SECRETARY-GENERAL'S GLOBAL COLLOQUIUM OF UNIVERSITY PRESIDENTS
NEW YORK UNIVERSITY – NOVEMBER 28 -29, 2007

October 15, 2007

TO: Participants in the 2007 Global Colloquium

FR: President John Sexton and Professor Richard Stewart

The 2007 Secretary-General's Global Colloquium of University Presidents will be held at New York University on Wednesday, November 28 - Thursday, November 29 to harness our combined intellectual efforts in confronting a key challenge of our time: global climate change.

Using the attached statement of President Sexton as a starting point, it is our hope that each university president will reflect on the ways universities intersect with and can contribute toward addressing concerns about global climate change and how we might most appropriately move our institutions along paths of sustainability. We are asking for a one-to two-page memorandum along these lines that will be distributed to all participants prior to the Colloquium.

At the same time, we are asking each faculty expert participating in the Colloquium to prepare a short memorandum that is responsive to the attached statement prepared by Professor Richard Stewart. His statement includes an Annex which provides an overview of climate change science and policy issues, which the university presidents may wish to review.

Your responses will be collected and made available to all participants in advance.

Please submit your memo as an e-mail attachment to *regina.syquia@nyu.edu* or by fax to to 1-212-995-4822 by Monday, November 5.

With the exciting news on Friday of the awarding of the Nobel Peace Prize to Al Gore and the IPCC, it is clear our colloquium is not only important but timely.

We so look forward to welcoming you to Washington Square next month.

Attachments

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John Sexton
President

Global Climate Change and the Role of Universities

Prepared by
President John Sexton

for discussion at the
2007 Secretary-General's Global Colloquium of University Presidents

There is strong and growing evidence that greenhouse gas emissions from human activity have been a cause of significant long-term atmospheric warming and other climactic changes. As emissions continue to increase, these effects will intensify, posing a significant challenge for future generations. It is also clear that universities have a central role to play in meeting that challenge.

Among the possible dimensions along which universities might have a role to play include:

- As operating entities that consume energy and have an ecological impact on their surroundings. Universities comprise physical plants and infrastructure; they purchase and consume various forms of energy; and they operate within fiscal and other constraints that can have an impact on their "carbon footprint".

- As centers of research and discovery that can marshal scientific knowledge in confronting serious global challenges, including climate change. From the physical and social scientists, to the humanists and artists, to the legal and business and international experts, universities can supply and help support the range of expertise needed to grapple with such a complex, multivariate issue.

- As disseminators of knowledge than can help inform the public debate about climate change and its effects. Universities provide platforms by which their scholars can share what they know with broader audiences and can often assume a leadership role in informing government leaders and policy makers in options and trade-offs.

- As places of teaching and learning where students can be informed about the impact of individual behavior on reducing environmental impacts and galvanized to change that behavior in thoughtful and sustainable ways.

- As institutions with missions and founding principles by which they measure themselves. Along with the broad academic norms and specific missions which animate most universities, they may seek to expand their foundational principles to include sustainability as a lens through which they define themselves.

This list is by no means complete, and some may fault it for including items beyond the pale of academic institutions. It is meant to stimulate your thinking about the ways in which universities may contribute to the challenge of global climate change.

The questions that I hope we will explore are:

- What are the appropriate ways in which universities can address the issue of climate change? Which of these ways are most in keeping with how universities currently envision themselves and operate? Which ones might call for a rethinking of those roles and operations?

- Given the scope and time pressures of the climate change, what should universities be doing now? Should they be realigning research priorities, providing incentives for further research and/or forming research consortia to expand the reach of science into certain areas? What areas?

- What mechanisms might universities put in place for collaboration among themselves – in basic research; in the dissemination of knowledge to broader audiences, including governmental and international bodies; and in business practices and operations – that might contribute to meeting the challenge of climate change?

The Challenge of Global Climate Change: The Post-Kyoto Policy Agenda

Prepared by Richard Stewart

For discussion at
Secretary General's Global Colloquium of University Presidents
New York University -- November 28-29, 2007

This memorandum is designed to frame the discussion at the Colloquium and identify topics for the Colloquium memoranda prepared by the faculty experts. The topics discussed herein are not intended to be exclusive; additional ideas are welcomed and encouraged.

The memorandum discusses the important policy and related research questions that must be tackled in the coming decade in order to make significant progress on the immense challenges of climate change. The issues are organized into four categories: securing wide and effective international cooperation in limiting greenhouse gas emissions; building effective domestic emissions limitations programs; initiating proactive adaptation measures; and other issues including public perceptions and values, mobilizing the private sectors, geoengineering, and the opening of the Arctic.

The Annex provides background information on the scientific evidence regarding climate change, economic and policy fundamentals, and regulatory tools for mitigating climate change. It also summarizes the distinctive and extraordinary policy challenges posed by climate change.

THE POST-KYOTO CLIMATE CHANGE POLICY AND RESEARCH AGENDA

The Kyoto Protocol has been criticized on various grounds, ranging from its lack of inclusiveness and long-run ambition to the fact that it will achieve relatively modest reductions in overall greenhouse gas (GHG) emissions growth at relatively high cost. Yet the Protocol represents an essential beginning on the long-term task of developing and implementing the far-reaching policy and institutional innovations needed to mitigate and adapt to climate change. The industrialized country Parties' commitments to achieve significant reductions of emissions relative to their 1990 baselines have stimulated domestic regulatory initiatives, technology investments, and progress in emissions reductions and also helped generate a global trading market in carbon credits. Independent of the Protocol's requirements, a number of other countries as well as sub-national and local governments and business firms have also begun to undertake measures to limit emissions and enhance sinks.

These steps, however, are only a bare beginning on what needs to be done. The Protocol's commitments extend only to 2012, and there is no plan in place for the years thereafter. Four of the six largest emitting countries are not Parties to the Protocol and have not adopted any regulatory programs to limit emissions. Emissions in developing countries are rapidly growing. The Protocol largely fails to address the need for the adaptation measures to address the adverse effects of the warming and other climactic changes that are already occurring and that will intensify in the future. Thus, while Kyoto represents an important beginning, there is an urgent need for fresh thinking to define a post-Kyoto agenda and identify the steps necessary to implement it. The purpose of the Colloquium is to contribute to this task. The faculty experts should address the following questions, along with any others that they wish to raise, in their memorandums.

- How should the post-Kyoto architecture for international regulatory cooperation in GHG emissions limitations be designed in order to maximize both participation and effectiveness? Should the focus be on extending the current Kyoto framework, or on new bilateral, regional or plurilateral agreements outside of the Protocol? What regulatory strategies should be used -- international emissions trading, harmonized emissions taxes, technology-based standards, or forms of cooperation that do not involve regulatory obligations?

- What are the best ways of engaging developing countries in emissions limitations while at the same time respecting their right to develop, their sovereignty, and global equity? Do emissions trading and credit schemes offer the greatest promise? What other approaches might be more successful?

- What are the greatest needs and most effective strategies for developing domestic programs to limit GHG emissions? Will the answers inevitably be specific to each country, or are there sufficient similarities to warrant efforts to develop common policy approaches? If so, what are they?

- What are the two or three most important steps that can be taken, internationally and domestically, to ensure effective adaptation to climate change?

The experts may also wish to address one or more of the following other issues:

- How can we gain a better understanding of how public attitudes regarding climate change and climate policy are formed? What steps can be taken to promote public awareness and support for climate policies?
- How can private actors be mobilized to mitigate and adapt to climate change?
- Should geoengineering be seriously pursued as a policy option?
- How should nations deal with the opening of the Arctic to development?

I. INTERNATIONAL COOPERATION IN CLIMATE MITIGATION

At the international level there is a critical need to engage major emitting countries that are outside the current Kyoto emissions limitation system -- most notably the U.S., but also China, India, Brazil, Indonesia and other major developing countries -- in cooperative measures to limit emissions including through new international climate regulatory agreements. Otherwise, investment and industrial development will “leak” to countries that lack controls and thus enjoy lower production costs, driving up emissions in such countries even higher and moving them on high-carbon development pathways that will be difficult and costly to reverse in the future. Innovative legal and institutional measures are needed to ensure participation by these countries in climate mitigation in the face of free-riding incentives, economic development imperatives, and international competitiveness pressures. Differences among countries in their stage of economic development and in the impacts of climate change also raise difficult environmental, equity, and economic issues in securing needed cooperation.

A. GOALS, ARCHITECTURES FOR COOPERATION, AND REGULATORY TOOLS

Fundamental goals and strategies

How should we define climate protection goals, in both the near and longer term? And, how should emissions limitations measures be linked to those goals? The Kyoto Protocol provides for a single installment of emissions limitations for industrialized countries, ending in 2012. Given the extended time

horizons needed for mitigation policy measures, the need to build stable and credible regulatory expectations, and the need to mobilize long-term public support, it would be highly desirable to adopt long term climate protection goals. These might be expressed, for example, in target atmospheric GHG concentrations, limits on warming, or long-term emissions pathways. These goals would provide the focal point for agreements on limitations over a series of shorter term periods. In order to minimize costs and maximize environmental effectiveness, such agreements should, to the maximum extent feasible, use emissions trading and other economic incentive systems and a comprehensive approach involving all gases, sources, and sinks.

The architecture for international climate policy cooperation

The impetus behind the UNFCC and the Kyoto Protocol was the recognition that climate change is a global problem that requires a global solution, following the highly successful example of the Vienna Convention and the Montreal Protocol in limiting global emissions of ozone-depleting chemicals. It remains the case that an inclusive global regulatory system for limiting net GHG emissions limitations must eventually be developed. But pursuing the Kyoto strategy of a single all-encompassing "top down" scheme may not be the best way to achieve further near-term progress and engage the major emitting countries that have not yet assumed limitations obligations. Bilateral, regional and plurilateral agreements offer more speed and flexibility in arrangements to widen participation. Moreover, such arrangements need not involve binding emissions limitations in the first instance. Greater progress may be achieved through coordinated domestic policies and measures, sectoral approaches, joint ventures, cooperation on technology development, and other steps that do not involve legally binding commitments. Also faster progress on new multilateral initiatives may be achieved if they are developed initially by smaller groups of countries, such as the G8+5 or the L20, rather than through the unwieldy UNFCC/Kyoto processes. On the other hand, such "club" arrangements must be sensitive to the interests and concerns of smaller countries, especially developing countries, which are not members but have a vital stake in global climate policy decisions. These different approaches can operate in parallel with the UNFCC/Kyoto system, with the prospect of eventual merger and consolidation. Widespread use of international emissions trading will operate to integrate different emissions limitation regimes because participants will constantly seek to widen the scope of the market in order to achieve greater cost savings.

International regulatory tools and strategies.

What types of regulatory measures should be used in international agreements to limit emissions? The Kyoto Protocol sets binding quantitative emissions limitation requirements for countries, but then authorizes countries to use various cost-saving flexibility mechanisms, including emissions trading and project-based emissions credit trading through the Clean Development Mechanism (CDM), to achieve those limitations. Some prominent economists and policy analyst favor use of internationally harmonized domestic taxes on GHG emissions in place of emissions trading They argue that, given the uncertainties in the cost and achievability of specific emissions limitation levels, it is preferable to impose a price on emissions rather than quantitative aggregative caps (as required under emissions allowance trading). They also point out that emissions trading requires that trading markets be developed and supported; tax systems do not. But in the international context, emissions trading has important advantages over taxes. As discussed below, it can be used to engage participation by developing countries by giving them generous emissions allowances. Even if they were to agree to impose domestic taxes on GHG emissions, developing countries would not agree to set them at the same level as developing countries. Lower emissions taxes in developing countries would result in leakage of investment in more carbon intensive industry to such countries, driving up their emissions. Also, the effectiveness of international agreement on domestic GHG taxes would be compromised because countries would engage in various stratagems to reduce or cushion the impact of such taxes on their industry; these stratagem will be hard to police. A cap and trade system imposes firm limits on emissions and is thus harder to "game."

An alternative regulatory approach to use international command and control measures instead of economic incentive systems by mandating that countries adopt technology-based controls and standards for particular sectors. Examples include requirements for energy efficiency in vehicles or buildings, minimum percentages of renewables in electricity supply, and so Proponents argue that it may be easier to reach agreement on and monitor implementation and compliance with such standards than with economic incentive systems. These claimed advantages, however, are contested. Moreover, command approaches inevitably sacrifice flexibility, involve higher compliance costs, and compromise the advantages of a comprehensive approach.

Other issues that require research are the relative performance of tax, emissions trading, and command regulation in encouraging innovation, and the distributional and equity characteristics of each set of tools.

Ensuring countries' compliance with regulatory obligations

New or expanded international agreements to limit emissions will achieve reductions only if countries comply with them. One of the significant weaknesses of the Kyoto Protocol is that compliance was addressed only belatedly. Compliance issues should be front and center in any new agreements. Achieving compliance requires accurate monitoring of emissions and sequestration (including possible use of remote sensing technologies), publicity about countries' performance, technical and possibly financial assistance to countries having difficulty in achieving compliance, and the potential for meaningful sanctions including, possibly, trade sanctions. The Montreal Protocol and other successful international agreements, including those not concerned with environmental protection, can provide helpful guidance on these issues. Tough compliance measures including sanctions may discourage participation, creating a potential tradeoff between breadth and depth. To the extent possible, however, the need for flexibility should be recognized in the design of substantive obligations, as discussed below.

Cooperation without binding obligations.

Other alternatives to building cooperation and progress in emissions limitations do not involve binding regulatory obligations. They include "pledge and review" mechanisms, under which participation countries each set non-binding emissions goals and strategies and periodically report and mutually assess progress in reaching goals; joint R&D or technology transfer agreements or other forms of cooperation on technology research, development and diffusion; and benchmarking of emissions performance, sharing of best practices on climate policy measures, and joint capacity development.

Regulatory linkages with trade, investment and intellectual property

The free flow of trade and investment can undermine climate policy by generating industry resistance to emissions limitations for fear of competitive disadvantage, and producing leakage of investment and economic activity from countries that adopt emissions limitations to those that do not. Trade measures may be used by countries, either with or without authorization in multilateral agreements, to prevent competitive disadvantage and also induce non-Party countries to join limitations agreements. The trade measures in the Montreal Protocol have been a major element in its success. Countries with GHG emissions limitations may seek to impose charges or other costly requirements on imports of products from countries without limitations, based on their "embedded carbon" (the additional carbon dioxide involved in their production due to the lack of regulatory controls). Imposition of such measures against imports from the U.S. has been widely discussed in Europe, and the U.S. Congress is currently discussing their use against imports from developing countries. The consistency of such measures with WTO Agreements and their status under future international climate regulatory agreements are important emerging issues.

Liberalizing trade in clean and energy-efficient technologies can promote climate objectives. So can technology transfer arrangements, especially from developed to developing countries, although intellectual property regimes may create significant obstacles. Emissions trading and project-based

emissions credit systems can harness foreign direct investment and promote technology-oriented joint ventures by generating international markets, including in developing countries, for low-GHG products, services, and projects,.

B. PROMOTING EMISSIONS REDUCTIONS IN DEVELOPING COUNTRIES

It is essential to engage, through as many ways as possible, major emitting countries in steps to limit emissions while at the same time respecting and supporting their right to develop economically. Developing country emission are growing rapidly and will surpass industrialized countries' emissions in less than two decades. For reasons of equity (including wealth disparities and the fact that the great part of current atmospheric concentrations were generated by the industrialized countries) and political reality, significant near to medium term reductions in developing country emissions will only be achieved if those reductions are financed in substantial part by the wealthy countries. The latter would benefit environmentally and economically by gaining emissions reductions at lower cost than they could achieve at home. But, even if their publics are willing to make substantial investments in climate mitigation (which may be especially questionable in the U.S. given that it is predicted to be less seriously affected and in some ways, benefited by climate change in the near term), they may not be willing to support large scale transfers to other countries. True, the rich industrialized countries have committed more than $2 billion to developing countries through the Montreal Protocol Multilateral Fund in order to finance reductions of ozone-depleting chemicals. But the amounts required for similar changes in GHG emissions would be vastly greater. The magnitude of the transfers involved makes it imperative to use regulatory strategies, especially economic incentive systems, that will minimize the overall costs of limiting emissions.

Entry strategies for developing country emissions limitations.

A number of "entry strategies" have been proposed with the goal of providing developing countries additional flexibility in order to enable them to assume emissions limitations without sacrificing economic growth. These include the grant of generous "headroom" emissions allowances to enlist their participation, as was done in the case of Russia and the Ukraine in the Kyoto Protocol. Such allowances, for example, could take the form of "growth targets" that would initially be set at BAU levels and gradually decrease with economic development. Another option consists of "graduation" schemes whereby developing countries would assume emissions limitations obligations once they pass a certain threshold of development, and assume more demanding obligations as they grew further. Other alternatives include hybrid "safety valve" schemes under which countries could sell additional allowances to their firms if the market allowance price exceeds a stipulated level; emissions limitations in the form of emissions intensity targets (emissions per unit of GDP) rather than absolute limits; and non-binding or "one way" limitations targets that are not legally binding but enable developing countries to sell emissions allowances to the extent that they reduce emissions below the target levels. When coupled with international emissions trading, these and other options would enable developing countries to benefit from additional investment and technology flows from firms in developed countries seeking commercially valuable credits or allowances through emissions limitation projects. Neither internationally agreed taxes nor command and control standards provide a built-in mechanism for large financial transfers to developing countries. The alternative of large-scale government-to-government aid would face political opposition in developed countries and would often be less efficient in securing limitations than reliance on the private sector initiatives fostered by international emissions trading. Any system will involve substantial wealth transfers from developed to developing countries, but the savings from using economic incentive systems would greatly reduce the amount required. Moreover, emissions trading systems have the political advantage of providing developed country firms with new business opportunities in developing countries.

Credit-based systems

At this point, however, developing countries may be unwilling to accept emissions limitations in any form. On option is expanded use of project-based emissions credit systems like the Kyoto Clean Development Mechanism. Although the CDM is finally beginning to deliver significant increased investments and technology flows to a few developing countries, it has been hobbled by high transaction costs and other problems. Some of these difficulties could be addressed by expanding the scope of the CDM to include an entire developing country sector, such as electricity production or forestry. A sectoral CDM could be a stepping stone to eventual economy-wide emissions limitations. Another promising proposal is to give countries commercially valuable emissions credits for reducing their rates of deforestation. Deforestation is a critical climate problem; deforestation emissions from just two developing countries (Brazil and Indonesia) are projected to amount to 80% of all of the emissions reductions achieved by the industrial country Parties to the Protocol. The Kyoto Protocol provides little in the way of incentives to reduce such deforestation.

Other forms of cooperation

Other forms of developed-developing country cooperation (which be used in tandem with arrangements involving emissions limitations or credits) include joint or cooperative research and development on clean, energy efficient technologies, transfers of technology and know how, assistance in building administrative and implementation capacities, and carefully targeted financial assistance. To the extent possible, these efforts should focus on measures (which many more advanced developing countries are already undertaking) that provide non-climate local benefits but also reduce GHG. These include structural reform of energy and industrial sectors, development of alternative energy sources to promote energy security, and measures to reduce local air pollution. Demonstrating local benefits from measures that reduce GHG can pave the way for further steps. Research to develop programs and projects that reap such benefits while also reducing GHG would be most valuable.

Integrating climate goals into international development assistance and project finance

Existing programs for multilateral and bilateral official development assistance and investment guarantees need to be fundamentally changed in order to promote and support climate friendly pathways to economic growth in developing countries. Some donors are still financing development of dirty coal plants and other climate-destructive projects. Some multinational institutions, such as the World Bank, have taken steps to promote energy efficiency, alternative fuels and renewables, and sustainable forestry and agriculture, but there is still a long way to go. A major challenge is to adapt such projects to the circumstances and needs of individual countries; there is no single pathway to climate sustainability. There is also a vital need to build local administrative and technical capacity to support climate policy initiatives.

C. GLOBAL GOVERNANCE FOR CLIMATE PROTECTION

The governance arrangements for international organizations and other global institutions making decisions that shape economic development should ensure that climate consequences receive full consideration and should promote decisions that advance climate protection. The key global decision makers include, of course, environmental regulatory bodies like the UNFCC/Kyoto Protocol and Montreal Protocol regimes, but also multilateral development and finance bodies and international bodies concerned with trade, intellectual property, health, agriculture and science and technology. More research and effort are needed on building mechanisms, including public access to information, open decision making, participation by civil society representatives, and review mechanisms, that promote accountability for decisions with important climate impacts. Special steps must be taken to ensure that the needs and interests of those countries and populations that will be most seriously harmed by climate change are heard and addressed by global decision makers.

II. DOMESTIC MEASURES TO ACHIEVE SUSTAINABLE ECONOMIES: INTEGRATING REGULATORY, TECHNOLOGICAL AND INSTITUTIONAL MEASURES

At the domestic level, most governments have barely begun to think through, much less implement, the sort of far-reaching and fundamental domestic policy measures need to make a serious beginning on mitigating climate change. Those who have begun this path have yet to grapple in depth with how their initial measures will be transformed to achieve far-reaching changes in technologies, the economy, transportation and land use, and institutions. Making the changes needed will require a carefully orchestrated combination of regulatory measures, government support for technology development, and institutional reforms. Mastering the complex interplay of these different elements will require the construction of a climate policy knowledge base with both theoretical and applied elements. A critical issue for analysis is the extent to which there are common problems and potential solutions that cut across countries.

Domestic regulatory tools and measures

Economic incentives, including emissions taxes and tradable remissions permits, have very important advantages; they can be applied comprehensively across different gases, sinks, sources and sectors to achieve environmental effectiveness, secure large cost savings by promoting flexibility in the means of achieving limitations and cost effective allocations of limitations efforts, and stimulate innovation. The success of the US sulfur dioxide emissions trading program in halving emissions while saving many billions of dollars relative to traditional technology-based regulatory standards is powerful evidence of these benefits. By imposing a price on emissions, economic incentive systems also internalize some of their external environmental and social costs, steering market demand away from goods and services with high embedded emissions and towards those with low amounts, thereby promoting beneficial changes in the structure of the economy. Emissions tax revenues and allowance auctions can provide revenue streams to be used to offset taxes on labor or capital, potentially enhancing overall economic growth, or recycled for investment in climate protection.

Economic incentive systems, however, may not be practicable for application to some sectors or to small business or to individuals, requiring use of command and control measures including technology-based requirements. And, technology-based approaches have provided successful when focused on specific, relatively homogenous industrial sectors such as automobiles or oil tankers. Also, countries with limited administrative resources may prefer broader use of such techniques in preference to economic incentives because they regard them as administratively easier to implement and enforce. Command measures should, however, follow the comprehensive approach and strive for cost-effectiveness to the extent feasible.

Information-base regulatory strategies can play a useful supplemental role. They include public disclosure of net emissions by firms and installations, corporate disclosure of potential GHG regulatory exposures, climate labeling of consumer products and services based on embedded GHG or other measures, and systematic analysis of climate consequences in environmental impact assessments. Such information can stimulate and support private sector initiatives, consideration by both public and private decision makers of the GHG implications of development projects and policies, political demands by the public for government and industry to adopt of more climate-protective measures and practices. An illustration of the power of information is the U.S. Toxic Release Inventory program, under which installations were required to report and publicly disclose their emissions of various toxic pollutants. Disclosure generated strong public and community pressures on firms, which cut emissions steeply. California's Proposition 65, which required businesses to make disclosure to their consumers if their products or places of business contained carcinogenic substances, prompted firms to institute far-reaching controls.

The interface between the international regulatory architecture and domestic regulatory measures requires careful attention. For example, if emissions trading is used internationally, that will promote domestic use of emissions trading to enable domestic firms to participate directly in international GHG markets. It is, however, possible to combine international trading with domestic regulatory use of taxes or command measures, but in that case the government may have to be the exclusive agent in international trading or establish a supplemental system to issue internationally tradable allowances to domestic firms being regulated through other types of tools. International technology-base command requirements, by contrast, would be incompatible with domestic use of emissions taxes or tradable permits for domestic firms subject to such requirements.

Government incentives and support for development and adoption of GHG-efficient technologies
Technologies for energy efficiency, renewable energy, low carbon or no-carbon fuels and energy sources, carbon dioxide capture and storage, and sink protection and enhancement provide positive environmental and social benefits that will not be fully captured by market producers or consumers. There is accordingly a strong case in principle for government measures, over and above the general incentives for innovation provided by intellectual property law, to support the development and diffusion of such technologies. Such measures could include government funding of basic research and pilot applications, and support for the scale up of technology applications through government purchases and subsidies and regulatory measures to stimulate demand (for example, requirements that electricity supply portfolios include a specified minimum level of renewables). Governments must also support the deployment of these technologies through appropriate investment in transportation and other infrastructure and through land use regulations and policies.

Ideally, the incentives for technology development should be designed to be as broadly and uniformly applicable across technologies and sectors as possible. For administrative and other practical reason, however, incentives often have to be more narrowly targeted. But targeted incentives create the danger that politically influential industries will win disproportionate subsidies, or that governments may perform quite poorly in picking and promoting technology "winners."

Government promotion of climate sustainable technologies will not by itself secure their development, adoption and diffusion. The underlying market failures also require effective government regulation to create demand by industry and consumers for their use. These twin aspects of government policy -- technology supply and regulatory demand -- must work in tandem. Moreover, they must work over comparatively long time horizons, on the order of decades, to bring on line the technologies that will achieve the ever-continuing reductions in GHG intensity necessary for climate sustainability. This will require development of regulatory programs that give credible and consistent long-term signals to private actors but are also sufficiently flexible to cope with new information and circumstances and the lessons of experience. Economic incentive systems appear well suited to meet these demands, but research and hard thought on how to design such programs is urgently needed.

Confronting perverse governmental practices and institutional barriers.
In addition to promoting development of new technologies and adopting regulatory measures to encourage their use, governments must remove existing obstacles to their adoption. Thus, governments must change existing government policies and practices to eliminate subsides and other forms of support for carbon intensive forms of production and consumption. Examples include subsidies for energy use, automobile use, and unsustainable forms of agriculture. These steps will be politically painful and require skill. Governments must also act to overcome existing institutional barriers that impede adoption of low-GHG technologies, goods and services, even where they cost less than more GHG-intensive counterparts. Energy use is again an example. Consumers may fail, for a variety of reasons, to invest in measures (such as insulation or energy-efficient appliances) to reduce energy use even though they would save money in

the longer term by doing so. Providing consumers with information about these opportunities may not be sufficient. Governments may accordingly need to devise regulatory controls or incentives for energy suppliers to invest in demand side management. Existing government regulatory or other policies, such as obsolete building codes, may also generate obstacles that need to be cleared. In many countries, government ownership or control of the energy sector and energy-intensive industries is associated with highly wasteful energy use, which has declined when these industries are fully privatized and subject to market disciplines. Analysts have identified these and many other institutional barriers as major impediments to the transition to a low-GHG economy; they demand a corresponding commitment to analysis and remedy.

Restructuring environmental law

The climate challenge will require a fundamental reorientation of environmental law and regulatory policy away from the current focus on particular types of pollution to a broader focus on underlying, cross-cutting causes of GHG-intensive modes of production and consumption. There must be far greater use of economic incentive systems for regulation. Inclusive climate mitigation action programs must be developed, together with new forms of technology assessment and a focus on climate issues in environmental impact assessment. Steps must be taken to strengthen compliance and enforcement with climate regulatory requirements. Under any regulatory system, whether command and control, emissions trading, or taxes, emissions must be accurately monitored and regulatory obligations enforced. These tasks presenting major challenges for many developing countries. The possibility of developing new forms of legal liability against emitters for injuries related to climate change merits serious attention.

III. ADAPTATION AND CLIMATE JUSTICE

A variety of widespread adverse impacts from climate change are already beginning to occur, including warming, changes in precipitation patterns, sea level rise, acidification of the oceans, and increased storm intensity. Warming and other climate changes will continue to intensify even if significant steps to mitigate GHG emissions are undertaken. These climate changes will cause increasingly serious harms to natural systems, biodiversity, and human welfare. Accordingly, governments as well as private citizens and firms must take extensive steps to anticipate and respond to these adverse impacts. Climate adaptation is a highly important and quite underdeveloped field of policy research and knowledge that requires major investment.

Domestic measures

Some scattered adaptation measures to avoid or reduce these impacts have been initiated by some governments, but a far more proactive, comprehensive, and ambitious approach is needed. The lesson of Hurricane Katrina and the 2003 heat wave in Europe (regardless of the extent to which climate change contributed to their intensity) is that even developed countries can be highly vulnerable to the physical, economic and community disruptions caused by extreme climate events. Depending on their circumstances, countries need to institute adaptation measures that can include changing development and land use policies and regulations to avoid low-lying coastal areas and other vulnerable areas; development of natural and artificial coastal barriers to tide surges and storms; relocation of vulnerable populations; development of improved water supply infrastructure; development of drought-resistant agriculture; steps to control desertification; public health initiatives to address the increased incidence of water-borne and vector-borne diseases; measures to protect and conserve biodiversity; and stronger emergency preparedness and response programs. In addition, governments should draw on social science to understand and enhance the resiliency of communities in confronting environmental stresses and emergencies.

International measures

Developing countries are far more vulnerable than developed countries because that have less in the way of resources and governmental capacities; because they are mostly located in regions that are more severely impacted by climate change; and because their vulnerable agricultural sectors constitute a much bigger portion of their economies. Further, (as Katrina again illustrates), the poorest segments of the populations within countries, whether developing or developed, generally suffer the most from climate-related disruptions. The developed countries and the rich can protect themselves at relatively affordable cost. Because they have contributed the most to current and near-to-medium term future warming, they have a moral obligation to undertake or finance adaptation measures to protect and compensate the climate underclass.

The vulnerability of developing countries requires that multilateral, bilateral, and private programs for development assistance and humanitarian aid promote adaptation planning and measures. Cooperative programs to anticipate and adapt to climate risks must be developed on a wide scale. The Kyoto Protocol established an Adaptation Fund, financed by a levy of 2% on emissions credits generated by the CDM. The Fund has been mired in controversy and after ten years has yet to go into operation. Pursuant to the UNFCC, two adaptation funds administered by the Global Environmental Facility have been established, the Special Climate Change Fund and the Least Developed Countries Fund. Grants from these funds are underway, but the scale is limited. There has, moreover, been relatively little interest on the part of developing country governments in the multilateral adaptation funding programs that have been established. Other relevant institutional bodies, such as the FAO and WHO, as well as national governments and private bodies can help build developing countries' adaptation capacities.

Climate justice may also justify new forms of liability by emitters for climate damage through international human rights law or transnational litigation. For example, legal claims have been brought by indigenous communities in Canada who are threatened by Arctic warning and ice melt, against the Canadian Government under the Inter-American Human Rights Convention and against major U.S business sources under the U.S. Alien Tort Claims Act.

IV. OTHER ISSUES

A. PUBLIC ATTITUDES AND CULTURAL CHANGE

Effective climate policy ultimately depends, in almost all countries, on public awareness of climate change and its consequence and public support for undertaking mitigation and adaptation measures. Developing economies and societies that will be able to maintain strict GHG controls for the indefinite future will require pervasive culture change, at least for the more affluent regions and populations of the world. Understandings, practice and values developed in the era of carbon abundance will have to change drastically in the coming low-carbon era. Yet we know relatively little about how public perceptions and values regarding climate change are formed and how they might be changed. The causes and mechanisms of transformations in public cultures are quite poorly understood.

It is obvious that schools and universities have a critical role in educating students and, by extension, the public about climate change. Governments can also seek to educate the public. There is evidence that the public has difficulty in dealing with abstract and uncertain risks, and are more likely to be motivated to take action themselves or support government measures by the prospect of concrete impacts on themselves, their families, and their communities. There are also some indications that more information and greater saliency regarding climate issues may produce greater polarization rather than convergence in the public's views on climate policy. There remain many uncertainties as to how far and by what means

governments or private actors can effectively influence public perceptions and values regarding climate change, much less transformations of public culture. Further, persuasion is a two-edged sword. It can be used by politicians and private actors to minimize climate risks and oppose strong climate protection policies.

These issues are of surpassing importance for successfully confronting the challenge of climate change. Research to build knowledge on these questions is a high priority.[1] It is clear, however, that experts can not successfully pose or resolve policy questions without engaging the public's perspectives.

B. MOBILIZING PRIVATE SECTOR ENERGIES

Governments and international authorities must take the lead in climate mitigation and adaptation, but progress at the scale needed requires that private actors also assume major roles.
Private economic actors, including consumers as well as producers, must be encouraged to internalize climate protection norms and apply their creative energies to transform the economy so that it leaves a much lighter climate footprint. These initiatives can help fill the inevitable gaps in government measures and generate innovative approaches that can be adopted more widely. The prospect of future government regulation and consumer and public demands can encourage firms, especially those with a prominent social franchise, to take climate initiatives as a matter of self interest. NGOs can play a pivotal role in generating and disseminating information, monitoring government and business decisions and performance, and engaging in education and advocacy. Citizens that take responsibility for climate protection in their own conduct can not only make a contribution to climate mitigation but are likely to support strong government measures to the same end.

The importance of the private sector is especially great in the international context and in those developing countries where institutions of governance are relatively weak. Multinational businesses are often not subject to very effective regulation in many of the locations in which they operate. Private sector financial institutions increasingly provide an alternative source of finance for development projects and structural reforms in developing countries, and often do so without many of the environmental and social conditions attached by multilateral or government donors. It is therefore crucial that multinational businesses and financial institutions avoid practices and investments that will exacerbate climate change. The relative weaknesses of international institutions also make the role of international NGOs a crucial one.

The decentralized and flexible structures for private decisional networks and their spontaneous quality are important virtues. Yet, governments can usefully take certain steps to encourage and support private initiatives for climate protection. Information systems that publicize the emissions of major emitters (including governments) and the embedded GHG in goods and services can help stimulate public and consumer demands for better performance and business steps to achieve it. Publicity regarding the climate-related decisions of multinational businesses and international finance firms and other steps to enhance their accountability can be valuable. Governments, international bodies, and NGOs can work in partnership with business firms to develop voluntary programs, like the UN Global Compact, that develop environmental principles or standards for businesses and monitor and review their performance. The existence of such programs can help alleviate firms' concerns about competitive disadvantage and encourage corporate initiatives. Significant additional work is required to understand how private sector energies, especially those of business firms, can be leveraged for climate protection.

[1] For an overview of what we know and don't know about these questions, see the articles collected in Climactic Change, Volume 77 (2006)

C. GEOENGINEERING: CLIMATE INSURANCE?

There is growing interest in geoengineering technologies that involve human modification of natural systems in order to lessen climate changes caused by other human activities. For example, proposals have been made to seed the ocean with iron particles to stimulate growth of phytoplankton in order to enhance uptake of atmospheric CO2. Another proposal is to use rockets to lodge sulfur particles in the upper atmosphere to absorb and scatter solar radiation, emulating the cooling effect of volcanic eruptions and SO2 emissions from fossil fuel combustion. These proposals have been sharply challenged on grounds of technical feasibility, cost, and environmental performance, including the potential for serious adverse side effects. They have also been attacked as an excuse for not undertaking needed mitigation measures. Because such measures involve global commons areas (the ocean and the upper atmosphere) they could, in practice, be undertaken unilaterally by a single nation, which would raise sharp political controversy and thorny legal issues. Nonetheless, if strong mitigation measures are not adopted in a timely fashion on a global scale and warming occurs at the upper end of the projected range, such measures may need to be considered in order to prevent major adverse impacts from climate change.

D. THE OPENING OF THE ARCTIC

The warming of the Arctic region and the melting of sea ice is making it much easier to more freely navigate and explore the region and develop its potentially very rich seabed mineral resources. The Russian government recently announced a plan to annex a vast 1.2 million square kilometer tract of the Arctic seabed, based on claims that it represents part of Russia's outer continental shelf. Currently, the Arctic has the legal status of a commons that is not owned by anyone. The Law of the Sea Treaty may be of little assistance in coping with development in the region. There is a risk of a wide-open international race among nations and private firms to exploit the regions' mineral resources, threatening economic waste and environmental degradation. The example of the Antarctic Treaty indicates that it may be possible to build a workable international legal and political regime to govern the Arctic, but the task will not be an easy one.

ANNEX

BACKGROUND INFORMATION ON CLIMATE CHANGE ISSUES

THE SCIENTIFIC EVIDENCE

As confirmed by the recent 2007 reports of the Intergovernmental Papal on Climate Change (IPPC), there is very strong evidence that greenhouse gas (GHG) emissions from human activity have caused significant warming over the past 50 years and will cause much greater long-term warming and other serious climatic changes in the future. [2] These effects are already occurring and will intensify in the future due to lags in warming due to past emissions and continuing and largely unchecked emissions growth.

The effects of anthropogenic climate change include warmer weather over most land areas, melting of Arctic ice, retreat of glaciers and reduced snow pack, heavier precipitation in some areas and increased droughts in others, more intense tropical storms, and increases in extreme high sea levels. Warming is also expected to lead to the spread of tropical diseases. These changes adversely impact human welfare and marine and terrestrial ecosystems. While agriculture in some areas will benefit from warming, higher atmospheric CO2 concentrations, and increased participation, it will suffer in most regions due to droughts, reduced runoff, floods, saltwater intrusion, and other changes. There is already evidence of adverse impacts on biodiversity, which will intensify. The rate of warming as well as the absolute level of increase is important for the ability of species and ecosystems to adapt. Coral reefs, for example, are already dying to a combination of warming, acidification of oceans, and other anthropogenic stresses. There is also substantial concern among scientists that warming may eventually have potentially catastrophic non-linear effects, such as the collapse of the huge West Antarctic ice sheet. Substantial uncertainties remain about the relations between increased GHG emissions, the extent of warming and other climactic changes, and the intensity and distribution of climate change impacts on natural systems and human welfare, but the main thrust is clear.

The geographic distribution of climate change impacts is by no means uniform. Countries in tropical zones, regions that are already arid, and low-lying coastal areas and islands will be most severely affected. Those that will suffer most are primarily developing countries and their populations, especially the least developed countries who are least able to cope with the adverse impacts of climate change. Countries and regions in the temperate zones may be less seriously affected. Indeed, during the next several decades some areas, including major parts of the United States and China, are projected to benefit overall due to warmer weather and enhanced agriculture productivity, although some regions in both countries will suffer from sea level rise and droughts. It is predicted that Europe will be substantially more adversely affected than either of these countries. Russia is projected to benefit (on balance) substantially from warming during the next several decades. The IPPC found, however, that it is very likely that all regions will experience increases in net costs or declines in net benefits as warming exceeds about 2 ºC to 3 ºC, which will likely occur later in this century.

GHG in the atmosphere (including water vapor) trap radiation of heat originating in sunlight, creating a greenhouse effect. In the absence of GHG, the earth would be lifeless, at least at the surface. But human activities have caused large increases in GHG emissions and concentrations in a very short time. These GHG emissions mix globally throughout the atmosphere, which functions as a common pool. From an environmental perspective, it does not matter where these emissions originate. GHGs are emitted by a very wide range of human activities. By far the most abundant and important anthropogenic GHG is CO2.

[2] See 2007 Reports of IPCC Working Groups I, II and III, available at http://www.ipcc.ch.

In the space of less than 200 years the concentration of CO2 in the atmosphere has, as a result of fossil fuel combustion and land use changes including deforestation, increased from a pre-industrial level of around 280 ppm (parts per million) to over 380 ppm today. The next most important GHG are methane and nitrous oxides. Agriculture is the most important sources of anthropogenic emissions of these gases. Methane levels have more than doubled since industrialization. Increases in nitrous oxide emissions have been less, but this gas is accumulating in the atmosphere as well. Overall, GHG emissions have been increasing in recent decades at a rate of about 1.5% annually. With continued economic growth, especially in developing countries, GHG emissions are expected to continue to grow rapidly unless stringent mitigation measures are taken. China appears to have recently surpassed the U.S. as the world's largest emitter of CO2, and developing country GHG emissions are expected to exceed those of the industrialized countries within 10-15 years.

Different GHG have different radiative forcing (warming) potency. Once emitted, they mix globally and reside in the atmosphere for substantial but varying periods of time before they are removed by natural cycles to sinks like the ocean and vegetation. CO2 emissions have a long residence time. They are removed from the atmosphere by natural processes quite slowly, and a modest fraction (~15%) of emissions will remain for millennia. Indices of the global warming potential (GWP) of different gases, based on their respective radiative forcing and residence times, have been developed to calibrate their relative contribution to global warming and climate change.[3] Warming and other climate changes are a function of GHG concentrations in the atmosphere, not current emissions. The atmosphere is a like a bathtub. Human activities have been adding far more GHG (the faucet) to the atmosphere than can be removed by natural sink processes (the drain). Even if the current level of emissions were slashed tomorrow, it would take a long time for atmospheric concentrations to diminish. Also, the lag in the warming of the ocean will cause warming to continue for a substantial period even if drastic mitigation measures are adopted. Moreover, GHG emissions are growing rapidly due to patterns of economic development that can not be easily or rapidly changed. Accordingly, as a practical matter all that we can hope to accomplish in the near term is to reduce their rate of growth. Even with stringent controls, achieving declines in absolute GHG emissions levels will take many, many years.

The IPCC recently concluded that past and projected future anthropogenic GHG emissions will cause global mean temperature to increase at a rate of around .2ºC for the next several decades. The range of warming predicted to occur by end of the 21st Century is between 1.0ºC and 6.4ºC, depending on assumptions about future emissions growth and climate sensitivity, both of which are subject to significant uncertainty. The magnitude of "business as usual" (BAU) emissions (those that will occur in the future in the absence of GHG regulatory controls) is a function of, among other factors, the level and structure of future economic growth, the technologies used, the price of energy, and regulatory controls and other policy measures to achieve non-climate goals, such as cleaner local air, reforestation, energy security, or structural economic reforms, that also reduce GHG emissions. Climate sensitivity depend on how much global temperature will change in relation to increased concentrations of different GHG, climate feedback loops, negative and positive, such as cloud formation and its effects, and other variables. There are also significant uncertainties regarding the extent of the other climatic changes associated with different levels and rates of warming, and the effects of these various changes on natural systems and human welfare.

[3] Global warming potential (GWP) indices for various GHG, based on their radiative forcing values and atmospheric residence times, express the warming effect of GHG other than C02 in terms of the amount of CO2 with the same warming potential. For example the GWP of methane is 21; a million metric tonnes of methane has the same warming effect as 21 million tonnes of CO2. Atmospheric concentration figures for GHG are expressed in CO2 equivalent in order to reflect the relative contributions of all GHG to warming.

If warming occurs at the lower end of the predicted 1.0ºC to 6.4ºC range, societies could cope with it, albeit at a cost and with varying degrees of success. Warming at the upper end of the range would be an unprecedented disaster for humanity. One of the gravest and most difficult challenges for climate policy is how to address such huge uncertainties.

ECONOMIC AND POLICY FUNDAMENTALS

Almost all the nations of the world are Parties to the 1992 United Nations Framework Convention on Climate Change (UNFCC), which establishes an international system of cooperation on climate policy but does not impose binding emissions limitation obligations. The UNFCC states as a goal the prevention of "dangerous interference" with the climate system. There has been no international agreement on what constitutes "dangerous interference." But many informed policy analysts and scientists as well as officials in Europe and developing countries believe that we need to limit warming to around 2ºC, and stabilize C02-equivalent GHG concentration somewhere in the range of 450-550 ppm. Others, more optimistic about the ability of humans and natural systems to adapt to changing climate, question indefinite stabilization as a desirable goal.

Measures to limit net GHG emissions, including measures to enhance sinks such as forests, are termed mitigation measures. Achieving stabilization of atmospheric concentrations would require mitigation measures to slow the current increase in emissions until emissions reach a peak and then begin to decline. The lower the level of stabilization and the sooner that it must be achieved, the more stringent and costly the controls that must be imposed on emissions and the sooner they must be imposed. The IPPC recently found, however, that even if atmospheric GHG concentrations were stabilized, temperatures would continue to increase for decades and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks.

The 1997 Kyoto Protocol to the UNFCC imposes obligations on industrialized country Parties to achieve, by a 2008-2012 First Commitment Period, specified limitations on their emissions relative to 1990 baseline levels. All of the industrialized countries other than the United States and Australia have become Parties to the Protocol and are making various degrees of progress in meeting their Protocol obligations. The developing countries are not subject to any emissions limitations. Even if the industrialized country Parties fully met their Kyoto commitments, only a relatively modest reduction in overall global emissions growth would be achieved.

Achieving stabilization or significant reductions in the growth of GHG emissions will require far-reaching changes in energy forms and uses and current patterns of production, consumption, transportation, land use, agriculture, and forestry. These changes will involve costs that are very large in absolute terms, but comparatively modest when framed as a percentage of global GDP. Achieving these changes without significant impairment of continued economic development and current lifestyles will require development and deployment of a variety of technologies to reduce energy use, shift to low carbon or no carbon energy sources, and in other ways reduce GHG emissions and enhance sinks. The suite of technologies that might be used has been analyzed in a widely influential article by Pacala and Socolow.[4] Limiting their analysis to C02 fossil fuel emissions, they posit a goal of stabilizing atmospheric concentrations at 500 ppm within 50 years. Achieving this goal would require measures to hold emissions constant at current levels for the next 50 years rather than doubling, as predicated under BAU. Pacala and Socolow identify a portfolio of different technology options or "wedges" to achieve the necessary reductions from BAU levels and build a sustainable carbon-neutral economy:

[4] S. Pacala and R. Socolow, Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies, 305 Science 968 (2004).

- Energy efficient vehicles
- Reduced vehicle use,
- Efficient buildings
- Efficient baseload coal plants,
- Gas baseload power in place of coal baseload power
- CO2 capture at baseload power plant and geologic storage,
- CO2 capture at hydrogen production plants and geologic storage,
- CO2 capture at coal-to-synfuels plants and geologic storage,
- Nuclear power in place of coal power
- Photovoltaic power in place of coal
- Hydrogen generated through wind power for vehicle fuel
- Biomass fuel in place of fossil fuel
- Reduced deforestation plus reforestation, afforestation and new tree plantations
- No-till or low-till agriculture

As noted above, the costs of climate mitigation depend heavily on the timing and levels of emissions limitations and the resulting shape of future emissions pathways. The underlying costs are subject to considerable uncertainty and dispute. For example, the IPCC found that least cost-emissions limitation pathways to achieve different atmospheric GHG stabilization ranges would involve the following costs: To stabilize concentrations in the range of 590-710 ppm CO2-equivalent would reduce global GDP between -.6% and 1.2% with a median value of .2 %. Stabilization in the range of 535-590 ppm would reduce GDP between .2 and 2.5% with a median value of .6%. Most of these analyses assume perfect information and competition and a lack of institutional barriers to adoption of cost-effective technologies. To the extent that real world conditions do not meet these assumptions, costs will be higher. Other uncertainties involved in generating such estimates include the performance and cost of various technologies for reducing emissions and enhancing sinks, the responsiveness of producers and consumers to regulatory and other incentives to reduce net GHG emissions, and institutional barriers that impede the deployment of new technologies and undermine the efficacy of policy measures.

Governments will inevitably balance the costs of mitigation measures against the benefits of reduced climate change in deciding on whether or not to institute mitigation measures and their timing and stringency. Economists and policy analysts structure this balancing through use of cost-benefit analysis to identify and assign economic values to relevant costs and benefits. Their objective in doing so is to identify the policy choices that will maximize net benefits to society. Policies that meet this criterion are those that minimize the sum of climate change costs (including adaptation costs) and mitigation costs. Of course, judgments by governments also involve a political calculus which is sensitive to the distributional consequences of both warming and measures to limit it: who is helped, who is hurt, who bears the costs, and who avoids paying. Also important is how to deal with the uncertainties in the extent of warming and small or unknown probabilities that emissions growth may trigger changes in natural systems with quite severe or disastrous consequences.

A critical policy variable in analyzing the costs and benefits of investments in climate mitigation is the discount rate applied in the analysis. Many mitigation measures, involve significant capital and other costs that must be incurred in the near term, while the benefits in terms of reduced climate change occur in the future over a long time horizon. The higher the discount rate, the lower the net present value of those future benefits. Applying cost-benefit analysis to climate policy analysis must also confront uncertainties about the adverse effects of climate change and the extent to which they will reduced by mitigation measures, and the difficulties in assigning reliable economic values to some of the adverse effects of climate change, such as loss of biodiversity, impairment of ecosystem services, and community disruption. Some environmentalists attack use of cost-benefit as improperly “commodifying” the

environment. Yet, governments must and will make tradeoffs in deciding on climate policies; it is desirable those decisions be made in an informed and disciplined fashion. Although cost-benefit analysis has significant limitations, it can nonetheless be a useful tool if its limitations are kept in mind.

Most economists and policy analysts, applying a cost-benefit framework, favor mitigation strategies involving relatively modest reductions in the near term, with steeper reductions later to take advantage of the turnover in the capital stock and the development of new low carbon technologies. They generally find that the costs of the near-term emissions limitations required by the Kyoto Protocol substantially exceed the benefits. Also, from an investment perspective, the discounted net present value of mitigation costs are lower if they are incurred further into the future. Furthermore, there is the policy option of managing climate risks by incurring adaptation costs in the future to address climate change impacts rather than investing in emissions limitations in the near term to mitigate the extent of those impacts. It is also argued that, due to continuing economic growth, future generations in the aggregate will be substantially richer than ours and better able to make the needed investments in mitigation or adaptation. Governments must sooner or later invest in both climate mitigation and climate adaptation. The appropriate balance between these two types of measures as well as among different types of mitigation and adaptation measures will vary by country and over present time. Economists would urge selection of a portfolio that will maximize the net benefits to society of managing climate risks.

Those favoring substantial early reductions in emissions emphasize the need to institute credible regulatory signals now to stimulate private sector R&D, to build regulatory institutions, to reduce interim climate damages, and provide insurance against nasty climate surprises. They also argue that many of those adversely affected by climate change will be people in developing countries who, even with future economic growth, will remain substantially poorer than citizens of the rich countries today. But the fact that developing countries and their populations will on the whole suffer far more from climate change than the industrialized countries may make it difficult to generate public political support in the industrialized countries for costly near-term emissions limitation measures.

REGULATORY TOOLS

For both environmental and economic reasons, regulatory approaches should be comprehensive in their coverage, including all GHG, sources, and sinks. Under a piecemeal regulatory approach -- for example one that focuses solely on fossil-fuel CO2 emissions -- investment and economic activity will “leak” to unregulated GHG and sources, leading to increases in the other GHG. For example, if fossil CO2 is regulated but methane is not, industry will have an incentive to shift to use of natural gas in lieu of petroleum or coal, which generate more CO2 relative to energy generated. But, methane from leaky pipelines (for example, in Russia) would be unregulated and would increase, offsetting some of the benefits of CO2 controls. Also, the costs of limiting different GHG or enhancing sinks vary substantially among countries and firms. The flexibility allowed under a comprehensive approach will allow those subject to limitations obligations to choose the most-cost effective mix of measures to limit net emissions. The savings, relative to an approach that regulates each gas and sink separately, can approach 50%. The UNFCC and the Kyoto Protocol embrace a comprehensive approach. The Protocol allows countries the flexibility to achieve their limitations obligations by different mixes of controls on different gases or sink enhancements. While much attention have properly been focused on reducing fossil CO2 emissions, non-fossil CO2 emissions (principally from deforestation) and emissions of other gases are quite important. These two categories together currently represent about 40% of total global emissions and 60% of current developing country emissions.

Further, as noted above, GHG emissions mix globally throughout the atmosphere. From an environmental perspective, it does not matter where reductions in net emissions (including through sequestration as well as emissions limitations) are achieved. The costs of limiting GHG emissions vary substantially among

different countries and regions as well as among different sectors of the economy. Large savings can be accomplished by the use of economic incentives, such as GHG emissions taxes or tradable GHG emissions allowances, that impose a price on emissions, thereby leading sources that can control emissions at lower costs to do no more in the way of limitation, and high-cost sources to do less. Under a "cap and trade" system, for example, the government allocates (by auction or some other system of allocation) allowances to sources. The total amount of allowances, and hence emissions is capped (the cap can be adjusted over time). Allowances can be freely bought and sold. The market will establish an emissions allowance price, based on the average marginal cost to firms of limiting emissions. Firms with control costs below the market price will invest in additional reductions and sell excess allowances, earning a profit, while firms with higher costs will buy allowances. This arrangement promotes the most cost-effective allocation of the overall limitations burden. By using the price system, economic incentive systems allow flexibility for individual actors but coordinate their myriad decisions to achieve socially desirable outcomes in the aggregate. For a variety of reasons, including the administrative burden of gathering and analyzing all of the needed information and devising appropriate controls, it is impossible to achieve a similar degree of cost savings through traditional command and control regulation, which specify the conduct required of each regulated actor. Further, because tradable permit systems impose a price on emissions, they create continuing incentives for firms to find ways to reduce their emissions in order to save money and gain competitive advantage. A cap-and-trade regulatory system has been employed with great success in the United States to reduce by 50% sulfur dioxide emissions at half or less than the cost of achieving those reductions through traditional technology-based controls. Taxes on emissions have similar efficiency and incentive properties.

The Kyoto Protocol authorizes emissions trading among industrialized countries.[5] Studies indicate that full use of GHG emissions trading among industrialized countries would reduce the costs of any given level of limitations by 50%. Including the developing countries, which typically have quite low costs of GHG emissions reductions, would reduce aggregate costs by 75% or more. Given the magnitude of the costs involved in drastically limiting GHG emissions, achieving these savings is of vital importance.

Including developing countries in global emissions trading would ordinarily involve some form of regulatory cap on their emissions. Developing countries have strongly opposed any such caps, or any other sort of regulatory obligation. They point out that most of the GHG currently found in the atmosphere have been contributed by the developed countries in the course of their industrialization, and argue that developing countries have a right to similar opportunities for development to benefit their populations, many of which remain quite poor. They also point out that GHG emissions per capita in most developing countries are much lower than in the rich industrialized countries. For example, per capita fossil CO2 emissions in the US are about 20 times those in India. On the other hand, developing country GHG missions are growing rapidly and before long will outstrip emissions from developed countries. From a climate protection perspective, it is essential to steer their development along a low-carbon path, and not repeat the pattern that the industrialized countries followed.

Because climate change and its effects are is already occurring and will intensify in the future, it will as noted above be necessary to adopt measures to adapt to the adverse effects. While much adaptation will occur spontaneously as individuals, groups, and firms react to changed environmental circumstances, government must plan and adopt proactive adaptation measures in order to minimize the adverse impacts of climate change on human welfare. Such measures include development of barriers to sea level rise and relocation of development away from low-lying coastal areas; improving water supply infrastructure;

[5] The Protocol also establishes a Clean Development Mechanism under which industrialized countries or their firms that invest in projects in developing countries to reduce net GHG emissions (for example, projects to develop renewable energy resource or establish new forests) can obtain GHG emissions reduction credits that can be used to satisfy their Kyoto or domestic regulatory obligations.

developing drought-resistant crops and agricultural techniques; protection of vulnerable ecosystems; and public health initiatives to combat the spread of disease; and stronger emergency preparedness and response programs. Developing countries will be most adversely affected because they are located in regions where warming and other climate changes will be greatest and often have characteristics that make them especially vulnerable to such changes. Such countries also often lack the resources and capacities to take adaptation measures to reduce adverse effects. However, vulnerable populations are found even in rich countries, and those countries have recently shown only a limited ability to deal with the sort of extreme events that are expected to increase markedly in the future, e.g., hurricane Katrina and the European heat wave of 2003.

THE CHALLENGE OF CLIMATE POLICY

The magnitude, complexity, and long term character of anthropogenic climate change and its underlying causes pose a daunting array of immense policy challenges, matched only by the challenge of nuclear security. The challenges of climate change include the following:

- Dealing with the exceptionally long time horizon of climate change and of the policy measures needed to achieve and sustain a sustainable global economy.

- Securing public understanding of the climate challenge and mobilizing public support for the far-reaching and costly policy measures required to address it.

- Achieving credible long-term regulatory commitments and taking other measures to stimulate successful development and adoption of wide array of new energy and other technologies to mitigate climate change.

- Achieving an unprecedented degree of long term global cooperation by all major emitting countries and firms in emissions limitations in the face of temptations to free ride on others' efforts, the competitiveness pressures generated by a global economy, and the uneven distribution of climate risks among countries.

- Limiting the rapid growth of emissions in major emitting developing as well as developed countries while respecting developing countries' equity claims, their opportunities for economic growth, and their sovereignty.

- Achieving the major legal and institutional changes needed to build domestic and international mitigation and adaptation programs and overcome institutional barriers to needed changes in production, consumption, and transportation patterns.

- Managing the very large uncertainties regarding future emissions growth, the impacts of higher GHG atmospheric concentrations, and the performance and costs of technologies and other measures needed for ambitious emissions limitations.

- Generating the political will to protect (through emissions limitations) and assist (through adaptation measures and compensation) the "climate underclass" -- the vulnerable, poor, and politically powerless in developed as well as developing countries that will be most seriously harmed by climate change.