COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENATIVES

HEARING CHARTER

The State of Climate Change Science 2007: The Findings of the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), Working Group III: Mitigation of Climate Change

Wednesday, May 16, 2007
10 a.m. to 12 p.m.
2318 Rayburn House Office Building

Purpose

On May 16, 2007, the Committee on Science and Technology will hold a hearing on the third section of the 2007 Fourth Assessment Report, *Climate Change 2007: Mitigation of Climate Change*, prepared by Working Group III of the Intergovernmental Panel on Climate Change (IPCC). Released in Bangkok, Thailand, on May 4, 2007, the summary document highlights the key findings of the comprehensive appraisal of the current state of scientific knowledge on strategies to mitigate climate change. The full underlying report will be released later this year.

The Committee will hear testimony from three witnesses who will discuss the findings of the Report and current mitigation technologies and strategies.

Key Findings of the 2007 Working Group III Report

On May 4, 2007 the Intergovernmental Panel on Climate Change (IPCC) released the third section of its Fourth Assessment Report, entitled "Mitigation of Climate Change." This third section of the IPCC Fourth Assessment Report builds upon information contained in the previous reports. Working Group III analyzed mitigation options for the main economic sectors in the near-term and provided information on long-term mitigation strategies for various stabilization levels, paying special attention to implications of different short-term strategies for achieving long-term goals. Furthermore, the report addresses the relationship between mitigation and sustainable development. The Working Group was co-chaired by Dr. Ogunlade Davidson from Sierra Leone and Dr. Bert Metz from The Netherlands.

Held from April 30th through May 3rd, the 9th plenary session of Working Group III (WGIII) gathered government delegates from more than one hundred countries, together with the WGIII Lead Authors. The IPCC-produced documents, including this Summary for Policymakers (SPM), are consensus documents, meaning that all member governments approve the Summary documents and the underlying chapters before each document is released.

This report updates information from the Third Assessment Report based on research conducted over the past six years. Looking in detail at the most promising technologies for reining in heat-trapping gases, Working Group III's report outlines the need for improving energy efficiency in buildings, vehicles and appliances; shifting energy sources away from fossil fuels, retaining forests as a carbon sinks, and reducing emissions associated with agriculture.

<u>Greenhouse Gas Emission Trends</u>

Global greenhouse gas (GHG) emissions have grown since pre-industrial times and continue to grow. They increased by 70 percent between 1970 and 2004, and by 24 percent between 1990 and 2004. Growth in CO_2 emissions dominates the growth in greenhouse gases. The growth in emissions has come from all sectors with the greatest percentage increases coming from the energy supply, transport, and industry sectors.

Emissions associated with income and population growth have overwhelmed decreases in the amount of energy utilized per unit growth (energy intensity) and continue to drive growth in emissions. Under current climate change mitigation policies global GHGs will continue to grow over the next few decades. Current policies adopted have limited greenhouse gas emissions, but the scale of adoption is too small to counteract factors driving growth in emissions. Under scenarios assuming no new mitigation strategies are adopted, emissions will increase by 25-90% by 2030. Two thirds of these increases will come from the less developed countries.

<u>Mitigation in the Short Term (2007-2030)</u>

Released earlier this year, the first two sections of the 2007 Fourth Assessment Report present a comprehensive appraisal of the current state of scientific knowledge of climate change and the impacts of that change on natural and human systems around the world.

The first two Working Groups presented information about the potential impacts associated with continued patterns of GHG emissions, making a strong case for mitigation. The report prepared by Working Group III focuses on options for mitigating climate change through a variety of technologies and policies. Some greenhouse-gas emissions can be cut through straightforward, cost-neutral measures such as improving insulation and replacing incandescent light bulbs with fluorescent lighting. Other techniques, such a Carbon Capture Storage (CCS), require substantial upfront funding, additional research, and a re-orientation of industry practices. Figure 1 illustrates the technologies and practices that Working Group III identifies as currently commercially available.

Figure 1: Key Mitigation Technologies and Practices Currently Commercially Available

Sector	Technology/ Practice
Energy Supply	Improved supply and distribution efficiency Switching from coal to gas Nuclear power Renewable heat / power (hydropower, solar, wind, geothermal, bio-energy) Combined heat / power Early application of Carbon Capture and Storage (CCS)

Transport	More fuel efficient vehicles Hybrid vehicles Cleaner diesel vehicles Biofuels Modal shifts from road transport to rail and public transport systems Non-motorized transport (cycling, walking) Land-use and transport planning
Building	Efficient lighting and day lighting More efficient electrical appliances, heating, and cooling devices Improved cook stoves Improved insulation Passive and active solar design for heating and cooling Alternative Refrigeration fluids Recovery and recycle of fluorinated gases
Industry	More efficient end-use electrical equipment Heat and power recovery Material recycling and substitution Control of non-CO_2 gas emissions Process-specific technologies
Agriculture	Improved crop and grazing land management to increase soil carbon storage Restoration of cultivated peaty soils and degraded lands Improved rice cultivation techniques Improved livestock and manure management to reduce CH_4 emissions Improved nitrogen fertilizer application techniques to reduce N_20 Dedicated energy crops to replace fossil fuel use Improved energy efficiency
Forests	Afforestation (converting open land into a forest by planting trees) Reforestation (restocking of existing, but depleted forests, with native trees) Forest management Reduced deforestation Harvested wood product management Use of forestry products for bio-energy to replace fossil fuel sources
Waste	Landfill methane recovery Waste incineration with energy recovery Composting of organic waste Controlled waste water treatment Recycling and waste minimization

Working Group II reported that global average temperature increases above 2 to 4 degrees Centigrade would lead to severe impacts in many parts of the world that could not be overcome by adaptation strategies. In order to avoid temperature increases in this range, atmospheric concentrations of carbon dioxide (CO_2) need to be stabilized in a range of 445-490 ppm.

Working Group III asserts it will be easier to reach and maintain a lower target stabilization range if mitigation efforts are undertaken early. This is because infrastructure built today has an associated energy demand that will go forward for the life of the infrastructure (25 years or more). If investments in infrastructure with high energy demand are made early, the opportunities for reducing GHG emissions going forward are constrained and it will be more difficult in the future to attain lower stabilization levels. The risk of severe climate change impacts increases with later implementation of mitigation strategies.[1]

Both bottom-up and top-down economic modeling studies indicate that there is a substantial economic potential for mitigation of global GHG emissions over the coming decades. However, macroeconomic cost estimates are sensitive to assumptions about rates of technological change, target stabilization level, and whether a multiple gas approach or carbon-only mitigation approach is adopted.

To stabilize GHG concentrations at a level that will avoid the most dangerous global warming, the Report estimates costs, generated by macroeconomic models, may vary from a reduction of three percent Gross Domestic Product (GDP) to an increase of one percent GDP. The reduction in GDP is greater for more stringent stabilization targets.

Another factor that influences macroeconomic cost estimates is the rate of technological change. Models that assume climate change policy enhances technological change, revenues from carbon taxes or auctioned permits are used to promote low-carbon technologies, or that assume a reform of existing taxation policies generally provide the lower macroeconomic cost estimates. Mitigation strategies that assumed a multiple-gas approach also resulted in substantially lower costs.

Not surprisingly, changes in lifestyle and behavior patterns of citizens across the world can contribute to climate change mitigation across all sectors. More wide spread adoption of existing mitigation practices can also have a positive role (Figure 1). New energy infrastructure investments in developing countries, upgrades of energy infrastructure in industrialized countries, and policies that promote energy security, can, in many cases, create opportunities to achieve GHG emission reductions compared to baseline scenarios. Additional co-benefits are country specific but often include air pollution abatement, balance of trade improvement, improvement of modern energy services to rural areas, and increases in employment opportunities.

Energy Supply

Investment in new energy supply infrastructure is estimated to be over 20 trillion dollars between now and 2030. The investments made in this time frame will impact GHG emissions for many years due to the expected lifespan of these facilities (25-50 years). A significant shift in energy supply to low-carbon technology is estimated to take decades even with aggressive incentives to promote them, but would result in a return to 2005 GHG emission levels by 2030 if the investment patterns were shifted to favor these technologies. The additional cost to achieve this shift is estimated to be small – on the order of five to ten percent more than investments in traditional energy supply technologies.

The pattern of investment will continue to be influenced by the market prices for fossil fuels. At higher fossil prices alternative energy sources will become more attractive, but other factors influence these decisions also. If higher fossil fuel prices lead to replacement of conventional oil

[1] Pages 26 and 27 of the Summary for Policymakers.

resources with oil sands, oil shales, heavy oils, and synthetic fuels from coal and gas, GHG emissions will increase from this sector unless these facilities are equipped with carbon capture and sequestration systems.

Working Group III indicates that electricity generated through renewable energy sources could supply 30-35% of the total electricity supply in 2030. The Report concludes that nuclear energy will increase by 2% by 2030 (from 16% in 2005). High costs, safety, concerns about weapons proliferation and waste continue to constrain nuclear energy development.

Working Group III also found energy efficiency investments to be more cost-effective than increasing energy supply to meet energy demand. Efficiency improvements also deliver benefits in terms of energy security, pollution reduction, and employment.

Transportation Sector

Pertaining to the transportation sector, multiple mitigation options exist, although these solutions must overcome many barriers, such as consumer preferences and lack of policy frameworks. Improved vehicle efficiency measures, leading to fuel saving, in many cases have net benefits but the market potential is much lower than the economic potential due to the influence of other consumer considerations, such as performance and size. It is important to note that Working Group III states that market forces alone, including rising fuel costs, are not expected to lead to significant emission reductions.

Depending on their production pathway, biofuels might play an important role in addressing GHG emissions in the transport sector. Biofuels used as gasoline and diesel additives/substitutes are projected to grow 3 percent of total transport energy demand in the baseline in 2030. This could increase to about 5-10 percent, depending on future oil and carbon prices, improvements in vehicle efficiency and the success of technologies to utilize cellulose biomass. Shifts in transportation use from cars to rail or public transport could provide great benefits to mitigated greenhouse gas emissions. This trend would further benefit from integrated urban planning to minimize the need for car travel.

Pertaining to air travel, medium term mitigation potential for CO_2 from the aviation sector could be gained from improved fuel efficiency, which can be achieved through a variety of means including technology, operations, and air traffic management.

Residential & Commercial Building Sector

Energy efficiency options for new and existing buildings could considerably reduce CO_2 emission with net economic benefit. Many barriers exist against tapping this potential, but there are also large co-benefits. The barriers to achieving more energy efficient buildings are higher in developing countries. This is another area where rapid improvements in building design, development and diffusion of energy efficient building technologies (e.g. heating, cooling, lighting), adequate financing, and better information would yield benefits in reduced energy demand and GHG emissions. The rate of construction in developing countries is high and investments in this infrastructure will have an impact on emissions from these areas now and in the future. Working Group III estimated up to 30 percent of the GHG emissions could be avoided with net economic benefit by 2030.

Industrial Sector

The economic potential for reducing GHG emissions in the industrial sector is predominantly located in the energy intensive industries. The new facilities in developing countries include new technologies that are more energy efficient and are associated with lower GHG emissions. However, there are many old, inefficient facilities in both the developed and developing countries that, if upgraded, could significantly reduce GHG emissions from this sector. Key barriers to achieving reductions from this sector include the long life-span of existing facilities, lack of financial and technical resources, and insufficient access to technological information on strategies for emission reduction.

Agriculture and Forestry Sectors

Agricultural practices collectively can make a significant contribution at low cost to increasing soil carbon sinks, to GHG emissions reductions, and by contributing biomass feed stocks for energy use. The mitigation potential in the agricultural sector is associated primarily with opportunities to increase carbon sequestration and through reductions in methane and nitrous oxide emissions in specific agricultural systems.

Working Group III found that biomass can be an important energy feedstock. However, its contribution to mitigation is dependent upon a variety of factors including the demand for bioenergy from the transport and energy supply sectors, water availability, and competition with other land uses including production of food and fiber.

Similarly, forest-related mitigation activities can considerably reduce GHG emissions. Much of the mitigation potential from this sector is located in tropical regions and half of the potential could be achieved by reducing deforestation. Improved forest management practices could also result in increased CO_2 removal from the atmosphere and more sustainable systems with many co-benefits.

Mitigation in the Long Term: Beyond 2030

As stated earlier, investment choices made in the 2005 to 2030 timeframe will determine the additional emissions reductions required in 2050 and beyond to stabilize atmospheric GHG concentrations at a level that will avoid dangerous impacts of climate change. Limited, preliminary results from analyses of costs and benefits associated with mitigating climate change indicate they are comparable.

In order to stabilize atmospheric concentrations of GHG, emissions would have to peak at some level and decline thereafter to achieve the new stabilized concentration. GHGs remain in the atmosphere for a long period of time once emitted and therefore achieving a lower stabilized concentration will not occur immediately once emissions are reduced. The current concentration of CO_2, the most important GHG is 379 ppm. Working Group III found that the stabilization levels they examined are achievable if currently available technologies and the technologies expected to be commercialized by 2030 are deployed. The technologies and practices predicted to be available by 2030 are listed in Figure 2.

Decision-making about appropriate level of global mitigation over time involves an iterative risk management process that includes mitigation and adaptation, taking into account actual and avoided climate change damages, co-benefits, sustainability, equity, and attitudes to risk. Choices about the sale and timing of GHG mitigation involve balancing the economic costs of more rapid emissions reductions now against the corresponding medium-term and long-term climate risks of delay.

The preferred choice rests on the assumption about the shape of the damage cost curve associated with increased global average temperature and on the sensitivity of the climate to continuing increases of GHG emissions. If the relationship between climate change and the costs associated with damaging impacts is gradually rising and the changes are predictable and regular in their growth, this would allow for greater adaptation and would economically justify a later starting date for implementing mitigation measures.

If however, the costs associated with climate change increase rapidly with time and if the rates of change are not predictable or stable, then earlier and more stringent mitigation strategies are required. Even small probabilities of catastrophic events such as significant melting of ice sheets in Greenland or Antarctica would justify earlier and more stringent action.

If climate sensitivity is high, earlier and more stringent implementation of mitigation is required than if climate sensitivity is low. The results from Working Group II, indicating more rapid and widespread impacts being identified over the past decade suggest the climate sensitivity may be high, especially if GHG emissions continue to grow.

Figure 2: Key Mitigation Technologies and Practices Expected to Be Available in 2030

Sector	Technology/ Practice
Energy Supply	Carbon Capture and Storage (CCS) for gas, biomass and coal-fired facilities Advantaged nuclear power Advantaged renewable energy (tidal and wave, solar, and solar photo voltaic)
Transport	Second generation biofuels High efficiency aircraft Advanced electric and hybrid vehicles
Building	Integrated design of commercial buildings including intelligent metering and control Solar PV integrated in buildings
Industry	Advanced energy efficiency CCS for cement, ammonia, and iron manufacturing Inert electrodes for aluminum manufacture
Agriculture	Improved crop yields
Forests	Tree species improvement to increase biomass productivity and carbon sequestration Improved remote sensing technologies for analysis of vegetation/ soil carbon sequestration potential and mapping land use changes
Waste	Bio-covers and bio-filters to optimize CH_4 oxidation

Policies, Measures and Instruments to Mitigate Climate Change

A wide variety of national policies and instruments are available to governments to create the incentives for mitigation actions. Their applicability depends on national circumstances and understanding their interactions, but experience from implementation in various countries and sectors shows there are advantages and disadvantages for any given instrument. Policies that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes. Such policies could include economic instruments, government funding and regulation.

Voluntary agreements between governments and industry and voluntary actions being adopted by corporations, non-governmental organizations, local and regional authorities and other groups may limit GHG emissions and stimulate innovative policies, but they have had limited impact on national or regional emission levels and have not resulted in significant reductions of GHG emissions.

Government support through financial contributions, tax credits, standard setting and market creation is important for effective technology development countries depends on enabling conditions and financing. Figure 3 illustrates possible government actions noted by Working Group III.

Figure 3: Environmentally Effective Polices, Measures, and Instruments

Sector	Policies, Measures and Instruments	Key constraints or opportunities
Energy Supply	- Reduction of fossil fuel subsidies - Taxes or carbon charges on fossil fuels	Resistance by vested interests may make them difficult to implement
	- Feed-in tariffs for renewable energy technologies - Renewable energy obligations - Producer subsidies	May be appropriate for countries that are building up their transportation systems
Transport	Mandatory fuel economy, biofuel blending and CO2 standards for road transport	Partial coverage of vehicle fleet may limit effectiveness
	Taxes on vehicle purchase, registration, use and motor vehicles	Effectiveness may drop with higher incomes
	- Influence mobility needs through land use regulations, and infrastructure planning -Investment in attractive public transport facilities and non-motorized forms of transport	Particularly appropriate for countries that are building up their transportation systems
Buildings	Appliance standards and labeling	Periodic revision of standards needed
	Building codes and certification	Attractive for new buildings but enforcement can be difficult
	Demand-side management programs	Need for regulations so that utilities may profit
	Public sector leadership programs	Government purchasing can expand demand for energy-efficient products
	Incentives for energy service companies	Access to third party financing is crucial

Industry	- Provision of benchmark information - Performance Standards - Subsidies, tax credits	May be appropriate to stimulate technology uptake. Stability of national policy important in view of international competitiveness
	Tradable permits	Predictable allocation mechanisms and stable price signals important for investments
	Voluntary agreements	Success factors include: clear targets, a baseline scenario, third party involvement, and cooperation between government and industry
Agriculture	Financial incentives and regulations for improved land management, maintaining soil carbon content, efficient use of fertilizers and irrigation	May encourage synergy with sustainable development with reducing vulnerability to climate change
Forestry	- Financial incentives (national and international) to increase forest area, to reduce deforestation, and to maintain and manage forests - Land use regulation and enforcement	Constraints include lack of investment capital and land tenure issues. Can help poverty alleviation.
Waste Management	Financial incentives for improved waste and wastewater management	May stimulate technology diffusion
	Renewable energy incentives or obligations	Local availability of low-cost fuel
	Waste management regulations	Most effectively applied at national level with enforcement strategies

Witnesses

Dr. Mark Levine, Division Director of the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory (LBNL)

Dr. Mark Levine served as a Coordinating Lead Author for Chapter 6 of the report entitled: *Specific Mitigation Options in the Short and Medium Term – Residential/Commercial Sector (Including Services).* **C**urrently, Dr. Levine works as division director of the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory (LBNL). He received his Ph.D. in chemistry from UC Berkeley and was a Fulbright scholar in Germany. Before joining LBNL in 1978, he was a staff scientist at the Ford Foundation Energy Project in Washington, D.C., and a senior energy policy analyst at SRI, International in Menlo Park. Dr. Levine research focuses on energy modeling, appliance energy efficiency policy, and other aspects of energy efficiency and climate change policy analysis. He sits on the boards of several energy policy organizations, including the American Council for an Energy-Efficient Economy and the Center for Clean Air Policy.

Dr. William A. Pizer, Fellow at Resources for the Future and a Senior Economist at the National Commission on Energy Policy

Dr. William Pizer served as a Lead Author for Chapter 11 of the report entitled: *Mitigation from a Cross-Sectoral Perspective.* Currently, Dr. Pizer is a Fellow at Resources for the Future and Senior Economist at the National Commission on Energy Policy. Dr. Pizer has a B.A. in physics from the University of North Carolina at Chapel Hill and a Ph.D. and M.A. in economics from Harvard University. Dr. Pizer's research seeks to quantify how various features of environmental policy and economic context, including uncertainty, individual and regional variation, technological change, irreversibility, spillovers, voluntary participation, and flexibility, influence a policy's efficacy.

Recently, Dr. Pitzer's work has considered the regional variation in household energy use, firm variation in pollution control costs, the effectiveness of voluntary programs, the role of technology programs in pollution control efforts, the relative efficiency of flexible performance standards and intensity targets, and the effectiveness of regional climate change policies. Since August 2002, Dr. Pizer has worked part-time as a Senior Economist at the National Commission on Energy Policy. During 2001-2002, he served as a Senior Economist at the President's Council of Economic Advisers where he worked on environment and climate change issues.

Mr. Steven Plotkin, Transportation Energy and Environmental Systems Analyst at the Center for Transportation Research, Argonne National Laboratory

Mr. Stephen Plotkin served as a Lead Author for Chapter 5 of the report entitled: *Specific Mitigation Options in the Short and Medium Term – Transport and Infrastructure.* Mr. Plotkin is a transportation energy analyst with the Center for Transportation Research of the Argonne National Laboratory. His recent work focuses on advanced automotive technology, greenhouse gas reduction strategies, and automotive fuel economy policy. He was a co-principal investigator of the joint U.S. Department of Energy/Natural Resources Canada study, *Examining the Potential for Voluntary Fuel Economy Standards in the United States and Canada* and a consultant to the National Research Council's study on the effectiveness and impact of Corporate Average Fuel Economy (CAFE) Standards. Mr. Plotkin received B.S. in Civil Engineering from Columbia University and his Masters in Aerospace engineering and did graduate work in applied physics/aerospace engineering at Cornell University.

Dr. Roger Pielke, Jr., Director, Center for Science and Technology Policy Research and Professor in the Environmental Studies Program at the University of Colorado

Dr. Roger Pielke is a Professor in the Environmental Studies Program and also Director, Center for Science and Technology Policy Research. With a B.A. in mathematics and a Ph.D. in political science from the University of Colorado, he focuses his research on the relation of scientific information and public and private sector decision making. His current areas of research are societal responses to extreme weather events, domestic and international policy responses to climate change, and United States science policy. Dr. Pielke’s research interests include understanding natural disasters and climate change, the politicization of science and decision making under uncertainty.

Definitions

Mitigation Potential: The concept has been developed to assess the scale of GHG reductions that could be made, relative to emissions baselines, for a given level of carbon price (expressed in terms of cost per unit of carbon dioxide equivalent emissions avoided or reduced). Mitigation potential is further differentiated in terms of “market potential” and “economic potential.”

Market Potential: The mitigation potential based on private costs and private discount rates, which might be expected to occur under forecast market conditions, included policies and measures currently in place, noting that barriers limit actual uptake.

Economic Potential: The mitigation potential, which takes into account social costs and benefits and social discount rates, assuming that market efficiency is improved by policies and measures and that barriers are removed.

Bottom-Up versus Top-Down Studies: Bottom-up studies look at mitigation options emphasizing specific technologies and regulations. In contrast, top-down studies assess the economy-wide potential of mitigation options. Bottom-up studies are useful for the assessment of specific policy options a sectoral level, while top-down studies better assess cross-sectoral and economy-wide climate change policies, such as carbon taxes and stabilization policies.

Greenhouse Gases: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). Water vapor is also a greenhouse gas – the most abundant greenhouse gas in the atmosphere. However, the concentration of water vapor in the atmosphere has not been significantly altered through human activities unlike the other above-mentioned greenhouse gases which are associated with fossil fuel production and use, land-use management and change, and industrial processing and consumer products.