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GLOBAL CLIMATE COALITION

July 2, 1997

The Honorable William J. Clinton
President
The White House
1600 Pennsylvania Avenue, N.W.
Washington, DC 20502

Dear Mr. President:

On behalf of the more than 60 national business organizations that make up the Global Climate Coalition, I am writing to express our disappointment and concern about the direction of your global climate policy as you enunciated it at the United Nations last week. Your remarks indicate a belief that the science is conclusive on the existence of human-induced climate change. That impression is reinforced by your more recent remarks suggesting that some damaging climate events over the past four or five years have been the result of greenhouse gas emissions. Mr. President, we believe that you have been seriously misinformed about the state of knowledge on this subject.

A U.S. position in the UN climate negotiations premised on such conclusions is at odds with the body of scientific knowledge expressed in the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and the views of established scientists that were published in the May 16 issue of the journal *Science*.

We agree that potential for human-induced climate change deserves serious attention. The Global Climate Coalition shares your view that a realistic policy is required and we have made suggestions that are likely to be supported by Congress and the American people. The United States has an enviable record of improving energy efficiency while leading the world in economic performance. Already U.S. industry has made significant progress in reducing the rate of emissions growth, largely through participation in Climate Action Plan programs initiated by your administration in 1993. We should not jeopardize our record of achievement by actions that are driven by political expediency rather than hardheaded analysis.

The Honorable William J. Clinton
Page Two
July 2, 1997

Any climate policy that is ultimately adopted will have global implications for decades to come. Therefore, it is imperative that there be a clear link to the scientific foundation that underpins it. Over the past few weeks eminent scientists have underscored the significant degree of uncertainty about the detection and attribution of climate change elucidated in the IPCC assessment. Indeed, recent modeled forecasts have not only reinforced the extent of uncertainty about the future changes in climate, but they also have revised downward the possible sea level rise and temperature increase in 2100 to perhaps as little as three inches and 1.5 degrees Celsius.

We believe that the most reasonable and defensible path forward will be guided by a U.S. policy that recognizes both the global and the long-term nature of the climate issue; recognizes that time properly used is an asset; and emphasizes investment in information to better inform policymakers of the costs and benefits associated with their decisions. Such a policy would increase research to reduce uncertainties; promote research and development of new technology; emphasize the diffusion of existing technology into developing countries; promote the economic turnover of our own capital stock; recognize different national circumstances; continue to promote voluntary initiatives to reduce greenhouse gas emissions; and balance greenhouse gas abatement activities with our national economic objectives.

You have expressed a desire to work with American business in addressing potential climate change. We stand ready to work to fashion a policy that will demonstrate both responsible action and protection of the nation's economic well being.

Yours truly,

A handwritten signature in black ink, appearing to read 'W. O'Keefe', written over a large, circular scribble.

William F. O'Keefe
Chairman



Global Climate Coalition
1275 K St. N.W.
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Washington, D.C. 20005
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July 3, 1997

The Vice President
Old Executive Office Building
Washington, DC 20501

Dear Mr. Vice President:

According to the June 26 issue of the Tennessean, you stated that "There is a small group that likes to spread dissension and skepticism" and that the skeptics of your views on global warming are like "tobacco executives who have a stake in saying that there's no problem at all. That's ... unethical."

Mr. Vice President, you are wrong on the science and it is demeaning to your office to resort to McCarthy-like tactics to advance your vision. Healthy debate is the hallmark of a free society; efforts to suppress it are not. You need look no further than the May 16 issue of Science to see that your views on the state of knowledge do not reflect the mainstream of scientific opinion.

Although the Global Climate Coalition does not share your views on the state of science and what it portends for the future, we do support responsible action to address the climate issue that does not expose our nation's economic well-being to needless risks.

Sincerely,

Gail McDonald
President



The Tennessean 6/26/97

Gore says environmental skeptics unethical

By HECTOR BECERRA
and JOE ROGERS

Staff Writers

Vice President Al Gore attacked skeptics of global warming last night, comparing them to tobacco executives who have a "stake in saying there's no problem at all."

Gore, in town for the Sixth Annual Family Re-Union Conference, spoke last night at Vanderbilt University to the Workshop on Climate Variability and Water Resource Management in the Southeast. The vice president described a planet on the verge of severe trauma — unless decisive steps are taken to counter the "greenhouse effect," which many scientists believe is leading to global warming.

"There is a small group that likes to spread dissension and skepticism, just like the big tobacco companies spent huge amounts of money telling tobacco smokers smoking is not

SCIENCE

"How can we say it's all right to create such a radical change on our planet's atmosphere? It's not all right."

VICE PRESIDENT AL GORE

bad for you," Gore said. "That's ridiculous and unethical."

"How can we say it's all right to create such a radical change on our planet's atmosphere? It's not all right."

In a victory for one of Gore's pet issues, President Clinton announced earlier that he would implement tougher Environmental Protection Agency standards for clean air.

John Gibbons, assistant to the president for science and technology, said the regional climate workshop is a step in a process toward understanding the implications of

climate variations.

"This is part of our attempt to raise consciousness broadly about what we do and don't know about these things," he said.

Gibbons said one of the challenges to the science and technology community is to make sure the advances in understanding are applied in other fields, such as agriculture.

"We aren't connecting the pieces yet," Gibbons said.

But Gore said the "pieces of the jigsaw puzzle" are more evident than before.

Bypassing his scheduled 7:35 p.m.

departure on Air Force II, Gore used graphs and charts to detail for the conference attendees a trend he said could result in catastrophic changes in the planet.

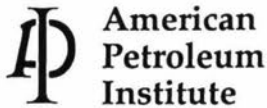
"We've got the technology, the entrepreneurs and the know-how to solve the problem. If we have will and desire, there's no question we can make things happen."

The series of regional workshops will lead to a national conference which itself will be a precursor to an international conference later this year, Gibbons said.

Among the major topics expected there is the greenhouse effect and what countries can mutually agree to do about it.

The problem is made worse by releases into the atmosphere from fossil fuel combustion, Gibbons said.

"It's especially a U.S. problem because we account for a fourth of all that's happening," he said.



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William F. O'Keefe
Executive Vice President

June 10, 1997

Dr. John H. Gibbons
Assistant to the President
for Science and Technology Policy
424 Old Executive Office Building
17th and Pennsylvania Avenue, NW
Washington, D.C. 20504

Dear Dr. Gibbons:

As a result of our recent discussion of climate change at the German Embassy, I have re-reviewed the study, *Changing by Degrees*, by the Office of Technology Assessment. Further, I am told that *Changing by Degrees* has been one of the more influential engineering studies on the feasibility of curbing CO₂ emissions. Nonetheless, neither *Changing by Degrees* nor any of the other similar studies demonstrate that Americans can substantially curb their use of fossil fuels (and, hence, their emissions of CO₂) at negligible economic cost. The costs of such curbs, in fact, would be substantial.

Like other technology-based studies, *Changing by Degrees* attempts to show that Americans—both at work and at home—waste substantial amounts of energy. Also, like the other studies, it then simply takes it for granted that government representatives are wise enough and can implement the right policy tools to eliminate the alleged massive waste, and thereby cut carbon emissions at an economic cost approaching zero. Assuming such perfection in the political marketplace is quite a leap of faith.

If Americans really do waste vast amounts of energy, the implications would be enormous—extending far beyond energy and CO₂ emissions. *Changing by Degrees* presents findings that strongly imply that economic reasoning and evidence do not apply to energy markets, no matter how well they may explain behavior in other markets. Since the U.S. economy is and has been one of the most robust on the world stage, Americans *must* be using labor, capital and raw materials extraordinarily well to compensate for their alleged incompetence in using energy. But, if Americans know how to use other resources well, why do their intelligence and talents fail them when burning a gallon of gasoline or using a kilowatt of electricity? No engineering study to date has offered an answer for such inconsistent economic behavior—or even acknowledged this larger issue.

More specifically, *Changing by Degrees* projects that by 2015 the U.S. industrial sector will emit 556 million metric tons of carbon, and then asserts that the adoption of cost-effective practices would reduce those emissions by 17 percent. OTA offers no explanation why profit-seeking U.S. industrial firms literally throw away billions of dollars annually, year after year, on needless energy use in an era of “downsizing” and cost-cutting. Surely, this anomaly deserves recognition and an explanation.

Economist Dr. Robert Hahn, of the American Enterprise Institute and Carnegie-Mellon University, and who has published extensively on government regulation, observes that regulatory agencies often claim “that it would be in the interest of firms to adopt [the agencies’ proposed] rules for purely economic reasons. Thus, the agencies effectively claim that firms are not maximizing profits without government intervention.” Dr. Hahn concludes that “one must be skeptical” of such claims since “companies are in the business of making money, while the government is not.”

Other findings in *Changing by Degrees* also raise important questions about the assumptions behind the study. For example:

- **What will be the consequences elsewhere in the economy if Americans start making the “correct” investments in energy-saving technology?** If Americans are not investing enough in energy-saving equipment, they must be spending too much money somewhere else. Dr. David Montgomery and his colleagues at Charles River Associates have found that, to finance the additional “cost effective” energy-saving investment, an implausibly large amount of money would have to be shifted away from other sorts of capital investment—thereby imposing substantial opportunity costs on the U.S. economy.
- **Why do consumers all make the *same* mistake: using too much energy?** Inherent human fallibility assures that it will never be cost-effective to attempt eliminating all mistakes—including all mistakes about energy use. However, while some mistakes are always to be expected, it is *not* realistic to believe that many millions of human beings will all make the *same* mistake—over and over again, decade after decade. Yet, this is what *Changing by Degrees* implies. Some people probably buy too much energy and others too little. As a consequence, total energy use in a world free of mistakes may not be that much different from what we observe in the real world. Furthermore, and most important, markets send signals and produce information. Why have not people learned from their mistakes and the pressures of competition?
- **How well can analysts measure the benefits and costs faced by energy users?** For instance, *Changing by Degrees* uses a discount rate of 7 percent to measure the cost of financing investments in energy-saving technologies. Since many (if not most) actual energy users use higher rates implicitly or explicitly in making investment decisions,

Changing by Degrees has undercounted the actual cost of making such investments and inferred “irrational” behavior when none may in fact exist. Furthermore, government intervention meant to improve energy efficiency will not change the financing costs faced by energy consumers. Also, OTA presumes that rational and cost-conscious energy users should expect higher energy prices. For instance, OTA assumes that the price of gasoline in 2015 will be \$1.85 a gallon in 1987 dollars, or about \$2.40 in 1995 dollars. It is interesting to note, however, that the U.S. Energy Information Administration’s *Annual Energy Outlook: 1997* projects the average U.S. retail gasoline price in 2015 at \$1.17 a gallon measured in 1995 dollars. Obviously, higher expected future energy prices make energy-saving technologies more attractive investments today—and OTA’s projected price for 2015 is more than twice that of EIA. While I have no idea whether a gallon of gasoline in 2015 will cost \$2.40, \$1.17 or something else, neither do the authors of *Changing by Degrees*. I will simply state for the record that the dominant long-term trend for the price of gasoline (and other fossil fuels), adjusted for inflation, has been *downward* during the 20th century. I note, too, that proved world reserves of crude oil are at historic levels—representing nearly a half century of supply at current rates of consumption. In light of these facts, energy users—rational and cost-conscious—could be expecting lower future energy prices than the authors of *Changing by Degrees*.

In short, *Changing by Degrees* and other engineering studies raise provocative questions about energy use—and, indeed, about how capitalist economies function in general—that deserve further study. However, these studies do not show that we should junk mainstream economic reasoning or that a vast reservoir of “free” energy savings exists for enlightened government policies to tap.

Indeed, besides violating both reason and experience, promises of a “free lunch” invite people to give short shrift to the enormously important scientific and policy issue of potential climate change. Without a clear grasp of the basic economics, we cannot expect the political system to produce a comprehensive, flexible and cost-effective climate policy.

Sincerely,

A handwritten signature in black ink, appearing to read "Will", with a long, sweeping underline that extends to the left and then curves back under the name.

William F. O'Keefe

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William F. O'Keefe
Executive Vice President

March 20, 1996

The Honorable Laura D'Andrea Tyson
Assistant to the President for Economic Policy
The White House
2nd Floor, West Wing
Washington, D.C. 20500

Dear Dr. Tyson:

In response to your request at our meeting on March 6, I have attached an API list of "Additional U.S. Actions to Address Greenhouse Gas Emissions".

I hope these ideas stimulate further White House discussion of this complex issue and that industry can continue to contribute in a positive way to the domestic and international climate change policymaking process.

Please call me if you would like further elaboration or clarification of the attached list. I look forward to opportunities in the future to continue the dialogue on the climate policy issue.

Thank you.

Sincerely,

A handwritten signature in black ink, appearing to read 'W. O'Keefe', written over a large, stylized circular flourish.

Enclosure

cc E. Holstein
E. Seidman
R. Brown

Additional U.S. Actions to Address Greenhouse Gas Emissions

U.S. industry recognizes the legitimate concerns about the potential long-term effects of increasing greenhouse gas emissions on the Earth's climate system. Increased energy efficiency reduces greenhouse emissions and most companies have sought to improve energy efficiency--and lower costs--since the 1970s. The EOP Group, for example, reported in 1993 that the U.S. achieved a 30 percent reduction in total energy consumption per unit of GDP from 1970 to 1990.

More recently, companies have launched their own initiatives or joined in government/industry voluntary programs aimed at limiting carbon dioxide, methane and other fossil fuel emissions, both in response to the Framework Convention on Climate Change, which entered into force on March 21, 1994, and to the U.S. Climate Change Action Plan that was released in October 1993. To date, while overall results of industry's efforts are positive, the magnitude remains uncertain, both because the greenhouse gas programs are so new and because the federal reporting system does not capture all private sector actions.

Some have responded to this uncertainty and to statements that we face catastrophic consequences if emissions are not reduced promptly by proposing policies and measures that would mandate substantial near-term emission reductions. This strategy is inconsistent with the current state of climate science and with a growing body of economic analyses. Current proposals for near-term emission reductions would be extremely harmful to the U.S. economy, reducing output, costing jobs and placing U.S. industry at a competitive disadvantage. Moreover, the only way to achieve such reductions in a 10-15 year timeframe is by a large energy tax.

A more productive approach would include the following actions:

- o government and industry cooperatively identify and assess cost-effective, flexible voluntary programs;
- o a policy and investment environment that would be conducive to increased private investment in new technologies and processes;
- o impediments to the economic turnover of energy-inefficient capital stock should be identified, reviewed and modified or removed;
- o tax rules should be reviewed to explore the possibility of fostering greater investment in new energy-efficient R&D; and,

- o an investment climate should be developed to encourage the export of U.S. energy-efficient technologies to developing nations.

The following list identifies several opportunities for government/industry cooperation.

o Identify, Expand and Report Cost-Effective Near-Term Actions

- work with government to expand vehicle scrappage programs aimed at reducing emissions from older vehicles
- work with government officials to identify, assess and expand the most cost-effective programs within the U.S. Climate Change Action Plan
- ensure intellectual property rights and patents protection for climate change technologies and discoveries
- remove impediments to the voluntary reporting of company programs and public/private programs aimed at limiting emissions

o Stabilize the Policymaking and Investment Environment

- focus funding of policy-relevant research on reducing major uncertainties about the climate system and on improving the accuracy of climate models, particularly with respect to possible regional impacts, and the role of oceans, clouds and water vapor
- encourage private investment in climate change research
- encourage corporations to include climate change considerations in their long-range business plans

o Accelerate Capital Stock Turnover

- reduce corporate tax rate
- revise depreciation rules to remove any disincentives to the early retirement of energy-intensive equipment and facilities

- change regulations that now discourage capital stock turnover (e.g., Superfund and impediments in the Clean Air Act to new investments)

o Stimulate Investment in Climate Change R&D

- explore the desirability of incentives aimed at increasing private sector R&D in energy-efficient technologies
- request the Treasury Department identify tax barriers that discourage investment in new energy-efficient R&D technologies and processes
- identify ways to encourage corporations to review current R&D plans and budgets and to consider enhancing investments in new energy-efficient technologies and processes
- explore ways to identify promising private technologies and whether accelerated commercialization would help limit greenhouse gas emissions

o Strengthen Climate Change Technology Investment Abroad

- take steps to remove "additionality" as a criteria for "Joint Implementation" activities
- work with international bodies to broaden "sovereign risk insurance" to cover political and other risks to foreign direct investment in technologies aimed at reducing greenhouse gas emissions
- examine export restrictions to see if any unnecessarily constrain the export of U.S. climate technologies
- work with foreign governments to increase direct investment opportunities in a way that provides an opportunity to earn an adequate return on investment
- protect intellectual property rights and patents on technologies transferred

U.N. CLIMATE CHANGE NEGOTIATIONS

The U.S. government is involved in United Nations negotiations pursuant to the "Berlin Mandate" for an amendment to the Rio Treaty on Climate Change. The Rio Treaty committed the United States and other nations to voluntarily stabilize carbon emissions at 1990 levels by the year 2000. Current negotiations are aimed at mandatory reductions below 1990 levels after the year 2000.

The Berlin Mandate specifically excludes developing nations from emission reduction requirements while legally binding the United States to future emission reductions. By exempting developing nations from any future commitments, the Berlin Mandate ensures that there will be no meaningful worldwide effort to stabilize atmospheric concentrations of carbon dioxide.

We believe the parties to the Rio Treaty made a fundamental error when they agreed to negotiate legally-binding carbon restrictions on the United States and other industrialized countries, while simultaneously agreeing to exempt high-growth developing countries like China, Mexico, Brazil and Korea from any new carbon reduction commitments. As much as 60 percent of global carbon emissions are expected to come from such countries in the next few decades, with China becoming the single-largest emitter in the near future. The exclusion of new commitments by developing nations under the Berlin Mandate will create a powerful incentive for transnational corporations to export jobs, capital, and pollution, and will do little or nothing to stabilize atmospheric concentrations of carbon. Such an uneven playing field will cause the loss of high-paying U.S. jobs in the mining, manufacturing, transport and other sectors.

Carbon taxes, or equivalent carbon emission trading programs, will raise significantly electricity and other energy prices to consumers. These taxes are highly regressive and will be most harmful to citizens who live on fixed incomes or work at poverty-level wages.

As corporations shut down domestic factories, mines and mills as a result of higher energy costs, they will have additional incentives, beyond the search for cheap labor and anti-labor regulatory regimes, to locate new capacity off-shore, in countries with no carbon reduction commitments. Carbon emissions, therefore, will be transferred to the developing world along with the jobs, thus providing no real benefit to the environment.

The U.S. government has not completed a thorough economic analysis of the effects of a treaty amendment on the U.S. economy, even though U.S. negotiators have been at the bargaining table for over 18 months and have agreed to a December 1997 deadline for reaching agreement on this far-reaching treaty amendment.

The AFL-CIO Executive Council calls upon the responsible agencies of the U.S. government to provide it and its affiliates with any existing studies of the economic impact of future treaty obligations and, further, make available the results of the economic modeling effort currently being undertaken by the government within 30 days of completion.

The AFL-CIO Executive Council further urges that in the ongoing negotiations to amend the Rio Treaty on climate change, the United States insist upon the incorporation of appropriate commitments from all nations to reduce carbon emissions; and seek a reduction schedule compatible with the urgent need to avoid unfair and unnecessary job loss in developed economies. The President should not accept and the Congress should not ratify any amendment or protocol that does not meet these standards.

III

105TH CONGRESS
1ST SESSION**S. RES. 98**

Expressing the sense of the Senate regarding the conditions for the United States becoming a signatory to any international agreement on greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

IN THE SENATE OF THE UNITED STATES

JUNE 12, 1997

Mr. BYRD (for himself, Mr. HAGEL, Mr. HOLLINGS, Mr. CRAIG, Mr. INOUE, Mr. WARNER, Mr. FORD, Mr. THOMAS, Mr. DORGAN, Mr. HELMS, Mr. LEVIN, Mr. ROBERTS, Mr. ABRAHAM, Mr. MCCONNELL, Mr. ASHCROFT, Mr. BROWNBACK, Mr. KEMPTHORNE, Mr. THURMOND, Mr. BURNS, Mr. CONRAD, Mr. GLENN, Mr. ENZI, Mr. INHOFE, Mr. BOND, Mr. COVERDELL, Mr. DEWINE, Mrs. HUTCHISON, Mr. GORTON, Mr. HATCH, Mr. BREAUX, Mr. CLELAND, Mr. DURBIN, Mr. HUTCHINSON, Mr. JOHNSON, Ms. LANDRIEU, Ms. MIKULSKI, Mr. NICKLES, Mr. SANTORUM, Mr. SHELBY, Mr. SMITH of Oregon, Mr. BENNETT, Mr. FAIRCLOTH, Mr. FRIST, Mr. GRASSLEY, Mr. ALLARD, and Mr. MURKOWSKI) submitted the following resolution; which was referred to the Committee on Foreign Relations

RESOLUTION

Expressing the sense of the Senate regarding the conditions for the United States becoming a signatory to any international agreement on greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

Whereas the United Nations Framework Convention on Climate Change (in this resolution referred to as the "Con-

vention"), adopted in May 1992, entered into force in 1994 and is not yet fully implemented;

Whereas the Convention, intended to address climate change on a global basis, identifies the former Soviet Union and the countries of Eastern Europe and the Organization For Economic Co-operation and Development (OECD), including the United States, as "Annex I Parties", and the remaining 129 countries, including China, Mexico, India, Brazil, and South Korea, as "Developing Country Parties";

Whereas in April 1995, the Convention's "Conference of the Parties" adopted the so-called "Berlin Mandate";

Whereas the "Berlin Mandate" calls for the adoption, as soon as December 1997, in Kyoto, Japan, of a protocol or another legal instrument that strengthens commitments to limit greenhouse gas emissions by Annex I Parties for the post-2000 period and establishes a negotiation process called the "Ad Hoc Group on the Berlin Mandate";

Whereas the "Berlin Mandate" specifically exempts all Developing Country Parties from any new commitments in such negotiation process for the post-2000 period;

Whereas although the Convention, approved by the United States Senate, called on all signatory parties to adopt policies and programs aimed at limiting their greenhouse gas (GHG) emissions, in July 1996 the Undersecretary of State for Global Affairs called for the first time for "legally binding" emission limitation targets and timetables for Annex I Parties, a position reiterated by the Secretary of State in testimony before the Committee on Foreign Relations of the Senate on January 8, 1997;

Whereas greenhouse gas emissions of Developing Country Parties are rapidly increasing and are expected to surpass emissions of the United States and other OECD countries as early as 2015;

Whereas the Department of State has declared that it is critical for the Parties to the Convention to include Developing Country Parties in the next steps for global action and, therefore, has proposed that consideration of additional steps to include limitations on Developing Country Parties' greenhouse gas emissions would not begin until after a protocol or other legal instrument is adopted in Kyoto, Japan in December 1997;

Whereas the exemption for Developing Country Parties is inconsistent with the need for global action on climate change and is environmentally flawed; and

Whereas the Senate strongly believes that the proposals under negotiation, because of the disparity of treatment between Annex I Parties and Developing Countries and the level of required emission reductions, could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof: Now, therefore, be it

1 *Resolved*, That it is the sense of the Senate that—

2 (1) the United States should not be a signatory

3 to any protocol to, or other agreement regarding, the

4 United Nations Framework Convention on Climate

5 Change of 1992, at negotiations in Kyoto in Decem-

6 ber 1997, or thereafter, which would—

4

1 (A) mandate new commitments to limit or
2 reduce greenhouse gas emissions for the Annex
3 I Parties, unless the protocol or other agree-
4 ment also mandates new specific scheduled
5 commitments to limit or reduce greenhouse gas
6 emissions for Developing Country Parties with-
7 in the same compliance period, or

8 (B) would result in serious harm to the
9 economy of the United States; and

10 (2) any such protocol or other agreement which
11 would require the advice and consent of the Senate
12 to ratification should be accompanied by a detailed
13 explanation of any legislation or regulatory actions
14 that may be required to implement the protocol or
15 other agreement and should also be accompanied by
16 an analysis of the detailed financial costs and other
17 impacts on the economy of the United States which
18 would be incurred by the implementation of the pro-
19 tocol or other agreement.

20 SEC. 2. The Secretary of the Senate shall transmit
21 a copy of this resolution to the President.

○

**COSPONSORS OF SENATE RESOLUTION 98
THE BYRD-HAGEL RESOLUTION ON GLOBAL CLIMATE**

DEMOCRATS

Akaka (D-HA)
Breaux (D-LA)
Bryan (D-NV)
Byrd (D-WV)
Cleland (D-GA)
Conrad (D-ND)
Dorgan (D-ND)
Durbin (D-IL)
Ford (D-KY)
Glenn (D-OH)
Hollings (D-SC)
Inouye (D-HI)
Johnson (D-SD)
Landrieu (D-LA)
Levin (D-MI)
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Mosely-Braun (D-IL)
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Allard (R-CO)
Ashcroft (R-MO)
Bennet (R-UT)
Bond (R-MO)
Brownback (R-KS)
Burns (R-MT)
Campbell (R-CO)
Coats (R-IN)
Cochran (R-MS)
Coverdale (R-GA)
Craig (R-ID)
DeWine (R-OH)
Domenici (R-NM)
Enzi (R-WY)
Faircloth (R-NC)
Frist (R-TN)
Gorton (R-WA)
Gramm (R-TX)
Grams (R-MN)
Grassley (R-IA)
Hagel (R-NE)
Hatch (R-UT)
Helms (R-NC)
Hutchinson (R-AR)
Hutchison (R-TX)
Inhofe (R-OK)
Kempthorne (R-ID)
Lott (R-MS)
Lugar (R-IN)
Mack (R-FL)
McConnell (R-KY)
Murkowski (R-AK)
Nickles (R-OK)
Roberts (R-KS)
Santorum (R-PA)
Sessions (R-AL)
Shelby (R-AL)
Smith (R-NH)
Smith (R-OR)

Specter (R-PA)
Stevens (R-AK)
Thomas (R-WY)
Thompson (R-TN)
Thurmond (R-SC)
Warner (R-VA)

Economic Baselines for Climate Policymakers

Emissions Scenarios

- U.S. emissions would have to drop 21% to return 2010 emissions to 1990 levels. (1997 U.S. Climate Action Report data: 1458 tons in 1990, 1834 tons in 2010)
- U.S. emissions would have to drop 32% to meet the EU proposal of 15% lower than 1990 levels by 2010. (Ibid: 15% reduction in 2010 would reduce U.S emissions to 1239 tons)

Population Data

- U.S. population is projected to grow 29% between 1990 and 2025, compared to less than 1% in the EU and Japan. (World Bank, *World Development Report*, 1992 and 1994)

Economic Studies

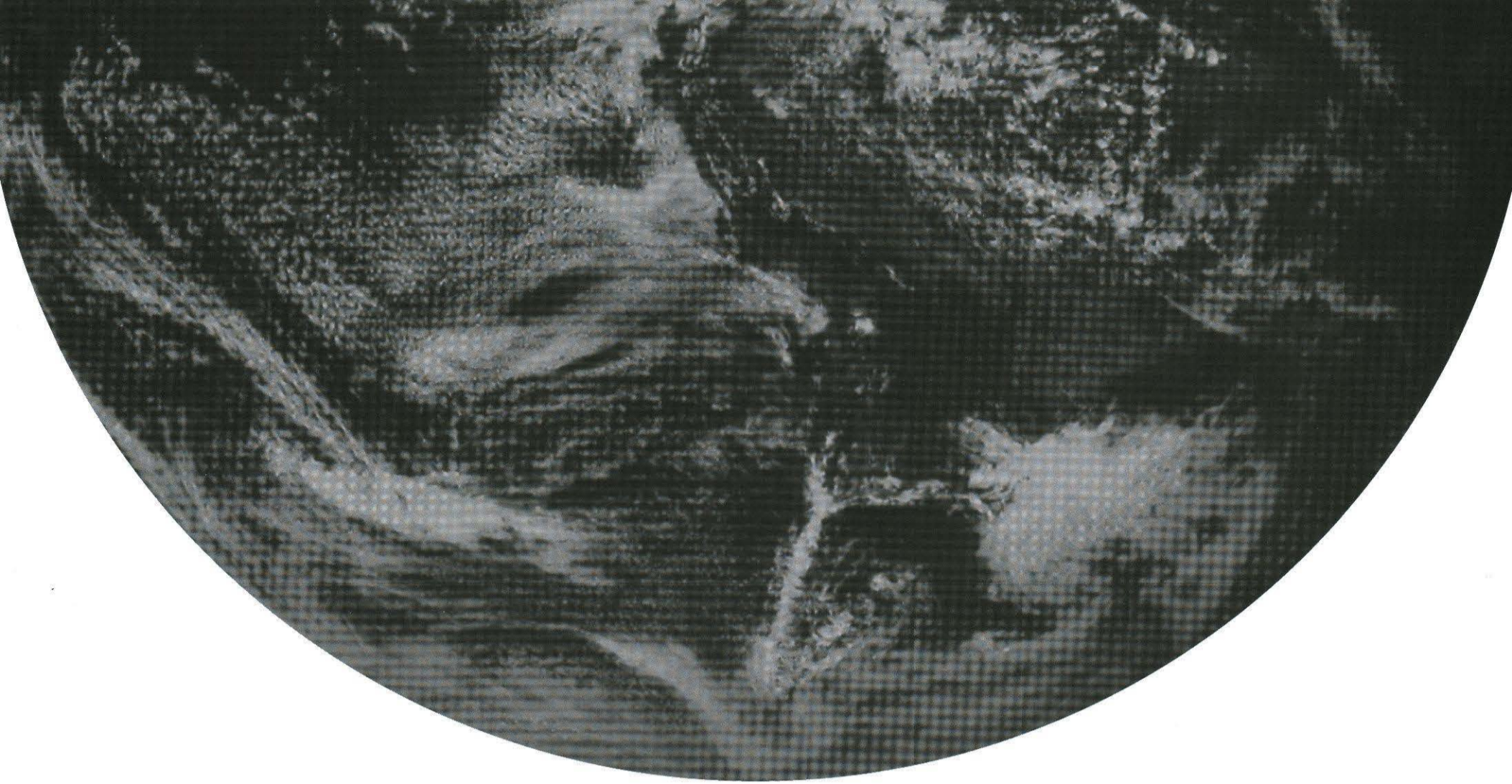
- \$125-\$200/metric ton tax is needed to return 2010 U.S. emissions to 1990 levels. (Charles River Associates, MIT, DRI, U.S. Energy Information Administration)
- The annual impact of a tax this size includes the following losses:
 - \$100 to \$275 billion in GDP
 - 200,000 to 500,000 U.S. jobs
 - \$65-100 billion in fixed business investment
 - \$50-110 billion drop in consumer purchases
- A global carbon tax greater than \$6/ton will cause more economic damage than it will prevent. (William D. Nordhaus, "A Regional Dynamic General-Equilibrium Model of Alternative Climate Change Strategies", *The American Economic Review*, September 1996)
- Dr. Jorgenson and Nordhaus, who sponsored a petition signed by 2,400 economists, agreed at a recent American Enterprise Institute forum that near-term reductions in fossil fuel use are not needed. (April 17, 1997 AEI transcript)

Technology and Energy Efficiency Gains

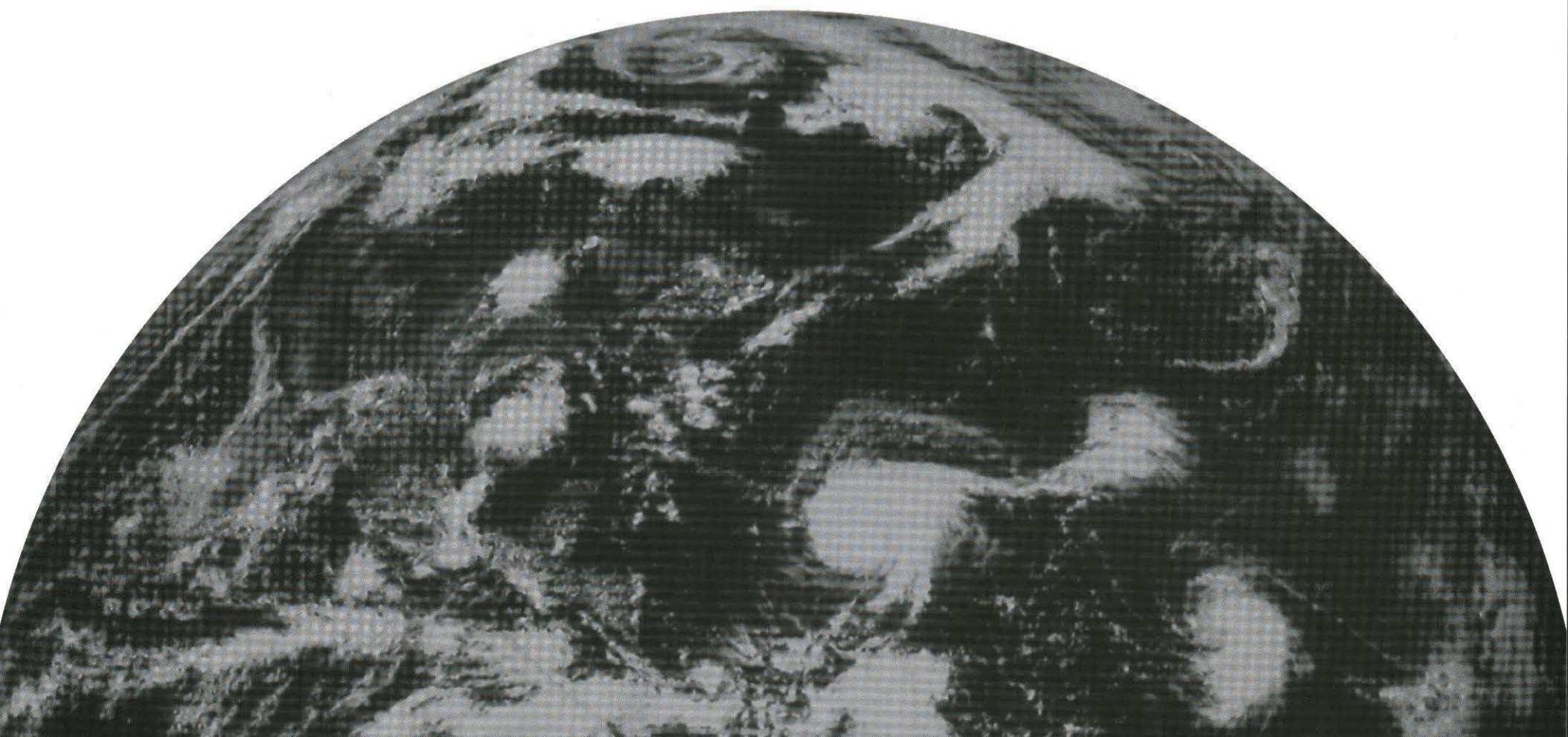
- Today, fossil fuels provide over 80% of U.S. energy needs; solar, wind and geothermal provide 0.64%. The balance is provided by nuclear (10%), hydro (4.5%) and biomass(4%). (1997 U.S. Climate Action Report—draft report)
- Technology provides no "free lunch" for reducing emissions. (W. David Montgomery, "No Free Lunch: A Review of Technology-Based Studies on Costs of Controlling Carbon Emissions," DRI/McGraw-Hill, July 1993)
- Technology R&D, the gradual replacement of existing stock and meaningful participation by developing nations, provides the best long-term climate strategy.

References

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**HOW DO YOU
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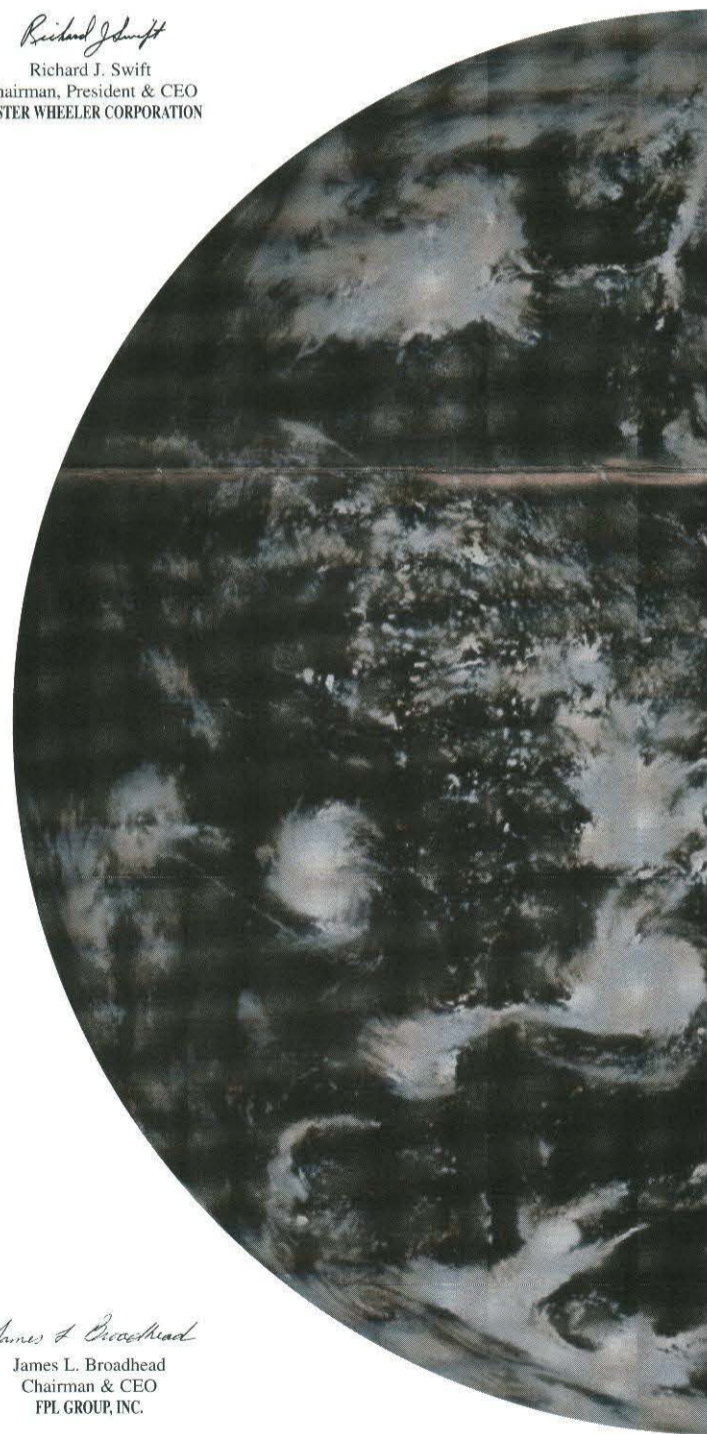
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WE'RE COMMITTED TO A HEALTHY EN

Later this year, the Clinton/Gore administration must decide whether to sign an international climate treaty designed to reduce greenhouse gas emissions. So far there has been little public debate on the treaty even though it could have a dramatic effect on the way we live and work here. At The Business Roundtable, we have a responsibility to ensure future generations will have a healthy economy and enjoy an ever-improving standard of living. We must do both with a balanced approach.

But a balanced approach is only possible with careful study, input from a wide variety of sources, and extensive public debate. We have analyzed the consequences of the treaty proposals have been thoroughly analyzed. Americans should have the opportunity to voice their opinion.

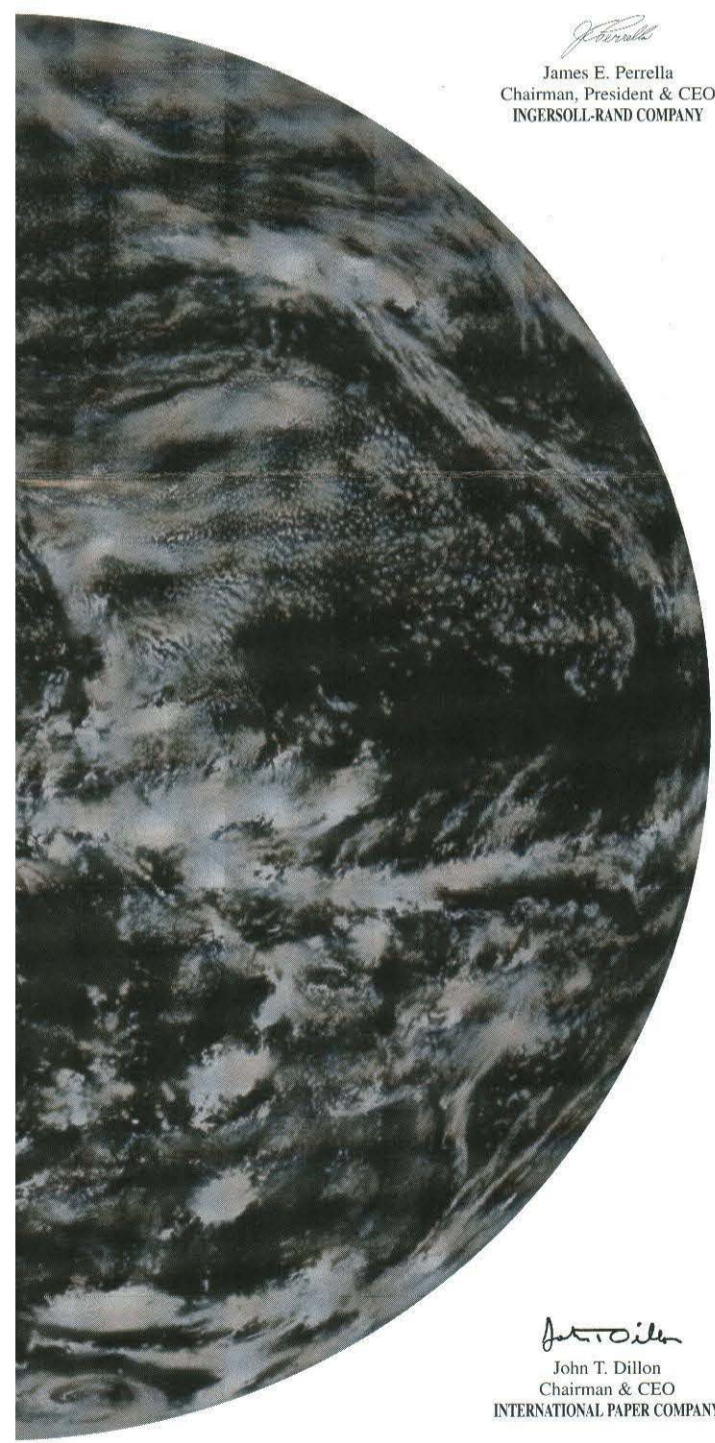
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ENVIRONMENT AND A HEALTHY ECONOMY.

The potential dangers of global warming. It may be the most important economic decision of this century and the next as well. In the United States. The lack of public debate means important questions about the impact of the treaty have not been addressed. Our rising standard of living. We have an equal responsibility to protect our environment for future generations. We believe it's possible to strongly urge the Clinton/Gore administration not to rush to policy commitments until the environmental benefits and economic costs of this important debate.



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Greenhouse Forecasting Still Cloudy

An international panel has suggested that global warming has arrived, but many scientists say it will be a decade before computer models can confidently link the warming to human activities

The headlines a year and a half ago positively brimmed with assurance: "Global Warming: No Longer in Doubt," "Man Adversely Affecting Climate, Experts Conclude," "Experts Agree Humans Have 'Discernible' Effect on Climate," "Climate Panel Is Confident of Man's Link to Warming." The official summary statement of the UN-sponsored Intergovernmental Panel on Climate Change (IPCC) report that had prompted the headlines seemed reasonably confident, too: "... the balance of evidence suggests that there is a discernible human influence on global climate." But as negotiators prepare to gather in Bonn in July to discuss a climate treaty that could require nations to adopt expensive policies for limiting their emissions of carbon dioxide and other greenhouse gases, many climate experts caution that it is not at all clear yet that human activities have begun to warm the planet—or how bad greenhouse warming will be when it arrives.

What had inspired the media excitement was the IPCC's conclusion that the half-degree rise in global temperature since the late 19th century may bear a "fingerprint" of human activity. The patchy distribution of the warming around the globe looks much like the distinctive pattern expected if the heat-trapping gases being poured into the atmosphere were beginning to warm the planet, the report said. But IPCC scientists now say that neither the public nor many scientists appreciate how many if's, and's, and but's peppered the report. "It's unfortunate that many people read the media hype before they read the [IPCC] chapter" on the detection of greenhouse warming, says climate modeler Benjamin Santer of Lawrence Livermore National Laboratory in Livermore, California, the lead author of the chapter. "I think the caveats are there. We say quite clearly that few scientists would say the attribution issue was a done deal."

Santer and his IPCC colleagues' overriding reason for stressing the caveats is their understanding of the uncertainty inherent in

computer climate modeling. The models are key to detecting the arrival of global warming, because they enable researchers to predict how the planet's climate should respond to increasing levels of greenhouse gases. And while predicting climate has always been an uncertain business, some scientists assert that developments since the IPCC completed its report have, if anything, magnified the uncertainties. "Global warming is definitely a threat as greenhouse-gas levels increase," says climate modeler David Rind of NASA's Goddard Institute for Space Studies (GISS) in New York City, "but I



Rough approximation. Models can't reproduce clouds, but they incorporate some cloud effects, including those of water (white) in the atmosphere, seen in the above model output.

myself am not convinced that we have [gained] greater confidence" in recent years in our predictions of greenhouse warming. Says one senior climate modeler who prefers not to enter the fray publicly: "The more you learn, the more you understand that you don't understand very much." Indeed, most modelers now agree that the climate models will not be able to link greenhouse warming unambiguously to human actions for a decade or more.

The effort to simulate climate in a computer faces two kinds of obstacles: lack of computer power and a still very incomplete picture of how real-world climate works. The climate forecasters' basic strategy is to build a mathematical model that recreates global climate processes as closely as possible, let the model run, and then test it by comparing the results to the historical climate record. But even with today's powerful supercomputers, that is a daunting challenge, says modeler Michael Schlesinger of the University of Illinois, Urbana-Champaign:

"In the climate system, there are 14 orders of magnitude of scale, from the planetary scale—which is 40 million meters—down to the scale of one of the little aerosol particles on which water vapor can change phase to a liquid [cloud particle]—which is a fraction of a millionth of a millimeter."

Of these 14 orders of magnitude, notes Schlesinger, researchers are able to include in their models only the two largest, the planetary scale and the scale of weather disturbances: "To go to the third scale—which is [that of thunderstorms] down around 50-kilometers resolution—we need a computer

a thousand times faster, a teraflops machine that maybe we'll have in 5 years." And including the smallest scales, he says; would require 10^{36} to 10^{37} more computer power. "So we're kind of stuck."

To get unstuck, modelers "parameterize" smaller scale processes known to affect climate, from the formation of clouds to the movement of ocean eddies. Because they can't model, say, every last cloud over North America, modelers specify the tempera-

tures and humidities that will spawn different types of clouds. If those conditions hold within a single grid box—the horizontal square that represents the model's finest level of detail—the computer counts the entire area as cloudy. But as modelers point out, the grid used in today's models—typically a 300-kilometer square—is still very coarse. One over the state of Oregon, for instance, would take in the coastal ocean, the low coast ranges, the Willamette Valley, the high Cascades, and the desert of the Great Basin.

Having the computer power to incorporate into the models a more detailed picture of clouds wouldn't eliminate uncertainties, however, because researchers are still hotly debating the overall impact of clouds on future climate. In today's climate, the net effect of clouds is to cool the planet—although they trap some heat, they block even more by reflecting sunlight back into space. How that balance would change under greenhouse warming, no one knows. A few years ago, a

Model Gets It Right—Without Fudge Factors

Climate modelers have been "cheating" for so long it's almost become respectable. The problem has been that no computer model could reliably simulate the present climate. Even the best simulations of the behavior of the atmosphere, ocean, sea ice, and land surface drift off into a climate quite unlike today's as they run for centuries. So climate modelers have gotten in the habit of fiddling with fudge factors, so-called "flux adjustments," until the model gets it right.

No one liked this practice (*Science*, 9 September 1994, p. 1528). "If you can't simulate the present without arbitrary adjustments, you have to worry," says meteorologist and modeler David Randall of Colorado State University (CSU) in Fort Collins. But now there's a promising alternative. Thirty researchers at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, have developed the first complete model that can simulate the present climate as well as other models do, but without flux adjustments. The new NCAR model, says Randall, "is an important step toward removing some of the uneasiness people have about trusting these models to make predictions of future climate" (see main text).

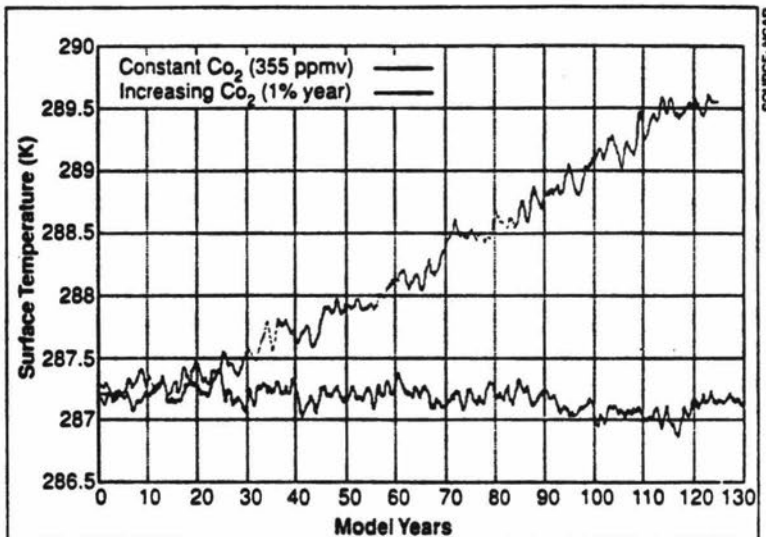
The NCAR modelers built a host of refinements into their new Climate System Model (CSM). But the key development, says CSM co-chair Byron Boville, was finding a better way to incorporate the effects of ocean eddies, swirling pools of water up to a couple of hundred kilometers across that spin off strong currents. Climate researchers have long known that the eddies, like atmospheric storms, help shape climate by moving heat around the planet. But modelers have had a tough time incorporating them into their simulations because they are too small to show up on the current models' coarse geographic grid. The CSM doesn't have a finer mesh, but it does include a new "parameterization" that passes the effects of these unseen eddies onto larger model scales, using a more realistic means of mixing heat through the ocean than any earlier model did, says Boville.

Even when run for 300 model "years," the CSM doesn't drift away from a reasonably realistic climate, says NCAR's Climate and Global Dynamics director Maurice Blackmon. "Being able to do this without flux corrections gives you more credibility," he says. "For better or worse, we're not biasing the results as was necessary before."

The first results from this still vastly simplified model imply that future greenhouse warming may be milder than some other models have suggested—and could take decades to reveal itself. Doubling atmospheric carbon dioxide concentrations in the model raised the global temperature 2 degrees Celsius, which puts

the model's sensitivity to greenhouse gases near the low end of current estimates. Based on an array of different models and other considerations, the UN-sponsored Intergovernmental Panel on Climate Change estimated in 1995 that a carbon dioxide doubling could raise global temperatures by as much as 4.5°C; their best guess was 2.5°C.

A 300-year run without any increase in greenhouse gases produced slow, natural variations in global temperature of about 0.5°C. If the real climate behaves the same way, "two-thirds to three-quarters of the [temperature variations of the] last 130 years



Drift-free. The NCAR model, which suggests that Earth will warm moderately (red), can reliably simulate present climate (blue).

can be explained as natural variation," says Blackmon. That would make the detection of a modest-size greenhouse warming all the more difficult.

The CSM is available on the Internet, but Blackmon warns that if you want to check out future climate scenarios, you'll "need the biggest supercomputer you can get." Indeed, even NCAR researchers haven't been able to experiment with the model on as large a computer as they would like. While their purchase of an NEC SX4 computer is tied up in a trade dispute with Japan (*Science*, 30 August 1996, p. 1177), they are making do with a leased Cray C-90 with perhaps 20% of the speed of the SX4. That worries some modelers. Americans have "been among the leaders of the field from the beginning," says CSU's Randall, but "if we can't get access to the most powerful machines, we are going to be left behind."
—R.A.K.

leading climate model—developed at the British Meteorological Office's Hadley Center for Climate Prediction and Research, in Bracknell—predicted that an Earth with twice the preindustrial level of carbon dioxide would warm by a devastating 5.2 degrees Celsius. Then Hadley Center modelers, led by John Mitchell, made two improvements to the model's clouds—how fast precipitation fell out of different cloud types and how sunlight and radiant heat interacted with

clouds. The model's response to a carbon dioxide doubling dropped from 5.2°C to a more modest 1.9°C.

Other models of the time also had a wide range of sensitivities to carbon dioxide, largely due to differences in the way their clouds behaved. That range of sensitivity has since narrowed, says modeler and cloud specialist Robert Cess of the State University of New York, Stony Brook, but "the [models] may be agreeing now simply because they're

all tending to do the same thing wrong. It's not clear to me that we have clouds right by any stretch of the imagination."

Nor are clouds the only question mark in researchers' picture of how climate works. Modelers saw for the first time the fingerprint of global warming when they folded an additional process into the models: the effect of pollutant hazes on climate. Wind-blown soil and dust, particles from the combustion of fossil fuels, and ash and soot from

agricultural burning all reflect sunlight—shading and cooling the surface beneath them. Including this aerosol effect in four independent climate models at three centers—Livermore, the Hadley Center, and the Max Planck Institute for Meteorology (MPI) in Hamburg, Germany—produced geographic patterns of temperature changes that resembled those observed in the real world over the past few decades, such as the greater warming of land than ocean.

Fingerprinting work since then has only strengthened the confidence of IPCC's more confident scientists that greenhouse warming has arrived. "I've worked with the models enough to know they're not perfect, but we keep getting the same answer," says Tim P. Barnett, a climatologist at the Scripps Institution of Oceanography in La Jolla, California, and a co-author of the IPCC chapter. Another climatologist and IPCC contributor, Gerald North of Texas A&M University in College Station, is similarly heartened. "I'm pretty optimistic about climate modeling. ... I don't know anybody doing [fingerprinting] who is not finding the same result."

But the assumptions about how hazes affect climate may have taken a hit recently from climatologist and modeler James Hansen of NASA's GISS—the man who told Congress in 1988 that he believed "with a high degree of confidence" that greenhouse warming had arrived. In a recent paper, Hansen and his GISS colleagues pointed out that recent measurements suggest that aerosols don't just cool; they also warm the atmosphere by absorbing sunlight. The net effect of this reflection and absorption, Hansen estimates, would be small—too small to have much effect on temperature.

Hansen and his colleagues conclude that aerosols probably do have a large effect on climate, but indirectly, through clouds. By increasing the number of droplets in a cloud, aerosols can amplify the reflectivity of clouds, and thus may have an overall cooling effect on the atmosphere. If true, this would greatly complicate the modelers' work, because meteorologists are only just starting to understand how efficiently particles of different sizes and compositions modify clouds. "I used to think of clouds as the Gordian knot of the problem," says cloud specialist V. Ramanathan of Scripps. "Now I think it's the aerosols. We are arguing about everything."

And the complications don't stop with the multiplication of aerosol effects, accord-

ing to Christopher Folland of the Hadley Center. Folland and his colleagues have been trying to sort out what was behind the intermittent warming of recent decades, which in the third quarter of the century was more rapid in the Southern than Northern Hemisphere. Earlier work by Santer and a dozen other colleagues showed an increasing resemblance between the observed pattern of warming through 1987, the end of their temperature record, and the results of a model run that incorporated aerosol effects. The researchers suggested that the North's more abundant pollutant aerosols could have been moderating the warming there from greenhouse gases. But when Folland



Crucial component. Thunderstorms like the one above help to shape climate by lofting heat and moisture.

compared the results of his model run with a longer, more recent temperature record, the resemblance that had been building into the 1980s faded by the early 1990s. Contrarian Patrick Michaels of the University of Virginia, Charlottesville, also has pointed out this trend.

The Hadley model suggests that "there appears to be more than one reason" for the variations, says Folland. The waning of aerosols as pollution controls took effect probably helped the North catch up, he says, but so did natural shifts in atmospheric circulation that tended to warm the continents (*Science*, 7 February, p. 754). Most provocatively, Folland and his colleagues are suggesting that a shift in North Atlantic Ocean circulation that has tended to warm the region also has contributed. "There's no doubt," says Santer, "that multiple natural and anthropogenic factors can contribute, and probably have, to the interhemispheric temperature contrast. ... We've learned something about detection."

All of which only adds to the skepticism of scientists who might be called the "silent doubters": meteorologists and climate modelers who rarely give voice to their concerns and may not have participated even peripherally in the IPCC. "There really isn't a per-

suasive case being made" for detection of greenhouse warming, argues Brian Farrell of Harvard University, who runs models to understand climate change in the geologic past. Farrell has no quarrel with the IPCC chapter on detecting greenhouse warming, but he says the executive summary did not "convey the real uncertainties the science has." He further contends that if IPCC scientists had had real confidence in their assertion that global warming had arrived, they would have stated with more precision how sensitive the climate system is to greenhouse gases. But the IPCC left the estimate of the warming from a doubling of carbon dioxide at 1.5°C to 4.5°C, where it has been for 20 years. "That's an admission that the error bars are as big as the signal," says Farrell.

Climate modeler Max Suarez of NASA's Goddard Space Flight Center in Greenbelt, Maryland, agrees that it's "iffy" whether the match between models and temperature records is close enough to justify saying that greenhouse warming is already under way. "Especially if you're trying to explain the very small [temperature] change we've seen already," he says, "I certainly wouldn't trust the models to that level of detail yet."

Rather than dwelling on model imperfections, IPCC co-author Barnett emphasizes some of the things that current models are doing fairly well—simulating present and past climates and the changing seasons, predicting El Niño a year ahead, and producing good simulations of decades-long climate variations. But he agrees that too much confidence has been read into the IPCC summary statement. "The next 10 years will tell; we're going to have to wait that long to really see," he says. Klaus Hasselmann of the MPI also sees a need to wait. He and his colleagues "think we can see the [greenhouse warming] signal now with 97% confidence." But, as North notes, "all that assumes you knew what you were doing to start with" in building the models. Hasselmann has faith in his model but recognizes that his faith is not universally shared. "The signal is not so much above the noise that you can convince skeptics," he observes. "It will take another decade or so to work up out of the noise."

That's no excuse for complacency, many climate scientists say. Basic theory, this century's warming, and geologic climate records all suggest that increasing carbon dioxide will warm the planet. "I'd be surprised if that went away," says Suarez, as would most climate researchers. North suggests that while researchers are firming up the science, policy-makers could inaugurate "some cautious things" to moderate any warming. The last thing he and his colleagues want is a rash of headlines saying the threat is over.

—Richard A. Kerr

SPECIAL REPORT

May 1997

Climate Change Policy: What Action Should We Take?

by Margo Thorning*

Over the past decade and a half, the ACCF Center for Policy Research has sponsored groundbreaking research on tax and environmental policies to encourage capital formation and enhance environmental quality. As the United States stands poised to agree in Kyoto, Japan in December of 1997 to limit future carbon emissions, the Center offers this Special Report to help focus the climate debate.

Under the Framework Convention on Climate Change signed in Rio de Janeiro in 1992, the United States has agreed to negotiate an international treaty on future greenhouse gas emissions without, according to many experts, careful evaluation of this many-sided issue. The experts believe that the agreement that the United States is poised to sign in Japan has potentially serious consequences for all Americans, and these consequences have not been fully analyzed and understood.

The release earlier this year of a letter signed by 2,300 members of the 20,000-member American Economic Association in support of carbon taxes or the auctioning of emission permits to reduce U.S. carbon dioxide (CO₂) emissions could lead some policymakers, as well as the average citizen, to believe that all the environmental and economic questions about climate change policies have been settled. This is not the case. Significant doubts remain in the academic and think-tank community about the wisdom of the United States signing a binding agreement to stabilize or reduce future CO₂ emissions.

ECONOMIC IMPACT OF BINDING EMISSION LIMITS

Research conducted over the past decade by top climate change scholars such as Professor Richard Schmalensee of the Massachusetts Institute of Technology, Professor Alan S. Manne of Stanford University, Dr. Richard Richels of the Electric Power Research Institute, Dr. W. David Montgomery of Charles River Associates, and Dr. Lawrence M. Horwitz of Primark Decision Economics, concludes that the cost of stabilizing CO₂ emissions would impose a heavy burden on U.S. households and industry. For example, Dr. Horwitz's analysis

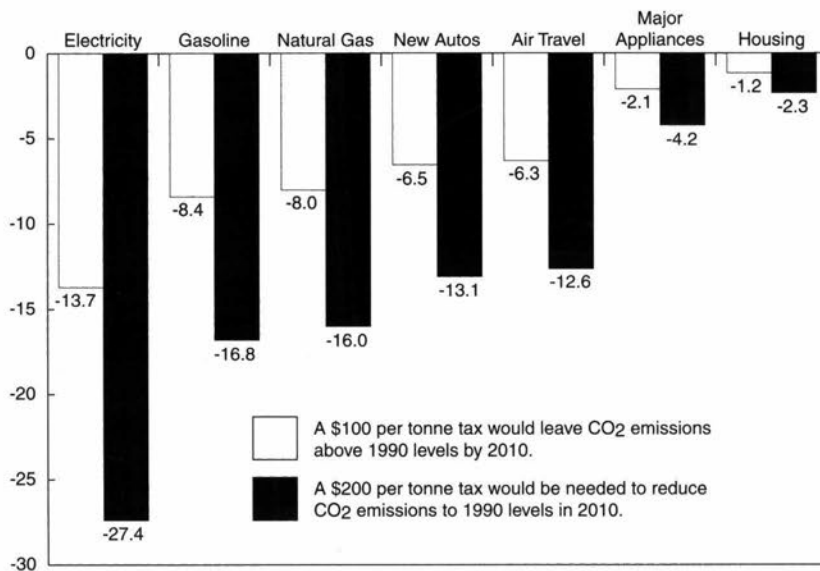
shows that reducing emissions to 1990 levels by 2010 or 2015 would require a tax in the range of \$200 or more per tonne of carbon emitted. Horwitz argues that these taxes would reduce U.S. GDP growth by more than 4.0 percent annually or over \$350 billion per year. Economic growth would slow as emissions are reduced due to lost output as prices rise for carbon-using goods—goods that must be produced using less carbon and/or more expensive processes. Output would also fall because of slower net capital accumulation, reflecting the premature obsolescence of capital equipment due to sharp energy price increases. In addition, Horwitz predicts that household disposable income would fall by 1.2 percent, and wages would also drop. At the same time, electricity prices could more than double from the current \$0.07 per kWh to as much as \$0.15–0.16 per kWh, according to a study by Montgomery. And as a result of the tax-induced price increases, household electricity consumption could fall by more than 30 percent, requiring a significant change in the daily life of practically every American citizen. Expenditures on items such as autos and housing would also decline, even if all the tax revenues were “recycled” back to consumers (see Figure 1).

ENVIRONMENTAL IMPACT OF EMISSION LIMITS

Scholars such as Professors Manne and Schmalensee and Drs. Jae Edmonds, James Dooley, and Marshall Wise of Pacific Northwest National Laboratory (PNNL) warn that there will be almost no environmental benefits were the United States and other industrialized countries to stabilize CO₂ emissions by 2010 or 2015 because most of the new emissions would come from China, India, the former Soviet Union, Latin America, and other emerging economies. In

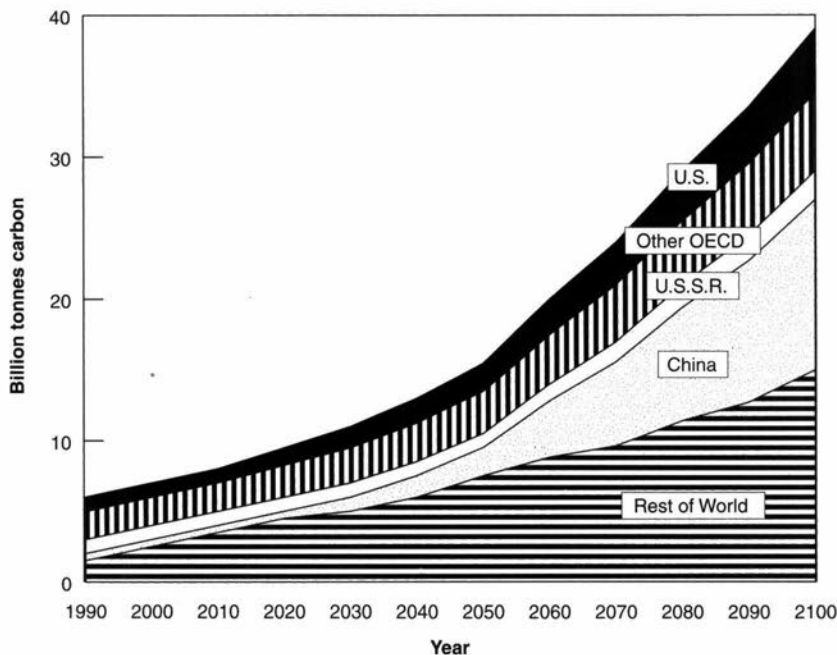
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Figure 1 Negative Impacts by 2010 on U.S. Household Consumption Due to Alternative CO₂ Emissions Reduction Proposals (% change from baseline)



Source: Lawrence M. Horwitz, "The Impact of Carbon Dioxide Emission Reductions on Living Standards and Lifestyles," in *An Economic Perspective on Climate Change Policies* (Washington, D.C.: American Council for Capital Formation Center for Policy Research, October 1995 Special Report)

Figure 2 Relative Carbon Contributions of Different Regions to Global Carbon Emissions



Source: Based on A.S. Manne and R.G. Richels, *Buying Greenhouse Gas Insurance: The Economic Costs of CO₂ Emission Limits*. (Cambridge, Mass.: MIT Press, 1992), p. 91.

fact, developing nations, which would not be required to cut CO₂ emissions under the proposed international treaty, already produce about 50 percent of all emissions—and by 2050 are expected to produce 75 percent of all greenhouse gases, according to Montgomery (see Figure 2).

COST-EFFECTIVE CO₂ STABILIZATION POLICIES AND U.S. ECONOMIC GROWTH

Reducing global CO₂ emissions should be a gradual, three-stage process, according to PNNL's Edmonds, Dooley, and Wise. During the next 25 years (Stage I), we should commit resources to the development and spread of new energy technologies such as hydrogen transformation from natural gas, advanced liquefied hydrogen fuel cells, biomass, solar photovoltaic, and nanotechnology (the design and building of structures atom-by-atom). These experts believe that although such technologies are now in their early stages, their development could revolutionize energy production while sharply reducing the cost of stabilizing atmospheric concentrations of greenhouse gases. Stage II, from 2020–2050, would see the enforcement of an emissions cap; Stage III could see the gradual phaseout of all free-venting of carbon into the atmosphere if the science indicates the need for such a policy.

CONCLUSIONS

The consensus of these noted scholars is clear. Given the need to increase U.S. economic growth to address challenges such as the looming retirement of the baby boom generation, policymakers should weigh carefully the likely negative economic impact of precipitous near-term reductions in U.S. CO₂ emissions and energy use. Adopting a thoughtfully timed climate change policy would both enhance U.S. and global economic growth and lead to long-term stabilization of carbon concentrations in the atmosphere. ❖

Progress Report on U.S. Industry Voluntary Actions to Curb Greenhouse Gas Emissions

Report to the
Global Climate Coalition



The EOP Group, Inc.

March 1996

Progress Report on U.S. Industry-led Voluntary Measures to Curb Greenhouse Gas Emissions

Global Climate Coalition

INTRODUCTION

In April 1993, President Clinton announced a "United States Climate Action Plan" designed to reduce greenhouse gas emissions, but at the same time to enhance prospects for new growth, job creation and competitiveness in a global market. Underpinning the initiatives included in the plan was the challenge to industry to work with government through new government/industry partnerships and to develop new voluntary initiatives independent of government actions which would contribute to the Plan's goal.

The voluntary approach is an effective approach. Economic growth has not declined, it has increased. Employment has increased. Energy use, and thus emissions, are declining for each unit of economic output. Participation in the global market is greater by some industries than in the past. This brief report is to provide a progress report on U.S. Industry-led voluntary initiatives that are improving energy efficiency and are already placing a curb on greenhouse gas emissions. The report finds that:

- The private sector has undertaken numerous initiatives aimed at addressing climate issues. Their initiatives frequently consider energy efficiency as well as environmental protection and productivity improvements when these critical capital investment and modernization decisions are made. Sometimes these initiatives address the commercialization of emerging and renewable technologies and the international transfer of technologies. **(INDUSTRY VOLUNTARY INITIATIVES)**
- Voluntary reporting under the Federal Government's Section 1605 (b) program gives firms the opportunity to report on emission reduction efforts. Although all firms taking such steps may not file reports with the government, in the first reporting cycle, over 600 separate measures were reported. **(VOLUNTARY REPORTING)**
- Since 1993, the over 35 voluntary initiatives included in the Climate Change Action Plan which involved both private sector and federal government action have been modified to be more effective and new programs have been added. To date, available information demonstrates tangible results even though some of the programs are less than one year old. **(FEDERAL VOLUNTARY PROGRAMS IN THE NATIONAL COMMUNICATION)**

Voluntary programs are successful because they represent a unique and innovative approach to addressing greenhouse gas emissions. They are easily adaptable to changing economic conditions. They can be tailored to unique national circumstances. They avoid costly and time consuming rulemaking and litigation. They harness the expertise, ingenuity and financial and human capital of the private sector. They facilitate innovation as technology improves and participants gain greater operating experience.

The successes of these new voluntary programs, which are just now beginning to be documented, offset many of the criticisms that have been raised regarding the efficacy of the U.S. National Communication and its dependence upon a voluntary approach.

Economic growth has been higher, and energy prices lower than the original plan assumed and thus projections of greenhouse gas emissions are higher than anticipated. This underscores the fact that arbitrary greenhouse gas emissions targets and timetables are not appropriate policy for a dynamic economy. Rather, the flexibility offered through voluntary programs allows industry to react to new business and competitive forces in such a way as to encourage economic growth and job creation.

This report, prepared for the Global Climate Coalition, the leading industry organization actively working for sensible and cost effective climate change policies, includes examples of a small portion of the initiatives in which GCC members are involved.

INDUSTRY VOLUNTARY INITIATIVES

The U.S. business sector voluntarily has taken an active role in addressing climate change. Much of this activity is focused on energy efficiency, in many instances through integrated programs which combine energy efficiency and environmental protection with overall and productivity and competitiveness enhancements. This integration ensures that energy efficiency is given appropriate consideration in capital investment and modernization plans. In turn, this longer range planning ensures that reductions of greenhouse gas emissions are permanent, not just one time, reductions. U.S. business is also engaged in other types of activities to reduce greenhouse gas emissions.

Some of these key industry activities are highlighted below. This list provides a small but representative sample of activities underway in the U.S. and is not meant to be comprehensive. Many of these activities are coordinated through industry associations and include government-sponsored voluntary programs as well as industry initiated activities that go beyond the scope on current government initiatives.

Domestic and International Partnership Programs

- **Utility Forest Carbon Management Program (UFCMP)** is an initiative developed by the Edison Electric Institute (EEI) with support from 55 electric utilities to expand utility industry efforts to manage CO₂ via forestry projects, both domestic and international. Based on a project solicitation, thirty proposals were received of which six were selected. A non-profit corporation, called the UtilTree Carbon Company, was established by 40 utilities to sponsor the project. The individual projects represent a mix of rural tree planting, forest preservation, management, and research efforts at both domestic and international sites.
- **International Utility Efficiency Partnerships (IUEP) Program** was formed by EEI in early 1995 to identify international energy project development opportunities, to work with host country government personnel to facilitate project investment, and to demonstrate U.S. utility commitment to voluntary approaches to global climate issues. The goal of the IUEP is to identify and support international activities, sponsored by the U.S. utilities, which reduce, limit, or avoid greenhouse gas emissions. The IUEP will be engaged in partnerships with DOE and other agencies to support the development of joint implementation (JI) projects. On December 19, 1995 a power project in Honduras, sponsored by the lead developer Tucson Electric/Nations Energy and the IUEP, was recognized by the U.S. as a certified JI project. In addition the IUEP issued a request for proposals that closed in September 1995; 44 project proposals from 18 countries were submitted.
- **The Climate Challenge Program** is a joint, voluntary effort of the electric utility industry and Department of Energy to reduce, avoid, limit or sequester greenhouse gases. Utilities make a commitment to report annually on activities and achievements under the Program. In a Participation Agreement the utility describes the actions that it has or will take towards achieving its commitments and agrees to report annually on its actions. As of November 1995, a total of 113 agreements, representing 61% of the 1990 electric generation and utility CO₂ emissions, had been signed. DOE estimates that the Climate Challenge will reduce carbon emissions by over 43 million metric tons of carbon equivalent (MMTCE) in the year 2000. The estimate is conservative, as it does not include reduction commitments not yet quantified or most of the benefits of the utility industry-wide initiatives.
- The American Iron and Steel Institute (AISI) has coordinated major **collaborative research and development projects** with DOE and other parties to develop and demonstrate fundamentally new technologies for making iron and steel, improved process control of traditional steel making operations, and waste recycling technologies. These projects have the potential for substantial energy reductions, pollution prevention, and waste reduction as the demonstrated technologies are adopted on a commercial basis in the coming years.

- The steel industry is also participating in the **EPA Common Sense Initiative** which, through its pollution prevention focus, will have some potential for energy savings and reduced CO2 emissions.
- Twelve of the thirteen U.S. aluminum companies have joined with EPA in the **Voluntary Aluminum Industrial Partnership (VAIP)** program to promote and achieve cost-effective reductions in perfluorocarbon (PFCs) emissions. PFCs are greenhouse gases produced in small quantities by primary aluminum production plants during the reduction process. These emissions only occur for short periods during high voltage conditions called anode effects. The focus of the VAIP is to reduce the frequency and duration of anode effects.

Elimination of anode effects is not technically possible today because a limited number of anode effects is important to smelter operation. Anode effects can provide critical information about the chemical balance in the smelting "pot" and on occasion are induced for this reason. Under the VAIP, producers work toward the minimum number of anode effects they can technically achieve without sacrificing competitiveness. VAIP partners are finding that it is feasible to reduce anode effects further than they thought was possible just a few years ago, thus improving their efficiency.

The Partnership has been designed with important and unique characteristics that reflect both the diversity within the primary aluminum industry and the differences between this and other industries. These unique characteristics include flexibility; a joint commitment to finding answers to critical technical questions; and a clear course for achieving substantial pollution prevention goals by the year 2000. EPA estimates that the VAIP will achieve reductions in PFC emissions of 30 - 60 percent across the U.S. primary aluminum industry -- or 1.8 million metric tons of carbon equivalent by the year 2000.

The VAIP agreement provides flexibility by allowing each partner to tailor the program to reflect its particular mix of technology, management structure, and operational practices, and to be recognized for past as well as future accomplishments. The VAIP also brings together experts from industry, government and academia to answer fundamental questions about the processes that lead to greenhouse gas emissions, the best way to measure these emissions, and how to most cost effectively reduce them. As a result, EPA is funding anode effect research at the Massachusetts Institute of Technology and gas standards developments at the National Institute for Standards and Technology. Finally, the VAIP provided partner companies with a framework for documenting their past accomplishments, setting achievable, cost effective goals for the future, and tracking progress toward meeting these future goals. It also provides partner companies with an opportunity to receive the recognition they deserve for taking the initiative to prevent atmospheric pollution.

- **Partnership for a New Generation of Vehicles (PNGV)** is a cooperative industry/government research and development partnership between the Federal government and the U.S. automotive industry. This program focuses government and industry R&D resources on a consensus set of goals and timetables that will preserve personal mobility while enhancing national competitiveness, reducing petroleum consumption and reducing emissions of greenhouse gases and pollutants. The three primary goals are:

- 1) To significantly improve national competitiveness in manufacturing by pursuing advances that can reduce production costs and product development times;
- 2) To pursue and implement commercially viable advances that can lead to improvement in the fuel efficiency and emissions of conventional vehicles; and
- 3) To pursue development of a revolutionary class of vehicles that could achieve fuel efficiencies of up to three times today's comparable vehicle; which will at the same time cost no more to own and operate; will maintain performance, size, and utility; and will meet or exceed safety and emission requirements.

The timetable is targeted towards development of a production prototype by 2004 that meets the Goal 3 criteria. Several promising research paths are initially being pursued, although the focus will be narrowed to a smaller list of component technologies that meet intermediate goals by 1997. This list will then be further refined as subsystem, vehicle level and manufacturing feasibility demonstrations are completed. It is hoped that PNGV will serve as a model for other U.S. industries and of efforts to apply advanced defense technologies to practical commercial uses that will create jobs and economic growth.

Information and Efficiency Promotion

- **Building Environmental Stewardship Tools (BEST)** is a National Petroleum Refiners Association (NPRA) program to promote environmental improvement and achieve environmental excellence. The commitment of NPRA's members to this activity is framed in Guiding Principles, one of which is "to further reduce overall emissions and waste generation." The BEST program uses various indicators including greenhouse gas emissions to measure the success of facilities in managing releases to the environment. The BEST program was implemented in 1994. A total of 144 facilities representing 65 members are participating in the program. A confidential "benchmarking" report, including information on 1993 emissions, was provided to each of these facilities comparing their performance to that of other similar facilities. The self-review resulting from benchmarking will guide improvements in future facility performance. The results of the improvements will be included in the trends analysis when 1995 data is available.

- **Semi-annual technical meetings** sponsored by the NPRA strongly support improved energy efficiency. Industry experts present technical papers and answer practical questions regarding changes, technologies and proven approaches to improve all aspects of petroleum refining efficiency, including energy, in meeting product requirements.
- Separately, the NPRA supports the annual **Energy Technology Conference** which focuses on the refining and petrochemical industries efforts to improve energy efficiency.
- The EPA and the Aluminum Association will co-sponsor an **International PFC Workshop** with cooperation from the Quebec, European and International Aluminum organizations. The Workshop will be held in May 1996 and will focus on the VAIP, the research conducted to better understand the behavior of PFCs and the activities of industry to measure and control the gaseous emissions from their facilities.
- **Improvements in energy efficiency and development of technical standards** in a broad range of facility operations and equipment are supported through industry associations such as the American Petroleum Institute. API technical standards are frequently utilized by state, federal and foreign governments. API member companies also participate in various government sponsored voluntary programs including: Climate Wise; Green Lights; Motor Challenge; Source Reduction and Natural Gas Star.
- The **Chemical Action Program**, adopted by the Chemical Manufacturers Association (CMA) in 1994, promotes voluntary and cost-effective efforts. The CMA program includes companies representing about 90% of the chemical industry, and emphasizes three elements:
 1. Development and analysis of greenhouse gas emissions and adoption of appropriate and economic sound measures to reduce these emissions;
 2. Submission of reports under the 1605(b) program, as well as participation in the annual CMA Energy Efficiency and CO2 Emissions Survey; and
 3. Participation in the Motor Challenge Program and other government voluntary initiatives in the U.S. Climate Change Action Plan.
- CMA has created an **Energy Efficiency Award Program** to provide companies an opportunity to achieve peer recognition for their outstanding energy efficiency accomplishments. Seven awards were made in 1994 and thirteen awards to ten companies were made in 1995. In order to increase awareness of the award-winning entries, CMA publicizes the awards.

- In 1993 CMA created the **Energy Efficiency Continuous Improvement Program** which has many elements including:
 1. Sponsorship of meetings and seminars for plant and corporate representatives to focus on energy efficiency programs, achievements, education, etc. Many types of examples of technology application are discussed in these meetings; and
 2. The Energy and Feedstocks Issues Newsletter reports on industry energy efficiency progress. It and other CMA publications have articles relating to energy efficiency improvements and technologies which have potential application to the industry.
- **Energy data, conservation and combustion technology workshops** organized through the American Iron and Steel Institute encourage continued efforts to improve energy efficiency and reduce CO₂ emissions. For example, the Institute collects and distributes to members energy statistics on an annual basis. The Institute has a committee on energy technology that sponsors workshops on energy conservation, combustion technology and related matters. Several of the company members are involved in the DOE Motor Challenge Program, others are involved in the EPA Green Lights program and some are participating in the "Waste Wise" program.

Specific Technology Programs

- The **National Earth Comfort Program** is a 6-year program, initiated in 1994 as a collaborative effort by DOE and an electric utility-led industry consortium to increase geothermal heat pump annual installations from 40,000 to 400,000 by 2001, raising their share of the market for space heating and cooling equipment from 1 to 12 percent. EPA data show that geothermal heat pumps are generally the most-energy-efficient and least-polluting of all technologies for space heating and cooling.
- The **EnviroTech (SM) Investment Fund** is a venture capital fund to invest in the commercialization of emerging electric and renewable technologies that are more energy efficient than those currently in the marketplace. Advent International, a well-known, international venture capital firm, has been selected to be General Partner to manage the Fund. In January 1996 the fund was closed for subscription with a total commitment of \$32.5 million. About 25-30 investments are expected to be made by the Fund and for every investment, some 1,700 proposals will be evaluated. The first investment was announced in January 1996.
- **EV America** is a program to accelerate the introduction of electric vehicles (EVs) into the marketplace through placement of as many as 5,000 EVs into utility, commercial, government and transit fleets by the end of 1997. EV America has been involved in testing vehicles during performance evaluations and developing common sets of specifications for EVs.

VOLUNTARY REPORTING

Section 1605 (b) of the Energy Policy Act of 1992 established a program for voluntary reporting by industry of actions to curb greenhouse gas emissions. This program is unique among the industrialized countries. The Department of Energy, Energy Information Administration (EIA) has worked closely with industry to develop the criteria and procedures for industry reporting. These requirements were developed in a manner to facilitate broad industry participation while ensuring accurate and verifiable emissions reductions. The first 1605 (b) reports, covering the years 1991 - 1994, have recently been filed. The EIA is currently in the process of validating the information of public release later this year.

The initial reports suggest that the voluntary reporting program will be very successful and will further enhance efforts to promote and monitor voluntary industry climate change actions. However, the results are likely to be understated. As the reports cover only the period through 1994, they do not reflect the beginning results of the voluntary programs undertaken over the last year. Not all companies that are taking voluntary actions to reduce or limit growth of greenhouse gas emissions have chosen to supply information under the 1605 (b) program. Initial information shows:

- Over 100 reports have been filed by individual companies. 40 of these reports include company-wide greenhouse emissions, while the remainder report on specific elements within the companies.
- A total of over 600 separate measures to reduce greenhouse emissions have been reported. The scope of the company reports varies greatly, with some companies reporting a single project while others have reported several dozen or more projects.
- The company reports provide data on greenhouse gas emissions reductions measured either against a baseline projection (in the absence of action), or against 1990 levels.
- Detailed information on the specific projects has not yet been released. Many of the projects encompass activities that are part of other government led or industry-led initiatives discussed in this report.

FEDERAL VOLUNTARY PROGRAMS IN THE U.S. NATIONAL COMMUNICATION

The U.S. National Communication contained a total of over 35 separate voluntary program initiatives. Some of these activities have been in existence for 1 year or less. Overall, these programs have already achieved substantial participation levels and are demonstrating tangible results. However, there is no U.S. Government reporting system that provides the status of all projects in a comprehensive manner. A summary of some of the more significant activities follows.

- **Climate Challenge.** This program is a collaborative effort between the electric utility industry and the Department of Energy (DOE). Through company-specific agreements, participating utilities have the flexibility to implement a portfolio of emission-reduction measures. Through August 1995, agreements have been signed that included 567 utility companies. Total emission reductions of at least 43 MMTCE by the year 2000 are projected. The U.S. National Communication did not provide a separate emissions reduction estimate for Climate Challenge, but other provisions of the plan assumed about 36 MMTCE reductions due to Climate Challenge activities. (This program was described in the previous section)
- **Climate Wise.** This EPA/DOE program, launched in 1994, is intended to encourage and publicly recognize voluntary efforts to reduce greenhouse gas emissions. It involves partnerships with business, industry, state and local governments, and other organizations that make commitments to reduce greenhouse emissions and report their results. Participants include companies that account for almost 4 percent of all U.S. industrial energy use. Emission savings of 4 MMTCE are currently projected by the year 2000. The U.S. National Communication did not include a separate estimate for Climate Wise emissions reductions.
- **Rebuild America** Following start up in 1995, the U.S. Department of Energy (DOE) awarded \$4.3 million in grants to six regional partnership teams that are expected to generate 3,000 jobs and over \$300 million in investments as a result of private sector contributions. In addition, the Mayors of 28 cities have pledged to facilitate Rebuild America regional partnerships by measuring their cities' energy use and making energy efficient upgrades. Rebuild America partners are contributing \$70 for each \$1 of Federal funding. There were 34 community partnerships established by the end of 1995, compared to an initial planning estimate of 20. By the year 2000, DOE estimates that Rebuild America partnerships will achieve \$650 million in energy savings and emissions reductions of 1.7 MMTCE.
- **Energy Star Buildings.** This EPA initiative provides assistance to building owners to increase the overall effectiveness of existing commercial building efficiency programs. American businesses spend \$70 billion annually to operate commercial buildings. EPA estimates that the operating costs could be reduced by \$28 billion through the use of energy-efficient technology. Energy Star is a five stage process beginning with Green lights; and progressing through a building tune-up; heating, ventilation, and air conditioning (HVAC) load reductions; fan system upgrades; and new, improved HVAC equipment. The program was launched in April 1995 with 58 charter partners representing over 384 million square feet. An example of a success is the upgrade of University Hall at the University of Missouri, which has achieved 60 percent savings in electricity and an 87 percent in natural gas usage.

- **"Green Lights"**. This EPA program involves partnerships between the EPA and corporations, utilities, nonprofit organizations, and other groups that agree to analyze and, where profitable, to upgrade lighting equipment with more energy-efficient systems. EPA provides technical support and on-site implementation assistance. Lighting accounts for 20-25 percent of all electricity sold in the U.S. Available technology can reduce the electricity used for lighting by 50 to 70 percent and earn internal rates of return (IRR) of 20 to 30 percent or more. EPA estimates that Green Lights could reduce annual CO₂ emissions by 225 billion pounds annually. Two examples of the savings include a Gillette Company facility in Santa Monica that has achieved 61 percent energy savings with 37 percent IRR on the project and a Whirlpool facility in Lavergne, Tennessee that achieved 54 percent energy savings with 72 percent IRR. More than 4.3 billion square feet of facility space has been committed to participating in the Green Lights program.

- **Cost-shared demonstration of emerging technologies**. This DOE initiative brings together appliance and equipment manufacturers with prospective purchasers to test and evaluate prototype equipment. Examples of Technology Partnerships include: 1) a consortium of hotel/motel chains; 2) the National Association of Energy Service Companies; 3) gas appliance manufacturers; and 4) a collaborative dedicated to applying an innovative lighting technology. By the end of 1995, there were 17 partners compared to the 5 forecast. This initiative is estimated to lead to a reduction of 1.5 MMTCE in the year 2000.

- **"Golden Carrot" market-pull partnerships**. This DOE/EPA program involves partnerships with nonprofit organizations, retailers, utilities and environmental groups to accelerate the commercialization and marketing of advanced energy-efficient appliances. By the end of 1995 there were 33 partners compared to the 10 forecast. Resources committed by the partners totaled \$46 million compared to the \$15 million forecast. Emission reductions from these types of projects are estimated at 0.7 MMTCE in the year 2000.

- **Home energy-rating systems and energy-efficient mortgages**. This DOE program is designed to provide home buyers with information on the energy efficiency of new and existing homes (Home Energy Rating Systems - HERS). The Energy Efficient Mortgages (EEMS) program is designed to allow home buyers to finance investment in energy improvements through their mortgage lender when the monthly energy savings are greater than the increased monthly mortgage payments. Fannie Mae has announced a \$1 trillion initiative, "Showing America a New Way Home" to provide energy efficient loans to homeowners. DOE and the Department of Housing and Urban Development (HUD) have agreed to upgrade 1 million housing units to reduce federal utility outlays by approximately \$300 million annually by the year 2000. Emissions reductions of 0.6 MMTCE have been projected.

- **"Cool Communities"**. This DOE proposed initiative promotes the planting of trees to shade residential and commercial buildings, and the use of light-colored building surfaces to reduce absorption of sunlight. Planting trees also helps create more sinks for absorbing carbon dioxide. Over 50 cities, local communities, Federal facilities, and local utility companies have stated an interest in participating in the program.
- **"Motor Challenge"**. This DOE program, initiated in October, 1993, is to test, verify and disseminate information on the cost-saving potential of improving industrial motor systems. Participation has far exceeded expectations: by 1995, 300 partners were expected but 1000 had enlisted. Twenty one showcase demonstrations, representing an industry investment of \$15 million, have been initiated. Emissions reductions of 5.5 MMTCE have been projected in the year 2000.
- **Energy analysis and diagnostic centers**. This DOE program is designed to increase the number of Energy and Diagnostic Centers (EADCs), which are university-based organizations that offer engineering students and faculty to perform energy audits and make recommendations to help manufacturers control costs, improve energy efficiency, and reduce waste. Emission reductions of 0.1 MMTCE by the year 2000 are estimated.
- **Source reduction, pollution prevention, and recycling**. This DOE/EPA/U.S. Department of Agriculture (USDA) program is focusing on ways to enhance recycling. Source reduction efforts encourage unit pricing wherein homeowners are charged by the amount of garbage they throw away, provide incentives and education to reduce waste at the source, and promote the design of longer-life, repairable goods. Recycling efforts foster "buy recycled" programs, expand access to information clearinghouses, increase the use of government loan guarantees for recycling manufacturing investment and provide technical assistance to state and local governments to improve the quality of recycled materials. About \$3.68 of private sector funding is being generated by each \$1 of Federal assistance. Emission reductions of 3.2 MMTCE are projected by the year 2000. By the end of 1995, there were 60 new partners compared to a target of 51 participants.
- **Renewable-energy market mobilization collaborative and technology demonstrations**. This DOE program is designed to accelerate the market acceptance of renewable technologies. It emphasizes commercialization of wind energy technologies, Photovoltaics, Biomass, and geothermal energy.

Wind. The National Wind Coordinating Committee was formed in October 1994. Three cost-shared wind energy projects were selected in September 1995 and six proposals to collect and analyze wind data have been selected. Emission reductions of 1.1 MMTCE by the year 2000 are projected.

Biomass. Projects totaling 1,000 mw of capacity were proposed in 1995. Emission reductions of 0.9 MMTCE by the year 2000 are estimated.

Photovoltaics. The Utility Photovoltaics Group (UPVG) represent all sectors of the electric utility industry and more than 45 percent of electricity sales in the United States. Several projects are underway, including one at Sacramento Municipal Utility District to install 1.5 mw of Photovoltaics capacity.

Geothermal heat pumps. The Geothermal Heat Pump consortium has been formed which includes 70 utility members. By the end of 1995, there were 100 partners compared to the target of 25 partners. Emission reductions of 0.4 MMTCE by the year 2000 are estimated.

Geothermal power. By 1997, the Geysers geothermal energy pipeline project is expected to be in operation. That and additional projects are expected to reduce emissions 0.2 MMTCE by the year 2000.

- **Coalbed methane outreach program.** This DOE/EPA program provides technical and financial assistance for coal mine owners to promote energy recovery. Of the fourteen proposals submitted by the private sector, ten coal mine sites have been selected for demonstration of the recovery and utilization of methane. Detailed design and implementation of the pilot demonstrations are scheduled for 1996 and 1997.

Global Climate Coalition

MISSION

The Global Climate Coalition (GCC) is an organization of business trade associations and private companies established in 1989 to coordinate business participation in the scientific and policy debate on the global climate change issue.

GCC is dedicated to: 1) assessing scientific research on global climate change, 2) analyzing economic and social impacts of policy options, 3) creating an understanding of the global dimensions of the issue to ensure that solutions are addressed equitably by all nations, 4) encouraging the transfer of technology to developing nations, and 5) promoting a voluntary commitment among members to " Guiding Principles for Business" that benefit the environment, and are consistent with good business practices and are technically and economic feasible.

PROGRAMS

GCC is the leading voice for industry on the global climate change issue, and represents its members both internationally and domestically before government agencies, Congress, the media and the general public. The coalition contributes to a balanced debate on global climate change by sponsoring independent research and studies that examine the potential impacts of proposed global climate change policies on the economy. Through educational materials and programs, GCC supports an informed press and public. and an open scientific dialogue.

POSITION ON CLIMATE CHANGE

GCC accepts the finding that there is a natural "greenhouse effect" which protects the Earth from the freezing rigors of space. GCC agrees that the amount of so-called greenhouse gases in the Earth's atmosphere is increasing. In addition, GCC also accepts that the Earth's climate has warmed about 0.5 degrees Centigrade since the late 19th Century. It is an open question, however, what the cause of this warming has been. The GCC believes that the preponderance of the evidence indicates that most, if not all, of the observed warming is part of a natural warming trend which began approximately 400 years ago. If there is an anthropogenic component to this observed warming, the GCC believes that it must be very small and must be superimposed on a much larger natural warming trend. These positions are consistent with the IPCC conclusions. The GCC believes there is no convincing evidence that future increases in greenhouse gas concentrations will produce significant climatic effects.

Considerable uncertainty remains within the scientific community about the fundamental questions relating to this issue. Significant reductions in these uncertainties are essential. For this reason, GCC supports a coordinated international research program, the continuation of U.S. climate research efforts (\$1.8 billion requested for FY 1995), in addition to independent and industry sponsored research. GCC also supports activities to reduce greenhouse gas emissions that make sense in their own right, thus continuing sound business practices that will lead to more efficient use of energy while supporting economic growth.

GCC believes that there are trade-offs associated with many of the regulatory schemes to control greenhouse gas emissions. Some of these proposals would impose a direct tax on businesses and consumers through energy or environmental fees while other proposals would impose a hidden tax through other indirect control measures. These trade-offs would include higher energy and product costs to American consumers, higher operating costs for industry and a potential negative impact on employment. Importantly, many of these proposals would create a competitive advantage for our international trading partners at the expense of U.S. jobs and economic growth.

MEMBERSHIP

The current membership of the GCC represents a broad cross-section of U.S. business organizations and companies representing a range of industrial sectors, including oil, coal, paper, automobile manufacturing, railroads, chemical manufacturing, airlines and utilities.



GLOBAL CLIMATE COALITION

GLOBAL CLIMATE COALITION MEMBERSHIP

Board Membership

Air Transport Association
Aluminum Association, Inc.
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PROVIDING BALANCE
IN THE GLOBAL CLIMATE CHANGE DEBATE

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Effective 7/1/97 the Global Climate
Coalition is moving to:

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THE GLOBAL CLIMATE COALITION

Position Statement on Climate Change

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The Global Climate Coalition believes that the issues of significant climate change is best addressed near-term through private sector and government programs that are comprehensive, flexible and cost-effective.

COMPREHENSIVE

The Coalition supports programs that:

- Foster greater scientific understanding of Earth's climate systems.
- Acknowledge that total concentrations of greenhouse gases, not annual emissions, are key to limiting the risk of significant climate change.
- Cooperatively engage all nations in reducing the risk of global climate change.
- Consider all policy response options available to managing the risk of climate change, including adaptation, mitigation and sequestration.
- Thoroughly assesses the economic and social impacts of specific climate policies and measures.
- Include all greenhouse gases in any policy or measure that aims to mitigate greenhouse gas emissions or concentrations.

FLEXIBLE

The Coalition supports:

- Measures based on the individual economic, technological, social and other circumstances of each country, including timing and implementation.
- Programs designed to achieve multiple benefits, including protection of the environment, advancement of sustainable economic growth, and the enhancement of standards of living and human health.
- Programs that can be adapted to change over the years as more scientific and economic information becomes available.



COST-EFFECTIVE

The Coalition supports programs that protect the environment and make economic sense, including:

- Voluntary industry initiatives and private sector partnerships with government.
- Adaptation and carbon sequestration programs.
- Actions implemented jointly between and among all interested nations and industries.
- Research, development and use of market acceptable, energy efficient technologies.
- Increased relationships with regional and multinational banks to promote partnerships where appropriate.

Reducing current scientific uncertainty about the risk of climate change and engaging in a transparent and balanced decision making process that produces comprehensive, flexible, and cost-effective policy responses that address known climate risks are the cornerstones of the Global Climate Coalition's public policy.

The Global Climate Coalition is an organization of business trade associations and private companies established in 1989 to coordinate business participation in the scientific and policy debate on the global climate change issue.

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Position Statement of the Global Climate Coalition

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Comprehensive

The Coalition supports programs that:

- ◆ foster greater scientific understanding of Earth's climate systems.
- ◆ acknowledge that total concentrations of greenhouse gases, not annual emissions, are key to limiting the risk of significant climate change.
- ◆ cooperatively engage all nations in reducing the risks of global climate change.
- ◆ consider all policy response options available to managing the risk of climate change, including adaptation, mitigation and sequestration.
- ◆ thoroughly assess the economic and social impacts of specific climate policies and measures.
- ◆ include all greenhouse gases in any policy or measure that aims to mitigate greenhouse gas emissions or concentration.

Flexible

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- ◆ programs that can be adapted to change over the years as more scientific and economic information becomes available.

Cost-effective

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BACKGROUND

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Technology Cooperation: Sustaining Economic Growth and Environmental Improvement

For over two decades, U.S. industry has been a world leader in developing energy technologies and implementing environmental policies. Every year, American industry spends more than \$100 billion to protect the environment, and many companies have environmental technology programs overseas. By providing cleaner, more energy-efficient technologies and know-how to developing countries, U.S. industry can simultaneously build on its existing accomplishments and help reduce global emissions of greenhouse gases. Technology innovation and cooperation, guided by the marketplace—not government mandates—is the key to addressing the dual challenges of sustaining economic growth and environmental improvement. U.S. business has the opportunity and the know-how to meet this challenge.

Purpose of Technology Cooperation

Technology cooperation is aimed at helping developing countries expand their economies and improve their quality of life, while at the same time improving their environmental performance. Emissions of greenhouse gases are reduced, in addition to limiting emissions of pollutants such as NO_x and SO₂. Technology cooperation includes efforts that combine technology and equipment with "soft" technology – training, management assistance and software. A major product of the private sector's vast operational experience, soft technology could be one of our country's greatest contributions to developing countries and those with economies in transition.

Importance of Technology Cooperation

Technology cooperation is an important component of the U.N. Framework Convention on Climate Change, which states, "The developed countries...shall take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer or access to environmentally sound technologies and know-how to other parties, particularly developing countries...."



The U.N. Intergovernmental Panel on Climate Change (IPCC), charged with assessing the science and economics behind global climate change, predicts that by 2025, non-OECD countries will be responsible for 67 percent of all energy-related carbon dioxide emissions.¹ In addition, both developing countries and former centrally planned economies already emit a far greater amount of greenhouse gases for each unit of GNP than industrialized nations. As the economies and energy demands of developing nations increase, their share of global greenhouse gas emissions are expected to rapidly increase. The IPCC has stated that this projected rapid growth in greenhouse gas emissions creates a crucial need to transfer advanced technology to developing countries.²

For this reason, developing countries have an important role to play in any strategy to reduce global greenhouse gas emissions. Special consideration should be given to providing appropriate help to these nations in upgrading their environmental policies, industrial performance and resource management. If steps are not taken to encourage sound economic and environmental developments in developing countries, massive increases in their GHG emissions would overwhelm any emissions reductions made by industrialized nations, thus making stabilization of GHG concentrations impossible.

Cooperation Between Government and Industry

Although technology cooperation is best achieved by the private sector, many developing countries lack the fundamental economic infrastructure. Significant improvements are needed within these countries to encourage cooperative arrangements. Clearly, there is a role for governments, in both developing and developed nations, to play in technology cooperation. For example, the U.S. government is already working to improve technology cooperation between itself and private industry to enhance the competitiveness of U.S. technology. The federal government's resources are important to helping industry identify opportunities for technology cooperation and to providing market-based financing options to encourage the export of American products. In addition, the United States and other governments support programs at the Agency for International Development, the Export-Import Bank, the World Bank and many regional development banks that could support international technology transfers.

The Private Sector is Essential. Transferring technology in a way that allows economic growth, while minimizing growth in GHG emissions is a burden that can be satisfied best by the private sector. It is insufficient for a country simply to acquire new technology:

"One should not attempt to solve energy-efficiency problems in isolation from other efficiency problems. Problems related to vintage equipment, scarcity of management skills, small-scale production, or poor technological infrastructure will not be solved by addressing climate-change or energy goals only."³

**Technology Cooperation Backgrounder
The Global Climate Coalition**

The expertise and experience of the private sector is therefore essential to any large-scale technology transfer effort.

Over the past five years, the Global Climate Coalition, the nation's leading business voice on global climate change issues, has participated in national and international panels on technology cooperation with representatives of Congress, the EPA, the DOC and the DOE. The coalition also has spoken on technology cooperation issues before the Intergovernmental Negotiating Committee (INC) and co-chaired a conference with the DOC on technology cooperation with Eastern Europe and participated actively in the IPCC. Many of GCC's member companies have joint ventures and other projects through which they provide advanced energy and environmental technologies overseas.

For example, The Southern Company, one of the largest investor-owned electric utilities in the United States, has undertaken a study for the Slovak Power Enterprise on how to improve the environmental performance and reliability of a 1,320-megawatt power plant. Kaiser Aluminum is working with Russian officials to improve the environmental performance of a smelter in Siberia and is also providing technical services to smelters and refineries in other countries. This experience has given the coalition useful and important insight into the special considerations necessary for improving technology cooperation programs.

Business Involvement in Technology Transfer Programs. The Global Climate Coalition and other business groups believe that, with greater cooperation from financial institutions and governments, U.S. industry could serve as a conduit for, and help coordinate, various programs to transfer technology and private industry assistance to many developing nations and countries with economies in transition. One mechanism by which this could be accomplished has been proposed: a business-initiated Management of Environmental and Energy Technology (MEET) Corps. This program would send industry managers overseas to examine environmental and energy-related issues and to design solutions to problems such as reducing methane leakage in natural gas systems or increasing the energy efficiency of fossil-fuel power plants.

Elimination of Impediments to Technology Cooperation. Although better coordination and communication between government and industry will facilitate technology cooperation, some issues still need to be addressed, including two identified by the IPCC:

"In regard to technology transfer, two issues are still unclear. One is trade barriers in the form of import tariffs and legal barriers for the protection of intellectual property rights. Such barriers affect the adoption of high-tech components of energy-efficient equipment. A balance between the interests of developing nations and the interests of industrial firms elsewhere must be struck."⁴

**Technology Cooperation Backgrounder
The Global Climate Coalition**

The guarantee of intellectual property rights, including protection for patents, trademarks and copyrights is essential. Without such a guarantee, companies will lack a strong incentive to pursue the work of technological and industrial innovation overseas. Also, the uncertainties surrounding antitrust implications should be resolved to encourage joint ventures among private firms, which will allow companies to merge their resources and develop and introduce new technologies more quickly and cost-effectively.

Benefits of Technology Cooperation. Improved technology cooperation between developed and developing nations and between the public and private sector will foster a stable foreign investment climate and contribute greatly to far-reaching environmental improvements in addition to increasing the number of high-wage jobs by opening new export markets for U.S. firms already established as world leaders.

1. Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment. Cambridge University Press., Table A3.7.
2. Climate Change 1995: The Science of Climate Change. Draft Contribution of Working Group II to the IPCC Second Assessment Report. Accepted by governments at IPCC Working Group II, Third Session, Montreal, 16-20, 1995. Document: WGII/3rd/ (31.VIII.1995), section 20.5.2
3. Ibid. #2, section 20.5.3.2
4. Ibid. #2 section 20.5.2.

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BACKGROUND

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"Activities Implemented Jointly": A Strategy Option for Global Emissions Reductions

What Is "Activities Implemented Jointly"?

"Activities Implemented Jointly" is a concept that recognizes or "credits" parties in one country for reducing greenhouse gas emissions in another. For example, a company in country A might achieve greenhouse gas reductions at its facility in country B. Under "Activities Implemented Jointly", each country would claim some of the reduction against its national goal for lower greenhouse gases.

The goal is to control global levels of greenhouse gases, not simply reductions in the emissions from a single nation or a select group of nations.

The Need For Cooperation

One of the most critical climate change issues facing policymakers is the rapid increase of greenhouse gas emissions resulting from growing economies in developing countries and countries with economies in transition. Developing nations' emissions of carbon dioxide (the greenhouse gas most often cited for its role in potential warming) already are greater than carbon dioxide emissions from industrialized nations, according to the U.S. Department of Energy.¹

Four-fifths of the world's people live in developing countries where most of the population, economic and energy demand expansion -- and resulting greenhouse gas emissions -- is expected to occur. The UN Intergovernmental Panel on Climate Change estimates that by 2025 developing nations and transition economies will be emitting 67 percent of the total energy-related carbon dioxide emissions.²

The dilemma is clear, economic growth is essential to improving the social conditions for millions of people in the developing nations. Yet, as these nations develop economically, increases in their greenhouse gas emissions will far exceed the reductions that can be achieved in developed countries. Clearly, reducing or stabilizing global emissions of greenhouse gases cannot be achieved without controlling those emissions in the developing world as well.



"Activities Implemented Jointly" addresses this challenge. In fueling their economic growth, many developing nations now employ outdated or inefficient energy and environmental technologies and resource management techniques. "Activities Implemented Jointly" projects can assist the transfer of environmental technology, investment capital and management know-how from the private and public sectors of developed nations to governments and industries in developing countries. As a result, developing nations' current and future greenhouse gas emissions can be substantially reduced, while billions of dollars flow into their economies. This, in turn, supports the development of environmentally sound economic projects and stimulates growth. In this sense, "Activities Implemented Jointly" is a model strategy for putting the principles of sustainable development into practice.

Robert Watson, testifying before a Senate committee in 1994 for the White House Office of Science and Technology Policy, underscored the importance of the private sector. "If we...decide there needs to be reductions in greenhouse gases, or at least some reduction in the rate of growth of emissions, we need to look at 'Activities Implemented Jointly'...This cannot, obviously, just be an exercise between governments, but must have the strong involvement of the whole private sector...I cannot conceive, personally, of a major effort to reduce greenhouse gases without 'Activities Implemented Jointly' governments and private sector all being strongly involved."

The Benefit to Developed Nations

The United States and other industrialized nations are extremely energy efficient when compared with developing nations and transition economies. Given this comparative energy efficiency in the developed world, the marginal cost of stabilizing or reducing greenhouse gas emissions by increasing energy efficiency is far higher in developed nations than in developing countries, and the margin for improvement is much more narrow. To illustrate, the cost of cutting one ton of carbon dioxide emissions from a facility in the United States is much greater than the cost of cutting the same amount from a facility in a developing country. Yet, the net impact on global atmospheric carbon dioxide levels (and, thus, any potential climate change) is the same.

Many economic experts have concluded that the cost of radical reductions in greenhouse gas emissions in the United States would be enormous, perhaps overwhelming enough to cause severe unemployment, decreased competitiveness of U.S. goods, and other grave economic disruptions. A flexible, market-based "Activities Implemented Jointly" approach offers developed nations a strategy to achieve substantial reductions in global greenhouse gas emissions much more efficiently than domestic command-and-control measures, and it avoids the unnecessary dire economic consequences. Successful "Activities Implemented Jointly" projects potentially could save billions of dollars and provide needed technological improvements in developing economies.

Among the other potential benefits of "Activities Implemented Jointly" projects are the promotion of growth and investment in overseas markets, the identification and opening of new markets for more energy efficient goods and services, and the creation of new business partnerships between U.S. companies and firms in developing nations.

The U.S. Initiative on "Activities Implemented Jointly"

Acknowledging the enormous potential for cost-effective greenhouse gas emissions reductions in developing nations, the Clinton administration included in its Climate Change Action Plan a pilot program titled "The U.S. Initiative on Joint Implementation (USIJI)." One goal of the pilot program is to encourage private sector investment and innovation in the development and dissemination of technologies that reduce greenhouse gas emissions.

On June 1, 1994, the State Department released the final ground rules for evaluating greenhouse gas reduction projects under the initiative. The ground rules establish an Evaluation Panel made up of appointees from eight federal departments (including the Departments of State and Energy and the Environmental Protection Agency) that will, among other duties, assess projects to determine whether they meet the criteria for inclusion in the USIJI.³ In addition to other requirements, USIJI projects must reduce or sequester greenhouse gas emissions beyond baseline estimates provided by the project's sponsors. The ground rules also require that the baselines reasonably reflect current environmental standards and business practices and that they contain adequate provisions for tracking and external verification of results.

The Evaluation Panel must also consider factors such as whether the project could lead to changes in greenhouse emissions elsewhere, the potential positive and negative effects aside from emissions reductions, whether the participants are emitters of greenhouse gases in the United States and whether they are taking steps to cut emissions at home.

¹ "Energy Use and Carbon Emissions: Some International Comparisons," DOE/EIA - 0579, March 1994.

² Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment. Cambridge University Press., Table A3.7.

³ *Federal Register*, 1 June 1994, p. 28442-46.

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**Activities Implemented Jointly Backgrounder
The Global Climate Coalition**

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THE GLOBAL CLIMATE COALITION

Position Statement in Support of Scientific and Economic Research

The Global Climate Coalition places a high priority on scientific and economic research to advance the understanding of earth systems, introduce new knowledge into climate models, and refine the tools necessary for decision-making with respect to long-term economic strategies necessary to address potential climate change.

The understanding of global climate change has evolved significantly over the past decade. Over just the last five years, as evidenced by a comparison of the findings of the intergovernmental Panel on Climate Change's First and Second Assessment Reports, the net effect of greater knowledge has been to lower climate change projections of a "business-as-usual" scenario - about a one-third smaller temperature change and about a one-fourth smaller sea level change is now highlighted in the IPCC report.

Despite extensive research, the range of uncertainty in key aspects of climate change assessment remains high. A careful reading of the IPCC's Second Assessment Report indicates many significant uncertainties remain in the basic science, climate modeling, and economic assessments of climate change. As noted in the IPCC Working Group I report (Section 8.7), "no study to date has positively attributed all or part of the [historic temperature] change to anthropogenic causes. Nor has any study quantified the magnitude of a greenhouse gas effect or aerosol effect in the observed data--an issue that is of primary relevance to policymakers."

With existing uncertainties in science and potential impacts, society may attempt to protect itself at an unnecessary high cost against what may be low probability or theoretically possible future impacts. Resolving uncertainty about the true nature of climate change risk allows for more efficient timing of any necessary mitigation and adaptation policies, and avoids unfounded and expensive reactions that may ultimately prove unnecessary. As Working Group II of the Intergovernmental Panel on Climate Change concluded in its Summary for Policymakers, "The value of better information about the processes, impacts of and responses to climate change is likely to be great."

In short, consistently improved and updated information about basic science, modeling, and potential climate change policies is vital. Critical issues include, but are not limited to: how the earth's climate systems work, including the role of the oceans, water vapor and clouds; how new and better knowledge about earth's systems can be incorporated into climate models; how changes in climate may impact society and ecosystems, particularly at the regional level; how social, technological and environmental change, as well as adaptation, can be integrated into appropriate baseline scenarios; and how the potential benefits and costs of government policies over an extended time-frame can be adequately assessed. Private sector and government support for global climate scientific and economic research is necessary to address this complex and evolving issue.

The Global Climate Coalition is an organization of business trade associations and private companies established in 1989 to coordinate business participation in the scientific and policy debate on the global climate change issue.

[26173: March 1996]

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IMPACTS ON TRADE AND COMPETITIVENESS FROM PROPOSED GREENHOUSE GAS EMISSION RESTRICTIONS

The Views of the Global Climate Coalition

Imposing near-term goals to stabilize or reduce carbon emissions would weaken the U.S. economy and cripple the nation's competitiveness in the global marketplace. Given the uncertainties about the impact of carbon emissions on global climate change, a more studied approach to the development of these greenhouse gas mitigation policies should be adopted.

Economist Dr. Alan Manne of Stanford University studied typical abatement proposals intended to stabilize global carbon emissions between 1990 and the year 2000, reduce them to 80 percent of this level by 2010, and stabilize them thereafter. According to Dr. Manne's findings, price-induced energy conservation and shifts to low carbon fuels to reach the goals set forth in these proposals would result in annual losses ranging from 1 percent of the U.S. Gross Domestic Product to nearly 2.5 percent of the nation's GDP.¹

Dr. Manne argues that these restrictive approaches to limit carbon emissions would hinder U.S. international competitiveness in such basic industries as chemicals, steel, aluminum, petroleum refining and mining -- all of which are energy intensive. He contends further that the U.S. coal exporting industry would be put out of business and severe strains would be placed on important trade pacts like NAFTA and GATT.

Dr. Manne's conclusions have been supported in studies conducted by Economist Lawrence M. Horwitz of DRI/McGraw-Hill, an economic modeling consultancy. Mr. Horwitz reports that efforts to reduce greenhouse gas emissions to 1990 levels by 2010 through the use of carbon taxes would reduce the U.S. GDP by 2.3 percent, or \$203 billion, relative to the baseline forecast; decrease business investment by almost 5 percent; and reduce consumer spending by 2 percent. Overall, 89 percent of consumption categories would be negatively affected by the carbon tax. An American economy so weakened could be a handicapped player in the

¹ "Costs and Benefits of Alternative CO₂ Emissions Reduction Strategies".



international marketplace.

According to the Intergovernmental Panel on Climate Change (IPCC), a panel of international climate and economic experts assembled by the United Nations, countries, such as the United States, that actually implement carbon taxes and other fiscal instruments to restrict greenhouse gas emissions may be at a severe disadvantage.

"Taxes that are not levied on a global scale may provoke industry relocation, which may adversely affect emissions efficiency as well as international competitiveness. Most countries are hesitant to embark on policy ventures that might endanger their international market position and their attractiveness as industrial locations...It is difficult for a single nation to impose full environmental cost accounting and remain competitive unless other nations do the same." (WGII FSM, section 20.5.3.3)

The IPCC estimates the cost of carbon-based taxes is fairly high. Estimates range from \$20 to \$150 per ton for the carbon taxes required to hold emissions at 1990 levels in 2010 and from \$50 to \$330 per ton to reduce emissions by an additional 20 percent. While the impact on economies from fiscal instruments such as carbon-based taxes can be assessed fairly easily, the social and economic impacts from potential warming cannot, according to the IPCC.

"The level of sophistication of climate change damage analysis is comparatively low. Damage estimates are generally tentative and based on several simplifying, and often controversial assumptions. The degree of uncertainty is correspondingly high, both with respect to physical impacts as well as their consequences for social welfare. No attempt has been made to specify confidence intervals. Rather, estimates are best guesses." (WGIII, FSM, section 6.1)

Economist Dr. W. David Montgomery, an IPCC lead author, argues that concentrating on near-term emissions reduction targets represents a costly and potentially unnecessary approach to climate policy. It would be much more cost effective to focus on the long-term stabilization of atmospheric concentrations of greenhouse gases rather than on short-term emissions.

Many of the reasons for this are cited in the IPCC Second Assessment Report.

"There are several reasons why a less restrictive near-term emissions path may turn out to be less expensive. First, large emissions reductions in the near term will require premature retirement of the existing capital stock. This is apt to be costly. There will be more opportunities for reducing emissions cheaply once the current capital equipment turns over. Second, the availability and cost of substitutes are likely to improve over time. There is ample historical evidence for improvements in the efficiency of energy supply, transformation, and end-

use technologies (Chapter 8) , and expectation of substantial further improvement in the future... Finally, even if the costs of removing a ton of carbon were the same in all periods, a positive marginal productivity of capital will favor the deferral of reductions. This is because with a positive real rate of return on capital, it will be desirable to invest some of today's potential emission reduction dollars in enhancing our future productive capacity. As a result, the same level of cumulative emission reductions can be achieved at a lower total cost to society." (WGIII, FSM, chapter 10, section "Cost-effective Strategies for Stabilizing Atmospheric CO₂ Concentrations")

Montgomery suggests that various steps are necessary for a more rational approach to developing climate change policies. Among these:

- analyze implications for U.S. net costs and benefits of international sharing of the burden of response;
- inventory possible policy responses and analyze the economic merits of alternative response options.

Emissions reduction policies that promote grave economic consequences for the U.S. economy and threaten the nation's foreign trade position should be avoided. Instead, a studied approach to greenhouse gas policy development should be adopted along with continued investment in climate science and the development of new energy technologies.

The Global Climate Coalition is an organization of business trade associations and private companies established in 1989 to coordinate business participation in the scientific and policy debate on global climate change.

WGI, WGII, WGIII = IPCC Working Groups One, Two and Three.
FSM = Full Supporting Material, the peer reviewed portion of IPCC's work.

[24814: 06/13/96]



THE GLOBAL CLIMATE COALITION MEMBERSHIP BACKGROUNDER

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The Global Climate Coalition (GCC) is an organization of private companies and business trade associations representing more than 230,000 firms. Membership includes a broad range of business from virtually every sector of the US economy. Large manufacturers in the aluminum and paper industry join small businesses with common interests in maintaining the abundant and inexpensive energy that keep American standards of living the envy of the world. Transportation industries such as the airlines, railroads and automobile manufacturers share a common interest in US energy policies along with independent and investor-owned power generating companies, the petroleum industry, chemical firms and owner-managed small businesses across the country. All are represented in the Coalition, the lead business voice on climate change issues.

Established in 1989 to coordinate business participation in the scientific and policy debate on the global climate change issue, the GCC places a high priority on scientific and economic research to advance the understanding of earth systems. The coalition also supports the improvement of climate models and the refinement of the tools necessary for decision-making with respect to long-term scientific and economic strategies to successfully address potential climate change.

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CRA No. 837-06

World Economic Impacts of US Commitments to Medium Term Carbon Emissions Limits

Prepared by:

Paul M. Bernstein
W. David Montgomery
Thomas F. Rutherford

Charles River Associates Incorporated

January 1997

**WORLD ECONOMIC IMPACTS OF US COMMITMENTS
TO MEDIUM TERM CARBON EMISSIONS LIMITS**

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**Prepared For:
American Petroleum Institute**

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EXECUTIVE SUMMARY

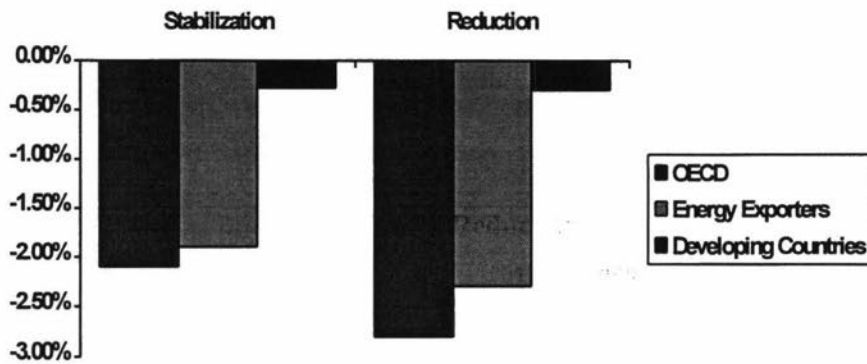
The United States has been participating in international negotiations dealing with limits on future emissions of greenhouse gases from industrial countries for a number of years. In July of 1996, the United States government for the first time endorsed the idea of setting firm emissions abatement targets that countries must meet sometime in the medium term (probably between the years 2005 to 2015). The U.S. government, however, stopped short of announcing support for any specific target or timetable.

In an attempt to assess the economic costs of a greenhouse gas abatement policy within the parameters of what the U.S. government announced a willingness to support, this study uses the International Impact Assessment Model (IIAM) to analyze two specific, but representative carbon abatement policies. The first requires that OECD countries return their emissions to 1990 levels by the year 2010 and maintain them at this level through 2030 ("Stabilization" proposal). Under the second proposal ("Reduction" proposal), OECD countries would be required to reduce their emissions to 90% of 1990 levels by the year 2010 and then maintain these emissions targets through 2030.

The IIAM is designed to analyze the impacts of climate policies on 80 individual countries and regions within a broader context of world trade. The IIAM builds on an extensive body of research on the economics of climate change and international trade theory. It uses a computable general equilibrium model of each country coupled with a model of international trade. The model is based on trade data from the United Nations, energy data from the International Energy Agency (IEA), and national economic data from a variety of sources.

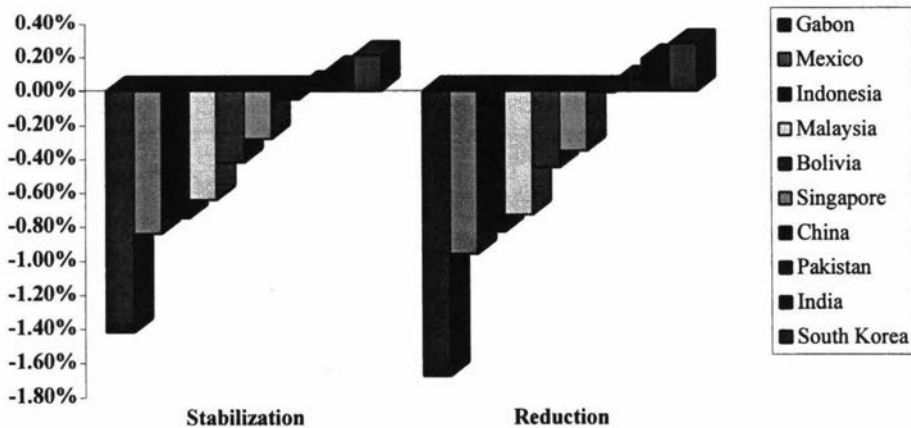
Estimated world GDP losses (by country type) resulting from implementation of the "Stabilization" or "Reduction" proposals are depicted in Figure 1. Because energy use must be reduced significantly in a relatively short-time period, either proposal would lead to substantial GDP losses in the industrial countries undertaking emissions limits. Other countries' GDP would also be reduced. The energy exporting countries would suffer losses comparable to the OECD, even if they did not undertake emissions limits, because of depressed international markets for fossil fuels.

Figure 1. Regional Impacts on GDP due to Emissions Limits in 2030



The ground rules for the current international negotiations on climate policy call for no additional commitments from developing countries. The entire world, however, is connected through international trade, and all countries will be affected if economic growth slows in the industrial countries. Therefore, the adoption of emissions limits by OECD countries would negatively impact most developing countries, as shown in Figure 2. Under either proposal, developing countries would face losses about 10% as large as those affecting the OECD. These losses would arise because OECD countries would demand fewer exports from developing countries, shifting the terms of trade against developing countries, thus reducing their gains from trade. Losses could exceed 1% of GDP for countries that are highly dependent upon trade with OECD countries and have little scope for benefiting from lower-energy costs.

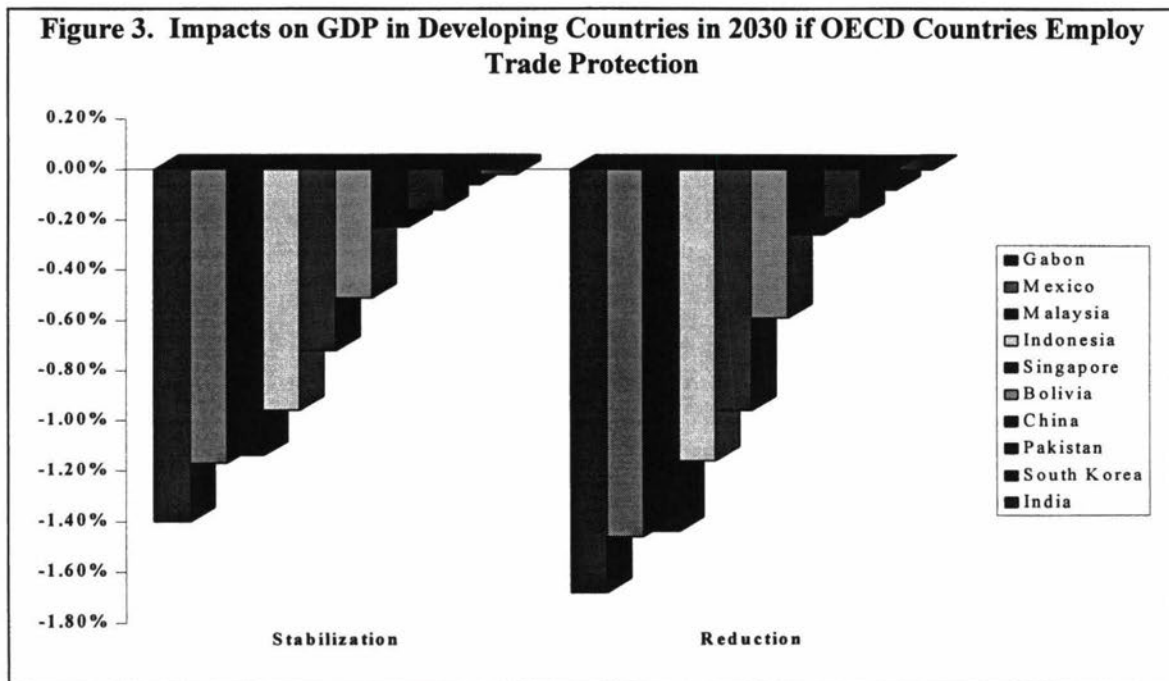
Figure 2. GDP Impacts on Selected Developing Countries in 2030



Potentially, some energy-importing developing countries -- including South Korea and India -- could benefit from having energy costs lower than those of the industrial countries with which they compete in world markets. Such countries would then be able to expand their energy-intensive industries and increase their share of world markets at

the expense of industries in the OECD. However, the IIAM finds that these benefits of lower energy costs are strong enough to offset the shrinkage in export markets for only a very few countries.

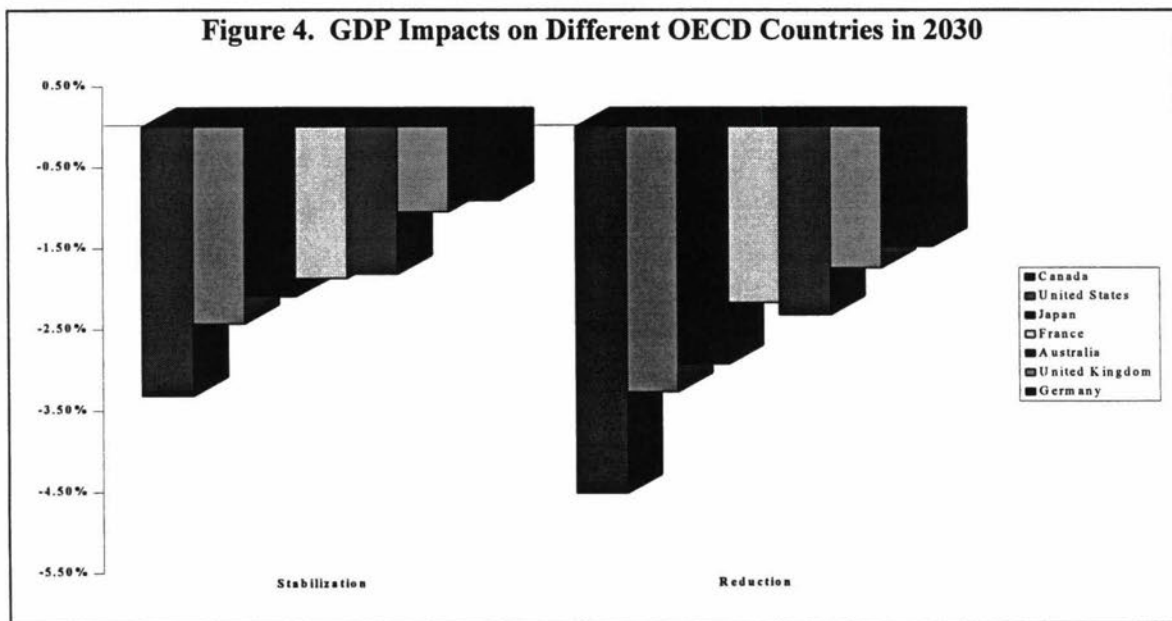
Losses to developing countries would be much larger if the industrial countries protected their energy intensive domestic industries from competition with exports from countries enjoying the benefits of lower energy costs. All developing countries would face economic losses under these scenarios, while the costs to industrial countries would be reduced. Figure 3 illustrates the impacts of trade protection for the same group of countries.



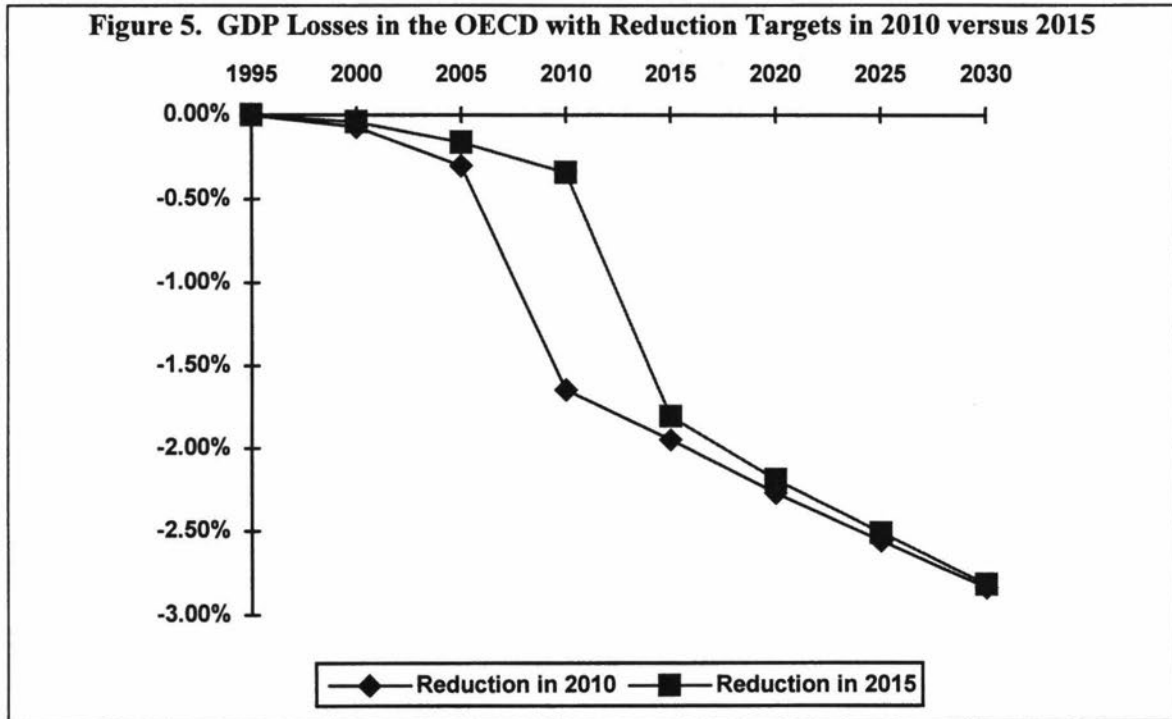
There are also likely to be significant differences among OECD countries in the size and nature of impacts, as seen in Figure 4. For reasons unrelated to climate policy, Germany and the United Kingdom will find it much easier to achieve their emissions goals than will other members of the OECD. As a result, these countries will not encounter the kind of energy cost increases likely to occur in other OECD countries and will gain a competitive advantage over their OECD trading partners. Canada will suffer larger losses than other OECD countries because it has a more energy intensive economy and a large share of its GDP is generated through exports of oil and other energy intensive goods. The United States will be near the OECD average.

Four major factors will influence differences in impacts among OECD countries: they are growth in emissions in the baseline, levels of pre-existing energy taxes, energy intensity, and exposure to competition in international trade.

- A country's costs to abate carbon emissions depends most critically on the baseline forecast for its emissions growth. Factors affecting baseline emissions growth such as population growth, output growth, and relative shares of fossil fuel use, differ across countries. Greater required reductions in carbon emissions, expressed as a percentage of baseline emissions, imply larger GDP losses.
- The marginal cost of abatement (or carbon tax) also depends heavily on the level of pre-existing energy taxes. Since pre-existing taxes in Italy, France, and Japan are much higher than in the U.S. and Canada, the carbon taxes required to achieve a given reduction are also much higher in the former countries.
- Countries in the OECD that have relatively energy intensive industries or economies will face higher costs of reducing emissions, in absolute terms and as a share of GDP.
- Countries with energy intensive processes or industries that are also heavily involved in international trade, and trade mostly with other OECD countries, will be hurt more than others. These countries will face greater than average increases in costs of producing goods that compete in international markets, and greater imports and exports as a share of GDP make international competition more important in the overall economic picture. In addition, trade competition among OECD countries is treated as being more intense than trade competition between OECD and non-OECD countries. Therefore, those countries whose trade is oriented toward other OECD countries will be hurt more than those whose trade is more oriented toward non-OECD countries. Most OECD countries benefit from lower world oil prices, but oil-exporting OECD countries will also suffer from lower world oil demand and lower prices.



The costs of emissions limits in the OECD countries are reduced when more time is allowed to achieve the targets, as shown in Figure 5. If emissions limits were not implemented until 2015, for example, fuel switching and improvements in energy efficiency could be achieved in a less costly fashion as the existing capital stock turned over. In the OECD countries, the result would be cost savings of several percent of cumulative GDP in the transition period.



BACKGROUND -- GLOBAL CLIMATE CHANGE NEGOTIATIONS

Increased concern about global climate change has resulted in several international initiatives that could ultimately result in the adoption of policies designed to reduce greenhouse gas emissions. The first important milestone in international negotiations was the signing of the U.N. Framework Convention on Climate Change in Rio de Janeiro in 1992, where participating governments agreed to non-binding goals for reducing greenhouse gas emissions. Three years later, the first session of the Conference of the Parties to the Framework Convention on Climate Change (COP-1) met to explore the "adequacy" of commitments made at the 1992 Framework Convention. At COP-1, participating governments decided that the non-binding commitments to reduce greenhouse gas emissions agreed to in Rio de Janeiro were not sufficient.

Therefore at COP-1, government representatives produced a decision document (known as the "Berlin Mandate") to establish a process that would "aim ... to elaborate policies and measures" as well as "to set quantified limitation and reduction objectives within specified time frames, such as 2005, 2010, and 2020" for greenhouse gas "emissions by sources and removals by sinks." Several proposals -- each calling for some type of commitment from industrial countries to reduce emissions below 1990 levels during the 2000-2010 time frame -- were tabled at COP-1. Environmental ministers convened again at COP-2 during the summer of 1996; among the stated goals of the COP-2 meeting was to "give fresh political impetus to the negotiations process."

At COP-2, the U.S. government first articulated support for firm ("legally binding") targets for reducing emissions. At that time, the U.S. government did not propose any specific targets or timetables. They did, however, state that the proposal put forth by the Alliance of Small Island States (AOSIS) is unrealistic and insupportable. The AOSIS proposal requires that all Annex I countries reduce their carbon emissions to 1990 levels by 2000, and then reduce carbon emissions to 80 percent of 1996 levels by 2005 (emissions are to be maintained at this level thereafter). In addition, they were in favor of medium-term goals which implied that policies would probably become binding between the years 2005 and 2015.

ASSESSING ECONOMIC IMPACTS OF CLIMATE CHANGE POLICIES -- THE DEVELOPMENT OF THE IIAM

Studies of the economic impacts of global climate change policies in the past several years suggest that adoption of the various proposed emissions reduction plans over the next two decades could entail large economic costs for all countries. However, costs to developing countries have been downplayed because the focus of international negotiations has been on industrial countries that are assumed to adopt carbon limits.

To examine the consequences of carbon abatement policies on individual countries, particularly developing countries, Thomas Rutherford and Charles River Associates developed the International Impact Assessment Model, which is a computable general equilibrium model. The IIAM provides a new method for analyzing the impacts of greenhouse gas abatement policies: it allows users to examine the consequences of emissions abatement policies for 80 countries and regions. The MRT model divides the world into five geopolitical regions: the Organization for Economic Cooperation and Development (OECD) nations, Non-OECD Asia (ASIA), Eastern Europe and Former Soviet Union or Centrally Planned Emerging Economies (CPEE), Middle East and North Africa (MIDE), and the rest of the world (ROW). By looking at the world as a whole, the model accounts for how countries are linked through international trade and energy markets. The IIAM builds on an extensive body of research on the economics of climate change and international trade theory. Papers based on this research are listed in the bibliography at the end of this report. Please refer to Appendix A for a detailed description of the model structure.

The Effect of Implementing Possible U.S. "Proposals"

For this study, Charles River Associates was asked by the American Petroleum Institute to estimate the possible economic impacts of carbon abatement policies that the U.S. government might endorse. Although the U.S. government has not yet proposed specific policies, it has, as noted above, expressed support for setting target limits. We have developed two scenarios that attempt to meet the U.S. government's announced criteria. The first requires that OECD countries return their emissions to 1990 levels by the year 2010 and maintain them at this level through 2030 (hereafter we refer to this proposal as the "Stabilization" proposal). Under the second proposal, known as the "Reduction" proposal, OECD countries would be required to reduce their emissions to 90% of 1990 levels by the year 2010 and then maintain these emissions targets through 2030. For many policies that are currently being tabled, all Annex I countries (OECD countries plus economies in transition, namely the Former Soviet Union and Eastern Europe) would be required to reduce their emissions. For this study, however, it is assumed that only OECD countries adopt carbon limits. Because the former Centrally Planned Emerging Economies are facing many financial difficulties, this study assumes that these countries would not be forced to adopt emissions limits.

Using the IIAM, we estimate the economic impacts of these two proposals on both major world regions and individual countries. This study reports how these two proposals impact a country's gross domestic product (GDP), non-energy exports, terms of trade, and carbon emissions. It also calculates a carbon tax necessary to achieve the goal. These impacts are measured relative to a business-as-usual scenario¹ in which carbon abatement policies are absent. The rest of this study is organized as follows: first, an explanation of the probable impacts on different country types is presented; next, results of these two proposals on world regions are discussed followed by an explanation of the effects on individual countries; and finally, sensitivity analysis on many of the key assumptions is conducted. In general, the impacts are reported as a percentage change from the levels in the business-as-usual scenario.

Implications for Major World Regions

To understand the impact on different regions and countries, we first discuss the likely impacts on three country types and explore the reasons why different impacts can be expected. A carbon abatement policy's impact on a specific country first depends on how that country is categorized: OECD member, energy exporter, or developing country. The economic impact on the OECD countries should be negative. It is only OECD countries that must adopt carbon limits. These limits require them to reduce their consumption of fossil fuels which would cause their domestic industries either to substitute away from fossil fuels to more expensive energy sources and other inputs or to employ more expensive manufacturing and production techniques. This would raise the costs of their domestically produced goods and make these goods less competitive internationally. In addition, fuel for final consumption would become more expensive; therefore, households would change their consumption mix. This would result in a loss of welfare (consumers' surplus) and real income for households.

Energy exporting nations would be adversely affected by carbon abatement policies. The price of fossil fuels would drop with a decline in the OECD countries' demand for these fuels. Thus, energy exporting countries would experience a loss of revenues from energy sales. Since these countries undertake no carbon limits, their domestic industries would benefit from lower energy prices. If an energy producing country such as Venezuela also has energy-intensive domestic industries, then its production costs could decline relative to the OECD and, therefore, make its goods more competitive internationally. Also, households would benefit from the lower energy prices. None of these potential benefits should be large enough to offset the loss in revenues from energy exports, but they should moderate GDP losses in energy exporting countries.

¹ The BAU scenario establishes a reference growth path over the model's time horizon for emissions, energy production, and GDP growth rate. For further details on the business-as-usual scenario, please see Appendix B.

The effect of carbon abatement policies on developing countries is ambiguous. These countries would not be required to undertake any carbon limits; thus, they would receive the benefits of lower energy prices. But there are two offsetting effects: an “income effect” and a “substitution effect.” Regarding the income effect, as the OECD’s income declines, OECD purchasing power decreases, and the OECD countries can only afford to purchase fewer imports from the developing countries. Most of these countries conduct approximately 60% to 75% of their trade with OECD countries. Therefore, the developing countries could experience a loss in export revenue. On the other hand, they benefit from the substitution effect. That is, since these countries do not undertake any carbon limits, they receive the full benefit of lower world energy prices and their domestic industries receive a competitive advantage relative to those in the OECD. Therefore, the non-OECD countries export more goods to other non-OECD countries which displaces OECD exports to these countries. The net impact depends on which effect dominates and consequently whether the terms of trade for a particular country improves or deteriorates.

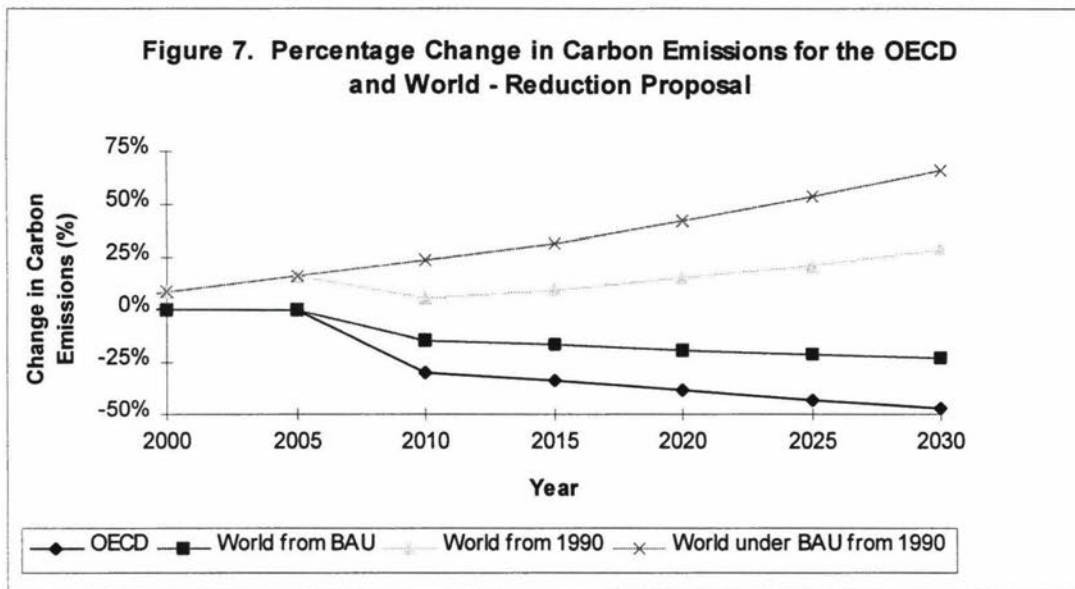
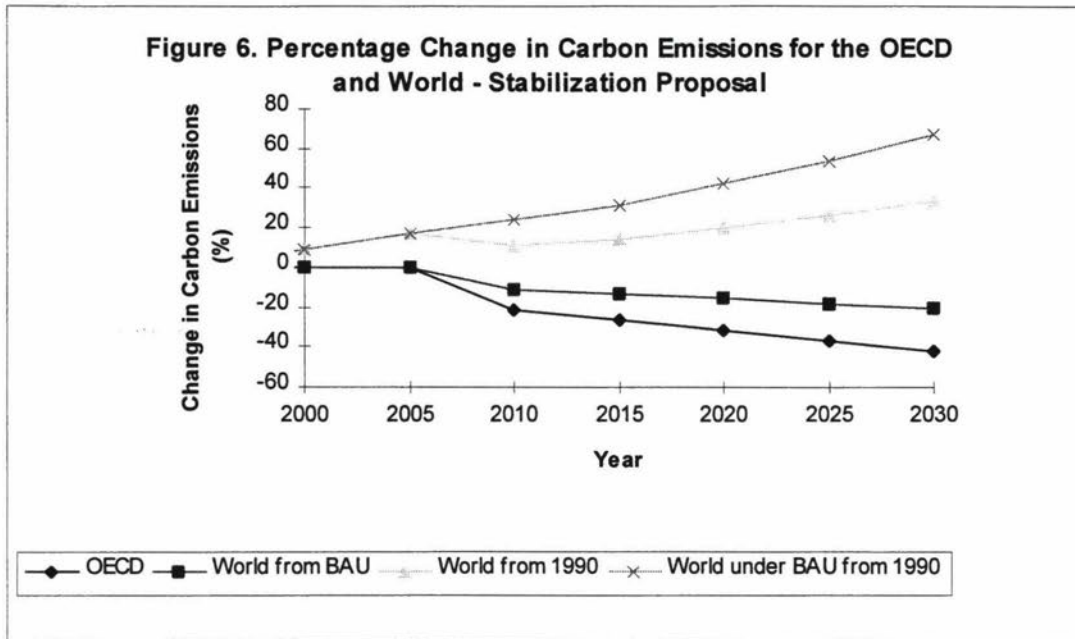
Results

To compute the impacts of the two proposals, the IIAM is first run under the business-as-usual (BAU) scenario with a common set of assumptions. Using these same assumptions (these assumptions include using accepted elasticity values as well as IPCC reference scenarios), the IIAM is then run under the Stabilization and Reduction proposals. We first report the results of these two proposals on world regions and then on individual countries. In the last part of this section, we vary some of the key assumptions and report the economic impacts that these variations have on world regions. In general, the impacts are reported as a percentage change from the levels in the business-as-usual scenario. All dollar figures are reported as 1992 U.S. dollars.

Results for World Regions

Carbon Emissions

According to the IIAM results, in 2010 the OECD region as a whole must reduce its carbon emissions by 22% and 30% from BAU levels in order to comply with the Stabilization and Reduction proposals, respectively (see Figures 6 and 7). In the year 2030, OECD countries must reduce their emissions further, relative to BAU levels: to adhere to the Stabilization and Reduction proposals, the OECD region must reduce emissions by 41% and 47%, respectively. This increase in emissions abatement over time occurs because, in the BAU scenario, emissions in the OECD region are forecasted to grow from 2.8 billion metric tonnes in 1990 to 4.7 billion metric tonnes in 2030. Therefore, the gap between the OECD’s emissions in the BAU scenario and the constant target of 1990 emissions levels continues to grow.



Reductions in OECD energy consumption and hence, emissions could be offset, at least in part, by increases in energy consumption and emissions in the non-OECD countries. First, because of the lower world energy prices under a carbon abatement policy, non-OECD countries are likely to consume more energy. The reduction in OECD fuel consumption causes a decline in world energy prices and induces the non-OECD countries to consume more fossil fuels. Second, because non-OECD countries experience lower fuel prices, some industries may relocate from OECD to non-OECD countries.

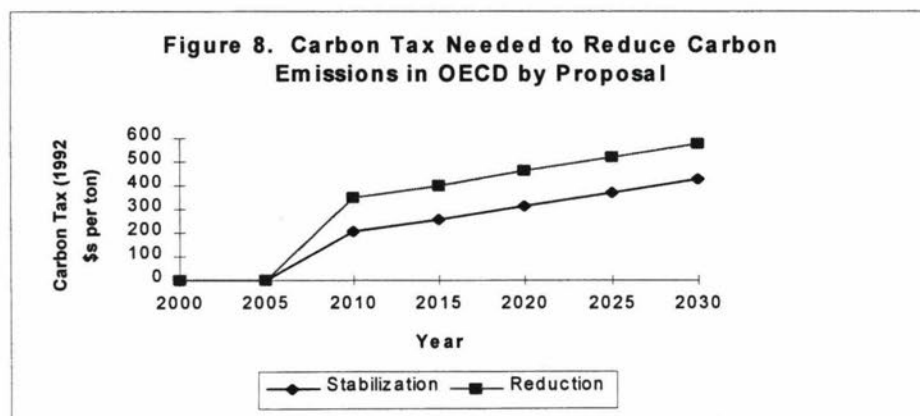
Two points need to be emphasized regarding the effect of these two proposals on world emissions. The ratio of the increase in non-OECD emissions to the decrease in OECD

emissions is referred to as *carbon emission leakage*. Under both proposals, the leakage is less than one percent, because negative economic impacts on non-OECD countries mostly outweigh any increase in carbon emissions per unit of output. Even though non-OECD countries do not participate in carbon abatement, world carbon emissions decline from what they would be in the business-as-usual scenario. The increase in non-OECD carbon emissions is far less than the reduction in OECD carbon emissions; hence, Figures 6 and 7 show that there is a decline in world emissions from the BAU under these proposals (lines denoted “World from BAU”). In 2030, the reduction in world emissions from the BAU scenario is 21% and 23% under the Stabilization and Reduction proposals, respectively.

Second, world emissions, however, do continue to increase from 1990 levels. Because non-OECD countries have no emissions restrictions placed upon them, their carbon emissions continue to grow (see lines denoted “World from 1990”). Under the Reduction proposal, there is an increase in world carbon emissions from 1990 levels of 6% in 2010 and 28% in 2030. Under the Stabilization proposal, there is an increase in world carbon emissions from 1990 levels of 11% in 2010 and 33% in 2030.

Marginal Cost of Carbon Abatement (Carbon Tax)

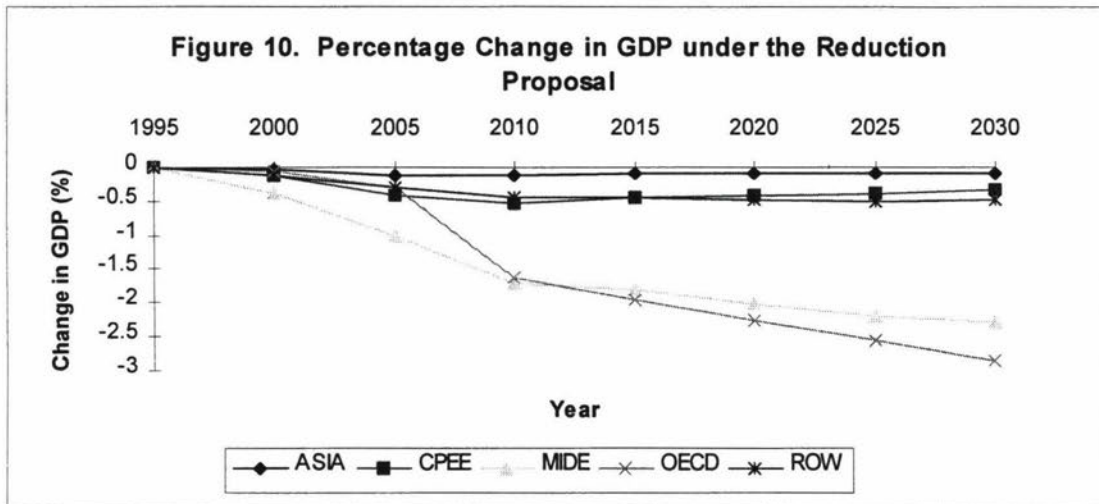
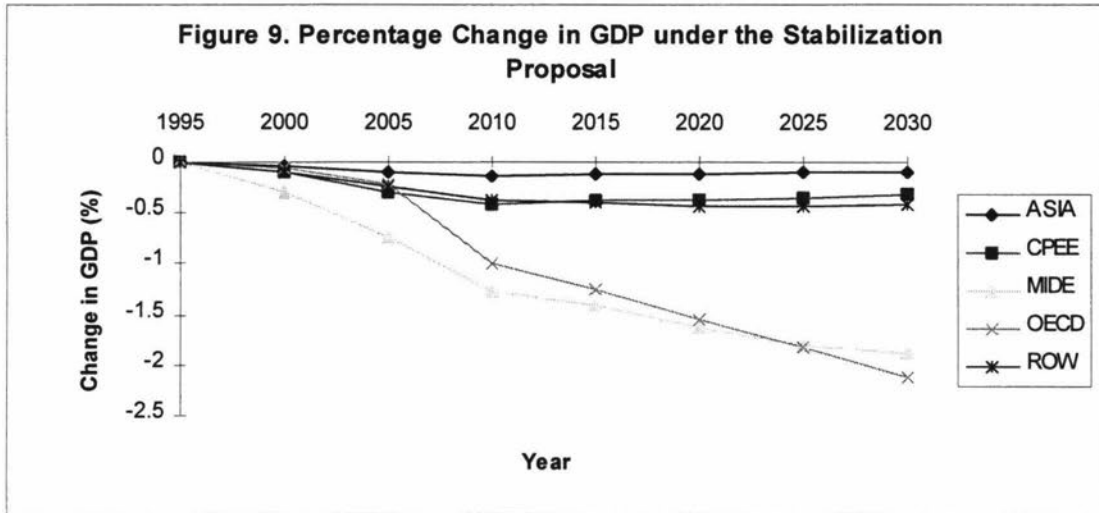
Under the U.S. Stabilization proposal, the marginal cost of abatement (or equivalent carbon tax²) starts at \$200 per ton of carbon in 2010 and rises to \$430 per ton in 2030. A \$100 per ton carbon tax equates to a gasoline tax of about \$0.27 per gallon. For the Reduction proposal, the required carbon tax starts at \$350 per ton in 2010 and rises to \$580 per ton in 2030 (see Figure 8). Therefore, in 2030, the required gasoline tax would be about \$1.50 per gallon. The carbon tax increases with time, which reflects the increasing marginal cost of abating carbon emissions. Because of the growth in emissions under the BAU scenario, more emissions must be abated in later years at a higher per unit cost as the least-cost options for abating emissions are already used.



² To force the OECD countries to comply with either proposal, the model places a carbon emissions limit on these countries that corresponds to the proposal of interest. That is, the model endows the OECD countries with non-tradable permits that allow them to emit carbon up to the level allowed by the specific proposal. Figure 8 displays the marginal cost of these permits, which can also be interpreted as a carbon tax that is assessed on each ton of emissions and refunded to the economy in lump sum.

GDP

Under both proposals, the required reduction in OECD carbon emissions causes a reduction in GDP in all regions (see Figures 9 and 10). Even though the proposals require only the OECD countries to adopt carbon limits, other countries are impacted through international trade in energy and non-energy goods.³



The OECD is directly affected by the carbon abatement policies. Their collective GDP declines by 2.1% and 2.8% under the Stabilization and Reduction scenarios, respectively, in the year 2030. Non-OECD regions' GDP are negatively impacted by the OECD's loss of income. The large decline in the OECD's demand for fossil fuel energy causes the

³ To meet the self-imposed limits, OECD countries must reduce their consumption of fossil fuels. As the economy grows and the demand for energy increases, the production cost within OECD countries increases since they must alter their mix of inputs to produce outputs and hence use less energy per dollar of GDP to manufacture goods. This increases the cost of producing both final and intermediate goods in the OECD. Non-OECD countries that use OECD-produced intermediate goods in manufacturing will see these price increases.

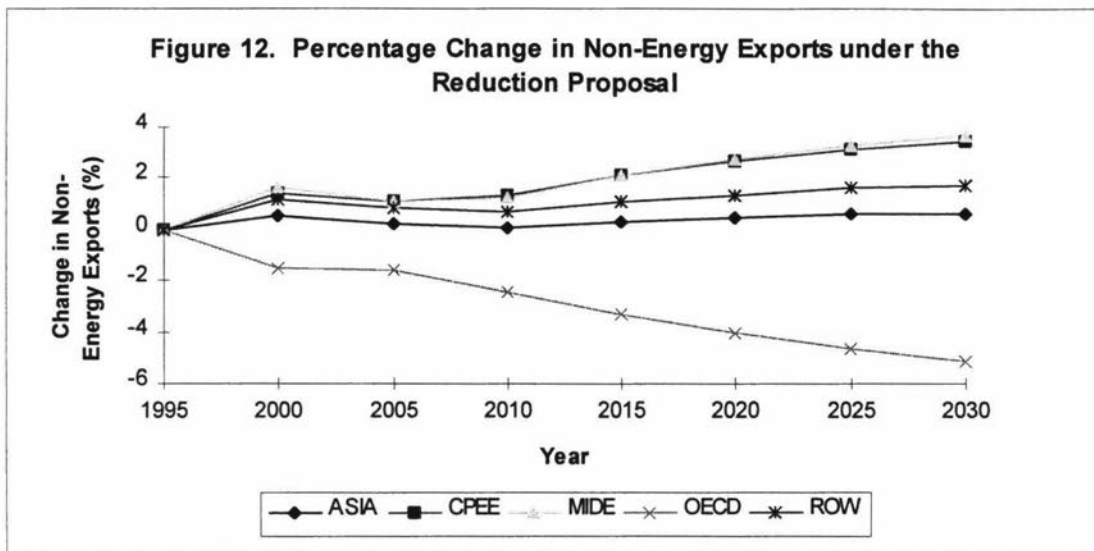
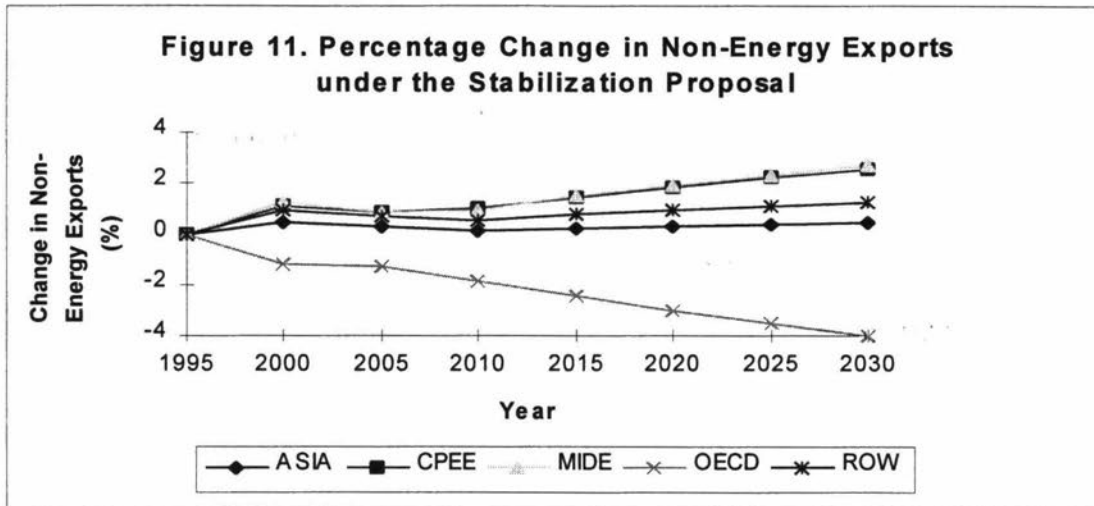
energy exporting countries to suffer almost as much as the OECD countries. In 2030, these nations experience a loss in GDP of 1.9% and 2.3% under the Stabilization and Reduction proposals, respectively.

The former Centrally Planned Emerging Economies (CPEE) and rest of the world (ROW) regions experience GDP losses in the range of 0.3% to 0.5%. These losses are greater than the losses in the ASIA region because the CPEE and ROW regions contain some countries that are significant energy exporters, whereas ASIA is dominated by countries that are non-energy exporters and energy importers.

For all three of these regions, the decline in GDP lessens in the more distant years because each region has significant time to reorganize its economy and make use of competitive advantages from lower world energy prices. In addition, in each future year, the OECD must use less energy per unit of output; this continues to raise their production costs. Therefore, the developing countries gain more of a competitive advantage and begin to benefit more from this advantage.

Trade Effects

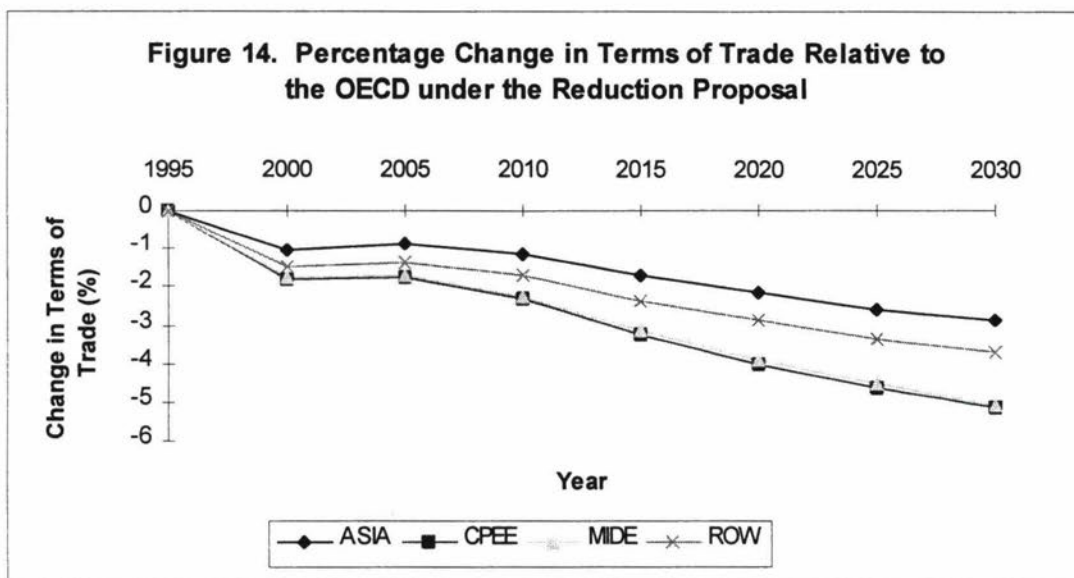
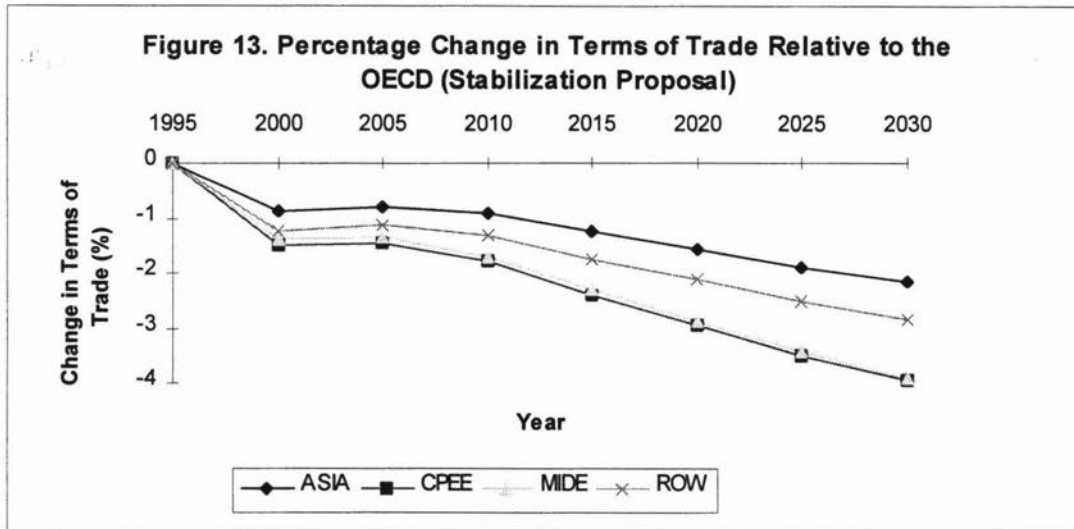
If the OECD countries were to adopt either the Stabilization or Reduction proposal, each region would experience significant effects on trade. The changes in each region's non-energy exports and terms of trade provide insights into how these proposals impact each region's GDP. Under either proposal, non-energy exports from all non-OECD regions increase from their business-as-usual levels, whereas the OECD's non-energy exports decrease (see Figures 11 and 12). This occurs because as OECD countries are required to further reduce emissions from BAU levels, they must continue to substitute away from energy to produce their goods. These inefficient changes in production drive up the price of OECD goods relative to those of non-OECD goods resulting in a decline in OECD exports and an increase in non-OECD exports.



Changes in terms of trade can be used to evaluate the relative change in a country's trade pattern. Terms of trade is measured as the ratio (in value terms) of a country's exports to its imports. Therefore, the change in a region's terms of trade from the BAU scenario captures the change in the relative value of goods that it exports to the value of goods that it imports. For example, if the value of a country's exports increase and its imports decrease, the country's terms of trade increases and its trade position improves.

The terms of trade in non-OECD regions, relative to that of OECD countries, declines for two reasons (see Figures 13 and 14). First, the cost of imports from the OECD increases because production costs are higher in the OECD under carbon emissions limits. Second, the decline in OECD income under either of these proposals means that OECD expenditures on the combination of domestically produced and imported goods will decline relative to the BAU scenario. However, depending on the change in the cost of imports relative to domestic goods, the OECD countries' expenditures on imports could either increase or decrease. Since the percentage change in terms of trade for these non-

OECD countries is negative, the cost advantage achieved by non-OECD countries is not, on balance, large enough to induce the OECD countries to increase their expenditures on imports. Although the non-OECD countries' overall level of exports increases (since their exports to other non-OECD countries increase by supplanting OECD exports), they receive fewer imported goods in return because they must still purchase high-cost OECD goods.⁴



⁴ Because of the IIAM's Armington structure, larger and larger price differences between imports and domestic goods are needed in order for a region to change its consumption mix between imported and domestically produced goods. The Armington elasticity helps determine how expensive it is for any country to substitute between domestically produced goods and imports from different regions. If the Armington elasticity were increased, the terms of trade for non-OECD countries would improve, but it would still be economical for these countries to import some goods from OECD countries.

Results for Individual Countries

In this section, we delve into the differences among countries within the various regions. First, we compare the economic impacts on the following eight OECD countries: Australia, Canada, France, Germany, United Kingdom, Italy, Japan, and the United States. Second, the economic impacts on developing countries are studied. We determine the economic profile needed for a developing country to benefit when carbon limits are placed on OECD countries. Finally, we look at impacts on energy exporters.

OECD Countries

Under a specific proposal, these eight OECD countries experience very different GDP losses. For both proposals, the ranking of countries from the least impacted to the most impacted in 2030 is as follows: Germany, United Kingdom, Australia, France, Japan, Italy, the United States, and Canada (See Tables 1 and 2). For example in the year 2030, under the Stabilization policy, Canada's GDP is estimated to decline by 3.3% relative to the BAU scenario, and Germany's GDP is estimated to decline by only 0.9%.

Table 1. Impact of Stabilization Proposal on GDP in Selected OECD Countries
(percentage change from BAU)

	1995	2000	2005	2010	2015	2020	2025	2030
Australia	0.00	-0.04	-0.19	-0.92	-1.15	-1.37	-1.60	-1.82
Canada	0.00	-0.08	-0.38	-1.69	-2.12	-2.56	-2.94	-3.29
France	0.00	-0.04	-0.20	-0.73	-0.97	-1.38	-1.70	-1.86
Germany	0.00	-0.01	-0.08	-0.28	-0.39	-0.54	-0.71	-0.91
Italy	0.00	-0.05	-0.24	-1.04	-1.34	-1.59	-1.86	-2.17
Japan	0.00	-0.02	-0.14	-0.83	-1.14	-1.50	-1.82	-2.11
United Kingdom	0.00	-0.02	-0.12	-0.36	-0.50	-0.66	-0.85	-1.06
United States	0.00	-0.05	-0.22	-1.12	-1.42	-1.77	-2.11	-2.44

Table 2. Impact of Reduction Proposal on GDP in Selected OECD Countries
(percentage change from BAU)

	1995	2000	2005	2010	2015	2020	2025	2030
Australia	0.00	-0.05	-0.25	-1.29	-1.55	-1.83	-2.10	-2.37
Canada	0.00	-0.12	-0.54	-2.82	-3.33	-3.80	-4.19	-4.52
France	0.00	-0.05	-0.24	-1.41	-1.65	-1.90	-2.07	-2.20
Germany	0.00	-0.02	-0.14	-0.69	-0.86	-1.07	-1.29	-1.52
Italy	0.00	-0.07	-0.32	-1.85	-1.98	-2.26	-2.50	-2.66
Japan	0.00	-0.04	-0.20	-1.52	-1.93	-2.35	-2.69	-2.98
United Kingdom	0.00	-0.04	-0.22	-0.87	-1.08	-1.31	-1.54	-1.79
United States	0.00	-0.07	-0.31	-1.85	-2.21	-2.61	-2.97	-3.31

Four major factors influence the varying degree of impacts among OECD countries: they are growth in emissions in the baseline, levels of pre-existing energy taxes, energy intensity, and exposure to competition in international trade.

- A country's costs to abate carbon emissions depends most critically on the baseline forecast for its emissions growth. Factors affecting baseline emissions growth such as population growth, output growth, and relative shares of fossil fuel use, differ across countries. Greater required reductions in carbon emissions (seen in Tables 3 and 4), expressed as a percentage of baseline emissions, imply larger GDP losses.
- The marginal cost of abatement (or carbon tax) also depends heavily on the level of pre-existing energy taxes. Since pre-existing taxes in Italy, France, and Japan are much higher than in the U.S. and Canada, the carbon taxes required to achieve a given reduction are also much higher in the former countries.
- Countries in the OECD that have relatively energy-intensive industries or economies will face higher costs of reducing emissions, in absolute terms and as a share of GDP.
- Countries with energy-intensive processes or industries that are also heavily involved in international trade, and trade mostly with other OECD countries, will be hurt more than others. These countries will face greater than average increases in the costs of producing goods that compete in international markets, and greater imports and exports as a share of GDP make international competition more important in the overall economic picture. In addition, trade competition among OECD countries is treated as being more intense than trade competition between OECD and non-OECD countries. Therefore, countries whose trade is oriented toward other OECD countries will be hurt more than countries whose trade is more oriented toward non-OECD countries. Most OECD countries benefit from lower world oil prices, but oil-exporting OECD countries also suffer from lower world oil demand and lower prices.

Under both proposals, Germany and the United Kingdom are impacted the least because their emissions are forecast to grow more slowly than those of the other six OECD countries. Germany and the United Kingdom need to reduce their emissions by 35% and 36%, respectively, from the BAU to meet the requirements of the Reduction proposal. Canada and the U.S., however, need to reduce their emissions by 48% and 52%, respectively, from the BAU in order to comply with the Reduction proposal.

Table 3. Impact of Stabilization Proposal on Carbon Emissions in Selected OECD Countries (percentage change from BAU)

	1995	2000	2005	2010	2015	2020	2025	2030
Australia	0.00	0.03	-0.04	-26.44	-32.32	-38.34	-43.84	-48.84
Canada	0.00	0.19	0.11	-23.29	-27.92	-33.02	-37.74	-42.06
France	0.00	0.02	-0.02	-21.37	-25.30	-30.58	-35.47	-39.91
Germany	0.00	0.04	0.03	-12.73	-15.52	-19.81	-24.11	-28.34
Italy	0.00	0.04	-0.01	-20.54	-24.39	-29.68	-34.57	-39.00
Japan	0.00	0.10	0.06	-22.46	-26.07	-31.24	-35.99	-40.28
United Kingdom	0.00	0.03	0.00	-11.73	-14.80	-18.74	-22.66	-26.49
United States	0.00	0.18	0.14	-24.53	-30.04	-36.12	-41.71	-46.82

Table 4. Impact of Reduction Proposal on Carbon Emissions in Selected OECD Countries (percentage change from BAU)

	1995	2000	2005	2010	2015	2020	2025	2030
Australia	0.00	0.04	-0.05	-33.79	-39.09	-44.51	-49.45	-53.95
Canada	0.00	0.25	0.14	-30.96	-35.12	-39.72	-43.97	-47.85
France	0.00	-0.03	-0.08	-29.23	-32.77	-37.53	-41.92	-45.92
Germany	0.00	0.06	0.03	-21.46	-23.97	-27.83	-31.70	-35.51
Italy	0.00	-0.02	-0.09	-28.49	-31.95	-36.71	-41.11	-45.10
Japan	0.00	0.11	0.06	-30.21	-33.47	-38.12	-42.40	-46.25
United Kingdom	0.00	0.04	-0.01	-20.55	-23.32	-26.87	-30.40	-33.84
United States	0.00	0.24	0.18	-32.08	-37.03	-42.51	-47.54	-52.14

Both Germany and the United Kingdom have announced that they will be able to meet the goal of holding emissions at 1990 levels through 2000 because of policies and events *independent* of climate policy. Germany's emissions growth is halted for a time because its base year included the former East Germany. Energy use was dominated by extremely inefficient use of coal in that country. Contraction of the former East German economy and replacement of its inefficient patterns of energy use have reduced emissions from that part of Germany, and held total emissions for the reunited country down relative to the rest of Europe. In the United Kingdom, policies to reduce subsidies to the coal industries and deregulation of energy industries, both of which began independently of climate change concerns, have also served to hold down emissions by encouraging substitution of natural gas for coal. Britain's somewhat higher costs, compared to Germany, are partly explained by the losses in oil export revenue that Britain faces.

Because of these developments in the German and British economies, their costs of near-term limits on carbon emissions are significantly smaller than in the rest of the OECD. The percentage increase in energy costs (measured by the implied carbon tax) is smaller than in other OECD countries because the required percentage reduction in emissions is

smaller, and both countries therefore, achieve trade benefits at the expense of other OECD countries.

Despite large required reductions in emissions, Australia experiences less of a loss in its GDP than do other OECD countries. In part, this is because relatively low existing energy taxes imply that relatively small energy price increases are required to sufficiently reduce energy demand to meet emissions limits. In addition, Australia is a large coal consumer in the baseline, and therefore, benefits from its ability to reduce some portion of its carbon emissions by merely consuming oil instead of coal. The IIAM probably underestimates Australia's GDP loss because it does not include a true world coal market. Therefore, the model does not capture all of Australia's income loss from a decline in coal trade and revenues from coal exports.

France, Japan, and Italy experience less GDP loss than the U.S. and Canada because those three countries use less energy per unit of GDP and have lower growth in baseline emissions, than the latter two countries. Nuclear energy supplies more than a third of France's energy needs. This means that more than a third of France's energy is already a carbon free energy source. This produces two opposite effects on the costs of carbon limits. France has less scope to replace fossil fuels used for electric power generation with other fuels, and therefore must rely on more expensive options to curtail growth in emissions. In the baseline, France is assumed to continue to expand its nuclear power industry so that about one-third of baseline growth in energy demand is also satisfied from non-carbon sources. If, however, France were to move away from nuclear power in the baseline, then its costs would be greater than estimated.

Current energy prices in France, Japan, and Italy are much higher than in the U. S. and Canada therefore, it takes a large carbon tax to produce the same proportionate increase in delivered energy prices to bring about the required reduction from baseline consumption of fossil fuels. The required level of the carbon tax becomes so high that the price of fossil fuels (including their associated carbon taxes) equals the cost of the backstop fuel (a new, carbon-free energy source that is assumed to be available in unlimited quantities at a multiple of today's price for fossil fuels). In other words, the backstop fuel becomes cost-effective in the year 2015. If no backstop fuel existed, these countries would require carbon taxes that were two to three times more than those in the U.S. and Canada. Since the model assumes that each country produces its own backstop fuel, the model underestimates the GDP loss in countries like Japan that are unlikely to do this. To address this issue, we made the price of Japan's backstop fuel twenty percent higher than that of the United States.

Trade effects play an important role in making Canada the most heavily impacted OECD country. Canada stands out as a country with a large ratio of exports to GDP, energy-intensive industries, a large share of trade with other OECD countries, and oil exports. This combination of trade factors, together with the high costs of reducing emissions, leads to larger harm for Canada than other OECD countries.

Impacts in these countries can lead to large employment shocks, becoming greatest in the year 2010 when the two policies would take effect. For example, in the year 2010, unemployment in Italy and Canada is predicted to increase by about 3.4 percentage points, from the level of unemployment in the BAU scenario (see Table 5).

Since introducing a full treatment of unemployment in a forward looking general equilibrium model adds considerable complexity (see “A Multisectoral Framework for One Analysis of Carbon Emission Restrictions and One Bilateral Trade in the European Union Model Formula and a Safe Alliance by Thomas F. Rutherford, Michael Ferris, and Christopher Bohriugen), the IIAM uses a relationship between deviations from the BAU path of wage growth and the level of unemployment to estimate an indicator of unemployment. The impact per percentage point reduction in emissions from the baseline is calibrated to other, more detailed studies.⁵ This version of a “sticky wage” model recognizes that union contracts and other factors may, for a time, prevent wage adjustments required to maintain full employment as an example of the short-run transition costs that need to be considered.

Table 5. Impact of the Reduction Proposal on the Unemployment Rate in Selected OECD Countries (Change in Percentage points)

	1995	2000	2005	2010	2015	2020	2025	2030
Australia	0.00	0.00	0.10	0.99	0.23	0.27	0.27	0.25
Canada	0.00	0.00	0.21	3.42	0.37	0.40	0.30	0.23
France	0.00	0.00	0.09	2.90	-0.04	-0.02	-0.05	-0.06
Germany	0.00	0.00	0.06	1.28	0.12	0.22	0.22	0.23
Italy	0.00	0.00	0.12	3.45	0.25	-0.04	-0.06	-0.07
Japan	0.00	0.00	0.08	2.45	0.28	0.35	0.28	0.23
United Kingdom	0.00	0.00	0.09	1.47	0.16	0.23	0.23	0.22
United States	0.00	0.00	0.13	2.45	0.33	0.39	0.32	0.26

Emerging Economies of Eastern Europe

It is assumed in these scenarios that despite their inclusion in Annex 1, none of the formerly planned economies in Eastern Europe and the former Soviet Union will agree to emissions limits. Countries in the CPEE (the Czech Republic, Hungary, Poland, Romania, and Russia) experience a loss in GDP ranging from 0.03% (for Poland) to 0.63% (for Russia) under the Stabilization scenario; and from 0.03% (for Poland) to 0.75% (for Russia) under the Reduction scenario in 2030 (see Tables 6 and 7). These countries do not benefit from lower world energy prices to the extent that developing countries do because of the large amounts of domestic energy production and large existing subsidies that lead to inefficient energy use. In addition, most of their trade is with the OECD, so that higher costs of exports from the OECD translate into higher costs of imports and a deterioration of the terms of trade.

⁵ Montgomery, Hughes and Yanchar, “Economic Impacts of Carbon Taxes,” EPRI 1995 for the U. S.

Table 6. Percentage Change from BAU in GDP under the Stabilization Proposal

COUNTRY / REGION	1995	2000	2005	2010	2015	2020	2025	2030
OECD:								
Australia	0.00	-0.04	-0.19	-0.92	-1.15	-1.37	-1.60	-1.82
Austria	0.00	-0.02	-0.10	-0.62	-0.81	-1.07	-1.27	-1.35
Belgium	0.00	-0.04	-0.24	-0.62	-0.92	-1.43	-1.87	-2.21
Canada	0.00	-0.08	-0.38	-1.69	-2.12	-2.56	-2.94	-3.29
Switzerland	0.00	-0.01	-0.08	-1.20	-1.16	-1.24	-1.32	-1.40
Germany	0.00	-0.01	-0.08	-0.28	-0.39	-0.54	-0.71	-0.91
Denmark	0.00	-0.03	-0.17	-1.22	-1.45	-1.63	-1.71	-1.79
Spain	0.00	-0.02	-0.15	-0.57	-0.81	-1.13	-1.45	-1.77
Austria Finland Sweden	0.00	-0.03	-0.15	-0.91	-1.17	-1.47	-1.73	-1.95
European Union 12	0.00	-0.06	-0.28	-1.11	-1.51	-1.97	-2.39	-2.75
Finland	0.00	-0.04	-0.22	-1.60	-1.91	-2.28	-2.59	-2.84
France	0.00	-0.04	-0.20	-0.73	-0.97	-1.38	-1.70	-1.86
United Kingdom	0.00	-0.02	-0.12	-0.36	-0.50	-0.66	-0.85	-1.06
Greece	0.00	-0.02	-0.21	-0.54	-0.89	-1.32	-1.77	-2.24
Ireland	0.00	-0.05	-0.32	-1.34	-1.85	-2.34	-2.76	-3.12
Iceland	0.00	-0.05	-0.23	-1.42	-1.75	-2.12	-2.36	-2.43
Italy	0.00	-0.05	-0.24	-1.04	-1.34	-1.59	-1.86	-2.17
Japan	0.00	-0.02	-0.14	-0.83	-1.14	-1.50	-1.82	-2.11
Luxembourg	0.00	-0.05	-0.34	-1.10	-1.65	-2.27	-3.02	-3.63
Netherlands	0.00	-0.06	-0.32	-1.55	-1.98	-2.35	-2.61	-2.72
Norway	0.00	-0.12	-0.39	-1.30	-1.48	-1.69	-1.86	-1.98
New Zealand	0.00	-0.09	-0.45	-1.98	-2.72	-3.50	-4.21	-4.88
Portugal	0.00	-0.03	-0.19	-0.53	-0.88	-1.28	-1.65	-1.99
Sweden	0.00	-0.02	-0.13	-1.22	-1.37	-1.51	-1.57	-1.62
Turkey	0.00	-0.09	-0.40	-1.15	-1.64	-2.21	-2.80	-3.42
United States	0.00	-0.05	-0.22	-1.12	-1.42	-1.77	-2.11	-2.44
Non-OECD and Non-Oil Exporters:								
Argentina	0.00	-0.06	-0.14	-0.20	-0.21	-0.22	-0.21	-0.18
Bolivia	0.00	-0.12	-0.30	-0.42	-0.45	-0.48	-0.48	-0.42
Brazil	0.00	-0.04	-0.09	-0.06	-0.04	-0.01	0.03	0.09
Chile	0.00	-0.05	-0.12	-0.13	-0.14	-0.15	-0.17	-0.18
China	0.00	-0.06	-0.15	-0.18	-0.14	-0.12	-0.09	-0.05
Colombia	0.00	-0.15	-0.41	-0.60	-0.67	-0.72	-0.71	-0.64
Cameroon	0.00	-0.15	-0.37	-0.57	-0.62	-0.68	-0.70	-0.67
Congo	0.00	-0.30	-0.77	-1.30	-1.41	-1.62	-1.79	-1.86
Ghana	0.00	-0.04	-0.07	-0.04	-0.02	-0.01	-0.01	0.01
Hong Kong	0.00	-0.04	-0.10	-0.09	-0.07	-0.07	-0.08	-0.10
India	0.00	-0.02	-0.07	-0.06	-0.03	0.01	0.06	0.12
Israel	0.00	-0.08	-0.12	-0.13	-0.16	-0.19	-0.22	-0.25
Jamaica	0.00	0.03	0.03	0.33	0.57	0.80	1.03	1.28

Table 6. (Continued)

Jordan	0.00	-0.08	-0.10	0.08	0.14	0.22	0.29	0.38
South Korea	0.00	0.00	-0.01	0.05	0.10	0.14	0.17	0.21
Morocco	0.00	-0.07	-0.09	-0.07	-0.09	-0.09	-0.09	-0.09
Nepal	0.00	-0.03	-0.05	0.00	0.02	0.05	0.07	0.10
Pakistan	0.00	-0.04	-0.08	-0.06	-0.04	-0.02	0.00	0.03
Panama	0.00	-0.01	-0.05	0.03	0.08	0.14	0.20	0.27
Peru	0.00	-0.07	-0.21	-0.28	-0.30	-0.29	-0.26	-0.19
Philippines	0.00	-0.01	-0.03	0.03	0.08	0.12	0.16	0.19
Paraguay	0.00	-0.02	-0.06	0.00	0.03	0.07	0.11	0.15
Rest of World	0.00	-0.09	-0.18	-0.25	-0.24	-0.25	-0.26	-0.26
Rest of South America	0.00	-0.20	-0.53	-0.83	-0.92	-1.03	-1.11	-1.12
Sudan	0.00	-0.02	-0.04	0.04	0.08	0.12	0.15	0.19
Singapore	0.00	-0.06	-0.13	-0.14	-0.14	-0.18	-0.23	-0.28
Sub Saharan Africa	0.00	-0.15	-0.35	-0.53	-0.57	-0.62	-0.65	-0.65
Thailand	0.00	-0.02	-0.10	-0.06	-0.03	-0.02	-0.01	0.01
Tunisia	0.00	-0.17	-0.32	-0.45	-0.52	-0.59	-0.65	-0.69
Taiwan	0.00	-0.03	-0.05	-0.04	-0.03	-0.03	-0.04	-0.05
South Africa	0.00	-0.05	-0.09	-0.10	-0.12	-0.14	-0.16	-0.18
Zaire	0.00	-0.09	-0.20	-0.28	-0.30	-0.33	-0.34	-0.34
Zambia	0.00	-0.03	-0.06	-0.03	-0.01	0.00	0.00	0.01
CPEE:								
Czech Republic	0.00	-0.06	-0.10	-0.10	-0.09	-0.10	-0.12	-0.13
Former Soviet Union	0.00	-0.07	-0.27	-0.48	-0.48	-0.51	-0.52	-0.49
Hungary	0.00	-0.05	-0.09	-0.10	-0.11	-0.12	-0.13	-0.14
Poland	0.00	-0.02	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03
Romania	0.00	-0.09	-0.17	-0.22	-0.22	-0.23	-0.24	-0.23
Russia	0.00	-0.13	-0.30	-0.49	-0.54	-0.60	-0.64	-0.63
OPEC:								
United Arab Emirates	0.00	-0.43	-0.97	-1.68	-1.85	-2.20	-2.50	-2.68
Algeria	0.00	-0.27	-0.60	-0.97	-1.10	-1.27	-1.40	-1.45
Egypt	0.00	-0.26	-0.66	-1.07	-1.14	-1.28	-1.38	-1.40
Iran	0.00	-0.32	-0.76	-1.28	-1.41	-1.63	-1.81	-1.91
Iraq	0.00	-0.24	-0.60	-0.94	-1.03	-1.15	-1.24	-1.27
Kuwait	0.00	-0.36	-0.90	-1.58	-1.72	-2.02	-2.28	-2.43
Libya	0.00	-0.34	-0.80	-1.35	-1.48	-1.72	-1.92	-2.00
Middle East and North Africa	0.00	-0.32	-0.75	-1.28	-1.42	-1.64	-1.82	-1.93
Oman	0.00	-0.37	-0.88	-1.54	-1.67	-1.95	-2.19	-2.31
Qatar	0.00	-0.36	-0.83	-1.43	-1.57	-1.84	-2.06	-2.18
Saudi Arabia	0.00	-0.38	-0.88	-1.51	-1.65	-1.94	-2.18	-2.31
Syria	0.00	-0.25	-0.66	-1.06	-1.13	-1.26	-1.36	-1.37
Venezuela	0.00	-0.34	-0.97	-1.57	-1.75	-1.97	-2.13	-2.13

Table 6. (Continued)

Other Oil Exporters:								
Angola	0.00	-0.36	-0.88	-1.49	-1.63	-1.90	-2.12	-2.23
Brunei	0.00	-0.30	-0.62	-1.05	-1.17	-1.39	-1.60	-1.72
Ecuador	0.00	-0.25	-0.74	-1.15	-1.26	-1.37	-1.42	-1.36
Gabon	0.00	-0.24	-0.63	-1.04	-1.14	-1.30	-1.41	-1.42
Indonesia	0.00	-0.15	-0.42	-0.63	-0.70	-0.76	-0.79	-0.75
Mexico	0.00	-0.16	-0.43	-0.64	-0.73	-0.82	-0.86	-0.84
Malaysia	0.00	-0.12	-0.31	-0.43	-0.45	-0.52	-0.59	-0.64
Trinidad & Tobago	0.00	-0.28	-0.77	-1.24	-1.37	-1.52	-1.62	-1.61

Table 7. Percentage Change from BAU in GDP under the Reduction Proposal

COUNTRY / REGION	1995	2000	2005	2010	2015	2020	2025	2030
OECD:								
Australia	0.00	-0.05	-0.25	-1.29	-1.55	-1.83	-2.10	-2.37
Austria	0.00	-0.02	-0.14	-1.24	-1.45	-1.69	-1.74	-2.02
Belgium	0.00	-0.06	-0.35	-1.47	-2.01	-2.43	-2.63	-2.75
Canada	0.00	-0.12	-0.54	-2.82	-3.33	-3.80	-4.19	-4.52
Switzerland	0.00	0.03	0.06	-1.27	-1.25	-1.37	-1.53	-1.90
Germany	0.00	-0.02	-0.14	-0.69	-0.86	-1.07	-1.29	-1.52
Denmark	0.00	-0.01	-0.09	-1.72	-1.73	-1.85	-1.94	-2.02
Spain	0.00	-0.04	-0.23	-1.20	-1.55	-1.93	-2.28	-2.55
Austria Finland Sweden	0.00	-0.04	-0.21	-1.63	-1.94	-2.25	-2.45	-2.49
European Union 12	0.00	-0.10	-0.41	-2.04	-2.55	-3.04	-3.37	-3.40
Finland	0.00	-0.06	-0.30	-2.64	-2.92	-3.15	-3.28	-3.36
France	0.00	-0.05	-0.24	-1.41	-1.65	-1.90	-2.07	-2.20
United Kingdom	0.00	-0.04	-0.22	-0.87	-1.08	-1.31	-1.54	-1.79
Greece	0.00	-0.06	-0.38	-1.28	-1.83	-2.41	-2.96	-3.49
Ireland	0.00	-0.08	-0.45	-2.36	-2.99	-3.52	-3.86	-3.95
Iceland	0.00	-0.05	-0.25	-2.23	-2.38	-2.55	-2.65	-2.70
Italy	0.00	-0.07	-0.32	-1.85	-1.98	-2.26	-2.50	-2.66
Japan	0.00	-0.04	-0.20	-1.52	-1.93	-2.35	-2.69	-2.98
Luxembourg	0.00	-0.09	-0.55	-2.45	-3.23	-4.03	-4.46	-4.69
Netherlands	0.00	-0.09	-0.44	-2.62	-3.01	-3.15	-3.18	-3.12
Norway	0.00	-0.16	-0.53	-1.96	-2.10	-2.28	-2.40	-2.46
New Zealand	0.00	-0.15	-0.70	-3.45	-4.41	-5.29	-6.01	-6.66
Portugal	0.00	-0.05	-0.31	-1.30	-1.82	-2.31	-2.66	-2.81
Sweden	0.00	0.00	-0.06	-1.58	-1.59	-1.68	-1.76	-1.82
Turkey	0.00	-0.15	-0.60	-2.18	-2.84	-3.58	-4.26	-5.02
United States	0.00	-0.07	-0.31	-1.85	-2.21	-2.61	-2.97	-3.31

Table 7. (Continued)

Non-OECD and Non-Oil Exporters:								
Argentina	0.00	-0.07	-0.17	-0.23	-0.23	-0.22	-0.21	-0.18
Bolivia	0.00	-0.14	-0.37	-0.48	-0.49	-0.50	-0.50	-0.45
Brazil	0.00	-0.05	-0.10	-0.04	0.00	0.04	0.09	0.15
Chile	0.00	-0.06	-0.12	-0.11	-0.10	-0.12	-0.16	-0.19
China	0.00	-0.08	-0.18	-0.21	-0.14	-0.09	-0.05	-0.01
Colombia	0.00	-0.19	-0.52	-0.74	-0.77	-0.79	-0.78	-0.70
Cameroon	0.00	-0.19	-0.48	-0.73	-0.75	-0.79	-0.80	-0.77
Congo	0.00	-0.39	-1.03	-1.75	-1.80	-2.00	-2.16	-2.23
Ghana	0.00	-0.04	-0.07	0.00	0.03	0.03	0.03	0.03
Hong Kong	0.00	-0.04	-0.10	-0.07	-0.02	-0.03	-0.06	-0.10
India	0.00	-0.02	-0.08	-0.04	0.02	0.07	0.12	0.19
Israel	0.00	-0.10	-0.13	-0.13	-0.18	-0.22	-0.26	-0.29
Jamaica	0.00	0.05	0.08	0.57	0.89	1.17	1.42	1.66
Jordan	0.00	-0.09	-0.11	0.19	0.26	0.34	0.41	0.49
South Korea	0.00	0.01	0.01	0.12	0.18	0.22	0.25	0.28
Morocco	0.00	-0.08	-0.10	-0.05	-0.07	-0.08	-0.09	-0.09
Nepal	0.00	-0.03	-0.05	0.03	0.08	0.10	0.12	0.14
Pakistan	0.00	-0.04	-0.09	-0.05	-0.01	0.01	0.04	0.06
Panama	0.00	-0.01	-0.04	0.11	0.20	0.26	0.32	0.38
Peru	0.00	-0.09	-0.25	-0.31	-0.30	-0.28	-0.24	-0.17
Philippines	0.00	0.00	-0.01	0.11	0.18	0.22	0.25	0.28
Paraguay	0.00	-0.02	-0.05	0.07	0.12	0.16	0.20	0.23
Rest of World	0.00	-0.11	-0.23	-0.30	-0.27	-0.28	-0.29	-0.29
Rest of South America	0.00	-0.25	-0.68	-1.04	-1.09	-1.19	-1.27	-1.29
Sudan	0.00	-0.02	-0.03	0.11	0.16	0.20	0.22	0.25
Singapore	0.00	-0.07	-0.14	-0.14	-0.13	-0.20	-0.28	-0.35
Sub Saharan Africa	0.00	-0.19	-0.46	-0.67	-0.68	-0.72	-0.75	-0.75
Thailand	0.00	-0.01	-0.06	0.04	0.10	0.11	0.09	0.07
Tunisia	0.00	-0.21	-0.41	-0.57	-0.64	-0.71	-0.78	-0.83
Taiwan	0.00	-0.03	-0.04	-0.02	-0.01	-0.02	-0.04	-0.06
South Africa	0.00	-0.05	-0.09	-0.10	-0.11	-0.14	-0.18	-0.22
Zaire	0.00	-0.11	-0.24	-0.33	-0.33	-0.35	-0.37	-0.38
Zambia	0.00	-0.04	-0.05	0.01	0.04	0.04	0.03	0.02
CPEE:								
Czech Republic	0.00	-0.07	-0.11	-0.10	-0.08	-0.10	-0.13	-0.16
Former Soviet Union	0.00	-0.10	-0.37	-0.65	-0.58	-0.57	-0.57	-0.54
Hungary	0.00	-0.06	-0.10	-0.11	-0.10	-0.12	-0.14	-0.16
Poland	0.00	-0.02	-0.03	-0.01	-0.01	-0.01	-0.02	-0.03
Romania	0.00	-0.11	-0.21	-0.26	-0.24	-0.25	-0.26	-0.27
Russia	0.00	-0.16	-0.40	-0.65	-0.67	-0.72	-0.75	-0.75

Table 7. (Continued)

OPEC:								
United Arab Emirates	0.00	-0.56	-1.32	-2.31	-2.41	-2.76	-3.07	-3.26
Algeria	0.00	-0.35	-0.79	-1.29	-1.40	-1.56	-1.69	-1.74
Egypt	0.00	-0.34	-0.90	-1.45	-1.43	-1.54	-1.63	-1.65
Iran	0.00	-0.41	-1.02	-1.74	-1.81	-2.01	-2.20	-2.30
Iraq	0.00	-0.32	-0.80	-1.26	-1.28	-1.39	-1.47	-1.50
Kuwait	0.00	-0.47	-1.22	-2.17	-2.22	-2.52	-2.78	-2.93
Libya	0.00	-0.45	-1.08	-1.83	-1.91	-2.13	-2.33	-2.41
Middle East and North Africa	0.00	-0.42	-1.01	-1.74	-1.82	-2.03	-2.22	-2.32
Oman	0.00	-0.48	-1.19	-2.11	-2.15	-2.42	-2.66	-2.79
Qatar	0.00	-0.47	-1.13	-1.96	-2.03	-2.29	-2.51	-2.63
Saudi Arabia	0.00	-0.50	-1.20	-2.07	-2.13	-2.41	-2.65	-2.78
Syria	0.00	-0.33	-0.89	-1.43	-1.41	-1.52	-1.60	-1.61
Venezuela	0.00	-0.45	-1.30	-2.08	-2.17	-2.36	-2.50	-2.51
Other Oil Exporters:								
Angola	0.00	-0.47	-1.19	-2.03	-2.10	-2.36	-2.58	-2.70
Brunei	0.00	-0.38	-0.84	-1.42	-1.51	-1.75	-1.96	-2.10
Ecuador	0.00	-0.33	-0.97	-1.49	-1.51	-1.59	-1.62	-1.55
Gabon	0.00	-0.31	-0.84	-1.39	-1.44	-1.57	-1.67	-1.68
Indonesia	0.00	-0.19	-0.52	-0.76	-0.79	-0.84	-0.87	-0.83
Mexico	0.00	-0.20	-0.53	-0.77	-0.84	-0.92	-0.97	-0.96
Malaysia	0.00	-0.14	-0.36	-0.47	-0.46	-0.54	-0.64	-0.73
Trinidad & Tobago	0.00	-0.37	-1.02	-1.62	-1.67	-1.79	-1.88	-1.87

Developing Countries

The results for developing countries are mixed because of the offsetting income and substitution effects discussed earlier. The majority of developing countries suffer a loss in GDP under the two scenarios but a small number benefit (see Figures 15 and 16). Countries with significant energy exports are hurt the most, followed by countries whose particular situations make them less likely to benefit from the “substitution effect” and more likely to suffer from the “income effect” of emissions limits adopted in the OECD.

Under the Berlin Mandate, there are to be no additional commitments to reduce emissions on the part of developing countries. But the markets in the OECD to which these developing countries sell a large share of their exported goods will shrink, so that most developing countries would also be harmed by the adoption of emissions limits in the OECD, as shown in Figures 15 and 16. Under either proposal, developing countries would face losses on average of about 10% as large as those experienced by the OECD. These losses would come about because OECD countries would demand fewer exports

from developing countries, shifting the terms of trade against developing countries and causing a reduction in their gains from trade. In addition, imports from the OECD would become more expensive. Losses could exceed 1% of GDP for countries that are highly dependent on trade with the OECD and have little scope for benefiting from lower energy costs.

Figure 15. Impact of Stabilization Proposal on Non-Participating Countries' GDP in the Year 2030

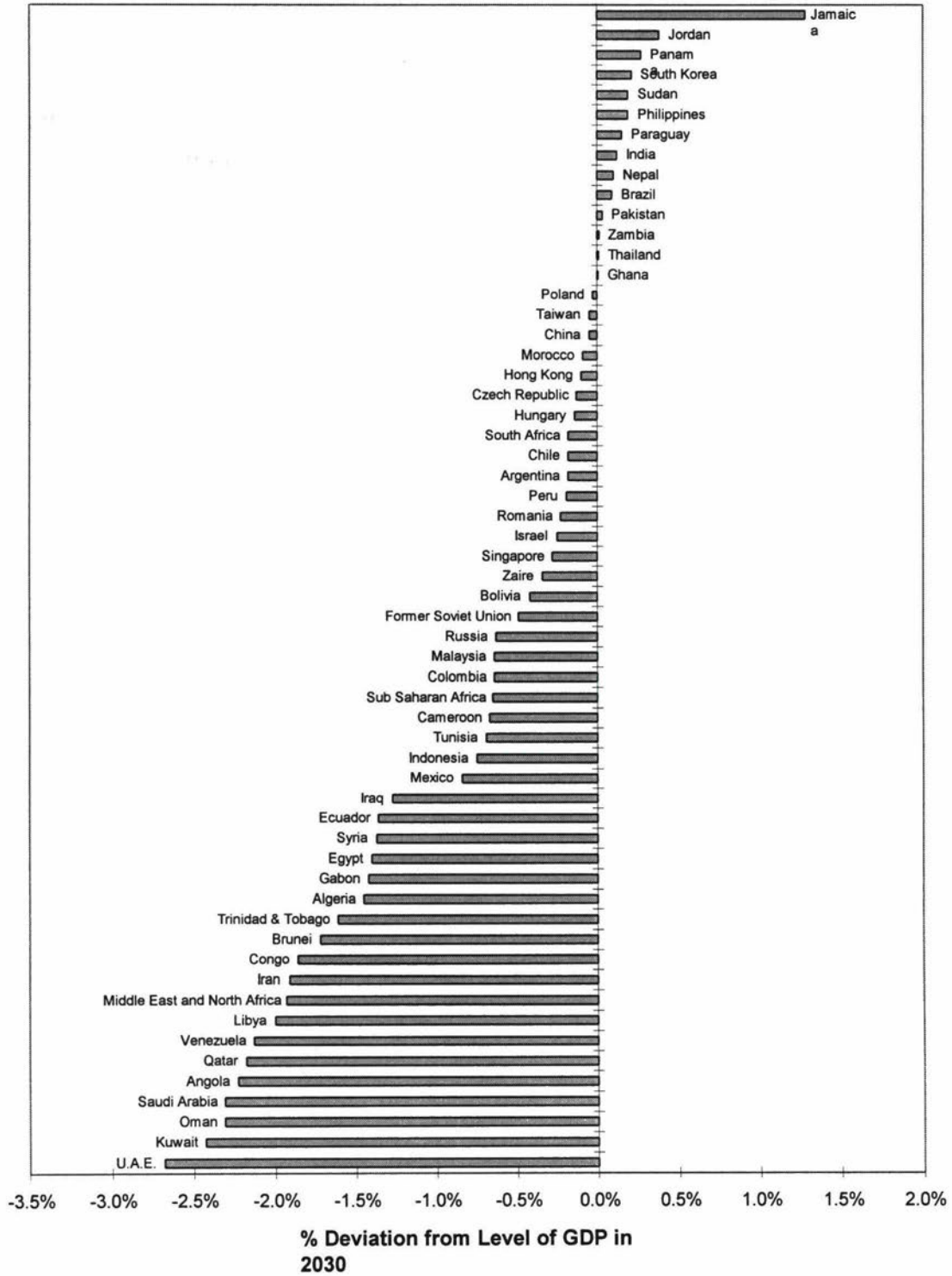
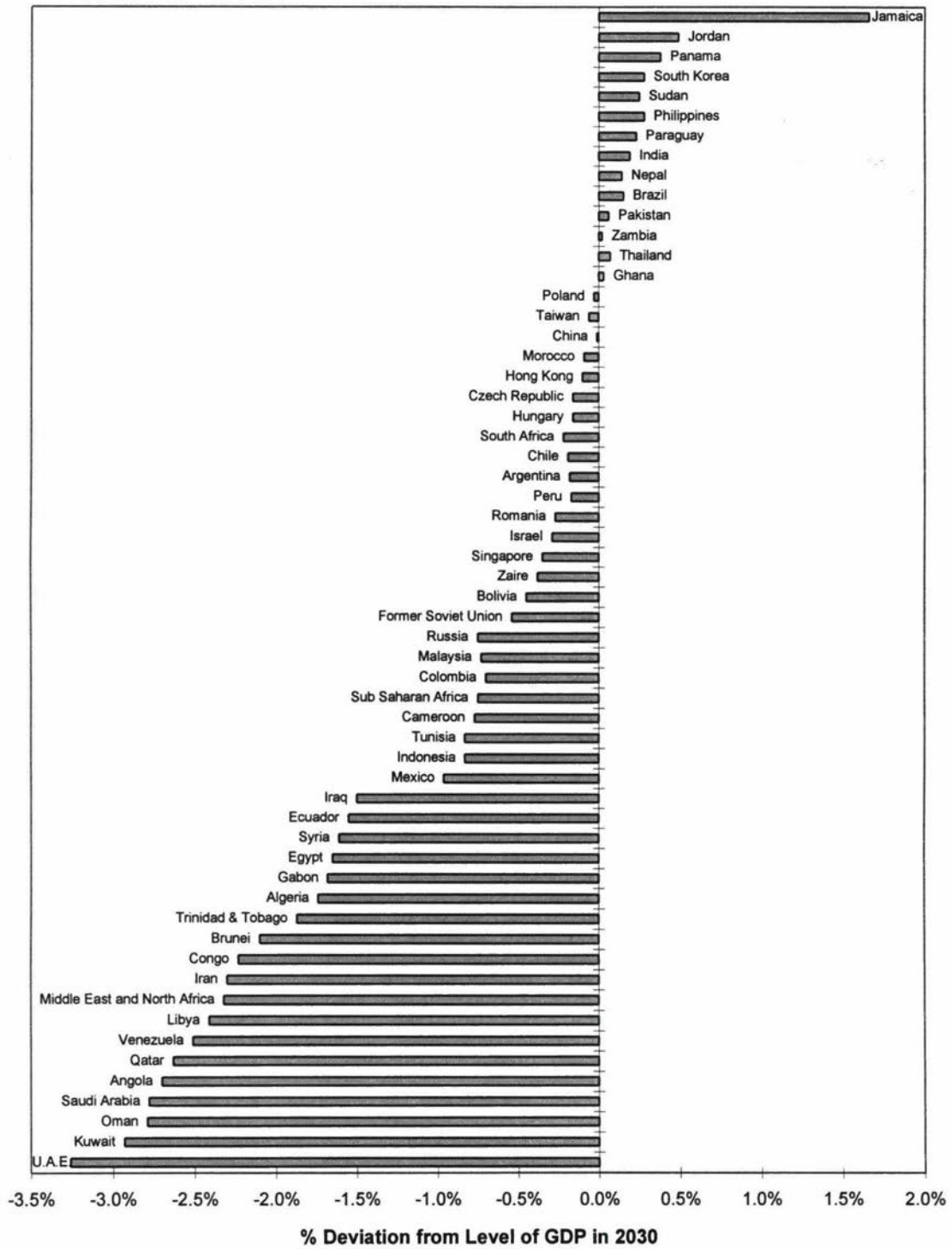


Figure 16. Impact of Reduction Proposal on Non-Participating Countries' GDP in the Year 2030



Developing countries that are not members of OPEC but do have significant oil exports suffer greater economic impacts than most developing countries. For example, under the Reduction proposal, Ecuador and Mexico experience declines in GDP of 1.6% and 1.0%, respectively, versus developing, non-oil exporting countries like China, which suffers a loss of only 0.05% in the year 2030 (see Tables 6 and 7). Furthermore, developing countries that are major oil importers, such as South Korea, benefit from the reduction in lower-energy prices and experience a slight increase in GDP from the two emissions abatement proposals.

Major Oil Exporters

The economic impacts on most major oil exporting countries are fairly uniform. These countries experience larger GDP losses under the Reduction scenario than under the Stabilization scenario because the price of oil declines more in the latter scenario. The GDP losses in the year 2030 for these countries averages about 2% under the Stabilization scenario and near 2.5% under the Reduction proposal (see Tables 6 and 7). Under the Stabilization proposal, the range in GDP losses varies from 1.3% (for Iraq) to 2.7% (for Saudi Arabia). There is a dramatic drop in each country's terms of trade because of each country's loss of revenue from its primary export, oil. In the year 2030, oil prices decline by 2.3% and 3.5% under the Stabilization and Reduction proposals, respectively. This greater price drop of 50% explains the 0.5% difference in GDP losses between the two scenarios.

Countries that Benefit from Abatement Proposals

Within the non-OECD, there are some countries that might benefit if the OECD countries were to adopt either the Stabilization or Reduction proposals: India, Jamaica, Jordan, Philippines, and South Korea. Jamaica prospers the most. Compared to the BAU, in the year 2030, its GDP increases by 1.4% and 1.8% under the Stabilization and Reduction scenario, respectively (see Tables 6 and 7). On the lower end, India's GDP increases relative to the BAU by only 0.12% and 0.19% under the Stabilization and Reduction proposal, respectively.

For a country to potentially benefit from OECD emissions limits, it needs to be an energy importer, have an energy-intensive economy, and conduct a significant portion of its trade with non-OECD countries. Developing countries with even limited energy exports will not benefit because the drop in energy prices hurts their terms of trade. Countries with energy-intensive industries can potentially benefit from lower world energy prices because of lower production costs in energy-intensive industries and competitive advantages over OECD countries. Consequently, developing countries with the most energy-intensive industries will gain the most from a reduction in the price of energy.

Finally, in order to benefit from carbon abatement proposals, a country must trade mainly with non-OECD countries. When a carbon abatement policy is enacted, such a country

will have healthier trading partners than a country that trades primarily with OECD nations. There are actually two effects of consequence. When a country is more heavily involved in trade with non-OECD countries:

- the cost of its imports does not increase as much when the OECD is forced to adopt carbon limits; and
- its exports are not affected as much by a decline in income in the countries that receive its exports.

These impacts are estimated assuming that capital flows freely into the developing countries to finance the conversion of their industries to take advantage of energy price differentials, and that the OECD countries do nothing to limit or offset imports of energy-intensive goods from countries not adopting carbon limits. As discussed below, trade protection by the OECD turns impacts on all developing countries negative.

See Appendix C for more details on individual countries.

SENSITIVITY ANALYSIS

In this section, the results from varying many of the key economic assumptions are reported. This sensitivity analysis helps determine the robustness of the above results, and for the five world regions, the importance of the following key assumptions made in the reference case⁶: oil prices, backstop fuel price, substitution between domestic and imported goods, emissions growth, trade protection, and first year of mandatory carbon limits. To address these assumptions, we look at nine alternative cases: low oil price, low-cost backstop fuel, low trade, high trade, low emissions, high emissions, 2015 target, and trade protection. The results from these cases are compared to those from the reference case.

The low oil price case assumes that world oil prices decline further than they do in the reference case. For the low-cost backstop case, the carbon free backstop fuel is assumed to be less expensive than in the reference case. In the low-trade case, imported goods substitute poorly for a region's domestically produced goods; whereas, in the high-trade case, imports substitute much more easily for domestically produced goods. For the low and high emissions cases, carbon emissions are projected to grow 15% slower or 35% faster than in the reference case. For the 2015 target case, we attempt to account for the uncertainty in the U.S. government's intentions regarding a medium-term target date for OECD countries to adopt emissions controls. For this case, it is assumed that the OECD postpones adopting emissions limits until 2015, at which time the OECD adopts either the limits of the Stabilization or Reduction proposals. Last, the trade protection case assumes that the OECD adopts import quotas in an effort to protect its domestic industries against non-OECD imports.

This sensitivity analysis is concerned with the change in impacts on the world regions. In this section, only the results of the sensitivity analysis for the Reduction proposal are presented, but qualitatively, the results apply to the Stabilization proposal (please see Appendix 4 for the numerical details of sensitivity analysis for the Stabilization proposal).

⁶In the reference case, the following four assumptions are made: oil supply elasticity equals 8.0; the Armington elasticity equals 1.5; the backstop fuel is assumed to cost six times the current fossil fuel energy aggregate; and carbon emissions grow at a rate that matches the Intergovernmental Panel on Climate Change's medium growth scenario. Please see Appendix A for a further explanation of these assumptions.

Lower Oil Price Case⁷

In this case, the price of oil falls by almost 6% in 2030 as compared to only a 3.5% decline under the reference case (see Table 8). This has the most direct impact on energy exporting nations. It causes a further measurable drop in the Middle East and North African Region (MIDE's GDP). For example, in 2030, the MIDE's GDP is 3.0% less than the BAU whereas in the reference case, its GDP is only 2.3% less than the BAU (see Table 9).

Table 8. Percentage Change from BAU in World Prices under the Reduction Proposal

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.27	0.95	1.42	2.88	-0.30	1.44	1.25	1.38	0.58
2005	1.27	0.93	1.37	2.86	-0.28	1.43	1.24	1.37	-0.28
2010	-0.45	-1.96	-0.46	0.90	-1.77	0.05	-1.16	1.32	-2.33
2015	-1.22	-2.89	-1.26	-0.02	-2.36	-0.52	-2.32	-0.68	-3.15
2020	-2.05	-4.01	-2.12	-1.02	-3.01	-1.16	-3.54	-1.69	-3.87
2025	-2.83	-5.03	-2.92	-1.96	-3.60	-1.77	-4.69	-2.55	-4.44
2030	-3.49	-5.90	-3.62	-2.78	-4.10	-2.29	-5.67	-3.26	-4.84

⁷ The model was run the model using a value of 4.0 for the elasticity of oil supply to achieve lower oil prices. This lower elasticity implies that the price of oil is more responsive to a change in the demand for oil. Therefore, when the OECD reduces its demand for oil, the price of oil drops more under the lower elasticity value than in the reference case.

**Table 9. Percentage Change from BAU in GDP for all regions under the nine cases
(Reduction Proposal)**

Region: ASIA

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.04	-0.02	-0.03	-0.12	0.00	-0.04	-0.03	-0.05	0.10
2005	-0.11	-0.07	-0.09	-0.23	-0.03	-0.10	-0.09	-0.13	-0.03
2010	-0.13	-0.05	-0.10	-0.32	0.03	-0.11	-0.09	-0.19	-0.18
2015	-0.10	0.00	-0.07	-0.35	0.11	-0.09	-0.01	-0.19	-0.32
2020	-0.09	0.03	-0.05	-0.39	0.17	-0.08	0.04	-0.14	-0.41
2025	-0.08	0.06	-0.04	-0.43	0.21	-0.07	0.08	-0.11	-0.45
2030	-0.08	0.08	-0.02	-0.46	0.24	-0.05	0.10	-0.09	-0.42

Region: CPEE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.13	-0.16	-0.13	-0.18	-0.08	-0.10	-0.15	-0.08	0.02
2005	-0.41	-0.48	-0.42	-0.52	-0.30	-0.34	-0.51	-0.24	-0.23
2010	-0.53	-0.61	-0.57	-0.71	-0.36	-0.44	-0.65	-0.55	-0.41
2015	-0.43	-0.51	-0.48	-0.64	-0.23	-0.36	-0.47	-0.69	-0.40
2020	-0.40	-0.45	-0.45	-0.63	-0.17	-0.34	-0.38	-0.50	-0.46
2025	-0.38	-0.39	-0.42	-0.62	-0.13	-0.32	-0.30	-0.41	-0.47
2030	-0.32	-0.31	-0.35	-0.58	-0.08	-0.28	-0.21	-0.33	-0.42

Region: MIDE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.40	-0.53	-0.40	-0.57	-0.22	-0.32	-0.50	-0.29	0.18
2005	-1.00	-1.20	-1.03	-1.31	-0.67	-0.81	-1.27	-0.61	-0.43
2010	-1.73	-2.22	-1.80	-2.21	-1.21	-1.40	-2.24	-1.22	-1.39
2015	-1.81	-2.38	-1.88	-2.40	-1.17	-1.45	-2.33	-2.06	-1.70
2020	-2.02	-2.64	-2.09	-2.73	-1.28	-1.62	-2.55	-2.06	-2.09
2025	-2.20	-2.85	-2.26	-3.03	-1.36	-1.75	-2.75	-2.17	-2.35
2030	-2.28	-2.95	-2.33	-3.23	-1.36	-1.80	-2.83	-2.23	-2.44

Table 9. (Continued)**Region: OECD**

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.07	-0.07	-0.05	-0.04	-0.09	-0.06	-0.09	-0.04	-0.78
2005	-0.30	-0.29	-0.20	-0.26	-0.32	-0.24	-0.38	-0.16	-1.61
2010	-1.65	-1.63	-1.29	-1.66	-1.63	-1.25	-2.48	-0.34	-3.06
2015	-1.95	-1.92	-1.45	-1.97	-1.93	-1.44	-3.03	-1.81	-3.27
2020	-2.27	-2.24	-1.63	-2.30	-2.24	-1.64	-3.56	-2.19	-3.30
2025	-2.56	-2.53	-1.78	-2.61	-2.51	-1.83	-3.98	-2.51	-3.13
2030	-2.84	-2.82	-1.95	-2.92	-2.77	-2.01	-4.26	-2.82	-2.82

Region: ROW

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.12	-0.12	-0.12	-0.22	-0.05	-0.10	-0.14	-0.10	0.02
2005	-0.31	-0.29	-0.30	-0.48	-0.17	-0.26	-0.34	-0.26	-0.22
2010	-0.46	-0.43	-0.45	-0.73	-0.22	-0.38	-0.51	-0.44	-0.50
2015	-0.46	-0.42	-0.44	-0.80	-0.14	-0.38	-0.47	-0.58	-0.67
2020	-0.48	-0.43	-0.45	-0.89	-0.11	-0.40	-0.45	-0.54	-0.81
2025	-0.49	-0.43	-0.45	-0.97	-0.08	-0.40	-0.44	-0.52	-0.88
2030	-0.48	-0.41	-0.42	-1.01	-0.04	-0.38	-0.43	-0.49	-0.86

The drop in oil prices, however, benefits the ASIA, CPEE, and ROW regions. This price drop not only allows them to produce goods less expensively but also reduces their expenditures on energy for final consumption. The ASIA and ROW regions benefit the greatest since most countries in these regions are energy importers. The CPEE region benefits slightly from lower oil prices. The gains it receives from lower fuel prices more than offset its loss in revenue from energy exports.

The OECD receives little benefit because its fuel consumption is constrained by the carbon limits; consequently it is unable to capitalize on the lower oil prices.

Lower Backstop Fuel Price Case⁸

The lower backstop price scenario differs from the reference scenario in two ways. First, the cost of the carbon-free backstop fuel is two-thirds of its cost in the reference case. Second, countries can more easily change their mix of energy and non-energy inputs to make final products. Therefore, both the cost of switching to non-carbon fuels and the use of non-energy inputs to produce final goods is less costly under the low backstop price case. The decrease in the carbon tax between the reference and low backstop price case reflects this reduction in emissions abatement costs: in 2030 under the Reduction proposal, the required carbon tax is \$580 per ton under the reference case as opposed to \$400 per ton under the low price backstop case (see Table 10).

Table 10. Carbon Tax in the OECD (1992 U.S. dollars per ton) for the nine cases (Reduction Proposal)

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0	0	0	0	0	0	0	0	0.00
2000	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0
2010	350	352	291	363	337	283	490	0	333
2015	402	405	314	417	386	318	578	404	383
2020	466	468	345	482	447	366	670	466	446
2025	524	527	374	542	504	412	751	524	507
2030	578	581	400	596	556	455	760	578	564

This cost reduction benefits the OECD most since it is the only region that adopts carbon limits. For the OECD, this reduction in abatement cost translates into a GDP loss of 2.0% in the year 2030 as opposed to a loss of 2.8% in the reference case.

Since the OECD has more income in the low backstop price case than in the reference case, it can purchase more non-OECD goods. This provides a boost to the economies of ASIA and ROW. However, since we assume that the OECD region produces its own backstop fuel and it is easier for countries to substitute away from fossil fuels in production and final consumption, the oil exporting nations will experience a larger loss in energy sales. For the MIDE and CPEE regions, this effect dominates their increase in non-energy exports so that their GDP declines from the reference case values. In

⁸For this case, the carbon-free backstop fuel is assumed to cost only four times the current fossil fuel energy aggregate. In addition, the long-run elasticity of substitution between energy and non-energy inputs (end use demand elasticity) into production is assumed to increase in the low backstop price case from a value of 0.5 in the reference case to a value of 0.6 (see Appendix A for more details on the end use demand elasticity).

summary, the non-energy exporting ASIA and ROW regions benefit slightly from the lower world fuel prices and the OECD's improved financial condition, but the MIDE and CPEE regions are impacted negatively when the cost of the carbon-free backstop fuel declines.

Low- and High-Trade Impact Cases⁹

The level of trade impact refers to how readily non-OECD countries can exploit a cost advantage to gain market share in markets where their goods compete with goods from the OECD. In the low-trade impact case, it is more expensive to substitute between domestically produced and imported goods than in the high-trade impact case, so that a given cost advantage translates into a smaller gain in market share. When imports and domestic goods substitute easily, countries can more readily substitute away from more expensive OECD goods toward cheaper, non-OECD goods. This lowers worldwide production costs and hence, GDP improves in all countries (see Table 9 cases Low and High Trade). This switch is reflected by the improvement in terms of trade for all four non-OECD regions relative to that of the OECD (see Table 11).

⁹ This model represents trade with an Armington structure. The low-trade case corresponds to a low value of 1.0 for the Armington elasticity. That is, the elasticity of substitution between imports and domestic goods is low so that it is expensive for a country to substitute between imported and domestically produced goods. For the high trade case, the Armington elasticity is set at 3.0. In the reference case, the Armington elasticity equals 1.5. For further details on the model structure, please see Appendix A.

Table 11. Percentage change from BAU in Terms of Trade relative to the OECD for the other four regions (ASIA, CPEE, MIDE, and ROW) and nine cases

Region: ASIA

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.05	-1.18	-1.01	-1.83	-0.45	-0.87	-1.07	-1.01	-2.86
2005	-0.90	-1.03	-0.92	-1.67	-0.29	-0.75	-0.87	-0.95	-3.94
2010	-1.14	-1.28	-1.20	-1.95	-0.47	-0.93	-1.26	-0.80	-4.61
2015	-1.70	-1.85	-1.73	-2.57	-0.94	-1.36	-2.14	-1.10	-5.13
2020	-2.16	-2.32	-2.15	-3.09	-1.31	-1.70	-2.91	-1.75	-5.30
2025	-2.56	-2.72	-2.51	-3.54	-1.62	-2.00	-3.65	-2.25	-5.27
2030	-2.86	-3.02	-2.77	-3.89	-1.84	-2.22	-4.29	-2.60	-5.12

Region: CPEE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.84	-2.68	-1.89	-2.76	-0.99	-1.50	-2.14	-1.63	-2.94
2005	-1.79	-2.60	-1.90	-2.70	-0.91	-1.45	-2.07	-1.59	-4.14
2010	-2.34	-3.20	-2.49	-3.33	-1.37	-1.88	-2.90	-1.62	-5.16
2015	-3.26	-4.21	-3.40	-4.35	-2.15	-2.59	-4.29	-2.33	-6.06
2020	-3.99	-5.03	-4.12	-5.19	-2.76	-3.15	-5.46	-3.40	-6.54
2025	-4.63	-5.72	-4.73	-5.92	-3.27	-3.63	-6.52	-4.19	-6.80
2030	-5.12	-6.26	-5.20	-6.49	-3.64	-4.01	-7.41	-4.75	-6.88

Region: MIDE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.74	-2.56	-1.76	-2.72	-0.83	-1.40	-2.08	-1.51	-2.94
2005	-1.68	-2.45	-1.77	-2.63	-0.78	-1.36	-2.01	-1.44	-4.15
2010	-2.25	-3.03	-2.39	-3.27	-1.24	-1.81	-2.84	-1.52	-5.13
2015	-3.15	-3.97	-3.29	-4.28	-1.98	-2.50	-4.18	-2.28	-5.97
2020	-3.88	-4.76	-4.01	-5.12	-2.56	-3.06	-5.31	-3.35	-6.43
2025	-4.53	-5.45	-4.64	-5.87	-3.07	-3.55	-6.35	-4.14	-6.71
2030	-5.04	-6.00	-5.15	-6.47	-3.46	-3.95	-7.24	-4.72	-6.82

Table 11. (Continued)**Region: ROW**

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.51	-1.82	-1.49	-2.47	-0.69	-1.24	-1.69	-1.37	-3.11
2005	-1.38	-1.68	-1.43	-2.33	-0.55	-1.13	-1.51	-1.32	-4.22
2010	-1.69	-1.99	-1.77	-2.68	-0.79	-1.38	-1.99	-1.22	-5.00
2015	-2.34	-2.64	-2.40	-3.41	-1.34	-1.87	-3.00	-1.62	-5.63
2020	-2.89	-3.18	-2.91	-4.03	-1.78	-2.28	-3.90	-2.37	-5.89
2025	-3.36	-3.64	-3.33	-4.57	-2.15	-2.63	-4.74	-2.96	-5.95
2030	-3.71	-3.99	-3.66	-4.99	-2.41	-2.90	-5.46	-3.38	-5.85

Table 12. Percentage change from BAU in Non-Energy Exports for the five regions and the nine cases

Region: ASIA

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.52	0.49	0.50	0.86	0.20	0.44	0.46	0.56	-0.13
2005	0.24	0.22	0.29	0.53	-0.05	0.20	0.11	0.39	0.00
2010	0.04	0.05	0.15	0.21	-0.08	0.05	-0.10	0.09	0.03
2015	0.31	0.33	0.43	0.39	0.27	0.25	0.37	-0.10	0.02
2020	0.48	0.51	0.60	0.50	0.52	0.38	0.74	0.21	-0.05
2025	0.60	0.64	0.72	0.56	0.71	0.46	1.09	0.41	-0.13
2030	0.65	0.69	0.77	0.55	0.81	0.50	1.40	0.50	-0.18

Region: CPEE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.38	2.28	1.46	1.64	0.95	1.11	1.66	1.22	-0.10
2005	1.12	1.96	1.25	1.34	0.74	0.89	1.34	1.03	0.11
2010	1.31	2.24	1.51	1.41	1.09	1.04	1.67	0.85	0.49
2015	2.08	3.16	2.30	2.08	1.94	1.64	2.85	1.18	0.91
2020	2.64	3.86	2.89	2.58	2.58	2.07	3.79	2.12	1.19
2025	3.11	4.46	3.38	2.99	3.11	2.42	4.62	2.76	1.44
2030	3.47	4.92	3.78	3.31	3.52	2.71	5.33	3.19	1.70

Region: MIDE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.62	2.70	1.67	2.07	0.93	1.29	2.02	1.40	-0.10
2005	1.12	2.04	1.24	1.50	0.54	0.88	1.39	1.04	0.12
2010	1.25	2.14	1.44	1.47	0.87	0.99	1.63	0.75	0.39
2015	2.14	3.08	2.38	2.25	1.85	1.69	2.97	1.06	0.68
2020	2.74	3.78	3.02	2.79	2.48	2.14	3.97	2.19	0.86
2025	3.26	4.38	3.57	3.27	3.02	2.54	4.87	2.91	1.04
2030	3.67	4.88	4.04	3.66	3.45	2.87	5.66	3.40	1.28

Table 12. (Continued)**Region: OECD**

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.51	-1.87	-1.47	-2.04	-0.90	-1.23	-1.68	-1.35	0.47
2005	-1.61	-1.96	-1.60	-2.20	-0.93	-1.32	-1.79	-1.44	-1.42
2010	-2.46	-2.81	-2.43	-2.99	-1.90	-1.99	-3.01	-1.56	-3.27
2015	-3.29	-3.65	-3.19	-3.75	-2.82	-2.62	-4.26	-2.57	-4.50
2020	-4.01	-4.38	-3.83	-4.44	-3.58	-3.15	-5.37	-3.51	-5.32
2025	-4.65	-5.02	-4.38	-5.05	-4.24	-3.63	-6.40	-4.27	-5.85
2030	-5.17	-5.53	-4.81	-5.55	-4.77	-4.01	-7.23	-4.85	-6.14

Region: ROW

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.16	1.38	1.16	1.61	0.61	0.95	1.30	1.06	0.04
2005	0.83	1.06	0.91	1.24	0.32	0.68	0.90	0.86	0.14
2010	0.66	0.89	0.81	0.93	0.33	0.54	0.72	0.57	0.22
2015	1.06	1.28	1.22	1.24	0.83	0.85	1.37	0.43	0.27
2020	1.36	1.58	1.52	1.47	1.21	1.07	1.94	0.92	0.27
2025	1.60	1.82	1.77	1.65	1.52	1.26	2.48	1.27	0.25
2030	1.75	1.96	1.94	1.75	1.72	1.38	2.96	1.48	0.26

The high-trade case allows both the MIDE and CPEE regions to more easily satisfy domestic needs with domestically produced goods. These regions reduce their exports of lower-priced energy and instead use this energy in domestic industries. Since we do not account for the rents associated with fossil fuel extraction, and capital is fully mobile across industries, the IIAM tends to overstate the ease in which the oil exporting countries (namely the MIDE region) can switch from the production of energy to non-energy goods. Therefore, in the high-trade case, the IIAM probably overstates the benefits to the MIDE and CPEE regions.

In the high-trade case, ASIA and ROW can take greater advantage of their lower costs in competing against the OECD. This improves their GDP relative to the OECD's. For the ASIA region, increasing trade from low to high results in a GDP improvement of 0.70%: from a loss of 0.46% in the low-trade case to a 0.24% gain in the high case relative to the BAU scenario in 2030. For the ROW region, under the same adjustments, its GDP improves from a loss of 1.0% to only a loss of 0.04% from the BAU level.

Low and High Emissions Forecast Cases

The emissions forecast determines, for the BAU scenario, each region's emissions growth from their 1990 levels. Both U.S. proposals require that OECD countries reduce their emissions to some percentage of 1990 emissions. Therefore, smaller emissions growth means less required emissions reduction. Since OECD countries need to reduce their fossil fuel consumption by a smaller amount, this mitigates the economic impacts of a carbon abatement policy on the OECD countries. Table 9 illustrates that under this scenario, the OECD's loss in GDP relative to the BAU scenario is about 2% in the low-emissions growth case and is more than twice this value (4.3%) in the high-emissions growth case. The carbon tax reflects the increased cost of reducing emissions under the high-growth case: the carbon tax in the low- and high-emissions growth cases is respectively \$460 per ton and \$760 per ton in 2030 (see Table 10). Therefore, the assumption about the growth in emissions greatly affects the estimates for the impacts on the OECD countries.

The MIDE region benefits significantly from the assumption of low-emissions growth in the OECD since this case results in a smaller drop in the demand for, and hence the price of, oil. In the low-emissions case, the price of oil declines by 2.3% in the year 2030 as opposed to a 5.7% decline from the BAU scenario in the high-emissions case (see Table 8). Therefore, an increase in the forecasted growth in emissions leads to a greater oil price reduction which causes the MIDE region's GDP to decline more.

ASIA, CPEE, and ROW benefit from lower energy prices and improvements in the OECD regions' rise in income and consequent increase in expenditures on imports. But the importance of these two effects varies among these three regions. The ASIA and CPEE regions are better off under high-emissions growth. In addition, the lower fuel prices and the OECD's increased production costs help the ASIA and CPEE regions' competitiveness relative to the OECD.

This implies that the reduction in energy prices is more valuable than the negative impact on terms of trade relative to the OECD. The ROW region is not as energy intensive as the ASIA and CPEE regions, so a drop in oil prices does not benefit them as much. The ROW benefits more from trade effects than changes in the price of energy. ASIA is not as dependent as the ROW on trade with OECD countries. Therefore, countries in the ASIA region can adapt easier to trading with other non-OECD countries.

In the low-emissions case, all three regions benefit relative to the reference case, indicating that reduced losses due to a smaller income effect outweigh their competitive gains from the substitution effect. The OECD is better off and can import more non-OECD goods, and the OECD goods are not as expensive to these non-OECD countries.

2015 Target Case

In this case, the time at which the two policies take effect is postponed from 2010 to 2015. For the Stabilization and Reduction policies, the OECD countries must reduce

their emissions to 100% and 90%, respectively, of 1990 levels in the year 2015 and maintain them at these levels thereafter. By delaying the start date, policymakers allow the OECD more time to develop more energy-efficient technologies and to switch to less carbon-intensive fuels. This delay allows adoption of these technologies and fuel switching with less forced premature retirement of the capital stock, and therefore, results in less loss to the OECD's economy. The IIAM incorporates this less costly long-run response by using elasticities of demand for fossil energy that increase over time, so that it takes smaller implicit carbon taxes to achieve the same percentage reduction in emissions at a later date.

Because of this delay, the OECD postpones reducing its carbon emissions and consequently its energy consumption. Therefore, the price of energy declines less in the near term under the 2015 target case than the reference case. This translates into less reduction in the MIDE's GDP than in the reference case (see Tables 8 and 9).

The CPEE and ROW regions experience less initial GDP loss relative to the reference case, but more between the years 2015 to 2025. By 2030, their loss in GDP is almost the same as it is in the reference case. The oscillation around the reference case occurs because in the early periods, the CPEE and ROW regions benefit from the OECD's better economic position and consequent increase in consumption, but in the later years, they suffer because more investment flows out of these regions under the 2015 target case. ASIA suffers slightly greater losses under the 2015 target case throughout the entire time horizon.

Trade Protection Case

Under the carbon abatement proposals, many individual countries increase their non-energy exports because of their cost advantage over the OECD in markets inside and outside the OECD. However, the OECD may choose to protect some of its industries. To account for this possibility, CRA ran a trade protection case.

In the trade protection case, we assume that the OECD countries adopt some combination of measures to protect domestic industries against competition from countries that do not adopt carbon emissions limits. These policies could be overt, in the form of border adjustment taxes based on approximations of the carbon content of different imports, or more readily concealed actions to benefit industries facing such competition, such as tax subsidies or exemption from carbon taxes or other policies designed to reduce emissions. We implement these trade restrictions by assuming that imports from non-OECD countries are limited to baseline levels (a form of quotas). Under these assumptions, all developing countries face negative impacts, and the average loss in developing countries increases (ASIA and ROW) from 0.3% to 0.6% of GDP in 2030 under U.S. 2 (see Table 9).

CONCLUSIONS FROM THE SENSITIVITY ANALYSIS

The sensitivity analysis illuminates the important assumptions and the robustness of the results. For the OECD countries, assumptions about the backstop fuel price and the baseline emissions growth have the greatest impact. Under the low price backstop case, the OECD's GDP declines the least. Among other things, this illustrates the value of policies to develop and decrease the cost of such techniques. The individual country analysis illustrated the importance of the assumed baseline emissions growth. The lower emissions growth path is the main reason why Germany's and the United Kingdom's GDPs decline less than in other OECD countries.

OECD Regions

The sensitivity analysis shows that varying the oil prices and the ease of substitution between domestic and imported goods have little effect on the OECD because the OECD cannot take advantage of lower-energy prices and it produces the majority of its goods domestically.

The sensitivity analysis also shows that under a wide variety of assumptions, the impact of the Stabilization policy on OECD countries is unambiguously negative. The eight different cases (the reference case plus the seven cases for the sensitivity analysis) produce a spread in the estimated decline of the OECD's GDP from 2.0% in the low-price backstop case to a loss of 4.3% in the high-emissions case. These results represent the percentage change in GDP under the Reduction proposal from the BAU scenario in the year 2030. The losses are not as great under the Stabilization proposal, but the range in GDP loss is between 1.4% and 3.6% (see Table A4.2).

Carbon permits (indirectly assumed here) allow the OECD to determine the most economically efficient method of reducing their carbon emissions. If command-and-control or specific carbon reduction strategies that attacked only specific industries were used, then the marginal cost of reducing carbon emissions and the GDP losses would likely exceed those estimated in this study.

Non-OECD Regions

Assumptions about how oil prices respond to changes in world oil demand and how demand for imports by OECD countries responds to changes in the price of imports are critical in determining the impacts on developing countries. These two assumptions, together with energy resources, industry structure, and share of trade with OECD and non-OECD countries, determine whether the "substitution effect" will outweigh the "income effect" for a particular country.

The assumption about the substitutability of imported goods for domestic goods has the greatest impact on the non-OECD countries' GDP. The ASIA, CPEE, MIDE, and ROW regions are affected most by changes in international trade. For the MIDE, additional

assumptions about oil price levels and emissions growth in the OECD are important since these assumptions directly impact the price of oil. Parameters that have less effect on the price of oil (e.g., the backstop technology price) will have less impact on the MIDE's economic well being.

Over a broad range of assumptions, most developing countries are impacted negatively when the OECD adopts one of these two carbon abatement policies. Only the ASIA region experiences gains in GDP from the BAU scenario. These gains under the Reduction proposal are on the order of 0.1 to 0.25%. When trade assumptions are changed to require larger price advantages to capture an increased share of OECD markets, or to give less reduction in world oil prices, all ASIA countries lose, as they do when there is trade protection. The CPEE and ROW regions always suffer a decline in GDP. Some countries, such as Jamaica, benefit from the OECD adopting carbon limits under the BAU scenario, but not when import elasticities are lower, oil prices are less responsive, or trade protection is invoked.

Over the range of input assumptions, the oil producing countries are impacted negatively. Energy exporters are hurt in all cases because world energy consumption declines thus leading to a decline in oil prices and hence, revenues from oil exports. The response of world oil prices and the willingness and ability of these countries to shift resources from oil export to production of domestic goods and services determine the size of impacts. In the year 2030 under the Reduction proposal, the MIDE region experiences between a -1.4% (the high trade case) and a -3.2% (low trade case) change in their GDP from the BAU scenario.

APPENDIX A -- MODEL STRUCTURE

The International Impact Assessment Model is a dynamic, multi-regional general equilibrium model used to study the effects of carbon restrictions on trade and welfare in the world economy. The IIAM is formulated as two compatible but separate general equilibrium models. The first is a multi-regional trade (MRT) model that provides an approximation of the changes in international terms of trade which could result from carbon dioxide restrictions in a subset of countries. The second is a general purpose open economy model that is used to study the implications of changes in international prices (provided by the multi-regional model) for particular countries. The IIAM provides a one-way link between the MRT and the single country open economy (SOE) models. This structure enables the user to study the consequences of carbon emissions limits placed on the OECD or Annex I countries on the well-being of any region within the MRT model or any individual country.

The MRT model divides the world into five geopolitical regions: the Organization for Economic Cooperation and Development (OECD) nations, Non-OECD Asia (ASIA), Eastern Europe and Former Soviet Union or Centrally Planned Emerging Economies (CPEE), Middle East and North Africa (MIDE), and the rest of the world (ROW). The model solves for the benchmark year 1992, and then it solves in five year intervals spanning the horizon from 2000 to 2030. The year 2000 is the first endogenous year.

There are six commodities:

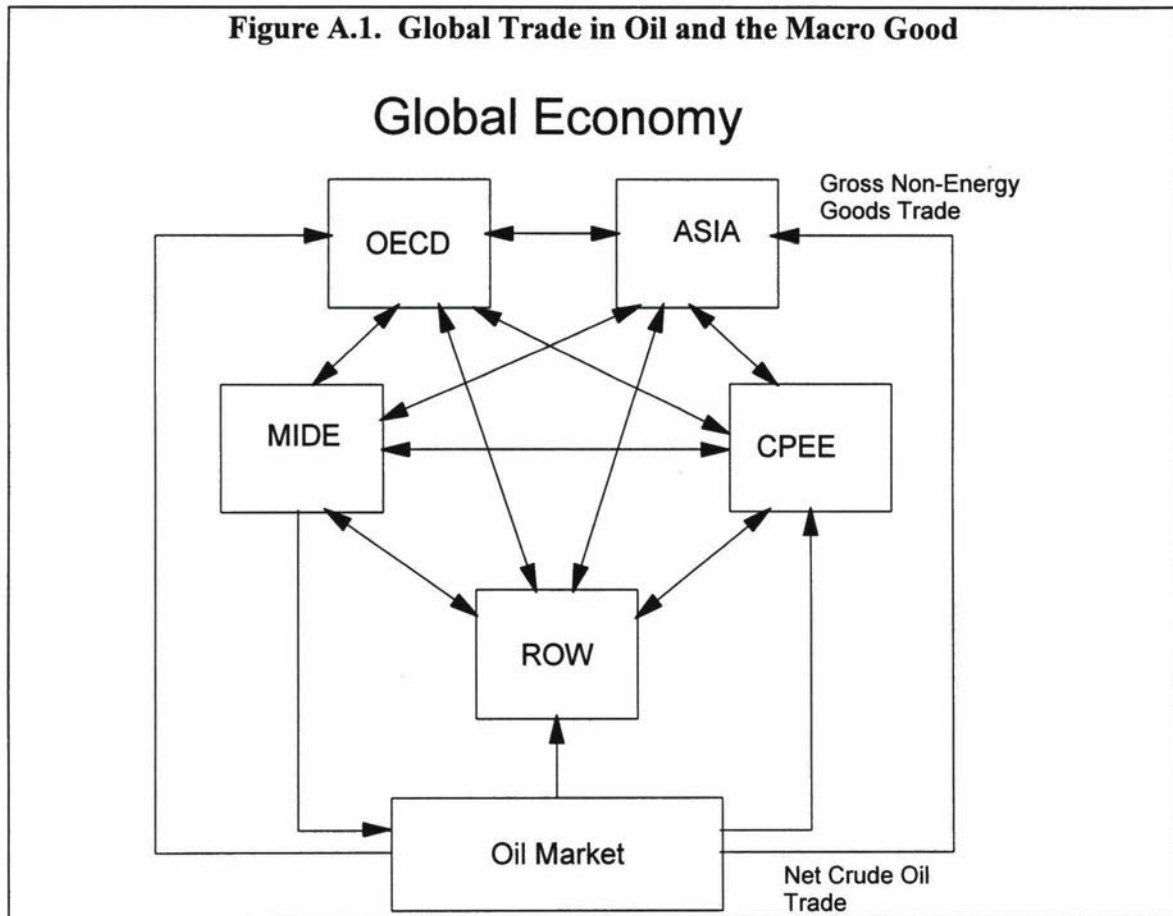
- Four fuels: oil, coal, natural gas, and a carbon-free backstop energy source
- A savings good
- A non-energy macro-good (aggregate macro output)

The ratio of trade in gas and coal to the trade in oil is fixed at the benchmark levels. Regions trade oil freely at a price determined by the interfuel supply and demand conditions. Therefore, oil is traded internationally under one world oil price. Depletion is assumed to lead to rising fossil fuel prices under constant demand. But the relation between depletion effects on the supply of oil and the actual supply of oil itself are ignored. That is, the model does not keep a record of the current stock of oil in each time period. World supply and demand determine the world price of oil, but supply and demand in each country determine a country-specific price for natural gas and coal. Current energy taxes and subsidies are included in each country's energy prices. The carbon-free backstop establishes an upper bound on the world oil price. This backstop fuel is a perfect substitute for the three fossil fuels and is available in infinite supply at one price, which is calculated to be a multiple of the world oil price in the benchmark year.

The MRT model has the following structure for trade, production, demand, savings and investment, and carbon restrictions.

Trade

First, the MRT model represents trade of the macro good with an Armington structure: Imports are imperfect substitutes for domestically produced goods. The elasticity of substitution between imports and domestically produced goods, referred to as the Armington elasticity, measures how easily imports can substitute for domestically produced goods. The Armington elasticity affects the potential gains in non-OECD export sales that will occur when lower-energy costs offer these non-participating countries a competitive advantage. This demand structure for imports versus domestic goods is illustrated below. Imported and domestic goods are combined into an aggregate consumption good (Y) with an elasticity of substitution equal to the Armington elasticity, σ_{import} . Consumers substitute aggregate end-use energy and the aggregate consumption good with an elasticity of substitution σ_{end} , which is approximately equal to the own-price elasticity of demand for energy.

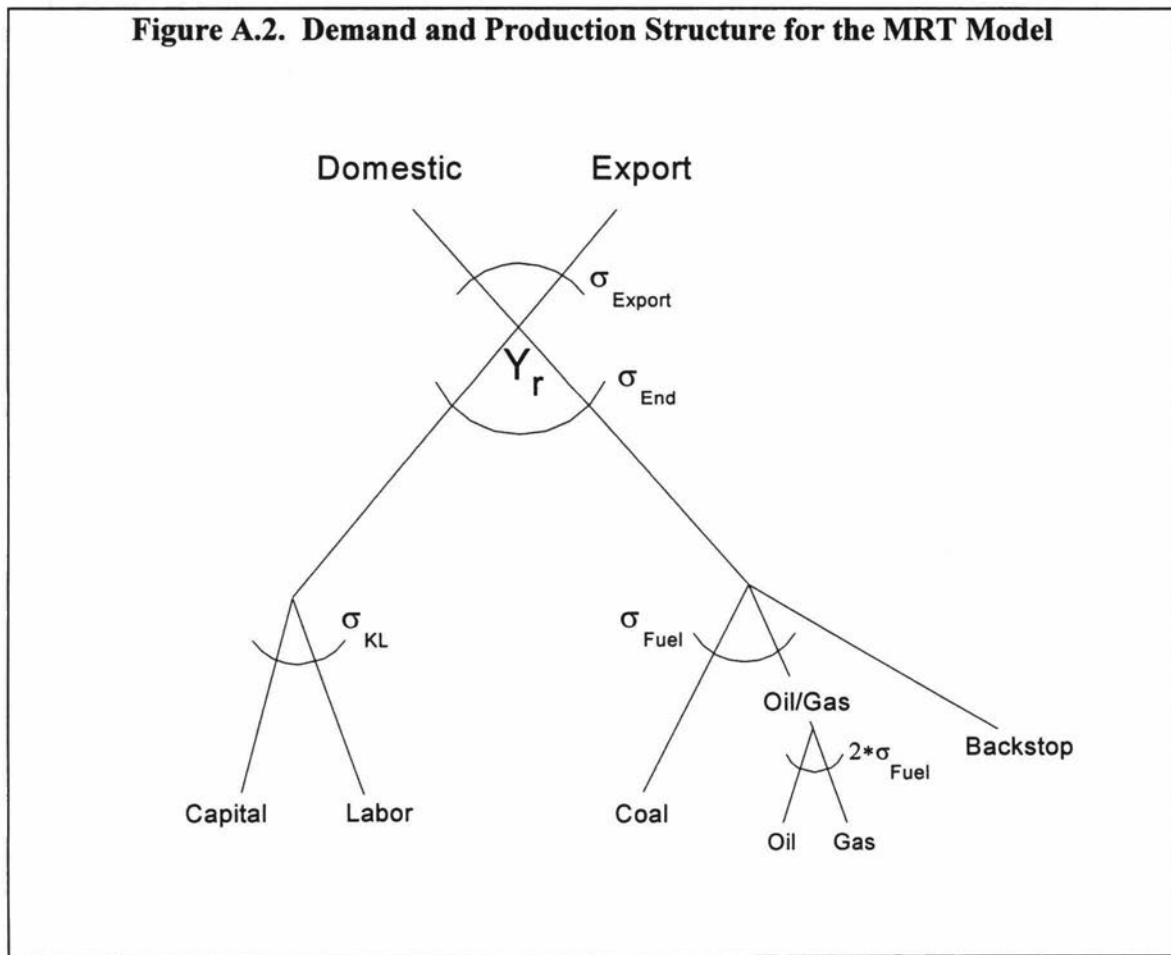


Trade takes place in energy and in the composite non-energy good. All bilateral trade flows for the non-energy good are represented in the MRT model, but only imports are

distinguished by region of origin in the SOE model. As for energy trade, all countries are represented as buying or selling one homogeneous oil good in the world market (see Figure A1).

Production of the Non-Energy Macro Good

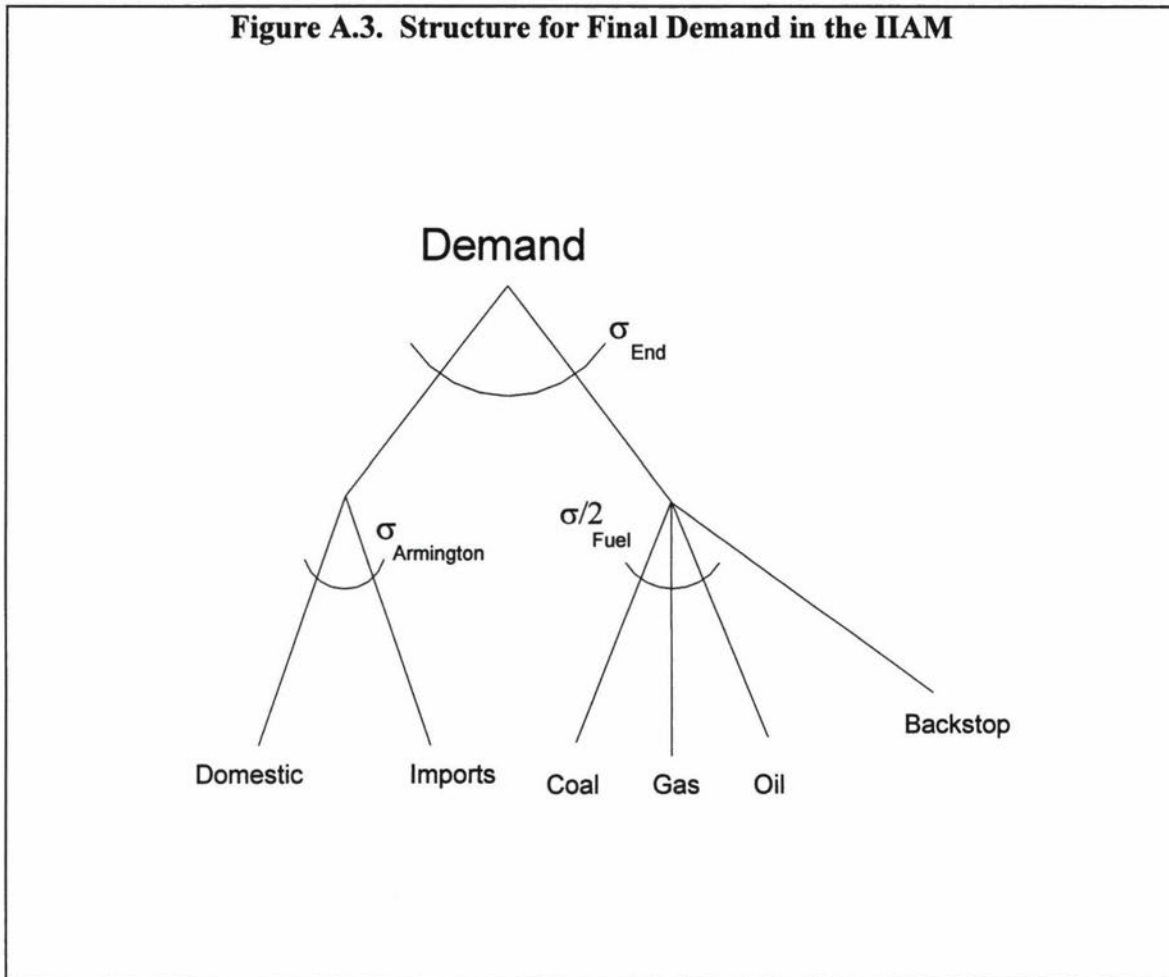
The aggregate non-energy good (Y) is produced from labor, capital, and the composite energy, through a nested CES technology. There is complete flexibility with respect to the structure of these cost functions. For example, energy and capital could be nested as complements rather than substitutes. The elasticity of substitution between the capital-labor aggregate and the composite energy good, σ_{end} , is equal to the own-price elasticity of demand for energy in industry. The production of the macro good is distinguished by destination as production for domestic use or for export according to a CES transformation technology and an Armington elasticity of transformation σ_{export} .



Production of the Energy Good

A composite energy good is produced either from the conventional fossil fuels - oil, gas, and coal - through a nested CES technology (with an elasticity of interfuel substitution σ_{fuel}) or from a backstop source through a Leontief technology. Oil and gas are nested together and substitute with an elasticity of substitution twice as large as the elasticity between their aggregate and coal. The production of the energy good from either fossil fuel or the backstop fuel is further distinguished by the final user so there is an energy good produced for industry and another one produced for households.

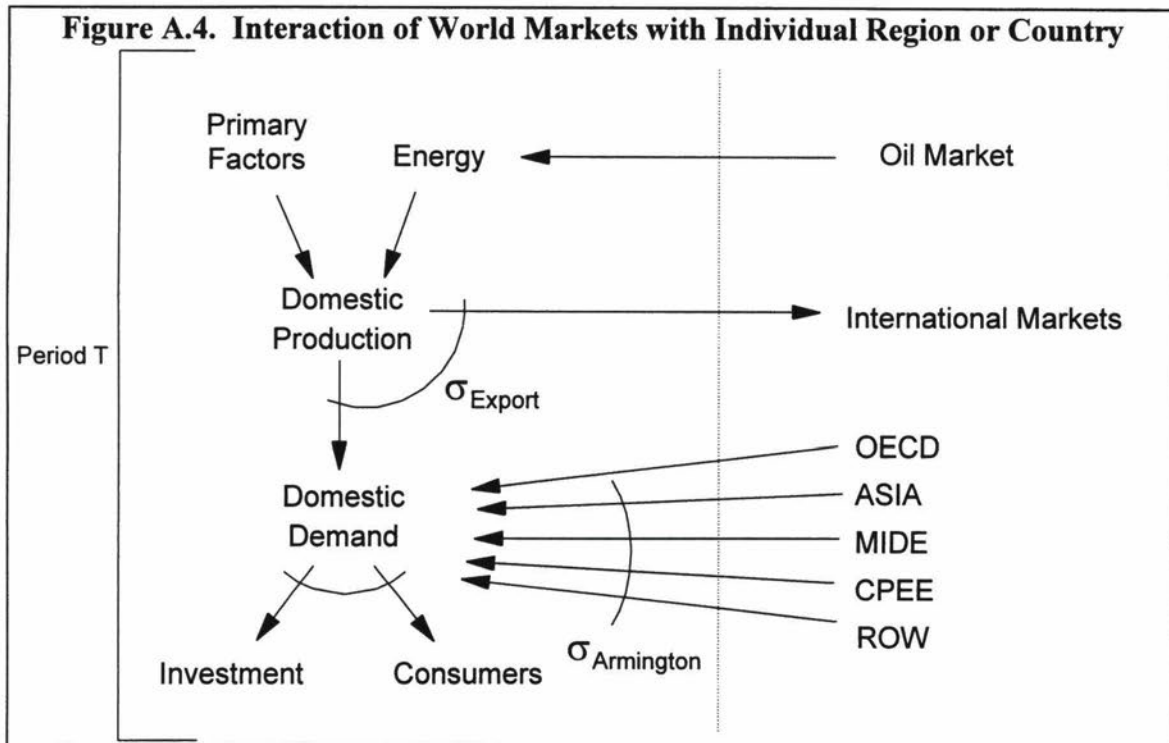
Demand



There is one representative agent in each region that demands a composite consumption good that is produced by combining the Armington good and the household energy aggregate good according to a CES configuration. σ_{end} describes the elasticity of substitution between the composite macro good and the energy aggregate. Aggregate end-use energy is composed of oil, gas, and coal with an interfuel elasticity of substitution equal to one. The backstop fuel is a perfect substitute for the energy aggregate. Purchase of the good is financed from the value of the household's

endowments of labor, capital, energy specific resources, and revenue from any carbon tax.

Figure A4 presents another depiction of the production and consumption structure. Every country buys and sells oil in a world market. Its domestic production is divided between domestic demand and exports with the elasticity σ_{export} . Domestic demand is satisfied by either domestic production or imports from other regions. These goods substitute based on the Armington elasticity $\sigma_{\text{Armington}}$, which is the same across all regions. In the SOE model, imports from the region to which the country belongs are treated as perfect substitutes for domestic production.

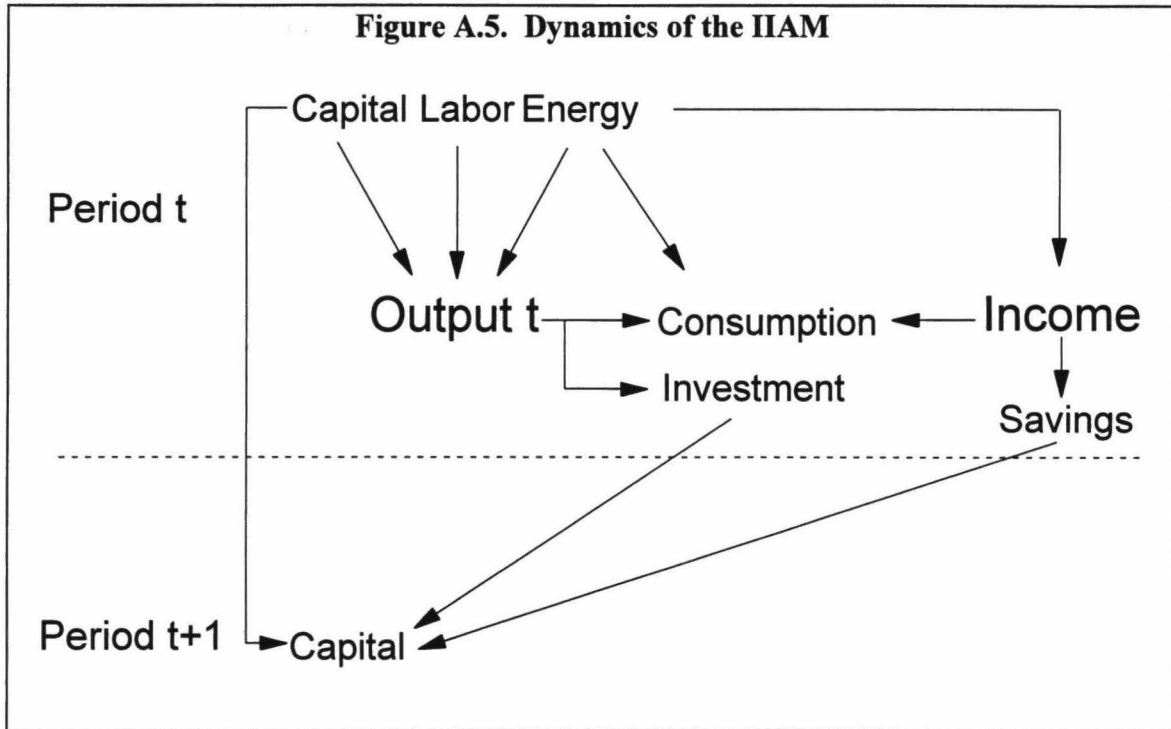


Savings and Investment (Dynamics)

Figure A5 illustrates the dynamics of the IIAM. This model has fully forward-looking investment behavior, so that announced future policies affect current behavior and produce impacts almost immediately. In the MRT model, the representative agent for each region maximizes its region’s discounted utility over the model’s time horizon. For the SOE model, there is one representative agent for the country of interest, which maximizes its country’s discounted utility over the model’s time horizon.

The primary factors, capital, labor, and energy are combined to produce output in period *t*. In addition, some energy is delivered directly to final consumption. Output is divided

between consumption and investment, and investment augments the (depreciated) capital stock in the next period. Capital, labor, and the energy resource earn incomes, which are either spent on consumption or saved. Saving equals investment through the usual identity.



The model possesses a Ramsey dynamics structure. Each representative agent has perfect foresight. There is a balance of payments equilibrium over time, and all countries borrow and lend at one world interest rate. Savings is determined by full intertemporal utility maximization. Investment is fully dynamic and forward looking where the return on investment is balanced against the cost of capital. Therefore, investment dollars are placed in the area where they will receive the highest return.

For the SOE model, the individual countries are modeled as small, open economies carrying out carbon emissions policies consistent with assumptions put forth in the world model. They have the same demand and production structure and scope as the MRT model. The SOE's trade structure, however, differs slightly from the MRT model. For the SOE model, international prices are exogenously determined by a user-specified MRT model run; whereas, the MRT model solves for international prices. In the SOE model, the individual countries take international prices as given. A country can import and export as much as it wants at the exogenously defined world prices. Trade takes place in energy and in the composite non-energy good. All bilateral trade flows for the non-energy good are represented in the MRT model, but only imports are distinguished

by region of origin in the SOE model. As for energy trade, all countries are represented as buying or selling one homogeneous oil good in the world market.

Carbon Restrictions

To comply with either of the U.S. proposals, the model places a carbon emissions limit on these countries that corresponds to the two proposals. The model endows the participating countries with emissions permits which allow them to emit carbon up to the level allowed by the proposals. In the MRT model, it is assumed that the emissions permits are tradable within the OECD, but in the SOE models, it is assumed that the permits are not tradable across countries.

The carbon permits allow the participating countries to determine the most economically efficient method of reducing their carbon emissions. If command-and-control or specific carbon reduction strategies that attacked only specific industries were used, then the marginal cost of reducing carbon emissions would be greater.

There exists a mathematical equivalency between placing a cap on a country's carbon emissions and having a country adopt a per ton carbon tax and return the revenues to the economy in lump sum. The shadow price on the emissions constraint equals the marginal cost to reduce carbon emissions. This is equivalent to the carbon tax required for a country to reduce its emissions by the amount that the proposals mandate. Therefore, the model would obtain the same equilibrium solution if a country applied a carbon tax that equals the marginal cost of the emissions permit or issued emissions permits. Because of this, the carbon tax also represents the lowest possible marginal cost of reducing carbon emissions under the assumption that revenues from the carbon tax are refunded to the economy in lump sum.

APPENDIX B -- BENCHMARKING AND CALIBRATING THE IIAM

This appendix describes how the IIAM was benchmarked and calibrated. For benchmarking, we needed to determine a reference level of emissions growth, GDP growth, energy production, energy, and non-energy trade. The model was calibrated to other prominent studies such as MIT's version of the GREEN model. This entailed assigning values to key elasticities, such as end-use demand, Armington, and oil supply.

The reference level emissions growth path is taken to be the International Panel on Climate Control's (IPCC) reference scenario IS92A. The IS92A scenario corresponds to the IPCC's baseline (medium growth) scenario which calls for worldwide carbon dioxide emissions to grow from 6.0 billion metric tonnes in 1990 to 10.7 billion metric tonnes by the year 2025. The reference level emissions growth determines the amount of emissions reduction required to meet the carbon limits called for by any carbon abatement policy.

The energy production and consumption forecasts were obtained from the Department of Energy's 1996, "Annual Energy Outlook." These forecasts were then calibrated to current IEA data and the IS92A scenario so that there was consistency between energy consumption and carbon emissions. The business-as-usual GDP growth rates were taken from the MERGE (a Model for Evaluating the Regional and Global Effects of greenhouse gas reduction policies) model which was developed by Alan Manne and Richard Richels. This model assumes the following GDP growth rates as a function of time for the five MRT regions.

Table B.1. GDP growth rates for the five MRT regions

Region	1992-2000	2001-2005	2006-2010	2011-2015	2016-2020	2021-2025	2026-2030
ASIA	6.0%	5.5%	5.0%	4.5%	4.5%	4.5%	4.5%
CPEE	0.0	4.0	4.0	3.5	3.0	3.0	3.0
MIDE	4.0	4.0	4.0	4.0	4.0	4.0	4.0
OECD	2.3	2.2	2.1	2.0	1.9	1.8	1.7
ROW	4.0	4.0	4.0	4.0	4.0	4.0	4.0

To match the GDP forecasts to the DOE's energy price and the energy consumption forecasts, the model uses a parameter called Autonomous Energy Efficiency Improvement (AEEI). AEEI reflects the rate of improvement in energy efficiency independent of any future energy price changes. A value of 0.7 was used in this study. This is consistent with other studies (e.g., Manne and Richels, 1994 see EMF printout on AEEI).

To develop a consistent database for energy and non-energy trade and input-output data, we merged non-energy trade data, input-output data, and input-output coefficients for energy from the GTAP database with data from the International Energy Agency. Prices

and quantities of all non-energy data are based on the 1995 GTAP database from Purdue University. This database provides trade and production statistics for 30 regions and 38 commodities for the year 1992. GTAP was aggregated into energy and non-energy goods for the five regions. The IEA database provides energy production and consumption, as well as price data in the production, industry, and final consumption sectors for oil, natural gas, and coal. This database replaced the GTAP energy data. The IEA database was used to determine the benchmark levels of energy prices and quantities. The benchmark year for the IIAM is 1992.

Calibration

There are several key parameters that need to be chosen for an IIAM simulation. Some of these are the oil supply price elasticity, Armington elasticity, end-use demand elasticity, interfuel elasticity of substitution, and the cost of the carbon-free backstop technology.

The supply elasticity for oil determines how the world oil price responds to changes in world oil demand. A value of 8.0 was chosen for the oil price supply elasticity. This implies that an 8% change in the quantity demanded results in a 1% price change. Increasing the oil price response will cause energy exporting nations to suffer more when a carbon abatement policy is enacted. On the other hand, higher oil price responses lead to greater benefits for the oil importing countries.

The Armington elasticity determines how easily a country can trade imported goods for domestically produced goods. This elasticity determines how much of the OECD's domestically produced goods would be displaced by non-OECD imports when a carbon abatement policy raises the cost of OECD produced goods. The Armington elasticity was set equal to 1.5 in the reference scenario, corresponding to a mid-range value.

The end-use demand elasticity determines the substitution between energy and other factors in production and consumption. Thus, this parameter determines how total energy demand responds to increases in the price of energy in both the short- and long-runs. To model the idea that this elasticity should increase over time, we assume a lower short-run value for the year 2000, a higher long-run value for the year 2030, and a linear increase from the short-run to the long-run value over the thirty-year time horizon. For OECD countries, the short- and long-run values equal 0.25 and 0.5, respectively. Because the non-OECD countries are less developed than the OECD countries, they are assumed to have lower values for the end-use demand elasticity: values of 0.2 and 0.4 are used for the short and long run, respectively. [These values are within the range suggested by Linbeck (1983).]

The interfuel elasticity of substitution determines how easily oil, gas, and coal substitute for one another. This elasticity affects the costs of switching fuels to reduce carbon emissions. For these simulations, the interfuel elasticity is set equal to one. This implies that if one fuel's price, coal for example, increases by one percent and the other two fuel

prices and the total quantity of energy demanded remains unchanged, then the quantity of coal consumed decreases by one percent and consumption of the other two fuels increases to cover the drop in coal consumption.

In addition to the three fossil fuels, the IIAM includes a carbon-free fuel that can substitute perfectly for any of the fossil fuels. This fuel is referred to as a backstop fuel of which each region is assumed to have an inexhaustible supply. Since this energy source is unavailable today, though it is believed to be available in the future, its price is assumed to be more expensive than the current fossil energy aggregate. The backstop fuel's price sets an upper limit on the cost of reducing carbon emissions in countries that adopt commitments because countries can use this fuel to satisfy all their energy needs. For the reference case, the backstop fuel is assumed to cost six times the 1992 fossil fuel energy aggregate.

If OECD countries adopt carbon limits, industries that are greatly impacted will likely lobby for some trade protection so that non-participating countries will not capture a large part of their domestic market. To account for this idea, the IIAM includes an import quota constraint where OECD countries would limit their imports from non-OECD countries. Because of the uncertainty in how the OECD countries would respond to increased competition from non-OECD countries, the reference case assumes that no trade restrictions will be implemented.

To compute the impacts of the two proposals, the MRT model is first run under the BAU scenario which includes the above set of elasticity values and assumptions. Using these same assumptions, the MRT model is run next for the Stabilization and Reduction proposals. These two proposals are assumed to affect only OECD countries. Because the CPEE countries are facing many financial difficulties, it is believed that they would not be forced to adopt emissions limits. Therefore, for these simulations, the Stabilization and Reduction proposals require that only OECD countries reduce their emissions.

APPENDIX C -- ADDITIONAL DATA ON INDIVIDUAL COUNTRIES

Tables of Impacts for Individual Countries by Country Types

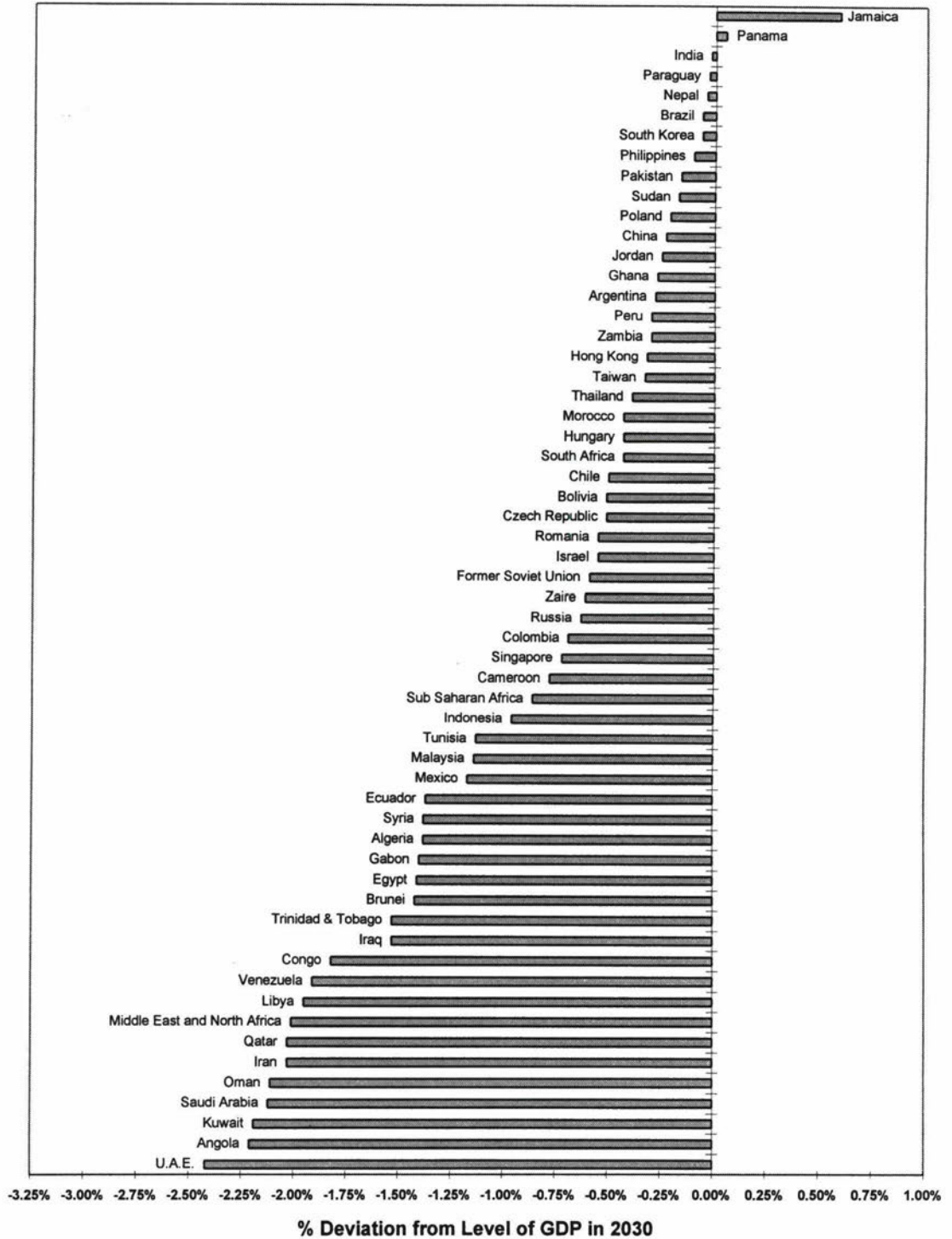
The following tables show the economic impacts on all countries under the Stabilization and Reduction proposals for the reference case (no trade quotas and reference assumptions for emissions growth, trade impacts, oil price response, or backstop price). These tables provide additional information about effects on trade and emissions that do not appear in the body of this report.

Results for the Import Quota Case

The following figures show the GDP impacts on all countries under the Stabilization and Reduction proposals for the import quota case. All other assumptions are the same as in the reference case (i.e., emissions growth, trade impacts, oil price response and backstop price).

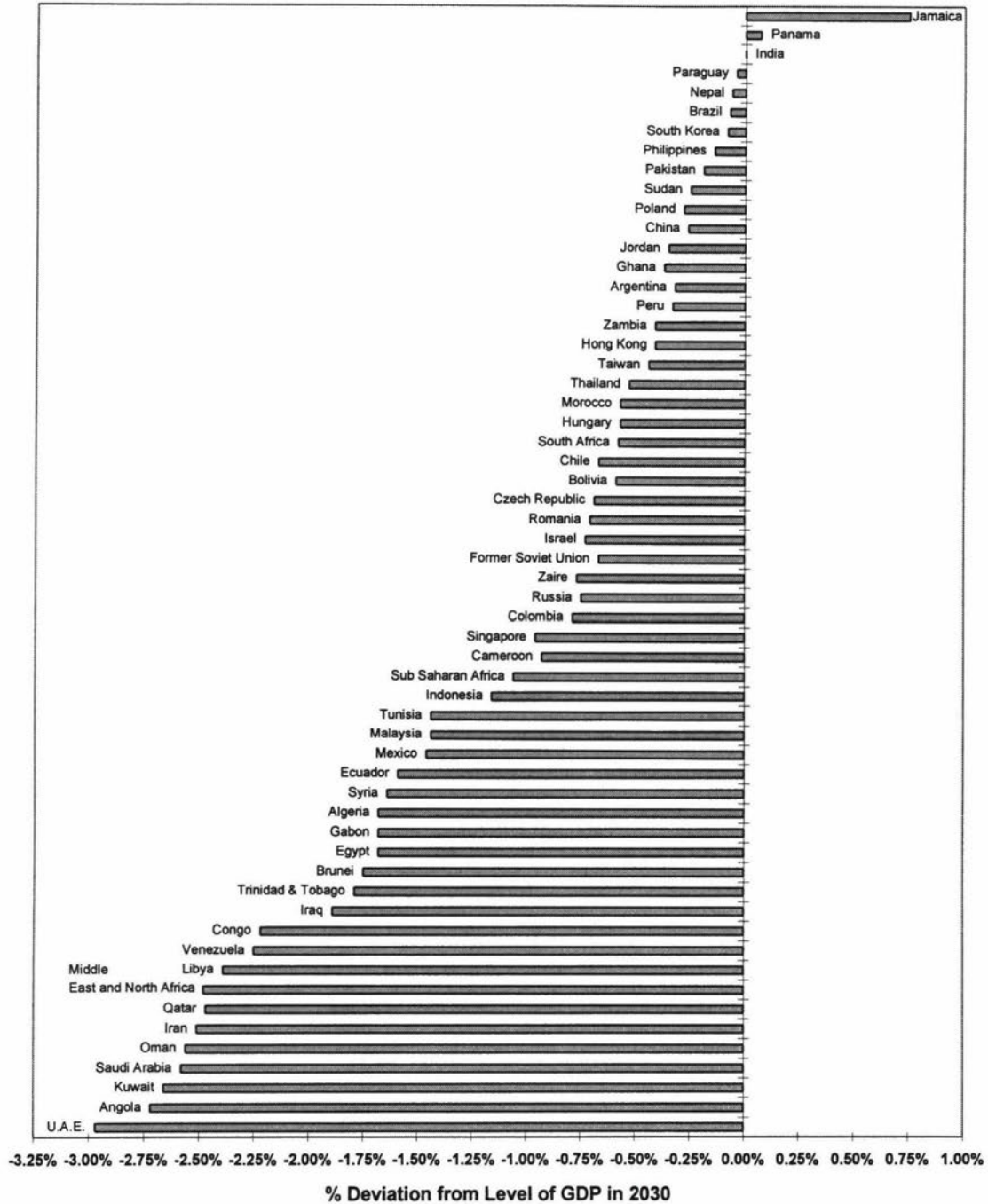
Stabilization Proposal

Figure C.1. Impact of Stabilization Proposal on Non-Participating Countries' GDP in the Year 2030 (Import Quotas)



Reduction Proposal

Figure C.2. Impact of Reduction Proposal on Non-Participating Countries' GDP in the Year 2030 (Import Quotas)



APPENDIX D -- SENSITIVITY ANALYSIS RESULTS FOR THE STABILIZATION PROPOSAL

The following tables report the results of the sensitivity analysis for the Stabilization Proposal. These tables show the impacts to the five regions under the following cases: low oil price, low-cost backstop, low trade, high trade, low emissions, high emissions, 2015 target, and trade protection. The results from these cases are compared against those from the reference case.

The low oil price case assumes that world oil prices decline further than in the reference case. For the low-cost backstop case, the carbon free backstop fuel is assumed to be less expensive than in the reference case. In the low-trade case, imported goods substitute poorly for a region's domestically produced goods; whereas, in the high-trade case, imports substitute much more easily for domestically produced goods. For the low and high emissions case, carbon emissions are projected to grow respectively 15% slower and 35% faster than in the reference case. For the 2015 target case, we attempt to account for the uncertainty in the U.S. government's intentions regarding a medium term target date for OECD countries to adopt emission controls. It is assumed that the OECD postpones adopting emissions limits until 2015, at which time, the OECD will adopt either the limits of the Stabilization or Reduction proposal. Last, the trade protection case assumes that the OECD adopts import quotas in an effort to protect its domestic industries against non-OECD imports.

Table D.1. Percentage change from BAU in world oil prices

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	201 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.45	0.34	1.59	3.20	-0.56	1.62	1.33	1.52	0.95
2005	1.45	-0.56	1.56	3.19	-1.10	1.62	1.32	1.52	0.10
2010	0.32	-2.86	0.33	1.88	-7.44	0.79	-0.43	1.48	-1.34
2015	-0.25	-3.77	-0.31	1.18	-9.11	0.39	-1.37	0.08	-1.95
2020	-0.96	-4.70	-1.06	0.34	-11.52	-0.13	-2.43	-0.73	-2.52
2025	-1.66	-5.34	-1.81	-0.51	-13.82	-0.66	-3.47	-1.48	-2.99
2030	-2.28	-5.85	-2.48	-1.28	-15.86	-1.14	-4.40	-2.13	-3.34

Table D.2. Percentage change from BAU in GDP for all regions under the nine cases**Region: ASIA**

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.04	0.08	-0.03	-0.10	-0.01	-0.03	-0.04	-0.04	0.15
2005	-0.10	-0.06	-0.09	-0.20	-0.04	-0.08	-0.11	-0.11	0.03
2010	-0.13	-0.19	-0.11	-0.27	-0.02	-0.11	-0.13	-0.17	-0.11
2015	-0.12	-0.30	-0.09	-0.30	0.03	-0.10	-0.10	-0.18	-0.24
2020	-0.12	-0.36	-0.08	-0.34	0.07	-0.10	-0.07	-0.15	-0.33
2025	-0.11	-0.37	-0.06	-0.37	0.11	-0.09	-0.05	-0.13	-0.36
2030	-0.09	-0.31	-0.04	-0.39	0.15	-0.07	-0.03	-0.10	-0.33

Region: CPEE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.10	-0.01	-0.10	-0.14	-0.06	-0.07	-0.12	-0.07	0.06
2005	-0.30	-0.23	-0.32	-0.39	-0.22	-0.23	-0.42	-0.19	-0.10
2010	-0.41	-0.42	-0.44	-0.55	-0.28	-0.32	-0.56	-0.42	-0.26
2015	-0.38	-0.47	-0.42	-0.54	-0.22	-0.30	-0.48	-0.55	-0.32
2020	-0.38	-0.51	-0.42	-0.56	-0.20	-0.31	-0.43	-0.45	-0.40
2025	-0.36	-0.49	-0.40	-0.57	-0.17	-0.30	-0.38	-0.39	-0.43
2030	-0.31	-0.41	-0.34	-0.52	-0.11	-0.25	-0.30	-0.31	-0.39

Region: MIDE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.30	0.09	-0.31	-0.44	-0.17	-0.23	-0.43	-0.23	0.30
2005	-0.74	-0.46	-0.77	-0.98	-0.49	-0.56	-1.05	-0.48	-0.12
2010	-1.28	-1.41	-1.35	-1.64	-0.89	-0.96	-1.84	-0.94	-0.84
2015	-1.41	-1.84	-1.49	-1.86	-0.93	-1.05	-2.01	-1.58	-1.20
2020	-1.63	-2.28	-1.72	-2.19	-1.05	-1.23	-2.27	-1.66	-1.60
2025	-1.81	-2.55	-1.90	-2.48	-1.14	-1.37	-2.50	-1.80	-1.88
2030	-1.89	-2.65	-1.98	-2.66	-1.15	-1.42	-2.61	-1.86	-1.97

Table D.2. (Continued)**Region: OECD**

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.05	-0.73	-0.04	-0.03	-0.07	-0.04	-0.08	-0.03	-0.77
2005	-0.22	-1.48	-0.15	-0.20	-0.23	-0.17	-0.31	-0.13	-1.54
2010	-1.00	-2.35	-0.79	-1.01	-0.98	-0.70	-1.67	-0.27	-2.46
2015	-1.26	-2.44	-0.95	-1.28	-1.24	-0.86	-2.16	-1.18	-2.63
2020	-1.55	-2.38	-1.13	-1.59	-1.52	-1.05	-2.69	-1.51	-2.63
2025	-1.83	-2.28	-1.30	-1.88	-1.78	-1.23	-3.16	-1.81	-2.45
2030	-2.12	-2.09	-1.48	-2.19	-2.05	-1.41	-3.61	-2.10	-2.12

Region: ROW

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.10	-0.02	-0.09	-0.18	-0.04	-0.07	-0.13	-0.08	0.09
2005	-0.25	-0.23	-0.24	-0.38	-0.14	-0.19	-0.32	-0.21	-0.09
2010	-0.37	-0.47	-0.37	-0.58	-0.20	-0.29	-0.48	-0.36	-0.33
2015	-0.40	-0.63	-0.39	-0.66	-0.17	-0.31	-0.48	-0.48	-0.50
2020	-0.43	-0.75	-0.41	-0.75	-0.15	-0.34	-0.50	-0.48	-0.64
2025	-0.44	-0.79	-0.41	-0.81	-0.12	-0.34	-0.50	-0.46	-0.71
2030	-0.42	-0.75	-0.38	-0.84	-0.08	-0.33	-0.49	-0.43	-0.69

Table D.3. Carbon tax in the OECD (1992 U.S. dollars per ton) for the nine cases.

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0
2010	206	185	176	216	195	154	315	0	193
2015	255	210	206	267	242	187	397	255	240
2020	315	244	242	329	300	233	486	315	300
2025	373	326	275	388	355	278	566	373	358
2030	426	422	305	442	407	321	638	426	414

Table D.4. Percentage change from BAU in non-energy exports for the five regions and the nine cases.

Region: ASIA

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.47	-0.16	0.44	0.72	0.23	0.37	0.54	0.49	-0.13
2005	0.25	-0.01	0.28	0.47	0.04	0.20	0.25	0.35	0.04
2010	0.09	0.01	0.16	0.22	-0.03	0.07	0.03	0.12	0.07
2015	0.21	-0.04	0.30	0.28	0.16	0.15	0.29	-0.05	0.03
2020	0.30	-0.12	0.41	0.32	0.31	0.21	0.51	0.12	-0.05
2025	0.38	-0.20	0.50	0.36	0.45	0.26	0.72	0.25	-0.12
2030	0.42	-0.24	0.56	0.35	0.55	0.30	0.88	0.32	-0.17

Region: CPEE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.10	0.17	1.18	1.30	0.78	0.83	1.50	0.99	-0.23
2005	0.90	0.39	1.01	1.07	0.61	0.67	1.23	0.84	0.01
2010	0.99	0.72	1.15	1.08	0.80	0.73	1.41	0.69	0.28
2015	1.47	1.10	1.68	1.50	1.34	1.07	2.23	0.89	0.56
2020	1.88	1.40	2.13	1.86	1.80	1.36	2.94	1.55	0.76
2025	2.27	1.69	2.56	2.21	2.24	1.65	3.61	2.04	0.97
2030	2.61	2.01	2.93	2.51	2.62	1.90	4.19	2.43	1.21

Table D.4. (Continued)**Region: MIDE**

Year	Reference	Low		High	Low	High	2015	Import
		Oil	Low					
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.28	0.16	1.33	1.62	0.76	0.95	1.13	-0.21
2005	0.90	0.36	1.00	1.18	0.46	0.66	0.85	0.06
2010	0.94	0.55	1.10	1.12	0.63	0.69	0.61	0.24
2015	1.49	0.76	1.71	1.60	1.24	1.08	2.29	0.41
2020	1.93	0.93	2.21	2.00	1.70	1.39	3.05	1.58
2025	2.37	1.14	2.70	2.41	2.17	1.72	3.78	0.69
2030	2.77	1.40	3.15	2.77	2.58	2.02	4.43	0.90

Region: OECD

Year	Reference	Low		High	Low	High	2015	Import
		Oil	Low					
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.23	-0.11	-1.22	-1.63	-0.78	-0.95	-1.60	-1.12
2005	-1.31	-1.97	-1.31	-1.75	-0.82	-1.01	-1.70	-1.19
2010	-1.86	-3.49	-1.86	-2.27	-1.41	-1.40	-2.55	-1.29
2015	-2.42	-4.46	-2.41	-2.81	-2.02	-1.80	-3.48	-1.98
2020	-2.99	-5.03	-2.93	-3.36	-2.60	-2.20	-4.40	-2.67
2025	-3.53	-5.39	-3.42	-3.89	-3.16	-2.58	-5.28	-3.28
2030	-4.00	-5.63	-3.84	-4.33	-3.65	-2.92	-6.08	-3.79

Region: ROW

Year	Reference	Low		High	Low	High	2015	Import
		Oil	Low					
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.95	0.09	0.95	1.28	0.54	0.72	1.24	0.88
2005	0.70	0.21	0.76	1.00	0.33	0.54	0.90	0.72
2010	0.55	0.26	0.66	0.76	0.28	0.42	0.71	0.49
2015	0.76	0.26	0.90	0.91	0.56	0.56	1.10	0.36
2020	0.95	0.23	1.11	1.05	0.81	0.69	1.47	0.66
2025	1.13	0.20	1.31	1.18	1.05	0.82	1.83	0.91
2030	1.26	0.21	1.46	1.27	1.22	0.92	2.14	1.08

Table D.5. Percentage change from BAU in terms of trade relative to the OECD for the ASIA, CPEE, MIDE, and ROW regions under the nine cases

Region: ASIA

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-0.89	-3.32	-0.86	-1.49	-0.42	-0.69	-1.10	-0.85	-2.34
2005	-0.78	-4.45	-0.80	-1.37	-0.31	-0.61	-0.94	-0.81	-3.47
2010	-0.91	-5.03	-0.96	-1.52	-0.40	-0.70	-1.17	-0.69	-4.03
2015	-1.25	-5.33	-1.30	-1.91	-0.68	-0.93	-1.76	-0.88	-4.33
2020	-1.58	-5.28	-1.63	-2.29	-0.93	-1.16	-2.34	-1.31	-4.34
2025	-1.90	-5.09	-1.93	-2.66	-1.17	-1.38	-2.90	-1.69	-4.22
2030	-2.16	-4.87	-2.17	-2.97	-1.36	-1.57	-3.42	-1.99	-4.01

Region CPEE

Year	Reference	Low Oil Price	Low Backstop	Low Trade	High Trade	Low Emissions	High Emissions	2015 Target	Import Quota
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.49	-3.74	-1.54	-2.20	-0.83	-1.13	-1.98	-1.35	-2.29
2005	-1.44	-4.94	-1.54	-2.15	-0.77	-1.10	-1.92	-1.31	-3.49
2010	-1.78	-5.83	-1.92	-2.54	-1.04	-1.34	-2.48	-1.32	-4.30
2015	-2.39	-6.52	-2.56	-3.23	-1.55	-1.77	-3.48	-1.80	-4.89
2020	-2.95	-6.83	-3.14	-3.89	-2.00	-2.17	-4.41	-2.57	-5.18
2025	-3.49	-6.95	-3.68	-4.51	-2.42	-2.56	-5.29	-3.20	-5.33
2030	-3.94	-6.99	-4.13	-5.04	-2.77	-2.89	-6.06	-3.69	-5.35

Table D.5. (Continued)**Region: MIDE**

Year	Reference	Low		High	Low		High	2015	Import
		Oil	Backstop		Trade	Emissions			
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.39	-3.73	-1.42	-2.15	-0.70	-1.05	-1.90	-1.24	-2.30
2005	-1.34	-4.93	-1.42	-2.08	-0.66	-1.02	-1.83	-1.18	-3.53
2010	-1.70	-5.75	-1.83	-2.48	-0.93	-1.27	-2.40	-1.23	-4.28
2015	-2.30	-6.35	-2.47	-3.17	-1.42	-1.70	-3.39	-1.75	-4.83
2020	-2.87	-6.63	-3.06	-3.84	-1.86	-2.11	-4.30	-2.53	-5.11
2025	-3.43	-6.76	-3.63	-4.49	-2.29	-2.52	-5.19	-3.18	-5.27
2030	-3.90	-6.84	-4.11	-5.05	-2.65	-2.87	-5.97	-3.69	-5.33

Region: ROW

Year	Reference	Low		High	Low		High	2015	Import
		Oil	Backstop		Trade	Emissions			
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	-1.24	-3.70	-1.23	-1.98	-0.60	-0.95	-1.60	-1.14	-2.46
2005	-1.14	-4.85	-1.18	-1.87	-0.51	-0.88	-1.47	-1.10	-3.62
2010	-1.32	-5.50	-1.39	-2.07	-0.63	-1.00	-1.77	-1.02	-4.27
2015	-1.73	-5.88	-1.81	-2.54	-0.97	-1.29	-2.46	-1.27	-4.65
2020	-2.13	-5.91	-2.21	-3.01	-1.28	-1.56	-3.14	-1.79	-4.76
2025	-2.51	-5.78	-2.58	-3.46	-1.57	-1.84	-3.80	-2.25	-4.71
2030	-2.82	-5.61	-2.88	-3.83	-1.80	-2.06	-4.39	-2.60	-4.55

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