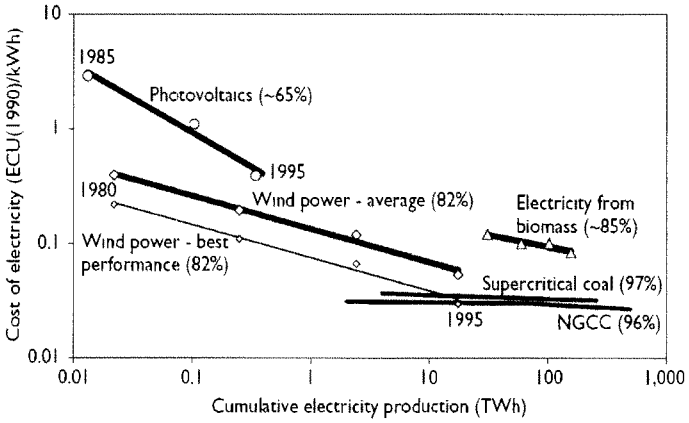
20.

'Experience curves' are well-established empirically – though with complexities in understanding causes, rates, asymptotes



21.

'Experience curves' are well-established empirically – though with complexities in understanding causes, rates, asymptotes



22.

If conceived as a simplistic *technology-push vs market-pull* choice, opposite conceptions of technical change can invert many policy-related conclusions

Issue	Technology-push: Govt R&D-led technical change	Market pull: Demand-led technical change
Implications for long-run economics of large-scale problems (eg. climate change)	Atmospheric stabilisation likely to be very costly unless big R&D breakthroughs	Atmospheric stabilisation may be quite cheap as incremental innovations accumulate
Policy instruments and cost distribution	Efficient instrument is government R&D, complemented if necessary by 'externality price' (eg. Pigouvian tax) phased in.	Efficient response may involve wide mix of instruments targeted to reoriented industrial R&D and spur market-based innovation in relevant sectors. Potentially with diverse marginal costs
Timing implications	Defer abatement to await technology cost reductions	Accelerate abatement to induce technology cost reductions
Carbon cost profile over time	Carbon cost starts small and rises slowly till meetings technology (Hotelling principle)	Big investment in early decades, cost declines as learning-by-doing accumulates
'First mover' economics of emissions control	Costs with little benefits	Up-front investment with potentially large benefits
Nature of international spillover / leakage effects arising from emission constraints in leading countries	Spillovers generally negative (positive leakage) due to economic substitution effects in non-participants	Positive spillovers may dominate (leakage negative over time) due to international diffusion of cleaner technologies

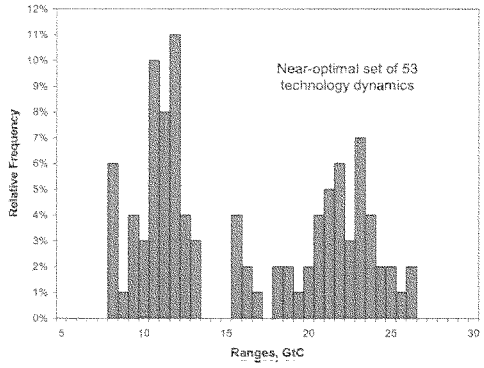
Source: Grubb, Koehler and Anderson, in Ann.Rev.Energy, 2002

23.

Induced technical change / learning curves can revolutionalise the long term view

Probability density distribution of least-cost carbon emissions in 2100

- Uncertainty in key inputs
- very wide range of energy technologies and resources
- learning-by-doing
- learning spillover effects in technology clusters



Source: Gritzevski & Nakicenovic, in *Energy Policy, 1999*

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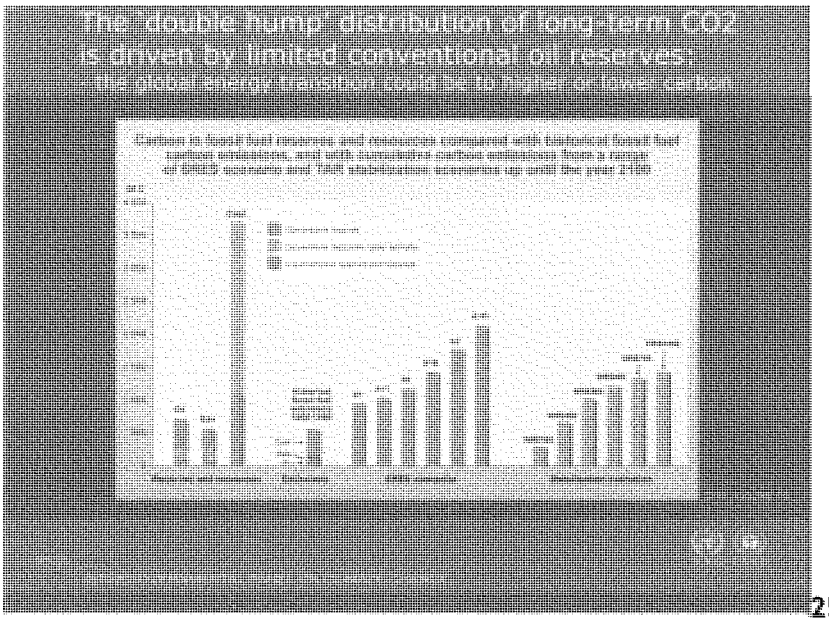

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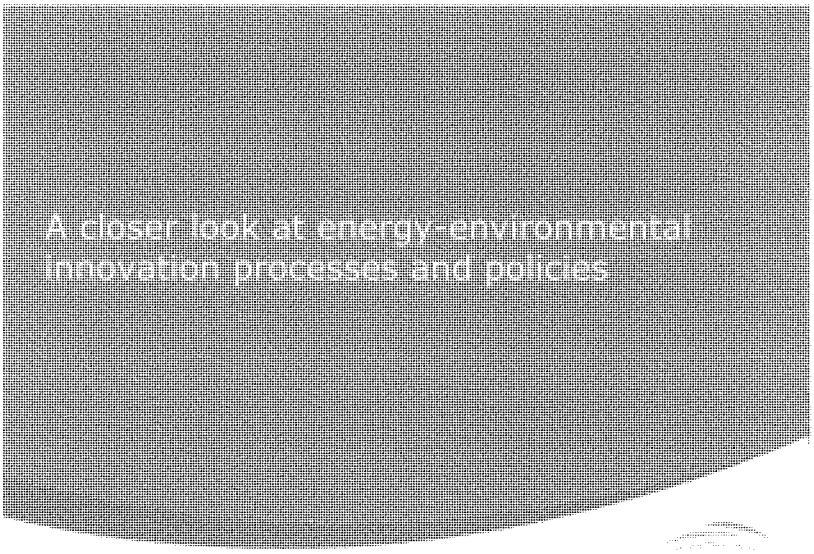

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26.

Technology-R&D push
– the track record is not encouraging..

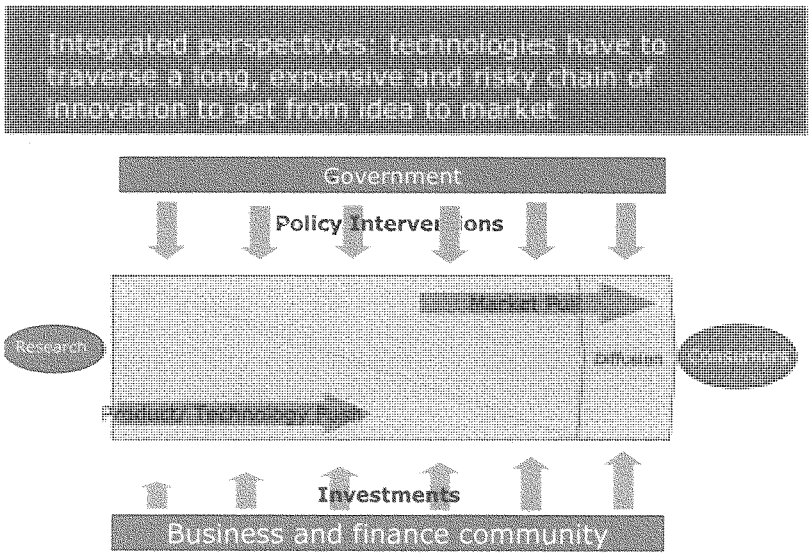
- **The theoretical basis**
  - **Classic R&D market failures**
  - **The impact of liberalisation**
- **Some classic energy examples:**
  - **Nuclear fission**
  - **Coal-based synthetic fuels**
  - **Nuclear fusion**
- **Basic problems of:**
  - **'picking winners'**
  - **Cooperation vs competition**
  - **Policy displacement**
- **Theoretical paradox of the 'classical' view**
  - **the giant leap**
  - **the 'valley of death'**

27.

Demand-led induced technical change
– if only markets were so perfect ..

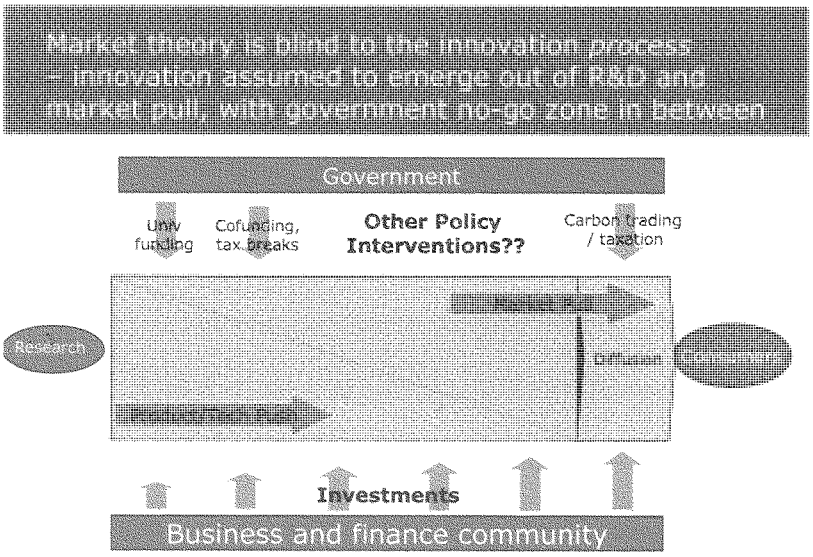
- **Some classic energy examples:**
  - **North sea oil**
  - **CCGTs**
  - **Wind energy ...?**
- **Basic problems of:**
  - **Classic R&D failures**
  - **Policy stability for environmental innovation**
  - **The real world is 'second best'**
- **Theoretical paradox of the 'classical' demand-led view**
  - **the need for perfect R&D markets**
  - **The need for long term certainty**
  - **The need for perfect communication between government, research, and industry**

28.



Source: Foxon (2003) adapted by the author

29.



30.

Consequently we lack investment across the innovation chain

- New entrants (technology and corporate)
  - require €/$ billions, and years, of development
  - Compete against established incumbants and rules
  - Rely upon regulation to embody external costs of incumbants
- political signals of future regulation are not 'bankable'
  - ('White paper reactions')
- fierce market competition and regulatory change in electricity has left:
  - Financial community extremely risk averse
  - companies without financial resources for longer term investment
  - ('CMI reactions')

31.

Strategic economics of innovation policy

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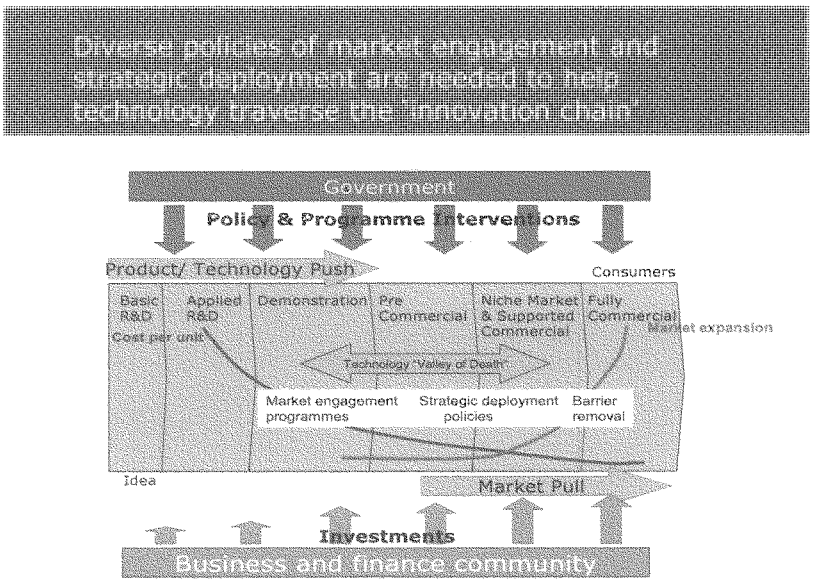
32.



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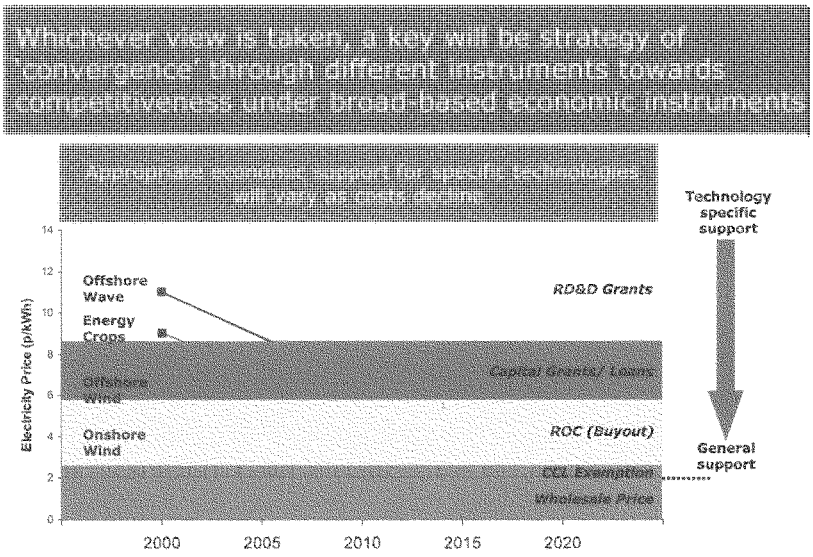
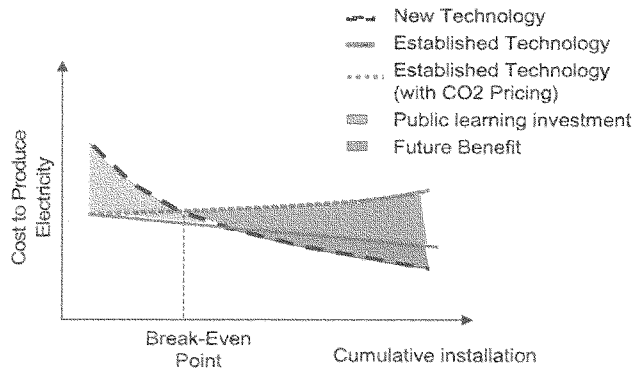


Note: ROC excludes recycling; Capital grant based on maximum of 40% of typical capital costs
Source: PIU Working Papers (OXERA II Base case cost decline)

34.

The cost-benefit of 'strategic deployment' programmes will depend on relative rates of learning, and of cost internalisation policies



35.

Innovation policy and carbon cap & trade

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36.

Carbon caps / prices cannot *on their own* deliver long-run solutions

- There are too many complexities and imperfections in energy demand systems (especially buildings and transport - but also industry)
- The innovation chain is too long, complex and imperfect for prices to deliver adequate innovation even if prices could be forecast
- In practice, the uncertainties are too deep (and political resistance too fierce) to establish long-run carbon prices now; but
- Industries (& finance communities) are too remote from science and governmental decision-making to act substantively on the basis of hypothetical and contested future political processes to internalise climate damage costs

37.

But caps / prices are crucial element and technology-driven international processes can only plausibly emerge as a contribution to delivering targets over time

- Carbon caps / prices are needed to:
  - deter carbon-intensive investment lock-in: $16tr projected to be invested in energy systems over next three decades
  - accelerate diffusion of available low-carbon technologies
  - influence portfolio R&D of the big multinationals and to reward innovative companies
  - incentivise and guide governments towards *effective* innovation strategies
  - provide a strategic price-based convergence goal for innovation strategies
- Innovation chain policies seek to increase the *speed, depth and efficiency* of the innovation response

38.

Some broad conclusions on mitigation economics..

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39.

Generic conclusions on economics of climate change mitigation

- Climate change policy poses challenging problems for economic appraisal, which needs ultimately to be set in global, long term context of the problem with following considerations:
  - Pervasive nature of CO2 emissions – six major economic sectors and no single "magic bullet" solution
  - Impacts potentially severe but with considerable uncertainty about nature, timing, attribution including value-dependent (ethical) considerations
  - Technical and behavioural evidence about the "energy efficiency gap" gives potential for economic gains from mitigation
  - Infrastructure development and inertia in the face of uncertainty implies need for action differentiated according to these characteristics
  - Endogenous innovation implies need to understand impact of economic policy on innovation in different areas, and balance between supply and demand side of innovation process
  - Global context implies need to differentiate upon basis of national potentials to establish comparative advantage in different areas

=> A single global carbon price, or a single instrument, is not a dynamically efficient solution. Unfortunately, real life is far more complex

40.

Specific conclusions on business delivery and economics of UK climate policy to 2020:

Targeted policy mix could balance carbon savings with –ve resource cost (benefits to firms) and limited competitiveness/GDP impact

Negative resource cost	**• In aggregate, continuing potential for companies to respond to well-designed instruments with net resource gains**
Cost-effectiveness requires mix of instruments	**• Regulatory or awareness-raising instruments can yield economic gains where they address barriers and avoid excessive "hidden costs"** **• Cost-effectiveness of pure economic instruments depends on allocation, revenue-recycling and disaggregated subsector responsiveness**
Upstream changes can enhance savings	**• High EU ETS price ("real" c.€20/tCO2) drives coal to margin of power generation, potentially doubling near-term impact of end-use electricity savings and may deliver aggregate > 10MtC/yr by 2010**
Isolated competitiveness effects	**• Marginal (or positive) impact on newsprint and petroleum (EU ETS sectors); car manufacture and brewing (CCA sectors); and Grocery Retail and Hotels**** **• Aluminium exposed, maybe steel and cement under strong packages post 2012 without wider international participation or trade protection**
Expect limited GDP impact	**• Macroeconomic models can produce very different results depending particularly on whether and how they recycle revenues, represent awareness effects and other market imperfections, and/or endogenise technical change.**

Note: *Resource cost = NPV (Cost to Gov + Net cost to firms)/(lifetime CO2 saved), in all packages net overall benefit to firms, ** Grocery Retail and Hotels are local markets and will be able to pass on extra cost of 100% auctioning in UK "CE ETS"; ***Based on market price of €15/tCO2 and €30/tCO2 in 2010 and 2020 and allocation cut back of 1%pa from 2005

41.

Conclusions on international strategies

- Sequential 'target and trade' is an appropriate foundational framework
- But it is fundamental mistake to conceive of it as a 'cap-and-trade' only agreement: such agreement incentivises governments at the highest level to address:
  - the full spectrum of technologies
  - across all six key components of the energy system
  - the full chain of innovation through to deployment
  - and to tackle barriers to diffusion and cost internalisation
- And it needs to be supplemented by range of policy measures related to technology, for some of which could be good case for international cooperation directed at:
  - RD&D for expensive big-unit high-risk technologies
  - Technology roadmapping and market building (sharing costs of strategic deployment)
  - international technology transfer and diffusion at scale
  - Appropriate 'division of labour' according to technological and natural resource base

42.