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[Global Climate Change Policy - Kyoto Protocol Analysis] [Binder] [3]

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- In the Czech Republic, the District Heating Project converted the Bynov District Heating Plant from a lignite coal burning facility to a natural gas-fired plant. In addition, a cogeneration facility for steam and electricity generation have been constructed. The project developers have estimated that this activity implemented jointly will achieve total carbon emissions reductions of about 166,000 tons of carbon equivalent (Environmental Protection Agency 1997). A6

- In Costa Rica, the Klinki Forestry Project arranges with farmers to plant Klinki trees and other fast-growing, high-sequestration tree species on marginal farmland and pastures. Participating farmers, who sign a 40-year contract, receive tree seedlings, technical assistance, and a cash payment. The trees yield a high-grade industrial wood, suitable for utility poles and plywood, both of which continue to store carbon. Project sponsors estimate that this project will sequester nearly 2 MMTCE over its 46 year life (Environmental Protection Agency 1997). A7

- In Belize, the BEL/Maya Biomass Power Generation Project involves the construction of an 18 megawatt biomass waste-to-energy facility adjacent to a sugar mill. This facility will provide power to the mill, local orange processors, and an electricity distribution firm. The biomass power plant will displace diesel oil-fired power generation, and achieve total carbon emissions reductions of 1.2 MMTCE according to project sponsors (Environmental Protection Agency 1997). A8

- In Russia, the Fugitive Gas Capture Project involves the capturing of fugitive methane emissions from two natural gas compressor stations. Over the approximate 25 year lifetime of this project, sponsors indicate that sealing valves at the compressor stations could reduce methane emissions by more than 7 MMTCE (Environmental Protection Agency 1997). A9

Other Countries' Efforts

Several European countries have also embarked on AIJ projects (Zollinger and Dower 1996).

- In 1996, the Netherlands set aside $51 million for AIJ projects in 5 countries: Bhutan, the Czech Republic, Ecuador, Hungary, and Uganda. A10

- Norway funds a coal-to-gas conversion project in Poland, through the World Bank and the GEF. Norway has another AIJ project with Mexico. A11

- Germany has 7 AIJ projects, in the Czech Republic, Indonesia, Jordan, Latvia, Portugal, and the Russian Federation. These focus on fuel switching, energy efficiency, and renewable energy. A12

EPA 236-R-97-002
2nd Printing
January 1998

Activities Implemented Jointly: Second Report to the Secretariat of the United Nations Framework Convention on Climate Change

U.S. INITIATIVE ON JOINT IMPLEMENTATION

Accomplishments and Descriptions of Projects Accepted Under the U.S. Initiative on Joint Implementation

Volume 1

USIJI is supported by:
Agency for International Development, Department of Agriculture, Department of Commerce, Department of Energy, Department of Interior, Department of State, Department of Treasury, and Environmental Protection Agency

energy demand. Because this generation will displace electricity that would have otherwise been generated by existing thermal plants, it reduces GHG emissions from fossil fuel combustion.

Project BIODIVERSIFIX

Project BIODIVERSIFIX combines two subprojects, WETFIX and DRYFIX, that will regenerate degraded tracts of tropical wet forest and tropical dry forest in the Area de Conservacíon Guanacaste (ACG) in Costa Rica. The ACG contains forest conserved for sustainable, non-damaging use of wildland biodiversity. Possible activities conducted on this land include low-impact controlled ecotourism, biological education programs, biodiversity prospecting, research programs, watershed protection, and regeneration and selective harvest of fine hardwoods. The GHG benefits of the project accrue from forest growth (i.e., carbon sequestration) that would not have occurred in the absence of project activities.

Project CARFIX: Sustainable Forest Management

Project CARFIX is a forestry project located in central Costa Rica. This project aims to stabilize the existing natural forest and create additional forest cover in the Central Volcanic Conservation Area, which constitutes a 290,187 ha buffer zone surrounding the World Biosphere Reserve of Braulio Carrillo National Park. The GHG benefits of the project accrue from conservation of existing carbon stocks and increased carbon sequestration on 108,265 ha of forest land.

Tierras Morenas Windfarm Project

The Tierras Morenas Windfarm Project involves the construction and operation of a privately owned and operated 20 MW wind facility near the town of Tierras Morenas in the Guanacaste province of Costa Rica. Electricity generated by the plant will be sold to the Costa Rican Institute of Electricity to meet a portion of Costa Rica's energy demand. Because this generation will displace electricity that would have otherwise been generated by existing thermal plants, it will reduce GHG emissions from fossil fuel combustion. The facility will become operational in June 1998, and is expected to produce an estimated 76 GWh of electricity per year.

CZECH REPUBLIC

City of Decin: Fuel-Switching for District Heating

A6

The City of Decin: Fuel-Switching for District Heating Project involves fuel-switching, cogeneration, and efficiency improvements at the Bynov District Heating Plant, located in Decin in the Czech Republic. The project has converted the plant from a coal (lignite) burning facility to a natural gas-fired plant, which provides both heat and potable hot water to local apartment blocks. A cogeneration facility for the production of steam and electricity has also been built, and improvements have been made to the distribution network to enhance the system's energy efficiency. On-site GHG emission reductions occur as a result of the fuel switch from lignite to natural gas and energy efficiency improvements. Off-site GHG emission reductions occur because the new Bynov plant is a cogeneration facility with the ability to produce both electricity and heat, and thus, reduces electricity consumption from the national utility grid.

COSTA RICA

Aeroenergía S.A. Wind Facility

The Aeroenergía S.A. Wind Facility Project is a privately owned and operated 6.4 MW wind facility consisting of 16 wind turbines. The project is located near the town of Tejona in the Guanacaste province of Costa Rica. Electricity generated by the plant will be sold to the Costa Rican Institute of Electricity to meet a portion of Costa Rica's energy demand. Because this generation will displace electricity that otherwise would have been generated by existing thermal plants, it reduces GHG emissions from fossil fuel combustion.

Doña Julia Hydroelectric Project

The Doña Julia Hydroelectric Project involves the construction and operation of a privately owned and operated 16 MW hydroelectric plant that is expected to produce an estimated 83 to 87.8 gigawatthours (GWh) of electricity per year, using the waters from the Puerto Viejo River and Quebradon Creek. The project will displace electricity and GHG emissions currently produced by thermal fossil fuel-burning facilities. The project facility became operational in October of 1996. Electricity generated by the project facility is being sold to the Costa Rican Institute of Electricity.

ECOLAND: Piedras Blancas National Park

The ECOLAND Project will preserve tropical forest through the purchase of approximately 2,500 privately-owned hectares (ha) in the Piedras Blancas National Park (formerly named the Esquinas National Park) in southwestern Costa Rica. The purchased land will be conveyed to the Costa Rican Park Service for permanent protection. GHG benefits accrue from conservation of existing carbon stocks on the park land.

Klinki Forestry Project

A7

The Klinki Forestry Project will convert pastures and marginal farmland to commercial tree plantations by promoting the planting of 6,000 ha of private farms with mixtures of selected fast-growing tree species in a matrix, with the Klinki tree as a major component. The trees will be harvested periodically for use in long-lived lumber products (such as utility poles) or left standing. The project will include small, medium, and large farms, educational pilot projects, and an investor farm. Farmers will be given incentives for planting in return for rights to the sequestered carbon. The objective of the project is to develop a demonstration of the involvement of the farmer in carbon sequestration as an economic activity using the latest tree farming technology while providing GHG, wood production, and conservation benefits.

Plantas Eólicas S.A. Wind Facility

The Plantas Eólicas S.A. Wind Facility involves the construction and operation of a privately owned and operated 20 MW wind facility near the town of Tejona in the Guanacaste province of Costa Rica. The facility has been in operation since June 1996. Electricity generated by the plant is being sold to the Costa Rican Institute of Electricity to meet a portion of Costa Rica's

IV. USIJI Project Abstracts

The following text presents abstracts of the 25 USIJI projects accepted to date. A detailed annual report for each of these projects is contained in Part Two: USIJI Project Reports (contained in Volume 2).

BELIZE

BEL/Maya Biomass Power Generation Project

The BEL/Maya Biomass Power Generation Project involves the construction and operation of an 18 megawatt (MW) biomass waste-to-energy plant to be located adjacent to the Belize Sugar Industries (BSI) sugar mill. The plant will generate electrical power for sale to Belize Electricity Limited and orange processors, and produce steam and electricity for in-house use and future sugar refining at BSI. The plant will be fueled by bagasse, orange processing wastes, and wood wastes from sawmills and other nearby sources. By displacing diesel oil-fired power generation with waste biomass fuel that would revert eventually to carbon dioxide (CO_2) in any case, the project will reduce utility CO_2 emissions.

A8

Rio Bravo Carbon Sequestration Pilot Project

The Rio Bravo Carbon Sequestration Pilot Project is a forestry project located in northwest Belize, adjacent to the Rio Bravo Conservation and Management Area. The project combines land acquisition and a sustainable forestry program to achieve greenhouse gas (GHG) benefits from forest growth (i.e., carbon sequestration) that would not have occurred in the absence of project activities. The objective of the project is to demonstrate an optimal balance between cost-effective carbon sequestration, economically sustainable forest yield, and environmental protection.

BOLIVIA

Noel Kempff Mercado Climate Action Project

The Noel Kempff Mercado Climate Action Project is a forest protection and sustainable management project located in eastern Bolivia. The project will expand the existing Noel Kempff Mercado National Park, and reduce future GHG emissions within both the existing Park and the Park expansion area, by eliminating legal and illegal logging activities (Component A). The project also will sequester carbon over time through the long-term protection and regeneration of the Park expansion area's already logged mahogany, oak, cedar, and palm forests, and through a mix of income-generating activities designed to support long-term preservation (Component B). Finally, GHG mitigation will also result from leakage prevention activities (Component C). Although GHG emission reductions and carbon sequestration are anticipated to occur within both the existing Park and the Park expansion area, the project will only claim GHG benefits associated with activities within the Park expansion area.

project site. The emission reduction estimates are based on displacement of a diesel fueled unit with a geothermal unit of equal capacity.

PANAMA

Commercial Reforestation in the Chiriquí Province

This project will reforest 500 ha of currently degraded lands in the Chiriquí Province in the western region of Panama. The project area will be planted with teak (*Tectona grandis*), established as a certified teak plantation, and managed in a sustainable manner as a source of high-quality hardwood. The project is estimated to result in net sequestration of carbon through tree growth and production of durable wood products over a 25-year lifetime.

RUSSIAN FEDERATION

Reforestation in Vologda

This project is a reforestation project located in Vologda, about 300 miles northeast of Moscow. Two thousand hectares of collective state farm land adjacent to and within the Russky Sever National Park will be converted from hay fields back to forest. The land will be removed from hay production, and allowed to regenerate naturally, supplemented initially by planting on about 15% of the area. If regeneration proceeds slowly, additional planting or soil preparation will be implemented during the third year of the project. GHG benefits accrue from forest carbon sequestration that would not have occurred in the absence of project activities.

RUSAFOR–Saratov Afforestation Project

The Russian Federation/USA Forestry and Climate Change Project–Saratov Afforestation Project (RUSAFOR-SAP) was conceived as a Russian-American forest carbon offset joint implementation demonstration project. The purpose of the project is to evaluate the biological, operational, and institutional opportunities to manage a Russian forest plantation as a carbon sink. The project established plantations on four sites in the Russian federation, totaling 900 ha. The sites were composed of marginal agricultural land and previously burned forest stands. GHG benefits accrue from avoided CO_2 emissions (due to avoided soil erosion and biomass decay), and from carbon sequestration (due to tree growth and soil carbon accumulation).

RUSAGAS: Fugitive Gas Capture Project

A9

The RUSAGAS Project will reduce GHG emissions by capturing fugitive natural gas emissions at two compressor stations located in Pallasovka and Saratov, Russia. The project, which has a lifetime of 25 years, is implementing a program to seal the valves at the compressor stations, and thereby reduce methane emissions that would occur otherwise.

Table 1. Summary of USIJI Projects

(A8)

Title of Project	Type of Activity	Stage of Activity[1]	Remarks Project life:[2]	GHG Benefits (tonnes)[3]			
				CO_2	CH_4	N_2O	Other
Belize							
BEL/Maya Biomass Power Generation Project	Energy: alternative energy generation (biomass)	Mutually agreed	31 years	3,418,444			4,860 (NO_x)
Rio Bravo Carbon Sequestration Pilot Project	Land-use change and forestry: forest preservation, sustainable harvesting, reduced impact logging, silviculture, fire management, manufacture of durable wood products	In progress	40 years	6,023,992			
Bolivia							
Noel Kempff Mercado Climate Action Project	Land-use change and forestry: forest preservation, reforestation, park expansion, and sustainable forest product enterprise development	In progress	30 years	53,190,152			
Costa Rica							
Aeroenergía S.A.Wind Facility[4]	Energy: alternative energy generation (wind)	In progress	21 years + 1 month (with possible extension)	36,194			
Doña Julia Hydroelectric Project[4]	Energy: alternative energy generation (hydroelectric)	In progress	15 years (with possible 5 year extensions)	210,566			
ECOLAND: Piedras Blancas National Park	Land-use change and forestry: forest preservation and natural regeneration	In progress	16 years	1,342,733			
(A7) Klinki Forestry Project	Land-use change and forestry: afforestation, reforestation, silviculture	In progress	46 years	7,216,000			
Plantas Eólicas S.A. Wind Facility	Energy: alternative energy generation (wind)	In progress	21 years + 5 months	397,173			

Title of Project	Type of Activity	Stage of Activity(1)	Remarks Project life:(2)	GHG Benefits (tonnes)(3)			
				CO_2	CH_4	N_2O	Other
Project BIODIVERSIFIX	Land-use change and forestry: reforestation, fire management, anti-poaching operations	Mutually agreed	51 years	18,480,000			
Project CARFIX: Sustainable Forest Management(4)	Land-use change and forestry: forest preservation, forest regeneration, reforestation, silviculture, sustainable harvesting, reduced impact logging	In progress	25 years	21,776,749			
Tierras Morenas Windfarm Project	Energy: alternative energy generation (wind)	Mutually agreed	13 years + 11 months (with possible 5 year extensions)	296,761			
Czech Republic							
City of Decin: Fuel-Switching for District Heating	Energy: fuel-switching, energy efficiency improvements, cogeneration	In progress	26 years + 8 months	607,150			
Ecuador							
Bilsa Biological Reserve	Land-use change and forestry: forest preservation	Mutually agreed	30 years	1,170,108			
Honduras							
Bio-Gen Biomass Power Generation Project, Phase I	Energy, waste: alternative energy generation (wood waste)	In progress	21 years	2,373,940			
Bio-Gen Biomass Power Generation Project, Phase II	Energy, waste: alternative energy generation (wood waste)	In progress	21 years	2,373,940			
Solar-Based Rural Electrification in Honduras	Energy: alternative energy generation (solar)	Mutually agreed	24 years	17,192			
Indonesia							
Reduced Impact Logging for Carbon Sequestration in East Kalimantan	Land-use change and forestry: reduced impact logging	Mutually agreed	40 years	134,379			

Ai

Title of Project	Type of Activity	Stage of Activity[1]	Remarks Project life:[2]	GHG Benefits (tonnes)[3]			
				CO_2	CH_4	N_2O	Other
Mexico							
Project *Salicornia*: Halophyte Cultivation in Sonora	Agriculture: Salicornia cultivation and crop management, technical analysis of soil carbon accumulation and commercial feasibility of Salicornia cultivation	In progress	59 years + 7 months	1,080			
Scolel Té: Carbon Sequestration and Sustainable Forest Management in Chiapas	Land-use change and forestry: agroforestry, reforestation, sustainable harvesting, silviculture	In progress	30 years	55,000-1,210,000[5]			
Nicaragua							
El Hoyo-Monte Galan Geothermal Project	Energy: alternative energy generation (geothermal)	Mutually agreed	37 years + 6 months	14,119,469			
Panama							
Commercial Reforestation in the Chiriquí Province	Land-use change and forestry: reforestation	Mutually agreed	25 years	57,640			
Russian Federation							
Reforestation in Vologda	Land-use change and forestry: assisted natural regeneration	Mutually agreed	60 years	858,000			
RUSAFOR–Saratov Afforestation Project	Land-use change and forestry: afforestation and reforestation	In progress	40 years (Sites I & II); 60 years (Sites III & IV)	292,727			
RUSAGAS: Fugitive Gas Capture Project	Energy: capture of fugitive methane emissions	In progress	27 years + 7 months		1,263,500		
Zelenograd District Heating System Improvements[4]	Energy: energy efficiency improvements	Mutually agreed	30 years	1,575,840			
TOTAL				136,025,229-137,180,229[5]	1,263,500		4,860 (NO_x)

A1

WRI ISSUES AND IDEAS

OCTOBER 1996

PRIVATE FINANCING FOR GLOBAL ENVIRONMENTAL INITIATIVES: Can the Climate Convention's "Joint Implementation" Pave the Way?

by Peter Zollinger and Roger C. Dower

The world of international development assistance and the environment is facing a growing contradiction. Government financing for development aid is flat or shrinking while such threats to the global environment—and security—as climate change are becoming clearer, along with the role of developing countries in reducing them. Yet, developing countries cannot be expected to address these threats without assistance and support from the developed world. Meanwhile, the private sector is increasingly viewed as the engine for economic growth and development that can help bridge the gap between government budget pressures and real environmental needs. New partnerships among government, multilateral and bilateral development assistance agencies, non-governmental organizations, and the private sector can help direct and guide private investment to meet development needs and environmental challenges. Such partnerships can also help strategically target and catalyze public sector resources. Unfortunately, one of the newest, most innovative, and creative mechanisms for merging economic and environmental interests—Joint Implementation of global greenhouse gas reductions—is off to a shaky start. This program could serve as a prototype for public/private partnerships to solve a broader array of global environmental challenges or it could turn into yet another permanent stumbling block on the road to effective North/South cooperation.

Getting the first round of greenhouse gas reduction initiatives off the ground requires forming North/South and public/private partnerships, defining fair "terms of trade," assessing financial risks, and coming to grips with a host of technical questions that only experience can answer.

The 1992 United Nations Framework Convention on Climate Change (the Climate Convention) is an agreement through which countries around the world are facing up to the risk that human activities are altering the global climate. *(See Box 1.)* But getting the first round of greenhouse gas reduction initiatives off the ground—identifying sound projects, lining up financing, and creating the institutional framework—requires forming North/South and public/private partnerships, defining fair "terms of trade," assessing financial risks, and coming to grips with a host of technical questions that only experience can answer. A true learning exercise would not only give practical answers to many of the complicated issues surrounding Joint Implementation; more important, it would also build the trust among North and South so vital to any political consensus on how to finance sustainable development and environmental cleanups worldwide.

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framework of policies and institutions needed to assess and approve projects. A closely related step is helping host countries develop *master legal agreements*—long used in the United States to pool finances for small-scale public infrastructure projects that protect or clean the environment—to reduce transaction costs and make international Joint Implementation contracts more enforceable.[21]

3. *Increase Project Financing.*

To increase project financing, investing countries should create a *venture capital fund* for Joint Implementation. Perhaps modeled on the Inter-American Development Bank's new investment fund for small environmentally friendly projects in Central America, such a fund could attract private capital by leveraging national and multilateral contributions.[22] *Trade-promotion programs*, such as the Export-Import Bank of the United States, could also be modified to help the private sector develop Joint Implementation projects. If expanded to include small environmental projects, this tack could create a huge global market for environmental goods and services. Options for investing countries include developing *multi-project financing facilities* and seeking *strategic alliances* with mainstream financial institutions on domestic and international capital markets.[23]

Where substantial private-sector finance can't be attracted, governments can *directly allocate funds* for valuable pilot projects with low financial returns and high social and environmental returns, including climate stabilization. (In a precedent in 1996, the Netherlands set aside U.S. $51 million for Joint Implementation projects in Eastern Europe and developing countries.[24] Norway is also setting up bilateral Joint Implementation demonstration projects.[25]) *Co-financing* with multilateral development banks is another promising option. Under the auspices of the World Bank Group Collaborative Program on Activities Implemented Jointly, Norway will co-finance International Bank for Reconstruction and Development (IBRD) and International Finance Corporation (IFC) climate-stabilizing investments and research. In most cases, the IFC will implement the projects and seek private sector co-financing when possible.[26]

4. *Develop Insurance Mechanisms.*

Finally, to make would-be investors feel more secure, governments could buy up part of the risk. In such an *insurance scheme*, either a public export-import agency or a private insurer could act as underwriter, as most industrial countries' trade ministries already do to protect private-sector investments in developing countries from expropriation, political upheaval, and currency inconvertibility. More specifically, "carbon risk" protection policies would insure early investors in Joint Implementation against the threat that emission credits will be worth less than expected.[27]

Host countries can scarcely think about what it takes to make Joint Implementation work apart from the incentives, macroeconomic conditions, and institutional policies needed to attract investment more generally.

Actions for Host Countries

1. *Build an Institutional Framework for Joint Implementation.*

For their part, host countries can scarcely think about what it takes to make Joint Implementation work apart from the incentives, macroeconomic conditions, and institutional policies needed to attract investment more generally. This is a plus insofar as efforts to make Joint Implementation work will pay off broadly and a minus insofar as the many interlocking determinants of success make for a high drag co-efficient in policy-making. Still, two steps could make an enormous difference on both fronts. First, host countries that have signed the Climate Convention can promote Joint Implementation investments by linking their programs to their National Action Plans. Several have already set up the national project-approval and offset registries needed to support project developers as they design projects and prepare the proposals and business plans for fundraising. Going further, countries such as Costa Rica are working hard to simply "get there first." (For its efforts, it can claim eight out of the first fifteen projects approved by the United States, though four of these still await funding.)

2. *Create Joint Implementation Securities.*

Second, host-country governments can combine projects for financing purposes only and eventually add governmental backing by adapting its institutional framework. Under Costa Rica's planned *Certified Transferable Offsets* (CTO) program,[28] a national Carbon Fund will sell CTOs (units of greenhouse gas emissions reduced or sequestered in bilaterally approved projects) to investors and provide financial resources to project developers, while a National Forestry Financing Fund will administer and finance national Joint Implementation land-use projects.[29] Instead of having to carry out investment feasibility fits of participants. For each type of project, how much greenhouse gas can be reduced or sequestered? How will the market price carbon offsets? What risks can investors expect, and how can this risk be mitigated? How big are the non-climate environmental benefits? Which contracts and other legal arrangements work best, and which are easiest to enforce? What are the best ways to monitor, verify, and report on progress and compliance? And how high are overall transaction costs likely to go?[8]

III. SO WILL IT WORK?

With these important questions looming, the use of Joint Implementation to reach the goals of the Climate Convention is gaining support. As of June 1996, twelve countries have included this program in their convention-mandated National Climate Action Plans: Australia, Canada, Costa Rica, Germany, Japan, the Netherlands, Denmark, Finland, Iceland, Norway, Sweden, and the United States.[9] The group of host countries trying to attract Joint Implementation investments is also growing. Bolivia, Costa Rica and six other Central American countries, Chile, Pakistan, and South Africa have all signed statements of intent to cooperate with the United States. The first annual review of the pilot phase, released at the second session of the Conference of Parties in July 1996, lists 17 host countries or regions where projects have been proposed or launched, while 32 projects, mainly in Eastern Europe and Central America, have received official bilateral approval.[10] *(See Table 1.)*

Table 1. Joint Implementation Project Summary

Investor/ Sponsor Country	**Australia**	**Germany**	**Netherlands**	**Norway**	**United States**
Total number of projects	2	7 A12	[illegible]	2	15
Host countries	South Pacific region	Czech Republic, Indonesia, Jordan, Latvia, Portugal, Russian Federation	Bhutan, Czech Republic, Ecuador, Hungary, Uganda A10	Mexico, Poland All	Belize, Costa Rica, Czech Republic, Honduras, Nicaragua, Russian Federation
Project Type					
Energy efficiency	1[a]	2 (1[a], 1[c])	1[b]	1[b]	
Fuel switching		2 (1[a], 1[d])	1[b]	1[b,e]	1[a]
Resource exploitation fugitives					1[a]
Renewables	1[a]	3 (2[a], 1[b])	1[a]		7 (6[a], 1[b])
Afforestation			2[b]		2 (1[a], 1[b])
Reforestation/restoration/preservation			1[b]		4 (1[a] 3[b])
Gases concerned	CO_2	CO_2	CO_2, precursors	CO_2, precursors	CO_2, CH_4, precursors

[a] Project is in the planning stage.
[b] Project is in the implementation stage.
[c] Project description does not clarify whether project is planned or implemented.
[d] Not clear from submission whether this project converts an existing plant to natural gas, or is building a new plant.
[e] One project implemented at two separate sites.
Source: United Nations Framework Convention on Climate Change (UN-FCCC), *Activities Implemented Jointly: Annual Review of Progress under the Pilot Phase, FCCC/CP/1996/14* (Geneva: UN, June 1996).
Note: Table includes only projects of those six parties that submitted reports for COP2.

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In addition, at least 6 other developed countries have included activities implemented jointly A12a in their national action plans: Canada, Japan, Denmark, Finland, Iceland, and Sweden. The group of potential host countries continues to grow. Projects have been launched or proposed in 17 A12b countries. Thirty-two projects have received approval from both host and sponsor governments (Zollinger and Dower 1996). Bolivia, all 7 countries of Central America, Chile, Pakistan, and South Africa have signed statements of their intent to launch cooperative projects with the United States. A12c

WRI
ISSUES AND IDEAS

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A12a

A12c

A12b

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Host countries	South Pacific region	Czech Republic, Indonesia, Jordan, Latvia, Portugal, Russian Federation	Bhutan, Czech Republic, Ecuador, Hungary, Uganda	Mexico, Poland	Belize, Costa Rica, Czech Republic, Honduras, Nicaragua, Russian Federation
Project Type					
Energy efficiency	1[a]	2 (1[a], 1[c])	1[b]	1[b]	
Fuel switching		2 (1[a], 1[d])	1[b]	1[b,e]	1[a]
Resource exploitation fugitives					1[a]
Renewables	1[a]	3 (2[a], 1[b])	1[a]		7 (6[a], 1[b])
Afforestation			2[b]		2 (1[a], 1[b])
Reforestation/restoration/preservation			1[b]		4 (1[a] 3[b])
Gases concerned	CO_2	CO_2	CO_2, precursors	CO_2, precursors	CO_2, CH_4, precursors

[a] Project is in the planning stage.
[b] Project is in the implementation stage.
[c] Project description does not clarify whether project is planned or implemented.
[d] Not clear from submission whether this project converts an existing plant to natural gas, or is building a new plant.
[e] One project implemented at two separate sites.

Source: United Nations Framework Convention on Climate Change (UN-FCCC), *Activities Implemented Jointly: Annual Review of Progress under the Pilot Phase, FCCC/CP/1996/14* (Geneva: UN, June 1996).
Note: Table includes only projects of those six parties that submitted reports for COP2.

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Divider Title: **3**

Developing Countries

Clearly, the challenge of climate change cannot be addressed adequately unless developing countries take measures themselves to limit greenhouse gas emissions. Our third objective in the Kyoto negotiations was to secure meaningful participation by key developing countries. The Kyoto Protocol does include a down payment on developing country participation through the Clean Development Mechanism (see discussion above) and other provisions. However, developing countries will need to do more to participate meaningfully in the effort to combat global warming. The Administration will not submit the Kyoto Protocol to the U.S. Senate for its advice and consent unless key developing countries more fully participate in the international efforts to address climate change.

It should be noted that the term "developing country" encompasses a wide range of nations which are at various stages of industrialization and contribute differently to global emissions. Accordingly, there is no one-size-fits-all approach to measuring developing country participation. A country with a relatively high per capita GDP or one that emits a proportionally large share of global emissions should be expected to do more than one that is extremely poor or whose emissions are negligible.

Meaningful participation implies different actions for different kinds of countries. For example, a developing country could voluntarily adopt an emissions target. Several developing countries were opposed to emissions targets during the Kyoto negotiations on the grounds that such targets would slow their economic development. However, emissions targets and approaches that reflect developing countries' needs to grow could facilitate their development while lowering the global costs of achieving the objectives provided in the Kyoto Protocol.

A13

If a developing country chooses to adopt a growth target and participates in international emissions trading, it could potentially enjoy substantial economic and environmental gains. Because developing countries can achieve emissions reductions relatively cost-effectively, they could reduce emissions below their target and sell their excess allowances to firms in other countries that find it in their best interest to comply with emissions targets at the lowest possible cost. Even with this participation, a country's emissions could continue to grow beyond current levels, as economic development continues. More importantly, such an approach provides both an incentive for firms to invest in energy efficient technologies in developing countries and the opportunity to export emissions allowances. While the Clean Development Mechanism can result in similar activity, it would likely occur on a smaller scale than what would be anticipated under an emissions target with effective international trading.

A world with broad-based participation in international emissions trading, including participation by Non-Annex I countries with growth targets slightly below their business as usual projections would likely result in lower global greenhouse gas emissions relative to a world with

A13

**A Proposal for Developing Countries:
Participation in a "Target and Trade" System**

I. This analysis demonstrates that the gains will be substantial if developing countries (a) accept binding targets at or slightly below their business as usual (BAU) emissions levels, and (b) trade from their respective targets. We believe that participation in a "target and trade" system should be the cornerstone of our international negotiations.

The economic and environmental rationale for such participation includes

- **Greater economic benefits to developing countries:** With targets at or only slightly below BAU, developing countries would enjoy net gains of many billions of dollars through the international sale of emission reductions achieved at lower cost than the world price.

- **Greater cost savings to the U.S.:** Participation by developing countries in international permit markets would greatly lower the costs to the U.S. of meeting its Kyoto target (as CEA testimony showed). In particular, costs would be lower than with trading among only Annex I countries.

- **Greater environmental benefits:** Targets slightly below business as usual would lower global emissions relative to a world with only Annex I targets. Further, reducing carbon dioxide emissions generates ancillary air quality benefits through lower particulate matter, sulfur dioxide, and nitrogen oxides emissions.

- **Target and trade yields greater benefits than CDM:** While the Clean Development Mechanism will likely result in cost savings to the U.S. relative to a world with only Annex I trading, a system including effective target and trade of developing countries' emissions would yield much greater cost savings to the U.S. and greater gains to developing countries than CDM. Further, target and trade could achieve environmental benefits not achievable by pursuing CDM, which only redistributes emissions geographically.

- **The principle of full participation:** Other rationale include the long-run benefits of including developing countries into global negotiations, for example, as recognized by the Byrd-Hagel resolution. By establishing participation now, further commitments might be feasible in future periods.

II. Problem: To persuade a developing country *voluntarily* to adopt a target and then to trade permits internationally, international agreements must be structured to reduce the risk of inadvertent stringency and in particular to reduce the possibility of a target so stringent as to cause large economic losses to the developing country.

Proposed Solution: Negotiations should focus on the estimated business as usual emissions level, where this level is expressed in a way that depends on the *future* values of economic variables, such as GDP.

Rationale: Such targets would avoid the risk of inadvertent stringency associated with higher than projected economic growth between now and the beginning of the commitment period in 2008. Developing countries would face only the much smaller risk that emissions would be higher than expected, *given* the economic conditions realized in 2007.

Basic principles for implementing such an approach are:

- **Reasonable Forecasts**: The relationship between the target (putting aside any real reductions in emissions) and the values of economic variables, when applied to emissions and such variables during recent years, should predict emissions reasonably well and be without demonstrable statistical bias. Relationships that give reasonably reliable predictions reduce the risk of either inadvertent stringency or paper tons which could increase global emissions.

- **No Perverse Incentives:** The target should depend on values of economic variables only indirectly related to emissions, to avoid creating perverse incentives for developing countries to increase emissions so as to have higher targets in the commitment periods. For example, the target should not depend on energy consumption in 2007, but could reflect pre-Kyoto emissions levels.

- **Predetermined Targets:** To avoid uncertainty during the commitment period about the country's target the target should not depend on contemporaneous values of economic variables. For example, the target generally should not vary with 2008 or 2010 GDP levels, but rather with 2007 GDP.

III. Illustration: One way of implementing the solution is described below. Other ways of implementing the solution may work as well or better. The conclusions are stated below; the details of our work follow in appendix 3.

- Defining the business as usual level for a developing country as a function of its GDP and population in earlier years and setting the emissions target at that level yields a negligible risk of leaving the developing country worse off under target and trade because of inadvertent stringency. Even a target slightly below BAU would also yield negligible risk of leaving the developing country worse off.

- Emissions targets for developing countries set below their business as usual emission level would of course result in gains from trade smaller than with a BAU target, while providing environmental benefits. The higher costs of a target set below BAU are borne by both the developing countries and the Annex I countries.

There are significant gains from trade for developing countries and large cost-savings to the U.S. if even one large developing country accepts an emissions target at BAU and participates in emissions trading. Table 1 and Charts 1 through 3 illustrate these gains from trade from a baseline of full Annex I trading.

Table 1. Illustrative Gains from Trade with Developing Countries that Target and Trade

Trading Scenario	Permit Price[1] (1997$/ton)	Country Gaining	Gains from Trade with Developing Countries
Annex I only	$54	United States	not applicable
Annex I + China	$26	China	$3.6 billion/year
		United States	$11.6 billion/year[2]
Annex I + India	$47	India	$1.6 billion/year
		United States	$2.5 billion/year[2]
Annex I + Mexico	$51	Mexico	$0.9 billion/year
		United States	$1.2 billion/year[2]

[1] These scenarios do not account for the cost savings available through the Clean Development Mechanism and carbon sinks.
[2] Gains from trade for the U.S. are estimated as the change in the U.S. total cost of complying with the Kyoto Protocol relative to an Annex I only trading regime.

Chart 1. China's 2010 Marginal Abatement Cost Curve and Gains from Trade

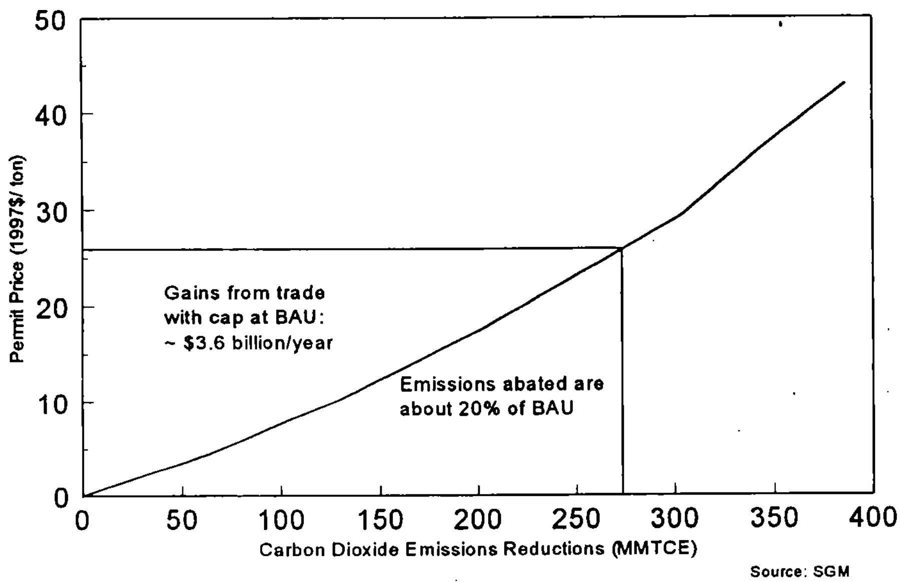


Chart 2. India's 2010 Marginal Abatement Cost Curve and Gains from Trade

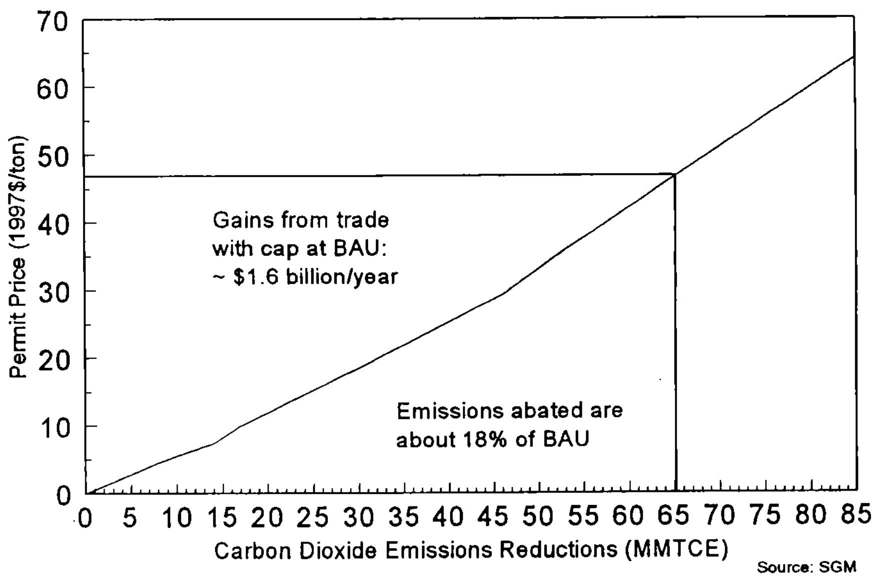
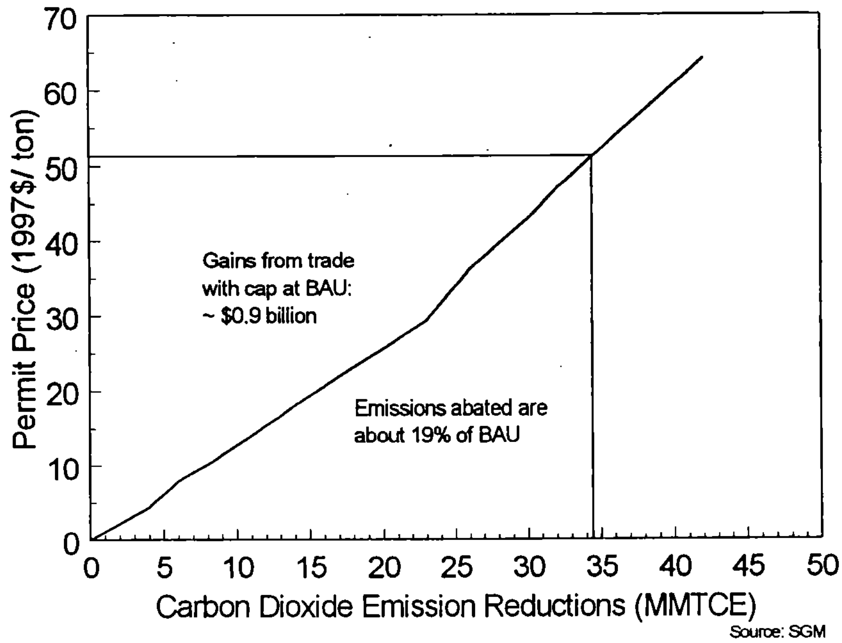


Chart 3. Mexico's 2010 Marginal Abatement Cost Curve and Gains from Trade



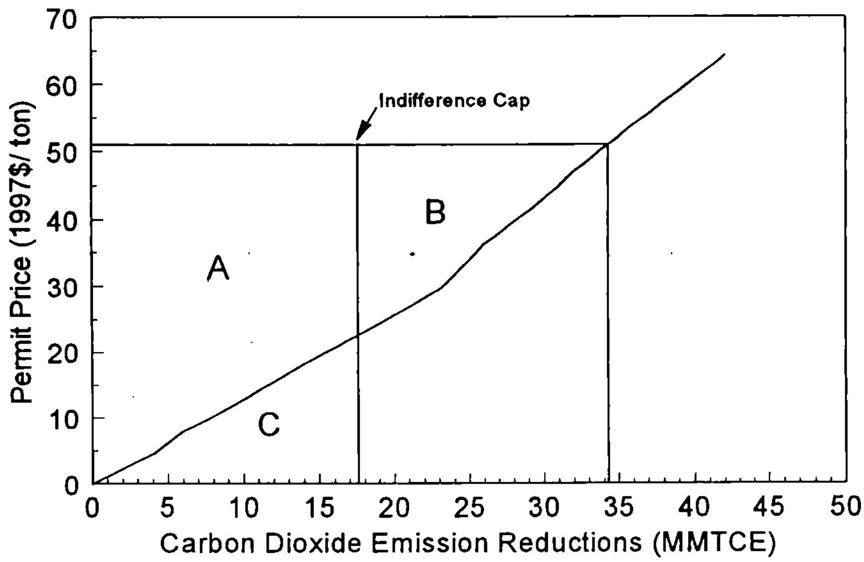
Appendix 1. Costs to the U.S. of Developing Countries Adopting Targets Below BAU

Regarding developing countries, most commonly discussed is the issue of fairness: what commitments to reduce emissions should be made by countries whose economic resources differ substantially? Generally neglected, but discussed below, is the issue of efficiency. In particular, what are the implications for U.S. costs of increasingly more stringent targets on emissions from key developing countries?

The environmental gains from emissions reductions below BAU come at the price not only of economic costs incurred by a developing country that adopts the below-BAU target, but also economic costs by Annex I. More stringent developing country targets raise U.S. costs by restricting the supply of permits in world markets and so raising the price of permits.

To assess the magnitude of this effect consider the target which just leaves a country no better off than no target at all. This "indifference" target is where the costs of meeting the target just equal the net gains from selling permits in world markets. Chart 4 illustrates gains from trade for a small country. For a target that is equivalent to a reduction from BAU of 17 MMTC, net gains from foreign exports are B, and the cost of meeting the target is C. Since B = C in this example, the net gains from trade are nil.

Chart 4. Illustrative 2010 Marginal Abatement Cost Curve and Indifference Target



Note: For simplicity, this indifference target is illustrated for a country whose participation in world permit markets does not affect world permit prices.

Table 2 provides an illustration of the effects of emissions targets more stringent than BAU on China with Annex I plus China trading. Note that a small reduction below BAU has no real effect on the Annex I trading price, and thus no economic effects on the U.S. However, as the target becomes more stringent, the Annex I trading price increases, resulting in higher total costs of compliance for the U.S. If China accepts a target below BAU, the cost of this additional stringency to the U.S. -- essentially, the cost of supplying the environmental benefits associated with these emissions reductions -- can become significant. Thus developing country participation in the form of acceptance of targets more stringent than business as usual will raise costs to the U.S.

Table 2. Effects of Various Chinese Emissions Targets with Annex I Trading

Emissions Target[1]	Permit Price (1997$/ ton)	Chinese Emissions Reductions (MMTC)	Chinese Emissions Sales (MMTC)[2]	Total Cost to U.S. of Complying with Kyoto	Cost to U.S. of Additional Stringency
BAU	$26	276	276	$13.4 b	not applicable
BAU - 1%	$26	276	262	$13.4 b	~$0
BAU - 5%	$29	304	235	$14.9 b	$22/ton
Indifference	$36	343	172	$17.9 b	$26/ton

[1] We employ the SGM BAU for China for the purposes of these calculations.
[2] Reductions in Chinese emissions less Chinese emissions sales yields net global reductions.

Imposing this "indifference" target on China, given that its participation lowers world permit prices, leads to the following conclusions.

- An indifference target for China increases annual U.S. costs by $4.5 billion or 33% relative to a BAU target for China.

- If China accepts an emissions target requiring reductions of approximately 170 MMTC below BAU, the average cost to the U.S. would be $26/ton. This is not the average cost of a ton of emissions purchased from China, but the average cost to the U.S. of the environmental benefits associated with China complying with a more stringent target.

Appendix 2. Ancillary Environmental Benefits of Target and Trade in Developing Countries

The voluntary reduction of greenhouse gas emissions by developing countries under a target and trade system will simultaneously reduce emissions of several pollutants, producing ancillary environmental and human health benefits in those countries. The environmental and health benefits that accrue to those developing countries are unlikely to be offset by decreases in environmental quality in the United States because of our stringent health-based air quality standards.

A recent study in *Lancet* examines the emissions of one pollutant that are reduced along with carbon emissions: airborne particulate matter (PM). The study projects that by 2020, a climate change policy scenario in which developing countries reduce emissions to 10% below their BAU could produce an annual reduction of 563,000 statistical deaths.

The analysis below adapts the predictions in the *Lancet* study to estimate the mortality risk reduced from participation by three developing countries (China, India, and Mexico) in a target and trade system. These illustrative calculations take as given the emissions reductions from BAU resulting from permit sales that are predicted by SGM. It suggests that significant public health gains could result from developing country participation in international carbon permit markets.

Table 3. The Effects of International Carbon Permit Trading on Mortality Risk Associated with Particulate Matter Emissions

Country	Predicted carbon emissions reduction from international permit sales	Share of non-Annex I population in 2010	Annual PM statistical deaths avoided in 2010 by international carbon permit trading
China	20%	23.7%	136,700
India	18%	20.3%	105,300
Mexico	19%	2.0%	19,700

For developing countries that are too "small" to affect the world permit price, adopting a carbon target more stringent than BAU and participating in international trade does not yield additional ancillary benefits relative to a BAU target. Large countries, by adopting targets below BAU, would raise the world price relative to a BAU target, and thereby achieve greater carbon emissions reductions and ancillary benefits.

<u>Caveats</u>

Major assumptions beyond those in the *Lancet* article include:

- Deaths avoided in each non-Annex I country are proportional to the country's share of non-Annex I population.

- Deaths avoided are proportional to carbon emissions reductions.

- Each key developing country is the sole non-Annex I country to adopt a target and participate in international trading.

Appendix 3. Summary of Analysis

A. Data

We have compiled data on 3 variables: emissions of carbon dioxide, GDP, and population for 117 countries for the time period 1970-1992. The carbon dioxide emissions data, measured in millions of metric tons of carbon, are from the Carbon Dioxide Information Analysis Center (Oak Ridge National Laboratory, DOE). The GDP data, measured in 1987 U.S. dollars, are from the World Bank. The population data, measured in thousands of individuals, are from the United Nations Population Division.

B. Methods

We have estimated a fixed effects linear regression on the logs of these variables, for the countries in our data set, excluding those listed in Annex I. Our regression uses four non-overlapping 5 year intervals for each country. Our forecasts include the country specific constants.

C. Results

The fixed effects regression we estimated is

$$\text{Emissions} = a\ \text{GDP}_{t-1} + b\ \text{GDP}_{t-2} + c\ \text{Population}_{t-1} + \gamma\ \text{trend}$$

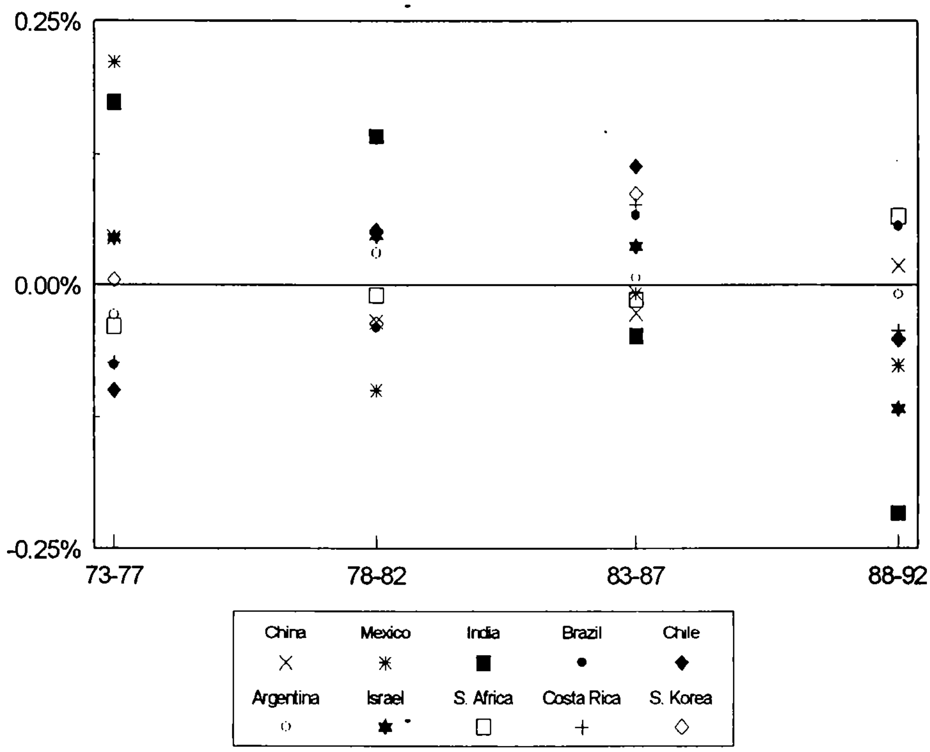
Emissions are the natural logarithm of the five year non-overlapping average of carbon emissions. All independent variables are lagged. GDP_{t-1} is the log of the gross domestic product in the year prior to the first year in the emissions variable, GDP_{t-2} is GDP in the year two years prior to the first year included in the emissions variable, and population_{t-1} is the country's population in the year prior to first year included in the emissions variable. Trend is one in the first 5 year period, and 2, 3, and 4 respectively in the subsequent 5 year periods. The useable data included 376 cross-section time series observations. The fixed effects regression used 98 degrees of freedom. The R squared was in excess of 0.99.

Table 4. Model I Results

Variable Name	Coefficient Estimate	Standard Error
GDP_{t-1}	0.9501823	0.2443047
GDP_{t-2}	-0.411297	0.23894
$Population_{t-1}$	0.4836006	0.2055439
trend	0.0073712	0.0310638

As one illustration of the model's accuracy in predicting emissions, consider the chart below that maps actual and predicted emissions using within sample data for ten selected developing countries. The predicted value is never more than 1/4 of one percent away from the actual emissions average for any of the five year intervals.

Chart 5. Error in Model I Prediction as a Fraction of Actual Emissions



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Divider Title: **4**

more narrow participation. Moreover, reductions in greenhouse gas emissions would generate ancillary air quality benefits through reductions in sulfur dioxide, nitrogen oxides, and particulate matter emissions. In many large cities in developing countries, the emissions of these air pollutants are a significant environmental health problem, and emissions reductions consistent with efforts to address climate change could assist in remedying this problem.

As noted earlier, trading, as a voluntary activity, benefits all parties involved. While developing countries may benefit from adopting a target and participating in trading, so would firms in developed countries.

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Divider Title: **5**

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ASSESSING THE COSTS AND BENEFITS OF REDUCING GREENHOUSE GAS EMISSIONS

Preliminary Assessment

The Administration employed a variety of tools to assess the various possible costs and non-climate benefits of our emissions reduction policy. Our overall conclusion is that the net costs of the Administration's policies to reduce emissions are likely to be small, assuming those reductions are undertaken in an efficient manner employing effective international trading and the Clean Development Mechanism and particularly if we are successful in securing meaningful developing country participation. That potential small net premium, even excluding the benefits of mitigating climate change, purchases a partial insurance policy against a serious environmental threat. Further, although we think the economic benefits of mitigating climate change are subject to too many uncertainties to quantify, those benefits over time are likely to be real and large (see p. 32).

In reaching this conclusion, the Administration has drawn on the insights of a wide range of models of the energy sector and economy over the next 25 years, including but not limited to the results of the Stanford Energy Modeling Forum (Gaskins and Weyant 1993, Weyant 1997), the Intergovernmental Panel of Climate Change's review of the economic and social dimensions of climate change (Bruce et al. 1996), the work of the OECD on the economic dimensions and policy responses to global warming (OECD 1997), and the Administration's staff-level interagency analysis (Interagency Analytical Team 1997). In addition, the Administration used other tools, such as a meta-analysis (Repetto and Austin 1997), overviews of the domestic and international energy sectors (Energy Information Administration 1997a, d), simple statistics regarding energy efficiency, greenhouse gas emissions, and economic indicators from World Bank, International Energy Agency, and Energy Information Administration databases, and basic economic reasoning.

A14 A15 A16 A17 A18 A19 A20 A21

The conclusion that the impact of the Administration's policies to address the risks of climate change will be modest is not entirely dependent upon, but is fully consistent with, formal model results. The Administration continues to believe that there are limitations to relying on any single model to assess the economic impact of the Kyoto Protocol. However, model results can further inform and improve the understanding of the effects of climate change policy. To complement the economic analysis of the Administration's policy to address climate change, we have conducted an illustrative assessment with a modified version of the Second Generation Model. The results from the SGM substantiate the conclusion that the economic effects of an efficient, effective, and global policy to address the risks of climate change will be modest.

Gaskins/Weyant

Model Comparisons of the Costs of Reducing CO_2 Emissions

By DARIUS W. GASKINS, JR., AND JOHN P. WEYANT*

Concern about the extent of global climate change and its potential consequences has increased dramatically in recent years. Many believe that unprecedented climate changes are—or soon will be—occurring as the result of man-made emissions of greenhouse gases. The largest man-made source of greenhouse gases is carbon dioxide produced by the combustion of fossil fuels in utility and industrial boilers and in internal combustion engines. Thus, any effort to reduce greenhouse-gas emissions will start with efforts to restrict these activities. Therefore, it seems essential to develop a range of projections of the likely costs of alternative levels of control of carbon emissions from the energy sector.

The EMF 12 working group of the Energy Modeling Forum specified 13 standardized scenarios reflecting a range of carbon emission-control levels, as well as sensitivities on key standardized inputs. These scenarios were ultimately implemented by 14 modeling teams employing a wide variety of technoeconomic models, although not every model could implement every scenario. In addition to these model comparisons, ten study groups were formed to analyze issues not being addressed by the 14 models and 13 scenarios. These groups used additional models and methods to analyze issues not addressed in the 13 original scenarios.

I. Basic Control Scenarios

Six of the 13 EMF 12 scenarios employed the same GDP, population, resource availability, and technology assumptions, but considered different levels and rates of CO_2 emissions control:

(i) *Reference.*—No control;
(ii) *20-percent Reduction.*—A 20-percent reduction in CO_2 emissions in the developed countries and no more than a 50-percent increase in the developing countries relative to 1990 levels by 2010;
(iii) *50-percent Reduction.*—The same as (ii), but with an additional reduction in CO_2 emissions in the developed countries to 50-percent below their 1990 levels by 2050;
(iv) *Stabilization.*—Hold CO_2 emissions in the developed countries to their 1990 levels by the year 2000, with the developing countries again constrained to no more than 50-percent above their 1990 levels;
(v) *Phased-In Carbon Tax.*—A tax that escalates from \$15 per ton in 1990 at 5 percent real per year;
(vi) *2 Percentage Points Per Year Reduction.*—Annual reduction in emissions relative to the reference case.

In implementing these scenarios the modeling teams generally used taxes based on the carbon content of fossil fuels to achieve the emissions reductions (except for the government revenues a carbon tax would produce, this formulation is equivalent to a system of carbon-emission permit trading). These carbon-tax projections provide us with a rough estimate of the degree of market

*Senior Partner at High Street Associates, 50 High Street, The Landmark Building, Boston, MA 02110, and Professor of Engineering-Economic Systems, Stanford University, Stanford, CA 94305, respectively. Gaskins was Chairman of the EMF 12 Working Group, and Weyant is Director of the Energy Modeling Forum. The full EMF 12 Working Group report is to be published as a book entitled *Reducing Carbon Dioxide Emissions; Costs and Policy Options* later in 1993. The contributions of the almost one hundred individuals who contributed to the EMF 12 study are acknowledged there.

intervention that will be required to achieve the carbon-emission reductions. Most of the models included anticipated results from new technology development and conservation programs in the reference case. However, in these models there is no explicit consideration of market imperfections that may be causing current energy consumption patterns to differ from what perfectly functioning competitive markets would produce. More efficient, but more expensive, technologies are generally selected in the control scenarios, but no additional technology development is generally assumed to occur. Only one model adds additional conservation programs explicitly in those scenarios, and only one model includes endogenously determined rates of technological change. Finally, in their initial implementation of these scenarios the modeling teams assumed no international emissions trading, lump-sum rebate of any tax revenues collected, and no carbon offsets, such as those that might result from tree planting. A number of general points can be made from examining cost-of-control projections for these scenarios:

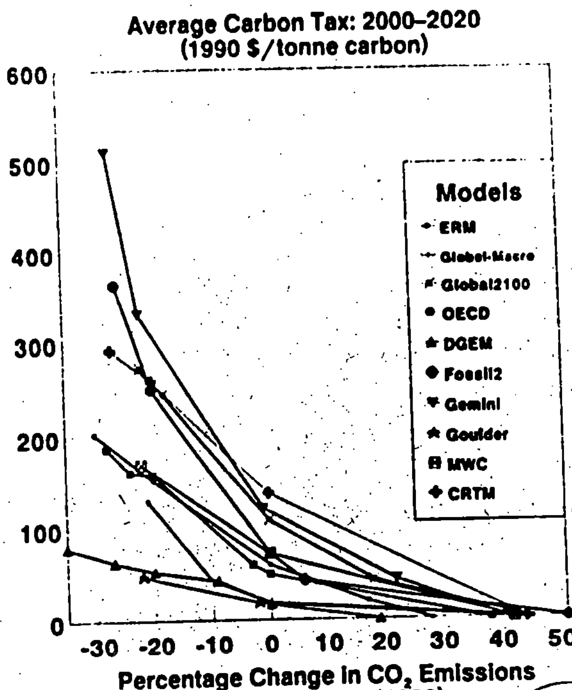

FIGURE 1. CARBON TAXES REQUIRED TO ACHIEVE CARBON-EMISSION REDUCTIONS IN THE UNITED STATES IN 2020

A) 1

1.—The impact of these control options on global climate change over the next 20 years may be quite limited. Even in the most tightly controlled scenarios, the reduction in cumulative CO_2 emissions over this period are projected to be no more than 25 percent relative to the reference case. The impact of the control programs on atmospheric concentrations of CO_2 and climate change over that time period would be even less. By 2050, however, the 50-percent reduction scenario results in cumulative emissions that are as much as 55-percent below those projected in the reference case.

2.—Despite the inclusion of improved technologies and improved energy efficiencies in the reference case, all models project that market intervention will be required to achieve each of the emissions targets in all regions. When the more stringent carbon limits are considered, many models project the intervention required to be equivalent to carbon taxes of hundreds of dollars per metric ton. For example, the projections of the average carbon tax required during 2000–2020 to reduce U.S. carbon emissions by 20 percent by the year 2010 with respect to their 1990 level range from \$50 to \$330 dollars per metric ton as shown in Figure 1.

3.—These carbon taxes would generate substantial tax revenues that could be used for a number of purposes including reducing other taxes, deficit reduction, and additional government spending. For example, the projections of the average annual tax revenues raised in the United States from 2000 to 2020 to achieve the 20-percent reduction in CO_2 emissions range from \$65 billion to \$300 billion.

4.—The impact of a carbon tax on gross domestic product (GDP) measures its costs to the economy in terms of lost output resulting from the increase in the price of goods requiring carbon emissions; those goods must either be produced with less carbon or by more expensive processes. The GDP loss also includes the impact of the

Joseph E. Aldy
06/18/98 01:20:17 PM

Record Type: Record

To: Matthew C. Weinzierl/CEA/EOP

cc:
Subject: Re: Key Oslo Cost Comparison Charts

--------------------- Forwarded by Joseph E. Aldy/CEA/EOP on 06/18/98 01:19 PM ---------------------------

weyant @ leland.Stanford.EDU
09/11/97 03:27:00 AM

Record Type: Record

To: Joseph E. Aldy

cc:
Subject: Re: Key Oslo Cost Comparison Charts

Joe:
Sorry I was at a conference in SF Yesterday.
At 12:55 PM 9/9/97 -0400, you wrote:
>Message Creation Date was at 9-SEP-1997 12:55:00
>
>John,
>
>Thanks a lot for the charts from your Oslo presentation -- Dr. Yellen really
>liked the summary chart I compiled from your charts (essentially, one chart
>with the stacked bar graphs representing all 6 models). I have a couple of
>questions about the charts that will help us descibe them in our paper:
>
>1) Are "costs" the present discounted value of foregone consumption with a
5%
>discount rate over the period 1990-2100?
>
Yes
>2) Do you have a summary sheet for these models analogous to Table 1 of your
>EMF-12 chapter? Essentially, I we really need is the full title of the
models
>and the authors.
>
See Attached WordPerfect Summary Chart
>3) Does CETA group EEFSU into OECD or non-Annex I (EEFSU cells are empty for
>this model)?
>OECD
>4) Could you provide a reference for these charts so we can appropriately

cite
>you (e.g., Weyant, J. title of presentation, title of Oslo conference,
date)?
>
IPCC/EMF Workshop on
"Economic Impacts of Annex I Actions on All Countries" A15
August 18-20, 1997
Oslo

>Again, we really appreciate all of the very timely assistance you have
provided
>us.
>
>Joe
>
Also,
We asked for carbon taxes, but only a couple of people provided that info.
We have issued a request for additional information but no reponses yet.

Thanks,
John>
>

Climate Change 1995

Economic and Social Dimensions of Climate Change

Edited by

James P. Bruce
Canadian Climate Program Board

Hoesung Lee
Korea Energy Economics Institute

Erik F. Haites
Margaree Consultants Inc.

Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change

A16

Published for the Intergovernmental Panel on Climate Change

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ECONOMICS DEPARTMENT
ECONOMIC POLICY COMMITTEE

Working Party No. 1 on Macroeconomic and Structural Policy Analysis

OECD WORK ON CLIMATE CHANGE: ECONOMIC THEORY AND POLICY IMPLEMENTATION

A7

This document has been prepared by the Economics Department for the Working Party No. 1 of the Economic Policy Committee.

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email: jean-marc.burniaux@oecd.org

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? Background

Call Rosina about Tongan's memo

cc: Amr JAF rmn JS

DRAFT--May 19, 1997

Economic Effects of

Global Climate Change Policies

1. 1995-2000 what is this?

Results of the Research Efforts of the

A18

2. When does announcement effect occur? 2000 or 1995?

Interagency Analytical Team

~~June~~ 1997

3. 2000+ Ramp up ~~[illegible]~~ What exactly does this mean

0.1 -> 1.5

Draft

Introduction

In June 1996, the Department of Energy (DOE) and the Environmental [illegible] Agency (EPA) sponsored a joint workshop where more than [illegible] from inside [illegible] outside the government made presentations on technical issues associated with [illegible] emissions trends and capability to reduce emissions trends in the next century. As a part of that workshop, the Interagency Analytical Team (IAT) released what [illegible] then preliminary results on the economic effects of emissions reduction proposals.

Since that June 1996 workshop, [illegible] IAT has reviewed [illegible] work, selected new modeling instruments, improved its approach to old ones, and developed a new set of modeling runs that lead to a [illegible] understanding of the economic [illegible] of the climate change policy problem. This paper [illegible] those efforts. It first summarizes the IAT model selection process. Second, it discusses the [illegible] base [illegible] to measure the effects of various policy options. Third, it discusses [illegible] IAT's core [illegible] reduction scenario. Finally, the bulk of this paper discusses the [illegible] of the IAT's analysis.

The modeling work performed [illegible] this analysis was done by economists at DOE and EPA. The IAT [illegible] included members [illegible] the Departments of Commerce, Treasury, Labor, and State, as well [illegible] members of the White House staff. The majority of the IAT members are still primarily from [illegible] and EPA -- [illegible] agencies that have [illegible] primary responsibility for the Administration's energy and environmental policies.

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Model Selection

The first task that the IAT confronted was to review the analytic "toolbox" to assure that it had all the tools necessary to specify the economic effects of a broad range of climate change proposals. At the time, the IAT relied primarily on the Data Resources, Inc. (DRI) macro model

Joe Aldy

WORLD RESOURCES INSTITUTE

THE COSTS OF CLIMATE PROTECTION:
A GUIDE FOR THE PERPLEXED

ROBERT REPETTO
DUNCAN AUSTIN

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CLIMATE PROTECTION INITIATIVE

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Divider Title: **6**

Difficulties of an Economic Analysis of Climate Change

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The difficulties associated with economic analysis of climate change fall into three broad categories. First are the uncertainties that still remain over the operational considerations of the treaty, necessitating assumptions on which the analysis is predicated. Second are the inherent limitations of available models to analyze the costs of abating emissions. Third is the impossibility of placing a single monetary figure on the long-term benefits of climate change mitigation, although such benefits are the motivation for the Kyoto Protocol. Economists have a difficult time projecting the behavior of the economy over the next quarter or year, let alone over the next two decades. The scale of the forecasting exercise is therefore daunting, and any specific results should be treated with substantial caution.

Uncertainties in the International Effort to Combat Climate Change

The Kyoto Protocol provides the foundation for the international effort to address climate change. However, the Protocol is still a work-in-progress. Uncertainties about the ultimate characteristics of the international climate change policy regime provide challenges in conducting an economic assessment.

For example, some of the rules pertaining to the flexibility mechanisms, such as emissions trading and carbon sinks, in the Kyoto Protocol require further delineation. These issues and others, including the role of developing countries, will be addressed in future negotiations.

More importantly, the international community has not yet negotiated agreements to limit greenhouse gas emissions beyond the 2008 to 2012 window. The emissions targets established in Kyoto provide for the first of many necessary steps to address the risks of climate change. The first step is critical because it sends a signal to the private sector regarding the value of reducing greenhouse gas emissions and it begins the task of reducing emissions relative to the business as usual path. However, subsequent steps are also necessary to address climate change risks adequately. Lack of knowledge regarding what the subsequent steps will be complicates any analysis of climate change mitigation.

Inherent Limitations of Models

In addition to these uncertainties about the details of the international effort to address climate change are the inherent limitations of the models used to evaluate that effort. Even within a given model, answers depend critically on the precise nature of the question asked. For example, the costs of emissions reductions depend on the extent of global participation and international

TESTIMONY OF DR. JANET YELLEN
CHAIR, COUNCIL OF ECONOMIC ADVISERS
BEFORE THE
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SMALL BUSINESS

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JUNE 4, 1998

Thank you, Mr. Chairman. The President has said that we can work to avert the grave dangers of climate change, while at the same time maintaining the strength of our economy. I agree and am pleased to have this opportunity to appear before the Committee to elaborate on the Administration's views on these issues.

The international agreement that was reached in Kyoto this past December is a crucial step forward in addressing global climate change. But it is only one step in a journey. Since the international effort to reduce greenhouse gas emissions is still in some respects a work-in-progress, it is not yet possible to provide a full authoritative analysis of it. Many of the specifics in several crucial areas are not completely resolved in the diplomatic arena, forcing analysts to make a variety of assumptions about the ultimate form of the international regime. In my testimony today, I will attempt to identify key elements of the agreement and the Administration's policy, such as international emissions trading, meaningful developing country participation, inclusion of land-use activities that absorb carbon ("sinks") and six categories of gases, as well as domestic initiatives, that together can ensure that reductions in global greenhouse gas emissions are consistent with continued strong economic growth. I will explain the reasoning underlying our conclusion that, under these conditions, economic impacts are likely to be modest.

The Administration is strongly committed to ensuring that these key elements are reflected in our domestic and international climate change policies. We are firmly committed to meaningful developing country participation, the use of sinks to offset emissions requirements, and emissions trading both domestically and internationally. And as you know, the President's FY 1999 budget includes a $6.3 billion package of tax cuts and R&D investments over the next 5 years; this package makes good sense in terms of energy policy and will jumpstart our efforts. A final component of the President's climate change policy is his support for electricity restructuring in a manner that will offer approximately $20 billion in cost savings to electricity consumers, while reducing greenhouse gas emissions.

I. Basic Economic Rationale of the Kyoto Treaty

To begin our analysis, it may be worth stepping back and examining the larger question of the basic rationale, from an economist's perspective, for the Kyoto Protocol.

The earth's surface appears to be warming from the accumulation of greenhouse gases from myriad sources worldwide. None of these emitters presently pays the cost to others of warming's adverse effects -- a classic externality in the language of economists. As a result of these distorted incentives, disruption of the Earth's climate is likely to proceed at an excessive pace and if left uncontrolled may pose substantial costs in terms of harm to commerce and the environment alike. The fundamental economic logic of the Kyoto Protocol is thus that without such an international agreement, individual nations will not have the proper incentives to address the threats from global climate change.

II. Costs of Climate Change

In evaluating efforts to mitigate global warming, the first step is to consider the costs of inaction. These costs --and they are significant-- provide the primary motivation for actions to reduce greenhouse gas emissions.

The Intergovernmental Panel on Climate Change (IPCC) jointly established by the World Meteorological Organization and the United Nations Environment Programme, concluded in 1995 that "the balance of evidence suggests that there is a discernible human influence on global climate." Current concentrations of carbon dioxide, methane, nitrous oxide, and the other so-called greenhouse gases have reached levels well above those of preindustrial times. Of these, carbon dioxide (CO_2) is the most important: net cumulative CO_2 emissions resulting from the burning of fossil fuels and deforestation account for about two-thirds of potential warming from changes in greenhouse gas concentrations related to human activity.

Climatic Impact

If growth in global emissions continues unabated, the atmospheric concentration of CO_2 will likely double relative to its preindustrial level by midway through the next century and continue to rise thereafter. As a result of the increased concentration of CO_2, the IPCC estimates that global temperatures will increase by between 2 to 6 degrees Fahrenheit in the next 100 years, with a best guess of about 3.5 degrees Fahrenheit. While scientists believe that human activities are leading to a gradual warming of the *average* temperature of the earth, the change in temperature in a given region at a given time may differ substantially from this average. Indeed, models predict warming will be greater in high latitudes than in the tropics, and greater over land than ocean.

Potential consequences associated with this shift in climate include a rise in sea levels, greater frequency of severe weather events, shifts in agricultural growing conditions from changing weather patterns, threats to human health from increased range and incidence of diseases, changes in availability of freshwater supplies, and damage to ecosystems and biodiversity.

Economic and Monetary Damages

The derivation of quantitative or monetary estimates of the damages from such a change in the climate is extremely difficult given the capacity of today's models. Estimates of the economic damages from climate change fall into the following broad areas: agriculture, sea-level rise, air conditioning and heating, water supply, human life and health, air pollution, and other costs (hurricanes, relocation costs, human amenity, construction, leisure activities, urban infrastructure, and ecological damages such as forest loss and species loss). Although the quantification of these effects is quite demanding, researchers have developed estimates that prompt substantial concern. The IPCC reports that a doubling of carbon dioxide levels would lead to approximately 10,000 estimated additional deaths per year for the current U.S. population from higher summer temperatures, even after netting out the effects of warmer winters and assuming acclimatization. Other researchers have predicted sea level increases of about 20 inches by 2100, with greater increases in subsequent years.

Despite the difficulties, respected researchers have developed estimates of the monetary damages expected from an average worldwide temperature increase. For example, William Cline, then of the Institute for International Economics, estimated that a temperature change of 4.5 degrees Fahrenheit would impose annual damages of about 1.1 percent of GDP per year on the U.S. economy. That amounts to $89 billion in today's terms. (Cline's original estimate is quoted in 1990 dollars. The figure given above translates this number into 1997 terms by scaling it to current GDP.) William Nordhaus of Yale University has likewise computed estimates of the dollar loss attributable to a doubling of greenhouse gas concentrations. Although he uses methods that differ from Cline's in several respects, Nordhuas estimates that a slightly larger temperature change of 5.4 degrees Fahrenheit would impose losses equal to about 1 percent of GDP. A third independent estimate reported by Nordhaus is close to Cline's. It must be noted, however, that this similarity among aggregated estimates masks the true uncertainty associated with forecasts of the damages from given increases in global warming -- the estimates are all fundamentally based on extrapolations from current and past experience, and may not fully incorporate effects that will unfortunately become apparent only with future experience.

One key difficulty in interpreting and monetizing these estimates of damages is uncertainty over the extent that they should be discounted because they occur in the distant future. Since the benefits of stemming future climate change accrue over not only decades but centuries, small changes in the discount rate can produce substantial changes in the results. But the precise discount rate that should be used to evaluate questions as important as the future climate of the planet remains a subject of intense debate. It is safe to say that there is, as yet, no professional consensus on the issue. Indeed there can be no technical answer to the ethical question how we should value the welfare of future generations.

A similar difficulty with such estimates is that they do not include potential non-linearities in the relationships between greenhouse gas concentrations and temperature, between temperature and economic damages, or in the various other complicated relationships governing interactions between greenhouse gas emissions, the climate, and the economy. Current estimates of damages do not, and cannot, accurately reflect the value of reducing the unknown risk of large-scale and potentially irreversible discrete events with potentially catastrophic consequences.

Two such possibilities serve as illustrations. Warming of Northern tundra may release huge amounts of methane from the permafrost, thereby leading to accelerated warming. We do not know at what point, if any, such potentially unstable activity would be triggered. Second, evidence from climate models suggests that some types of climate change may lead to changes in ocean currents, including weakening of the Gulf Stream that warms Western Europe. Scientific evidence suggests that abrupt seawater temperature shifts have occurred over periods as short as decades.

To what extent are we willing to take such chances with our planet? There is a strong argument for the Kyoto Protocol as a form of planet insurance. But what numerical weight should one assign to these catastrophic risks? In other words, what is the value of the insurance policy? Although it is difficult for an economist, or anyone, to know, reductions in the risk of such catastrophic outcomes must be considered in addition to the costs and benefits that can be reasonably quantified. Since human beings are typically averse to risk, such catastrophic risks are especially important in evaluating whether the benefits of a particular climate control policy justify the costs. One must have at least some sympathy with those who criticize economists on the grounds that the effects of climate change are extremely difficult to quantify in a single monetary number.

III. Addressing Global Climate Change in an Efficient Manner

The costs of unabated climate change may thus be difficult to quantify, but they are nonetheless real and provide the motivation for reducing greenhouse gas emissions. In taking action to reduce those emissions, economic analysis suggests that two elements are absolutely essential:

- The effort must be <u>global</u>, to address the global externality inherent in the nature of the problem.

- The effort must be <u>flexible and market-based</u>, to ensure that we achieve our objectives in the most efficient manner possible.

Need for Global Action

Climate change is a global problem requiring a global solution. As I mentioned earlier, no single country has an incentive to reduce emissions sufficiently to protect the global environment against climate change. Each has an economic incentive to "free ride" on the efforts of others. Even if the United States sharply reduced its emissions unilaterally without an international agreement limiting emissions abroad, greenhouse gas emissions from all other countries would continue to grow, and the risks posed by climate change would not be significantly reduced. It is important to emphasize that emissions of different gases anyplace in the world have very similar effects on global climate.

The threat of disruptive climate change has led to coordinated international efforts to reduce the risks of global warming by reducing emissions of greenhouse gases. A landmark international agreement to address global warming was the Framework Convention on Climate Change signed during the Earth Summit in Rio de Janeiro in 1992. This convention established an objective of limiting greenhouse gas concentrations and called upon industrial countries to return their emissions to 1990 levels by 2000. Since then, it has become clear that the United States and many other participating countries will not meet this voluntary goal; quite the contrary, emission levels have continued to rise not fall among both developed and developing countries.

To address the lack of progress among many industrialized countries toward meeting the Rio objective, the United States and approximately 160 other nations agreed in negotiations held in Kyoto, Japan, last December, to reduce emissions of greenhouse gases. The Kyoto Protocol, which requires the advice and consent of the Senate, would place binding limits on each industrial country's combined emissions of the six principal categories of greenhouse gases: carbon dioxide (CO_2), nitrous oxide (N_2O), methane, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons. These limits apply to the 38 so-called Annex I countries, which are the industrialized countries, defined to include Russia, Ukraine, and most Eastern European countries.

Under the Kyoto Protocol, each industrial country's baseline is its 1990 emissions of CO_2, methane, and N_2O and its choice of 1990 or 1995 levels of the other three categories of gases. The United States agreed to a target of 7 percent below this baseline by the period between 2008 and 2012. Given the changes in the definition of the baseline for the three long-lived chemical compounds (HFCs, PFCs and SF6) from 1990 to 1995 combined with a change in the way sinks are accounted for in the baseline, the actual reduction required in the U.S. is no more than 2-3% more than the President originally proposed as the U.S. negotiating position. The targets for the European Union and Japan are 8 percent and 6 percent below 1990 levels, respectively. Australia, New Zealand, Norway, Russia, and Ukraine all have limits somewhat less ambitious when phrased as cuts relative to their 1990 levels. In sum, over the period from 2008 to 2012, the industrial countries are expected to reduce their average emissions of greenhouse gases to about 5 percent below their 1990 levels.

The President has made clear that he will not submit the Kyoto Protocol to the Senate without meaningful participation from key developing countries (who are not included in Annex I).

There are several reasons why meaningful participation from developing countries is essential. First, developing countries are projected to contribute a majority of world emissions around 2030 under a continuation of business-as-usual. Without the participation of developing economies, efforts by the industrialized countries to limit emissions will therefore not provide adequate protection from climate change.

Second, developing country participation is crucial because it would permit relatively low-cost emissions reductions to be internationally recognized as a substitute for more expensive emissions reductions that might otherwise be achieved domestically by U.S. companies and those in other industrialized countries. Since greenhouse gas emissions have the same basic impact on the climate regardless of where they occur, emission reductions in developing countries have the same environmental benefit as reductions in the U.S. But these reductions are much less costly than reductions in the U.S. or in other developed nations, because of the very inefficient and carbon-intensive uses of energy in these countries today. It thus makes sense, from both an environmental and an economic perspective, to incorporate emissions reductions in developing countries into the international system.

Third, principles of basic fairness suggest all countries should do their part, depending, in part, on their ability to contribute to the solution. Thus even poor countries should participate, although the lack of resources in such countries may limit the extent of their participation.

Some have expressed fears that the Kyoto Protocol might adversely affect the competitive position of American industry. Evaluating how the Kyoto Protocol could affect competitiveness of a few specific manufacturing industries -- especially those that are especially energy-intensive, such as aluminum and chemicals -- is complex. The answer depends, in part, on the impact of the agreement on energy prices, which we will shortly address. In general it is difficult to undergo a structural change in the economy without having the effect of expanding some sectors and contracting others. But to provide some perspective on this issue, consider the following facts. First, on average, energy constitutes only 2.2 percent of total costs to U.S. industry. Second, energy prices already vary significantly across countries. According to the *1997 Statistical Abstract,* for example, in 1996 premium gasoline cost $1.28 per gallon in the United States -- but only 8 cents per gallon in Venezuela. Similarly, gas prices were $3.71 per gallon in Switzerland and $4.41 per gallon in France. Electricity prices also vary significantly: in the U.S., for industry, they were 5 cents per kilowatt hour in 1995, a fraction of prices in Switzerland of 13 cents per kilowatt hour. Yet U.S. industry is not moving en masse to Venezuela, nor is Swiss industry moving to the United States. Third, roughly two-thirds of all emissions are not in manufacturing at all, but in transportation and buildings, sectors which, by their very nature, are severely limited in their ability to relocate to other countries. We therefore believe we need developing country participation because the problem is global and cost-effective solutions are essential, than to avoid adverse effects on competitiveness.

Flexibility and Market Mechanisms

A global solution is thus critical to the global problem of climate change. Globalizing the solution is not, however, enough by itself. We must also ensure that our reductions in global greenhouse gas emissions are attained in the most efficient manner possible. The nature of the climate change problem suggests three basic methods to lower costs of achieving given levels of environmental protection. They can be characterized in terms of three categories of flexibility: (1) "when" flexibility; (2) "what" flexibility; and (3) "where" flexibility, which may be the most important of all. Such methods have long been championed by economists interested in increasing the efficiency of protection. Indeed, over 2,500 economists from academia, industry, and government alike urged such approaches in a letter they signed last year advocating action on climate change:

> "Economic studies have found that there are many potential policies to reduce greenhouse gas emissions for which the total benefits outweigh the total costs...The most efficient approach to slowing climate change is through market-based policies."

1. "When flexibility" (timing)

First is "when flexibility" or timing. Since climate change is a long-term problem, the exact timing of emissions reductions is, within some range, not of primary importance. Thus the freedom to delay or accelerate reductions within an agreed upon time frame -- while ensuring credibility of emissions reductions -- lowers costs.

As a result of U.S. leadership, the Kyoto Protocol incorporates this principle of "when flexibility" in four ways:

- First, the initial emissions reductions are less severe, and the period over which they occur ends much later than what had been proposed by many other countries. By adopting a gradual and credible path of reductions in the early years, we can greatly reduce costs such as those from prematurely scrapping coal-fired electricity plants, while attaining the same ultimate environmental goals.

- Second, under the Kyoto Protocol, the emissions target is not specified in terms of a specific year, but rather in terms of an average over a five-year period (2008-2012). Averaging over five years, instead of requiring countries to meet a specific target each year, can lower costs, especially given an uncertain future. The averaging can smooth out the effects of short-term events such as fluctuations in the business cycle and energy demand, or hard winters and hot summers that would increase energy use and emissions.

- Third, there is allowance for "banking" emission reductions within the 2008-2012 commitment period, for use in a subsequent commitment period [although the emission targets of the subsequent periods have not yet been specified].

- Fourth, CDM credits achieved between 2000 and 2008 may be banked until 2008 to 2012.

2. "What flexibility" (gases and sinks)

The second type of flexibility is "what flexibility", along two dimensions. The first is the inclusion in the agreement of all six greenhouse gases. Emissions of different kinds of gases, not just carbon dioxide, contribute to the greenhouse effect. Since the IPCC has developed conversion factors for all greenhouse gases by estimating their global warming potentials, reductions in emissions of one gas can be used to substitute for increases in emissions of another by an amount that has equivalent environmental effects. Again at U.S. urging, all six gases are included, while Japan and the EU had insisted until the end on covering only three. Thus the U.S. succeeded in having the Kyoto Protocol stipulate that countries with binding targets are to reduce their *total* greenhouse gas emissions by certain percentages, but does not require specific reductions for specific gases. Since a molecule of sulfur hexafluoride is 23,900 times more potent over 100 years than a molecule of CO_2, it may be cheaper to achieve the same environmental benefit by eliminating one molecular unit of SF_6 than nearly 24,000 units of CO_2.

Some initial analysis indicates that a strategy of reducing non-CO_2 greenhouse gas emissions by a greater percent than CO_2 emissions could lower emissions permit prices by as much as 10 percent. Thus allowing countries flexibility in what gases they reduce -- essentially trading emissions reductions across gases -- can help lower significantly the costs of meeting their targets.

The second source of "what flexibility" is the treatment of sinks, i.e., land use activities that promote the removal of carbon from the atmosphere through the growth of plants. At the urging of the U.S. delegation, sinks can be used to offset emissions targets. Promoting such sinks through afforestation and reforestation may reduce atmospheric concentrations of CO_2 at much lower costs than reducing emissions of greenhouse gases.

3. "Where flexibility" (international)

The third type of flexibility, and perhaps the most important, is "where flexibility" (international). As I have already emphasized, emissions have the same environmental consequences regardless of where in the world they occur. Therefore, the least-cost approach to controlling climate change is to reduce emissions wherever such reductions are cheapest. The Kyoto Protocol, because of U.S. insistence and persistence, includes three important cost-saving provisions of this nature.

- First, it provides the opportunity for countries that take on binding targets to trade rights to emit greenhouse gases with each other. This market in emissions permits could ensure that emissions reductions occur where they are least expensive within the industrial countries. In particular, U.S. companies could purchase emissions reductions in other participating countries when doing so would reduce their costs -- thus lowering costs without affecting the level of environmental protection. While currently only industrialized countries have emissions caps, this mechanism also offers an incentive for developing countries to take on emissions targets.

- Second, the agreement provides for Joint Implementation by Annex I countries. Thus if some countries do not develop programs to trade permits internationally, U.S. firms could nonetheless implement projects in those countries for which they could receive emissions reductions credits in the U.S.

- Third, the agreement allows industrial countries to invest in "clean development" projects in the developing world and use these projects' certified emissions reductions toward meeting their targets. Many such clean development projects may be quite cheap in terms of the cost per ton of emissions avoided, as has been illustrated by the Joint Implementation pilot program that is already in place in the U.S.

Details of how these provisions will operate will be discussed in future negotiations such as the one in Buenos Aires later this year. Nonetheless, effective international trading of emission credits, Joint Implementation, and the Clean Development Mechanism can lead to substantial reductions in costs relative to alternative policies that do not exploit the power of market incentives. To illustrate briefly the ability of U.S. industry to perform beyond expectations when given appropriate economic incentives, consider further EPA's highly acclaimed sulfur dioxide (SO_2) program, which relies, among other things, on a system of tradeable permits to reduce emissions of SO_2 from electric utilities. The SO_2 program has been successful in several ways: a large number of utilities participate, SO_2 emissions and ambient concentrations have fallen and the costs of reducing emissions are considerably lower than originally forecast.

As has been frequently noted, the average cost of SO_2 emissions reductions has recently been significantly lower than was originally forecast, in part due to the role of incentives in fostering innovation. Emission permit prices, currently at approximately $100 per ton of SO_2, are well below earlier estimates of around $250 to $400 per ton.

Trading programs may not always bring cost savings as large as those achieved by the SO_2 program; trading programs will not always be accompanied by the discovery of much cheaper control strategies. However, the SO_2 experience demonstrates clearly how programs like international permit trading, Joint Implementation, and the Clean Development Mechanism will lead firms to find cheaper ways of reducing emissions that can lead to unexpectedly low costs.

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IV. Difficulties of Economic Analysis of the Kyoto Protocol

Now that we have a Protocol -- even if it is not yet fully complete nor ready for the President's submission to the Senate -- it is possible to examine it in somewhat more detail from an economic perspective. But, once again the inherent limitations of any such estimates deserve emphasis. Such limitations should not be surprising to you: economists have a difficult enough time projecting the behavior of the economy over the next quarter or year, let alone over the next two decades. The scale of the forecasting exercise is therefore daunting, and any specific results should be treated with substantial caution.

The difficulties associated with economic analysis of climate change fall into three broad categories. First are the uncertainties that still remain over the terms of the ultimate treaty, necessitating assumptions on which the analysis is predicated. Second are the inherent limitations of available models to analyze even short-term costs and benefits. And finally is a topic discussed earlier: the impossibility of putting a single monetary number on the long-term benefits of climate change mitigation, although there will clearly be economic benefits of emission reductions.

Uncertainties in the International Effort to Combat Climate Change

The Kyoto Protocol was an historic accomplishment, delineating the broad terms of the international effort to address climate change. But although we know a lot more than we did before Kyoto about how that international system can work, and that informs our analysis, there is still much that we do not know.

First, some provisions raise complex implementation issues. At issue here is the treatment of so-called sinks -- activities that affect the rate at which carbon is removed from the atmosphere and "sequestered," e.g., by the planting of trees.

Second, the details of a number of items -- primarily concerning international trading, the Clean Development Mechanism, and developing countries -- are the subject of further discussions including future negotiations in Buenos Aires next fall, because they had not been definitively settled by the end of the Kyoto talks.

Finally, and most importantly, we have not yet negotiated international agreements to limit emissions beyond the 2012 window. The emission cuts agreed upon at Kyoto are only a first step on a long journey. The first step that we propose to take over the next 15 years is critical. But the reason it is critical is *not* that, by itself, it will solve the climate change problem -- emissions during any given decade are small compared to the cumulative concentrations in the atmosphere. Rather, the first step is critical because we can not take the second and third steps until we have taken the first. At the same time, any analysis is complicated by the lack of knowledge over what the subsequent steps will be.

Inherent Limitations of Models

In addition to these uncertainties about the details of the international effort to address climate change, are the inherent limitations of the models used to evaluate that effort. Even within a given model, answers depend critically on the precise nature of the question asked. For example, the costs of emissions reductions depend critically on the extent of global participation and international trading that a treaty is assumed to feature. But in addition to the dependence of the results from a given model on the precise assumptions, different models can give different answers even when all the assumptions are specified to be the same -- a concrete illustration of the range of uncertainty to which we must assign the predictions of any one individual model.

One area in which the uncertainty is particularly large is the pace of technological progress --especially the diffusion of existing energy-efficient technologies, but also the development of new technologies -- and the extent to which the pace will accelerate in response to government programs. Models and experts on climate change policy tend to have a wider range of disagreement on the scope for speeding the diffusion of existing energy-efficient technologies than on any other single issue.

Furthermore, each model has strengths and weaknesses; each has questions to which it is better or worse suited to answer. Some, for example, model the energy sector in detail. Some allow for the fact that a coal-fired power plant cannot costlessly be converted to one that runs on natural gas. Some show the effects of hypothetical tax cuts made possible by the new revenues earned through the auction of emissions permits. Some are capable of showing recessions and booms. Others include a long-term "carbon cycle" model that can keep track of the accumulation of greenhouse gas concentrations in the atmosphere and their climatological effects. Some break down the rest of the world into regions and so can model international trade. No one model does everything, and therefore we must not rely blindly on the results of any one model or set of models. Professional judgement and economic intuition, along with diplomatic assessments, are also crucial.

Benefits of Averting Climate Change

As discussed above, it is evident that the benefits of averting climate change are potentially immense. But we have chosen not to try to quantify them in monetary terms, in light of the difficulties we have enumerated. These include the uncertainty of these benefits, their timing and therefore the extreme sensitivity of the results to the chosen discount rate, and the dependence of benefits on emissions paths after the 2008 to 2012 budget period specified in Kyoto.

V. Assessing the Kyoto Protocol

In order to evaluate the likely net economic impact of the Kyoto Protocol, *excluding the benefits of mitigating climate change itself*, we have drawn upon a variety of tools to assess the various possible costs and non-climate benefits of the Administration's emissions reduction policy. To give away the punch line, our conclusion is as follows: the net costs of our policies to reduce emissions are likely to be small, assuming those reductions are undertaken in an efficient manner and we are successful in securing meaningful developing country participation as well as effective international trading, and the Clean Development Mechanism in future negotiations. That potential small net premium, even excluding the benefits of mitigating climate change, in effect, purchases a partial insurance policy against a serious environmental threat.

Because the results from any model must be treated with caution, the Administration has employed a broad set of economic tools to assess the Kyoto Protocol. We have drawn on the insights of a wide range of models of the energy sector and economy over the next 25 years, including but not limited to the results of the Stanford Energy Modeling Forum exercises, the IPCC's review of the economic and social dimensions of climate change, the work of the OECD on Economic Dimensions and Policy Responses to Global Warming, and the staff-level Interagency Analytical Team analysis produced last year. Other tools include simple relevant statistics, "meta-analyses" such as work by the World Resources Institute, models, and basic economic reasoning. Drawing on this broad array of analytical tools is crucial to an intelligent evaluation of the policy alternatives.

To our knowledge, no model -- whether used inside the government or not -- has yet been set up to analyze the implications of the Kyoto Protocol, since this agreement is only a few months old and remains unfinished. In particular, no model is currently designed to assess Kyoto's treatment of sinks, or all six greenhouse gases. Some model-builders outside the government tend to take as long as several years to incorporate changes in policy parameters into their models.

Our thinking has been informed, however, by simulations conducted with the Second Generation Model of Battelle Laboratories, one of the leading models in the field. The SGM is one of the models best positioned to analyze the role of international trade in emission permits, which we consider to be a critical element of the Kyoto Treaty. However, the SGM does not cover all six gases included in the Kyoto Protocol or include a role for sinks. We have used the SGM model as one input into our overall assessment of the Kyoto treaty, but have attempted to supplement its results with additional analysis to account for such special features of the agreement as the inclusion of six gases, a possible trading arrangement that could include a subset of the Annex I countries and the Clean Development Mechanism. We will share with you today some preliminary results of this analysis. To the extent possible, we have compared results obtained with the SGM model with those of other modelling efforts.

Mindful of the limitations of any single model, we are eager to see features of the Kyoto Protocol assessed by other models to obtain a better feel for the range of possible effects. This work is just beginning and much of it will continue to go on outside the government. For example, the Energy Modeling Forum, based at Stanford University, is a long-running model comparison exercise involving many of the leading climate models. EMF is currently studying how features of the Kyoto legal language can be translated into terms recognizable to economic modelers. We expect that the group will conduct a full scale analysis of the Kyoto Protocol. The Energy Modeling Forum believes that its members will need at least until mid-year to update their results.

VI. Assessing the Potential Costs of Emissions Reductions

I said in Congressional testimony last July that we can do this smart or we can do this dumb. I was referring to the point that the costs of cutting emissions can be much reduced if flexible, market-based mechanisms are used. Our economic analysis highlighted the importance of such flexible, market-based mechanisms -- which are therefore reflected, at the President's insistence, in the Kyoto Protocol and our ongoing diplomatic strategy.

Within the Kyoto Protocol, this means an insistence on international trading, Joint Implementation, the Clean Development Mechanism, and, ultimately, on meaningful developing country participation. Domestically, this means that we implement any emissions reductions through a market-based system of *tradeable* emissions permits, which ensures that we achieve reductions wherever they are least expensive. But this also means taking serious and responsible steps in the short run to prepare us to meet our obligations in the longer term.

The first such step is the inclusion in this year's budget of an aggressive, $6.3 billion program of tax cuts and R&D investments -- $1.3 billion more than the $5 billion package the President promised in his October 22 speech on this issue. The goal is both to stimulate the development of new energy-saving and carbon-saving technologies and to encourage the dissemination of those that exist already. The proposed package contains $3.6 billion over the next 5 years in tax cuts for energy efficient purchases and renewable energy, including tax credits of $3,000 to $4,000 for consumers who purchase highly fuel efficient vehicles, a 15 percent credit (up to $2,000) for purchases of rooftop solar equipment, a 20 percent credit (subject to a cap) for purchasing energy-efficient building equipment, a credit up to $2,000 for purchasing energy-efficient new homes, an extension of the wind and biomass tax credit, and a 10 percent investment credit for the purchase of combined heat and power systems. The package also contains $2.7 billion over the next 5 years in additional research and development investments -- covering the four major carbon-emitting sectors of the economy (buildings, industry, transportation, and electricity), plus carbon removal and sequestration, Federal facilities, and cross-cutting analyses and research. One example of the R&D effort is the Partnership for a New Generation of Vehicles (PNGV). PNGV is a government-industry effort to develop attractive, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. In FY99, the combined proposal for PNGV is $277 million, up from $227 million appropriated in FY98. Similar government-industry efforts are proposed to develop more efficient diesel engines for both light trucks and heavy trucks.

A second responsible step entails industry-by-industry consultations to prepare emission reduction plans in key industrial sectors. The Administration will work in partnership with industry to identify ways in which the Federal government might remove regulatory hurdles that discourage energy efficiency. In addition, DOE will spearhead a comprehensive effort to improve the energy efficiency of the Federal government's own operations and purchases.

The third step is the promotion of an environmentally-responsible electricity restructuring bill, which the President identified as part of his domestic climate change package in his address to the National Geographic Society on October 22. An electricity sector freed from government regulation would be a more efficient energy sector. Costs to consumers would fall. In addition, stronger incentives for improved generation efficiency in conjunction with appropriate market based provisions could achieve modest reductions in emissions. A reasonable overall estimate of the contribution of federal electricity restructuring to the rest of the President's program to address climate change is that it would make further progress to the same emission reduction goals at a cost saving of roughly $20 billion per year. These steps should be taken regardless of Kyoto, because they make sense in terms of energy efficiency. But they have the added benefit of preparing us for Kyoto.

Estimated Reduction in Costs from Annex I Trading

In the language of the treaty, "Annex I," is the set of countries that have agreed to take on binding limitations in emissions of greenhouse gases. Even without meaningful developing country participation -- which, again, the President has emphasized is essential before the treaty would be submitted for ratification -- costs could be reduced substantially by emission trading among the Annex I countries. To provide some indication of the possible efficiency improvements, Russia and Ukraine consume six times as much energy per dollar of output as does the United States. Such large international differences in energy efficiency suggest that adoption of existing U.S. technology would yield very large emissions reductions in these countries.

Estimates derived from the SGM model confirm that emissions trading among Annex I countries can reduce the cost to the United States of achieving its targets for 2008-2012 emissions by about half relative to a situation in which such trading was not available. This concept of costs is meant to capture aggregate resource costs to the US economy, including the cost to domestic firms of purchasing emission permits from other countries where emission reductions may be cheaper than in the United States. Although these estimates reflect idealized international trading in efficient markets, the overall conclusion is clear. <u>The dramatic reduction in costs potentially available from Annex I trading within the SGM model -- cutting the costs involved by half -- highlights why the President insisted that international trading be part of the Kyoto Protocol</u>; and why its achievement by our negotiators in Kyoto was such an important accomplishment.

Estimated reduction in costs from umbrella trading

One possibility that emerged in Kyoto, which none of us foresaw, was the idea developed there by the U.S. delegation, that the United States might undertake trading with a subset of Annex I countries, dubbed the "umbrella". Countries that have expressed interest in the umbrella include the United States, Australia, Canada, New Zealand and Russia, with strong indications of interest from some others. This subset of Annex I countries shares a common interest in promoting market-based mechanisms, most specifically, fully flexible rules for international trading of emissions permits.

It is too early to state the precise form the umbrella will take. But we can envision a number of potential benefits. The umbrella could, for example greatly reduce costs to the U.S. Results that we have derived from various SGM simulations of efficient international trading suggest that, relative to the situation in which there is no trading at all, the umbrella can reduce costs by an estimated 60-75 percent, depending on whether the former Warsaw Pact countries fall within the umbrella. The Kyoto Protocol classifies these countries outside of the EU bubble for the first budget period 2008-2012.

Estimated reduction in costs from developing country participation

The next consideration is participation by developing countries. The President has said that he will not submit the treaty for ratification without meaningful participation by key developing countries. Such participation would further reduce the costs involved.

The substantial potential gains from meaningful developing country participation are highlighted by the significant benefits that will likely accrue from the limited role that the developing countries have already agreed to: the Clean Development Mechanism (CDM), modeled after the U.S. joint implementation concept. The CDM cannot realistically be expected to yield all the gains of binding targets for developing countries, but it might shave costs by roughly another 20 to 25 percent from the reduced costs that result from trading among Annex I countries.

Another possibility is that we persuade some of the key developing countries that are the largest emitters to commit to targets, and allow us to buy emission reductions from those paths. Simulations with the SGM model suggest that full participation by non Annex I countries could cut roughly 55 percent off the reduced costs that result from Annex I trading. The actual cost reduction would depend on the extent of developing country participation that is ultimately obtained, as well as the effectiveness of international trading arrangements. The more developing countries that take on modest binding targets and trade in international permit markets, the lower will be costs.

These cost-saving opportunities are fundamental tenets of the U.S. position. The promise of Kyoto cannot be achieved without effective emissions trading. Moreover, if we do not get meaningful participation by key developing countries, we won't submit the treaty for ratification to the Senate. So, while our analysis may be predicated on some ambitious conditions concerning trading and developing country participation, it is exactly those conditions that form the foundation of the U.S. position in international negotiations including those at Buenos Aires.

Accounting for Carbon Sinks

The preceding discussion has emphasized the importance of trading arrangements and the CDM. In reaching an overall economic assessment, it is also important to factor in the potential role of carbon sinks. Again, the U.S. delegation obtained a novel concept, that carbon absorbing activities called sinks could be used to offset emissions. The arrangements concerning carbon sinks in the Kyoto Protocol have received less attention than they merit. The Kyoto Protocol specifies that removals of CO_2 by sinks count toward meeting the target. The Kyoto Protocol counts the net emissions effects of three sink activities --afforestation, reforestation, and deforestation. Very preliminary estimates of the implications for the United States of the Kyoto provision on sinks indicate that carbon sinks could comprise a significant portion of the total required emissions reductions. Moreover, decreasing the required emissions reduction by, for example, 10% would likely result in cost-savings greater than 10%.

Even this estimate of the effect of sinks is conservative in one respect: it is based on an assumption for sink activity in the U.S. over the 2008-2012 period, and no assumed benefits from sinks elsewhere in the world. Very preliminary estimates suggest that incorporating the gains from sinks *throughout the world* can substantially reduce the costs of meeting the Kyoto target, on top of the gains from trading among Annex I countries. (Furthermore, no model has yet even tried to take into account that government policies can help increase the activities qualifying as allowable sinks, like some tree-planting.) Because the quantitative uncertainty is so large, we do not yet have an estimate with which we are comfortable. But we expect that complete modelling of the Kyoto provision pertaining to sinks will likely have favorable and potentially large effects on projected costs.

Accounting for the role of improvements in energy efficiency

Another issue in analyzing the Kyoto protocol concerns future improvements in energy efficiency due to innovation and diffusion of existing technology. The parameter that figures most prominently in analysis of energy efficiency is the rate of improvement in the so-called Autonomous Energy Efficiency Index (AEEI), that is the rate at which the total use of energy falls relative to GDP. A plausible assumption on the AEEI is an improvement of 1.0 percent per year. Reflecting a conservative interpretation of the 15-year impact of various climate change initiatives, this is only a small increase above the 0.9 percent number in the Energy Information Administration's <u>Annual Energy Outlook</u>. That assumption is not the most optimistic outcome that might occur. Some authorities in the field of energy policy forecast more rapid technological progress. Experts at five national laboratories managed by the Department of Energy, using an engineering approach rather than an economic paradigm, found that a third of the emissions reductions necessary to return to 1990 levels by 2010 could be achieved through the adoption of existing energy-efficient technologies at no net resource cost, or even some savings. The National Academy of Sciences reached qualitatively similar conclusions in a 1992 report.

The President's FY 1999 budget, as I have noted, includes a $6.3 billion package of tax cuts and R&D investments intended to spur the discovery and adoption of new technologies. If the Administration is successful in this effort, the rate of improvement in energy efficiency could rise and such improvements would lower the cost of meeting our Kyoto target. For example, published results based on SGM model simulations with different assumed rates of AEEI suggest that an increase in the AEEI of 25 percent could lead to declines in the permit price of approximately 40 percent.

Our justification for incorporating into our assessment a small assumed impact of Administration technology policies is somewhat analogous to the Administration's rationale for employing mainstream economic assumptions in our budget forecasts: in the presence of uncertainty, we are conservative in our estimates of the speed with which the economy will grow, tax receipts will rise, and the budget will improve. That way, any revisions or surprises that occur are likely to be in the pleasant direction. In this instance, we prudently and conservatively assume that there will be substantial delays between investments in new technology or the diffusion of existing technology, and the returns to such investments.

Moreover, at the recent automobile show in Detroit, General Motors announced that it has developed a hybrid-based vehicle that can achieve fuel efficiency of 80 miles per gallon, and that this car could be in commercial production within a few years. Ford also exhibited a prototype of a light-weight highly fuel efficient sedan that could be in commercial production by the middle of the next decade. These announcements followed an earlier breakthrough announced by DOE and its partners of a fuel cell that could run on gasoline and double current fuel economy while reducing conventional air pollution emissions by 90 percent. These technological advances have been made possible through the efforts of the Partnership for a New Generation of Vehicles between the Administration and the U.S. auto companies and their suppliers.

Such progress may be replicated in other sectors. VCRs and TVs, while switched off, consume about $1 billion worth of electricity annually. EPA has established a partnership with major manufacturers that has a goal of achieving up to a 70 percent reduction in energy use by VCRs and TVs while they are switched off, without sacrificing product quality, usefulness, or increasing costs. This partnership offers promise of substantial improvements in energy efficiency.

Non-Climate Benefits

A final factor that should be included in any comprehensive assessment of the economic implications of the Kyoto protocol are the benefits of the agreement. The literature has emphasized that any relative price shifts that prove necessary to reduce emissions should produce non-climate benefits in three areas: traffic congestion, highway accidents, and air pollution unrelated to climate change. These benefits are hard to quantify precisely but are potentially significant: our rough estimates suggest that these three benefits could offset approximately a quarter of the resource cost of the climate change policy.

Synthesis

A comprehensive evaluation of the economic impact of the Kyoto Protocol must integrate all of the factors described above: reliance on flexible market-based mechanisms domestically; international trading and Joint Implementation among Annex I countries; the Clean Development Mechanism; meaningful developing country participation; the potential cost-mitigating role of including six gases and carbon sinks; the benefits of electricity restructuring; and emissions reductions achieved as a consequence of other proposed Administration climate change initiatives. Assuming that effective mechanisms for international trading, Joint Implementation and the Clean Development Mechanism are established, and assuming also that the U.S. achieves meaningful developing country participation, our overall assessment is that the economic cost to the United States in aggregate and to typical households of attaining the targets and timetables specified in the Kyoto Protocol, will be modest.

This conclusion that the impact will be modest is not entirely dependent upon, but is fully consistent with, formal model results. I have previously emphasized the limitations of relying on any single model in assessing the economic impact of the Kyoto Protocol, and continue to view any such results as just one input into an overall analysis. But it is worth emphasizing that model results reflecting the details of the Kyoto Protocol are consistent with our conclusion. For example, under the assumptions of either trading under the umbrella or within Annex I, the CDM and permit trading with developing countries, estimates derived using the SGM model, which adjust for the inclusion of six gases and assume little banking of credits beyond 2012, suggest that the resource costs of attaining the Kyoto targets for emission reductions might amount to $7 to $12 billion per year in 2008 to 2012. This implies that overall costs, excluding not only climate and non-climate benefits, but also such cost mitigating factors as sinks and payoffs from the President's electricity restructuring and climate change initiatives, would reach roughly one tenth of one percent of projected GDP in 2010.

A more tangible measure of costs is the estimated effects on energy prices. Excluding the impact of electricity restructuring and the ancillary benefits of mitigation and better forest management, the SGM-based estimate, corresponding to the gross resource cost estimate cited above, is an emissions price in the range of $14 to $23 per ton of carbon equivalent. This translates into an increase in energy prices between 2008 and 2012 at the household level of between 3 and 5 percent, an increase in fuel oil prices of about 5 to 9 percent, natural gas prices of 3 to 5 percent, gasoline prices of 3 to 4 percent (or around 4 to 6 cents per gallon), and electricity prices of 3 to 4 percent. This increase in energy prices at the household level would raise the average household's energy bill in ten years by between $70 and $110 per year, although such predictions may not be observable because they would be small relative to typical energy price changes, and nearly fully offset by electricity price declines from Federal electricity restructuring. In particular, this increase in energy prices is small relative to the average of *year to year* real energy price changes experienced by U.S. consumers since 1960: such *annual* changes have averaged 3.8 percent. In addition, by 2008-2012, the anticipated 10 percent decline in electricity prices from the restructuring that is part of our climate change agenda is projected to lead to expenditure reductions of about $90 per year for the average household.

As highlighted earlier, there are substantial but unavoidable uncertainties surrounding estimates like these. For example, the estimate just discussed is predicated, among other things, on the developing country participation that we are insisting upon as a condition for our ratifying the Kyoto Protocol, but which is not yet part of that Protocol, and on effective international trading. Moreover, other models will yield other answers and much work remains to be done by the modeling community to test the robustness of these results. Preliminary comparisons of the SGM model to the few other models that have attempted to evaluate the Kyoto accord, suggest that its predictions concerning the impact of the Kyoto Protocol on carbon permit prices are neither the most conservative nor the most optimistic of the models that have been developed. The predictions of the SGM model are robust in the sense that virtually all energy models reveal the potency of effective, flexible, domestic and international trading mechanisms to reduce substantially the cost and energy price impact of meeting the Kyoto targets.

Of course, the most important factor that has been left out of the above assessment is the benefit of mitigating climate change itself. A full cost-benefit analysis would include mitigation in the benefits column. The only reason we have not done so, explained repeatedly above, is the difficulty in coming up with a number to capture the monetary benefits. But nobody should lose sight of our ultimate objective -- keeping our planet the hospitable home that we enjoy today.

Effects on employment and aggregate output

So far we have said nothing about job losses resulting from climate change policy. Although there may be job gains in some sectors and job losses in others, we do not anticipate any significant aggregate employment effect if we achieve the conditions we have discussed. The effects on energy prices described above will occur only 10 to 14 years in the future. Not only are these effects small relative to historical variations in energy prices, and offset by other policies like electricity restructuring, they would occur sufficiently far in the future to enable monetary policy to keep the economy operating at its potential. In energy-intensive sectors some employment reduction could occur, although given the very small predicted change in energy prices, impacts in most such sectors are apt to be minimal. Furthermore, a large number of jobs will be created in other sectors -- many of them high-tech jobs paying high wages. The President is firmly committed to assisting any workers who are adversely affected during the transition to a climate-friendly economy.

VII. Conclusion

In conclusion, the Kyoto Protocol and the President's general approach to climate change reflect the insight of economic analysis. The Kyoto Protocol includes key provisions on international trading and Clean Development projects. The President's approach relies on market incentives -- first, with a system of tax cuts and R&D investments, and then later with a market-based system of tradeable permits -- to ensure that our objectives are achieved as efficiently as possible.

Our overall conclusion is that the economic impact of the Protocol will be modest under the conditions we have identified. The purpose of this testimony has been to explain the reasoning underlying this conclusion, which draws insights from not only the forecasts of individual models, any one of which has its own strengths and limitations, but also a broad variety of additional analyses.

I look forward to continuing to work with members of this Committee, as well as other interested parties, in further analyzing the Kyoto Protocol and evaluating the net effects of reducing greenhouse gas emissions. It is my hope that economic analysis will continue to play a key role in designing policies in this area.

I welcome your questions.

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trading that a treaty is assumed to feature. But in addition to the dependence of the results from a given model on the precise assumptions, different models can give different answers even when all the assumptions are specified to be the same -- a concrete illustration of the range of uncertainty surrounding the predictions of any one individual model.

Benefits of Averting Climate Change

In conducting this analysis the Administration has not attempted to quantify the benefits of mitigating the risks of climate change. While several economists have estimated the damages of global warming under a doubling of atmospheric concentration (Cline 1992; Fankhauser 1993; Nordhaus 1994), they all assumed an endpoint -- an atmospheric concentration, and subsequently, an increase in global temperature. However, the Kyoto Protocol only stipulates an emissions path through 2012. To calculate the benefits of averting climate change-induced damages, it is necessary to know the emissions path for many years beyond 2012. Thus while the benefits of getting started on the Kyoto path to reducing greenhouse gas emissions may be quite large over time, we cannot estimate these benefits without knowing where the path goes in the years after the Kyoto compliance period.

Cline (1992) assessed the economic damages from warming associated with two temperature increases: 2.5° C (4.5° F) and 10° C (18° F). He presented the former temperature change as the likely effect of a doubling of the atmospheric carbon dioxide concentration and the latter temperature change as the result of "very long term warming". Under the scenario where the temperature increases 4.5° F, Cline found that the annual damage to the U.S. would be about 1.1% of GDP, or about $89 billion in today's terms.[13] Cline's "very long term warming" scenario resulted in economic damages of about 6% of GDP. A23

Cline's estimates of annual economic damage of global warming take account of the following categories of impact: agriculture, forest loss, species loss, sea-level rise (including costs of constructing dikes and levees, wetlands loss, and drylands loss), electricity requirements, non-electric heating, human amenity, human life, human morbidity, migration, hurricanes, construction, leisure activities, water supply, urban infrastructure, and air pollution. Cline provides only qualitative assessments for several categories. In addition, he found that non-electric heating expenditures decline with global warming, so this is actually considered a benefit, not a cost, associated with warming. A23a

The economic damage under a doubling of the atmospheric carbon dioxide concentration found by Cline is not significantly different in magnitude from the results of Nordhaus (1994) and

[13] Cline's original estimate is quoted in 1990 dollars. The figure given above translates the Cline estimate into 1997 terms by scaling it to 1997 GDP.

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The Economics of Global Warming

INSTITUTE FOR INTERNATIONAL ECONOMICS
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:fers to the exponential pace of the expansion of damage as temperature rises $D = k[\Delta t]^{\gamma}$), where specific text estimates are not made.[45]

The estimates here indicate that, even for benchmark warming of $2 \times CO_2$-quivalent, damages for the United States could be relatively large. The $61 illion estimate is approximately 1.1 percent of GDP.[46] Moreover, it excludes :veral of the unestimated effects, and the potentially important species loss ıay be underestimated. The table's estimates for damage from very-long-term ⁄arming are more striking and, on average, are approximately 5½ times the stimates for $2 \times CO_2$-equivalent.

The very-long-term damages require appropriate scaling. Most of the effects ⁄ould rise proportionately with GDP, and some would rise more than proporonately (e.g., species loss, if existence value to society is an income-elastic :rvice). The long-term damages are thus on the order of at least 6 percent of DP.

A23

The central damage estimates of this study, based on estimates for the United tates, are that warming associated with benchmark doubling of carbon-dioxidequivalent (2.5°C) would impose losses of at least 1 percent of GDP and that ery-long-term warming of 10°C would cause damage amounting to at least 6 ercent of GDP. As indicted in table 3.4, numerous damages are excluded in ıese central figures. Incorporation of some of the "softest" estimates could ıbstantially raise calculated losses.

Thus, as noted above, the annual value of species loss for benchmark doubling ıight well be $40 billion rather than $4 billion; annual human amenity costs ıight amount to $10 billion, health damages $3 billion, and the side benefits f pollution reduction from emissions abatement at least $6 billion. If these stimates are included, the total damages from permitting unabated global warming :ach $117 billion annually for benchmark doubling, or 2 percent of GDP.

The benefit-cost analysis below accordingly uses a range of 1 percent to 2 ›ercent of GDP for damages from benchmark warming (the doubling of carbon-:ioxide-equivalent, with warming at 2.5°C). As it turns out, this is the same ange proposed by Nordhaus (1991a). Although his direct calculations reach ›nly ¼ percent of GDP, he suggests the range of 1 percent to 2 percent of GDP o take account of effects he does not measure.

Even the range of 1 percent to 2 percent of GDP for carbon-dioxide-equivalent loubling, and correspondingly 6 percent to 12 percent of GDP for very-long-

·5. Note, however, that the estimate for leisure activity rises less than linearly in the long-erm estimate, because the ski industry is already cut by more than half in the $2 \times CO_2$ cenario.

·6. This estimate is approximately seven times the direct estimate of Nordhaus (1990b), vhich is $6.6 billion at 1981 prices. However, it is consistent with his "medium damage" stimate, placed at 1 percent of GDP to allow for unmeasured effects in his direct estimate.

term warming, does not reflect the damage associated with upper-bound warming (climate sensitivity parameter $\Lambda = 4.5°C$). With a damage function exponent of $\gamma = 1.3$, damage for upper-bound warming would reach levels 2.15 times as high ($= [4.5/2.5]^{1.3}$). Thus, with upper-bound warming, damage would be expected to reach 2.1 percent to 4.3 percent of GDP for carbon-dioxide-equivalent doubling, and 13 percent to 26 percent of GDP for very-long-term warming. On this basis, even for $2 \times CO_2$, the high-damage case considered here has approximately twice the highest damage considered by Nordhaus (1991a).

Conversion of the damages in table 3.4 into avoidance benefits requires a sense of the portion of damage that could be avoided with an aggressive antigreenhouse policy. As analyzed in chapter 2, over the very long term it is likely that as much as 2.5°C out of a total 10°C potential warming (central estimate) cannot be avoided even with aggressive action. The 2.5°C minimum is equivalent to $2 \times CO_2$-benchmark warming. On this basis, the amount of long-term damage that can be avoided through energetic policy measures should equal the difference between the first and second columns of table 3.4 (stated, in both cases, against a 1990-scale US economy). This difference, which amounts to 5 percent of GDP, is the basis for the (somewhat more conservative) "avoidance proportion" applied in the benefit-cost analysis of chapter 7.

This analysis has the sobering implication that much of the damage usually considered is already unavoidable. It also emphatically underscores the importance of the very-long-term analysis. If all that were in store were the damages typically associated with benchmark $2 \times CO_2$-warming, there would be some basis for largely abandoning attempts at abatement on the grounds that a large portion of the damage is unavoidable (although the slower speed of the warming with abatement might still warrant action on ecological grounds). Attention would then more appropriately focus on adaptation. But if the much larger stakes in the very long term are valid, there are correspondingly much stronger grounds for abatement policy action.

A23a

Table 3.4 Estimates of annual damage from global warming to the US economy at 1990 scale (billions of 1990 dollars)

	$2xCO_2$ (2.5°C)	Very-long-term warming (10°C)
Agriculture	17.5	95.0
Forest loss	3.3	7.0
Species loss	$4.0 + \Delta_s$	$16.0 + \Delta'_s$
Sea-level rise		35.0
Construction of dikes, levees	1.2	
Wetlands loss	4.1	
Drylands loss	1.7	
Electricity requirements	11.2	64.1
Nonelectric heating	−1.3	−4.0
Human amenity	X_a	Y_a
Human life	5.8	33.0[a]
Human morbidity	X_m	Y_m
Migration	0.5	2.8[a]
Hurricanes	0.8	6.4[b]
Construction	$\pm X_c$	$\pm Y_c$
Leisure activities	1.7	4.0
Water supply	7.0	56.0
Urban infrastructure	0.1	0.6[a]
Air pollution		
Tropospheric ozone	3.5	19.8[a]
Other	X_o	Y_o
Total	61.6 $+X_a+X_m+X_o+\Delta_s \pm X_c$	335.7 $+Y_a+Y_m+Y_o+\Delta'_s \pm Y_c$

a. $\gamma = 1.25$.

b. $\gamma = 1.5$.

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Fankhauser (1993). Nordhaus estimated that a temperature increase of 5.4° F would result in annual costs of about 1% of GDP. Fankhauser found that under the same 5.4° F temperature increase the annual costs of warming would be about 1.3% of GDP for the U.S., and 1.5% of GDP worldwide. However, the similarity among the aggregated estimates of these three researchers masks both the differences in their methodologies and the true uncertainty associated with long-term forecasts of the damages from given increases in global warming. Different researchers account for different categories of damages, and even within the same category, they may estimate different effects. More importantly, the estimates are all fundamentally based on extrapolations from current and past experience, and may not fully incorporate effects that will unfortunately become apparent only with future experience.

The other major surprise is that the projected shifts in the sectoral and national distributions of output over the next century have a negligible effect upon the estimated impact of climate change on total world output. According to the calculations, the total impact of a CO_2 doubling is within .06 percentage points of 1.33 percent of output for the entire period 1987–2100. The reason for the lack of change in global vulnerability is the following. On the one hand, agriculture's share of output is shrinking in most countries, which leads to a decline in vulnerability. On the other hand, those countries with a large part of their economies devoted to agriculture are growing more rapidly than the industrialized economies, and growth is strongest in countries which appear to have high coastal vulnerability. These two trends appear to offset each other over the next 100 years. It should be noted, again, that, because of infirmities in the underlying estimates of damage, these projections are subject to large margins of error.

On the basis of these calculations, we will use a baseline estimate of the impact on real income of a CO_2 doubling, measured as a 3°C warming, of 1.33 percent of output. In addition, there is evidence that the impact increases sharply as the temperature increases, and we assume that the relationship is quadratic. Therefore, the final relationship between global temperature increase and income loss is

$$d(t) = (.0133/9)\ T(t)^2\ Q(t), \tag{4.2}$$

where $d(t)$ is the loss of global output.

Comparison with Other Estimates

The empirical study on which the DICE model is based can be compared with studies of other researchers. It must be emphasized that impact studies are in their infancy, that studies of impacts in low-income regions are virtually nonexistent, and that estimates for global impacts have scanty empirical support and are generally extrapolations from results for the United States.[4] For comparison purposes, we show the estimates from a number of different studies in table 4.3.

At present there are two comprehensive studies of the economic impacts of climate change by Cline (1992) and Fankhauser (1993). These two studies use largely the same data base as Nordhaus (1991c) and come to largely the same conclusions. Cline includes a larger group of

4. S haus 1993 for a discussion of results in developing countries.

Nordhaus 1994

Table 4.3
Comparison of estimates of impact of global warming: Impact on incomes of CO_2 doublin (in billions of 1988 U.S. dollars and percent of total output)

	United States				Global		
	Nordhaus	Cline	Fankhauser	Other	Fankhauser	Other	DICE Mode
Heavily affected sectors							
Agriculture	1	15.2	7.4	1.2[b]	39.1	12.0[b]	
Coastal areas	10.7	2.5	2.3				
Energy	0.5	9	0				
Other sectors	38.1						
Wetland and species loss	[a]	7.1	14.8				
Health and amenity	[a]	8.4	30.3				
Other	[a]	11.2	12.1				
Total							
Billions of $	50.3	53.4	66.9				
Percent of output	1.0	1.1	1.3		1.5	1.9[c]	1.33[d]

Sources: Nordhaus 1991c, Cline 1992a, Fankhauser 1993.
Notes:
a. These are included in the total for "other sectors."
b. From Reilly and Hohmann 1993, with full adaptation and CO_2 fertilization.
c. The median response for the 50th percentile of outcomes from a survey of experts (Nordhau 1994).
d. See table 4.2.

sectors than does Nordhaus. While Cline's discussion encompasses a number of different findings, many of the extensions outside of the marketed sectors are extremely tenuous and his central estimates tend to rely on studies that may lean toward overestimating the impacts. For example, Cline's estimates of the impact of losses from storms assume that storms become more severe whereas both the IPCC and the National Academy studies concluded that the effect of warming on storm intensity is ambiguous.[5] Another example is leisure activities, where he includes losses to skiing but excludes any gains from the much larger warm weather industries such as camping. For agriculture, Cline's central estimate relies on studies that allow for little or no

5. See IPCC 1990, 155, and NAS 1992.

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Divider Title: **9**

Illustrative Calculations: Methodology

To provide a concrete illustration of this conclusion the Administration undertook an examination of the possible economic impact on the U.S. economy of the Kyoto Protocol. Since no one model exists to handle all of the parameters of the Kyoto agreement, several tools had to be used to calculate the estimated costs of climate policy. First, the Administration constructed emissions baselines for all six categories of greenhouse gases and 2010 business as usual levels for these gases for Annex I countries. These emissions estimates would serve as the basis for calculating the emissions reductions required to achieve the Kyoto targets. Second, we developed cost curves for reducing greenhouse gas emissions. For carbon dioxide, marginal abatement cost curves were derived from more than 60 model runs with the Second Generation Model. For other greenhouse gases, we used a bottom-up marginal abatement cost curve developed by the Interagency Analytical Team (1997). Third, we assessed several different trading scenarios based on the required emissions reductions and the constructed cost curves. Equalizing marginal costs across countries and regions generated a common permit price across the trading bloc. Fourth, we calculated the effects of the permit price on energy prices, energy consumption, GDP, investment, and consumption. A25

Construction of a 6 Gas Baseline and 2010 "Business as Usual" Baseline

To assess the potential economic impact of the Kyoto Protocol, it was first necessary to construct 1990/1995 baseline emissions and business as usual emissions paths that account for all six categories of greenhouse gases. While estimates of 1990 emissions and 2010 projected emissions for carbon dioxide are widely available for most Annex I countries and many large Non-Annex I countries, the Administration gathered data on the other greenhouse gases from more than 25 submitted National Communications to the Framework Convention on Climate Change, official reports of the Framework Convention, and Environmental Protection Agency and Department of Energy analyses. In some cases, we made extrapolations from one country to another based on common characteristics (e.g., GDP). These data provide the basis for our preliminary estimates until the parties to the Framework Convention provide more detailed information on historical and projected emissions of all six categories of greenhouse gases. With these baseline estimates, the Administration estimated the magnitude of the emissions reductions required of Annex I countries under the Protocol.

Carbon Dioxide Emissions

For projections of carbon dioxide, we used the business as usual projections in the Second Generation Model, with the exception of the United States, where we used the more recent Energy Information Administration (1997a) estimate of 2010 BAU for energy-based CO_2 and the Climate Action Report (1997) projection for non-energy-based CO_2. For the European Union, the

? Background

Call Rosina about Tongn's memo

cc: [illegible] JAF RMM JS

DRAFT--May 19, 1997

Economic Effects of

Global Climate Change Policies

1. 1995-2000 what is this?

Results of the Research Efforts of the

2. When does announcement effect occur? 2000 or 1995?

Interagency Analytical Team

June 1997

3. 2000+

Ramp up ~~[illegible]~~

What exactly does this mean

$\boxed{0.1 \rightarrow 1.5}$

Introduction

In June 1996, the Department of Energy (DOE) [illegible] Environmental [illegible]ection Agency (EPA) sponsored a joint workshop where more than [illegible] from inside [illegible] outside the government made presentations on technical issues ass[illegible]ted w[illegible] [illegible] emission trends and capability to reduce emissions trends in the next cent[illegible] As a [illegible] of that wo[illegible]op, the Interagency Analytical Team (IAT) released wh[illegible] e the [illegible]liminary [illegible]sults on the economic effects of emissions reduction proposals.

Since that June 1996 worksh[illegible] [illegible] AT has reviewed [illegible] work, selected new modeling instruments, improved its approa[illegible] to old ones, and [illegible]eloped a new set of modeling runs that lead to a [illegible] understanding of the econom[illegible] [illegible]nsions of the climate change policy problem. This paper [illegible] those efforts. It first summarizes the IAT model selection process. Second, it discusses the [illegible]licy) base [illegible] to measure the effects of various policy options. Third, it discusses [illegible] core emiss[illegible]s reduction scenario. Finally, the bulk of this paper discusses the [illegible] IAT's analysis.

The m[illegible]ng work performed [illegible] this analysis was done by economists at DOE and EPA. The IAT [illegible]ncluded membe[illegible] the Departments of Commerce, Treasury, Labor, and State, as w[illegible] members of the [illegible] House staff. The majority of the IAT members are still primarily from [illegible]E and EPA -- [illegible] agencies that ha[illegible] pr[illegible]ry responsibility for the Administration's [illegible]d environm[illegible]al policies.

31

Model Selection

The first task that the IAT confronted was to review the analytic "toolbox" to assure that it had all the tools necessary to specify the economic effects of a broad range of climate change proposals. At the time, the IAT relied primarily on the Data Resources, Inc. (DRI) macro model

A25

Appendix Table A: Assumptions Regarding

Non-Carbon Greenhouse Gases

(Million Metric Tons of Carbon Equivalent)

	1900	1995	2000	2005	2010	2015	2020
Baseline Emissions							
CH4	169	178	150	152	152	154	155
HFC PFC	24	n/a	42	69	[illegible]	115	133
N2O	37	34	31	32	[illegible]	36	[illegible]
Sinks	-136	-128	[illegible]	-120	[illegible]	[illegible]	[illegible]
Total	95	n/a	[illegible]	[illegible]	158	[illegible]	223
Cost Effective Reductions in Emissions (assuming an implicit price of carbon of $70 per ton)							
CH4					27	29	29
HFC PFC					51	75	110
N2O					4	4	4
Sinks				7	15	15	15
Total Reduction					97	123	159
Emissions with Cost Effective Reductions							
CH4	169	178	150	152	125	126	126
HFC PFC	24	n/a	42	69	40	41	23
N2O	37	34	31	32	30	31	33
Sinks	-136	-128	-121	-120	-134	-126	-118
Total Other Gas Emissions	95	n/a	102	133	61	[illegible]	64
Reductions Below 1990 Levels					34	23	31

Note: Million metric tonnes of carbon equivalent calculated using 100 year Global Warming Potentials (GWP) (IPCC, 1995). The $70 per ton implicit price of carbon was ballpark figure used by the IAT prior to generating implicit price of carbon using the IAT models..

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10

Divider Title: ______________________________

HFCs, PFCs, and SF_6 Emissions

Hydrofluorocarbons (HFCs) and perfluorinated compounds (PFCs) have been introduced as alternatives to the ozone-depleting substances being phased out under the *Montreal Protocol* and Clean Air Act Amendments of 1990. Because HFCs and PFCs are not directly harmful to the stratospheric ozone layer, they are not controlled by the *Montreal Protocol*.

However, these compounds, along with sulfur hexafluoride (SF_6), are powerful greenhouse gases. Therefore, they are considered under the United Nations' Framework Convention on Climate Change (FCCC). In

Table 3-5

1995 Emissions of HFCs, PFCs, and SF_6

HFCs, PFCs, and SF_6 are powerful greenhouse gases. In addition to having high global warming potentials, SF_6 and most PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere.

Compounds	MMTs of Gas	Atmospheric Lifetime (yrs.)	Global Warming Potential	MMTCE
HFCs	**0.02071**			**20.92**
HFC-23	0.00426	264	11,700	13.61
HFC-125	0.00227	33	2,800	1.74
HFC-134a	0.01086	15	1,300	3.85
HFC-143a	0.00004	48	3,800	0.05
HFC-152a	0.00091	2	140	0.03
HFC-227	0.00186	37	2,900	1.47
HFC-4310	0.00051	17	1,300	0.18
PFCs	**0.00410**			**7.93**
CF_4	0.00250	50,000	6,500	4.43
C_2F_6	0.00057	10,000	9,200	1.42
C_4F_{10}	0.00001	2,600	7,000	0.02
C_6F_{14}	< 0.00001	3,200	7,400	< 0.01
PFCs/PFPEs*	0.00102		7,400	2.05
SF_6	**0.0129**	**3,200**	**23,900**	**8.40**

* PFC/PFPEs are a proxy for many diverse PFCs and perfluoropolyethers (PFPEs), which are beginning to be used in solvent applications. Global warming potential and lifetime values are based upon C_6F_{14}.

A27

Administration adjusted the Western Europe value in SGM to reflect the non-participation of Iceland, Norway, Switzerland, and Turkey in the E.U. bubble. Based on CO_2 emissions estimates from the Carbon Dioxide Information Analysis Center, we deducted 66.1 MMTCE from the Western Europe estimate to derive the E.U. 1990 baseline CO_2 emissions value. For 2010 BAU, 85 MMTCE were deducted from the Western Europe 2010 estimate.[14] A26

Emissions of Other Greenhouse Gases

For projections of the other five categories of greenhouse gases, we used information provided in the national communications to the Framework Convention on Climate Change. In some cases, 2010 emissions were extrapolated from projections of 2000 emissions levels. In addition, some projections in emissions were based on growth rates in comparable countries. For a country-by-country discussion of the emissions baselines derivations, refer to Appendix B.

Converting to Carbon Equivalence

In all cases where data are provided in tons of gas, or tons of carbon dioxide equivalent, the Administration converted the data to tons of carbon equivalent based on their 100 year time horizon global warming potential (Houghton et al. 1996; refer to Table 2). Some countries aggregated all HFCs into one value (and in some cases, all PFCs into one value). We constructed an HFC weight and a PFC weight based on specific HFC and PFC emissions in the United States in 1995. For HFCs, the following weight was used:

$$[2*GWP(HFC\text{-}134a) + GWP(HFC\text{-}23)]/3 = 1300$$

HFC-134a was 52% and HFC-23 was 21% of all U.S. HFC emissions in 1995. For PFCs, the following weight was used: A27

$$[2*GWP(CF_4) + GWP(C_6F_{14})]/3 = 1854$$

CF_4 was about 60% and C_6F_{14} was about 25% of all U.S. PFC emissions in 1995.

[14] We assumed that these four non-E.U. European countries would experience the same emissions growth rate as the E.U. over the 1990-2010 period to calculate their 2010 emissions.

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Carbon Sinks

The Kyoto Protocol specifies that removals of CO_2 by certain kinds of sinks count toward meeting emissions targets. Very preliminary estimates suggest that incorporating the gains from carbon sinks throughout the world could substantially reduce the costs of meeting the Kyoto target, on top of the gains from trading among Annex I countries. Such gains could be substantial under business as usual and even larger after taking into account the additional effects of government policy. Government policy could, for example, provide an incentive to increase the activities qualifying as allowable sinks, like tree-planting. However, no model has yet tried to account for such additional effects. Because the quantitative uncertainty is so large, we do not yet have an estimate with which we are comfortable. But we expect that complete modeling of the Kyoto provision pertaining to sinks would have favorable effects on projected costs. For the analysis reported here, the Administration employed a conservative assumption that all countries' sinks equaled zero and that no country would implement policies to stimulate the creation of carbon sinks. A27b

A-27a on next pg.

Kyoto Targets

The emissions targets for Annex I countries were from Annex B of the Kyoto Protocol. For Non-Annex I countries, the assumed emissions targets were equal to those countries' business as usual emissions levels in 2010.

Constructing Marginal Abatement Cost Functions

To construct marginal abatement cost functions for carbon dioxide, the Administration used model results from Battelle Laboratory's Second Generation Model (SGM). SGM is a computable general equilibrium model designed to provide estimates of the economic costs of actions to reduce carbon dioxide emissions.[15] SGM models the energy sector in greater detail than other sectors, so it can provide information on the trade-offs in the consumption of different fuels under a policy to reduce carbon dioxide emissions. It also serves the purpose of evaluating the effects of international emissions trading, because it includes twelve countries and regions (see Table 3). The capacity of the SGM model to take into account international trading is an obvious virtue of this model relative to the other two models used in the Interagency Analytical Team process, both of which only modeled the economic effects of emissions reductions in the United States. The SGM, like all models used to assess economic effects, has strengths and weaknesses. Therefore, the results from this analysis should be considered illustrative. However, the results of the Stanford EMF's

[15] For more information about the Second Generation Model, refer to Edmonds et al. 1992.

draft; close hold, 1/23/98

CEA-Treasury

Costs and benefits of a program to address Global Climate Change

Agenda

I. Costs:
How low can international trading bring costs down, under successively more ambitious assumptions?

II. Benefits:
(1) reducing air pollution
(2) reducing traffic congestion,
(3) reducing traffic accidents

III. How sensitive are the above results to alternative
(1) models?
(2) assumptions about how sinks are accounted for?
(3) a more optimistic assumption about technology (AEEI)?

Answer: very sensitive. Nevertheless, the general result is as follows: Optimistic assumptions about trading are sufficient to bring costs down a lot, but not enough to bring them below benefits.

IV. To close the gap between costs and benefits, one needs *either:*
(1) to include the cost savings of a federal electricity restructuring bill ($18 billion?), *or*
(2) to assume that permits are auctioned to raise revenues used to cut taxes on capital, *or*
(3) simply to argue that the future benefits of mitigating global climate change, while difficult to quantify in a single monetary number, should be large enough to merit the net costs that emerge from parts I and II above.

Sinks
Cave + Chart 2d

draft; close hold, 1/23/98

Costs and Non-Climate Benefits without Sinks

Table 1. U.S. Costs and Non-Climate Benefits Summary (assuming 1.0 AEEI)

Scenario (no sinks)	**2010 Permit Price**	**2010 Resource Cost**	**2010 Monetized Benefits[1]**
10/97 Administration Position (6 gases, net-net sinks, 1990 by 2010, updated baseline)	$148/ton	$41 billion	$13 - 25 billion
Kyoto: No International Trading[2]	$171/ton	$51 billion	$15 - 29 billion
Full Annex I Trading	$48/ton	$22 billion	$4 - 8 billion
Umbrella excluding EU and Eastern Europe	$43/ton	$20 billion	$4 - 7 billion
Umbrella excluding EU	$26/ton	$13 billion	$2 - 4 billion
Annex I Trading + JI (JI = 20% worldwide trading)	$36/ton	$17 billion	$3 - 6 billion
Annex I Trading + Participation by Key Developing Countries	$20/ton	$10 billion	$2 - 3 billion
Annex I Trading + Full Worldwide Trading	$19/ton	$10 billion	$2 - 3 billion
Umbrella excluding EU + Full Worldwide Trading	$10/ton	$6 billion	$1 - 2 billion

A27b

[1] Benefits include reductions in local air pollutants, traffic accidents, and congestion.
[2] All subsequent cases evaluate the Kyoto Protocol.

Table 2. With accounting for sinks (assuming full Annex I trading)

Sinks Assumption	**2010 Permit Price**	**2010 Resource Cost**	**2010 Monetized Benefits**
No Sinks (U.S.: 0 MMTCE)	$48/ton	$22 billion	$4 - 8 billion
Half of Land Use Change and Forestry Sinks (U.S.: 52 MMTCE)	$26/ton	$12 billion	$2 - 4 billion
All of Land Use Change and Forestry Sinks (U.S.: 104 MMTCE)	$11/ton	$5 billion	$1 - 2 billion