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The Global Climate Debate: Keeping the Economy Warm and the Planet Cool

Impact on Five Key Industries: Airlines, Automobiles, Chemicals, Semiconductors and Steel

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To date, the debate on global warming has focused primarily on scientific issues and the macroeconomic effects of reduced greenhouse gas emissions.

Because such analysis is based on numerous assumptions and aggregation of numbers, it often misses important elements that can have large effects on individual industries.

The Economic Strategy Institute (ESI) therefore has taken a "bottoms up" approach in this study and looked at the impact of emissions reductions on output, trade and competitiveness of a range of key industries including:

- *airlines*
- *automobiles*
- *chemicals*
- *semiconductors*
- *steel*

We believe these are representative of a range of other industries we did not have the time to analyze.

Finally, we would remiss if we failed to acknowledge the assistance of Hilary Dauer, Andrew Harig, Lisa Hill and Yee Wong in the completion of this report.

-- The authors

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Executive Summary

The Issue

- In December 1997, representatives of the world's governments will meet in Kyoto, Japan, to conclude an agreement committing developed countries to mandatory reductions of greenhouse gas emissions to at least 1990 levels by 2010.
- Developing countries are not expected to be included in this agreement, and thus would have no commitments with regard to greenhouse gas emissions, despite the fact that their emissions are rising rapidly and will soon exceed advanced country emissions.
- Such an agreement would have significant implications for the United States, because it could result in substantially higher energy costs and the elimination of production processes that are essential to several key industries.
- The Economic Strategy Institute (ESI) has attempted to estimate the impact of any agreement on the overall U.S. economy, as well as on several key industries (chemicals, steel, autos, passenger airline services, and semiconductors) from the point of view of competitiveness and trade. The key results of this study are summarized below.

The Science of the Issue

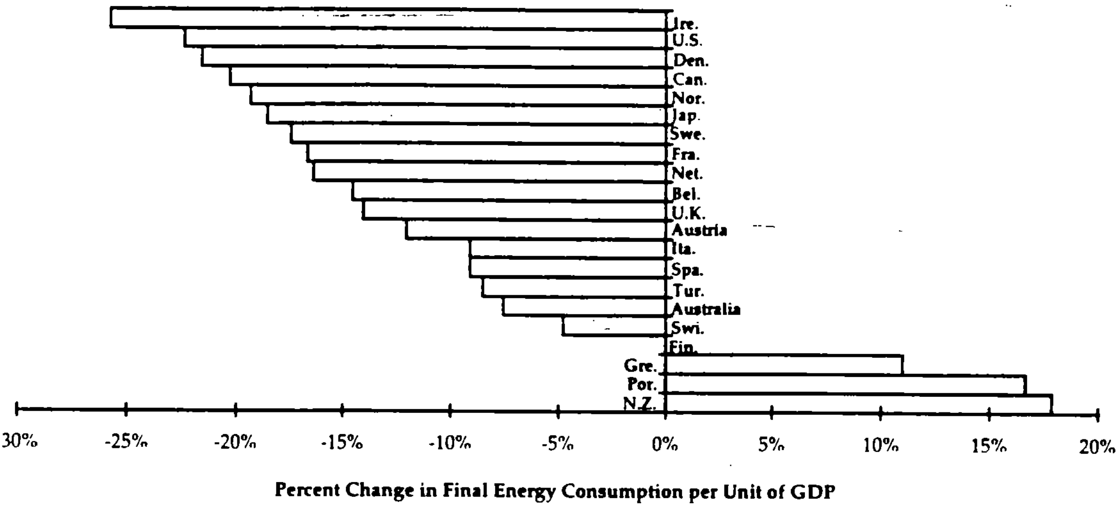
- The science of global climate change is in dispute. Global climate models show temperatures should be rising, but satellite and weather balloon data show temperatures have been stable. ESI's purpose is not to contest the science, but to look at the impact of proposals for dealing with a problem that has not been conclusively proven to exist.

Status of the United States

- Other governments and commentators have asserted that the United States is particularly at fault. This is not the case. U.S. emissions of carbon dioxide per unit of output are below the world average, and most of the rise in U.S. emissions since 1990, the baseline for emissions proposals, reflect population growth and economic expansion, not declining energy efficiency. In fact, U.S.

energy efficiency since 1980 has improved more than that of most industrialized countries.

Exhibit ES.1
Change in Total Final Energy Consumption per Unit of GDP
1980 - 1993



Source: OECD

Survey of Existing Models

- Most of the estimates of the economic impact are based on models which incorporate key economic variables and behavioral relationships. These models contain flaws which lead them to underestimate the economic impact of a greenhouse tax or other measures required to return U.S. emissions to 1990 levels. Optimistic assumptions include:

  -understating the emissions tax necessary to reduce emissions,

  -assuming away the higher costs that would result from increased regulation, and

  -discounting the likelihood that offsetting tax cuts would be used unwisely.

- ESI has concluded that the overall impact on the U.S. economy would be somewhat larger than many models are predicting. This assessment is based on the U.S. experience during and after the oil crises of the 1970s, and on recent model simulations which do not include the rosy assumptions of other estimates. One such simulation, by The WEFA Group, shows that much larger tax levels, perhaps two times larger than the $100 per metric ton of carbon assumed in recent administration simulations, would be required to reduce U.S. emission levels to 1990 levels by 2010.

Exhibit ES.2
Changes in Real U.S. Prices of Various Energy Sources, 1973-1987 Versus Expected Changes Due to a Carbon Tax

	1973-1987	1994-2010
Oil	67%	70%
Natural Gas	223%	45%
Coal	24%	198%

Sources: Derived from data in Gary W. Yohe, *Climate Change Policies, Living Standards, and Real Wage Growth;* Argonne National Laboratory, *The Impact of High Energy Price Scenarios on Energy Intensive Sectors: Perspectives from Industry Workshops;* and ESI Calculations.

Exhibit ES.3
Average Growth Rates of Real GDP 1960-1973 and 1973-1989

	1960-1973	1973-1989
United States	3.95%	2.42%
European Union	4.68%	2.27%
OECD	4.82%	2.63%
OECD Europe	4.67%	2.31%
Japan	9.57%	3.84%
Note: EU, OECD and OECD Europe refer to 1991 membership		

Source: OECD

Analysis of Key Industries

- To determine the impact of emissions reduction policies on specific industries, ESI used a bottom-up approach which took into account energy intensities, trade and output levels, the level of sectoral trade with developing countries, foreign direct investment patterns, and the other industry-specific factors. The results show that damage from a greenhouse gas tax would extend to high tech and service industries, as well as to traditional manufacturers. Losses in output and competitiveness would be substantial.

Exhibit ES.4
Estimated Impact of a $100 per Ton Carbon Tax
Summary of Output and Trade Effects by 2010
Percent Change from Base Case

	Output	Exports	Imports
Chemicals			
-with feedstock exemption	-3.3	-3.6	3.5
-without feedstock exemption	-4.6	-7.2	7.0
Steel	-21.9	-18.0	14.3
Automobiles	-5.8	-3.8	3.6
Airline Services	-6.5	-3.0	2.8
Semiconductors*	-8.0	-6.0	5.8

*Semiconductor estimates include the effect of regulations on PFC production
ESI Calculations

- The disturbingly high losses in the semiconductor industry reflect the likelihood that perfluorocarbon emissions (PFCs) would be reduced through regulation. Since there are currently no substitutes for PFCs in the semiconductor manufacturing process, drastic emissions limits would put U.S. manufacturers at a major disadvantage against unregulated competitors from developing countries.
- Exempting developing countries from greenhouse gas limits would dramatically increase the U.S. deficit. With tensions over trade with developing countries already high, support for the World Trade Organization would almost certainly erode. This development would run counter to efforts by this and previous U.S. administrations to open markets and expand free trade.

Conclusions and Recommendations

- Given the ambiguity surrounding the science of global warming and the substantial economic costs of reducing greenhouse gas emissions though taxation and regulation, the U.S. government should be extremely cautious in dealing with the Kyoto agenda. **In particular, it should not agree to proposals being made by other countries for mandatory reduction of emissions by 2010.**
- The United States should resist efforts to exempt developing countries from emissions reduction efforts and encourage cooperative arrangements, financing, and technology transfers that would lead to emissions reductions in developing countries.

- Participants at Kyoto should consider cooperatively financing a Manhattan-type project to achieve massive increases in energy efficiency.

Chapter I: Introduction

In early December 1997, representatives of the world's governments gathering in Kyoto, Japan are expected to finalize a pact committing dozens of countries, including the United States, to reduce emissions of greenhouse gases.[1]

Most man-made emissions are the byproduct of burning fossil fuel for energy, which enables production of goods and services, transportation of goods and people, and simplification of day-to-day tasks. Because energy from fossil fuels has become the driving force of human economic activity, any decisions coming out of Kyoto that affect energy use will inevitably have a far-reaching impact on the global economy. In particular, as the world's largest economy and biggest consumer of fossil fuels, America has much riding on the outcome of these discussions.

Background

In June 1992, at the United Nations Conference on Economic Development in Rio de Janeiro, Brazil, representatives of 154 governments signed the Framework Convention on Climate Change. The ultimate aim of this treaty, which took force on March 21, 1994, is to prevent any climate change that could result from high concentrations of atmospheric greenhouse gas. As part of efforts to reach this goal, Annex I countries (the OECD countries as of 1992, plus Eastern Europe and the old Soviet Union) voluntarily committed to reduce greenhouse gas emissions to 1990 levels by the year 2000.[2]

Since Rio, there have been two major meetings of the Climate Change Convention. The first conference of the parties (COP-1), occurred in Berlin in late 1995. Participating ministers concluded that the voluntary commitment mechanism was insufficient and consequently adopted the Berlin Mandate, which exempted developing countries from emissions limits while beginning the process of setting post-2000, mandatory limits on developed country emissions. The Ad Hoc Group of the Berlin Mandate was tasked to devise a legal

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[1] Greenhouse gases are carbon dioxide, water vapor, methane, nitrous oxide and tropospheric ozone. Man-made chemicals, such as chlorofluorocarbons, hydrofluorocarbons and perfluorocarbons, act as greenhouse gases and could be affected by Kyoto discussions as well.

[2] The United States objected to an explicit treaty commitment during negotiations, but changed its stance in April 1993.

instrument that would commit developed countries to more stringent targets after 2000.

In July 1996, at COP-2 in Geneva, Switzerland, participants stressed the need to strengthen the Climate Change Convention. The Kyoto meeting in December 1997 will be the third conference of the parties, and is aimed at agreeing to strict, mandatory emissions limits for Annex I countries.

Issues

From the outset, the treaty has been controversial. Many scientists worry that the science underlying climate change predictions is too uncertain to warrant hasty, drastic action. Outside the scientific community, concern is mounting that the proposals to be discussed at Kyoto represent unrealistic, panicked reactions that could lead to slower economic growth and lower living standards - a high price to pay for solving an uncertain problem.

The Science

Though the scientific debate is beyond the scope of this paper, it deserves mention because the Intergovernmental Panel on Climate Change (IPCC), an international network of scientists, presents itself as representing the scientific consensus on global climate change. IPCC scientists have concluded that "... the balance of evidence suggests that there is a discernible human influence on global climate;"[3] that man-made greenhouse gases will lead to significantly warmer weather during the next hundred years; and that warmer temperatures will result in more extreme weather changes in some areas, including more severe or less severe floods and droughts.

The IPCC's predictions of impending global warming and its impact, however, are not universally accepted. Hundreds of scientists at the Rio conference signed the Heidelberg Appeal, which warned against concluding a treaty without a proper scientific basis. In 1996, nearly one hundred climate scientists signed the Leipzig Declaration, questioning the validity of global warming forecasts based on computer model simulations.[4]

The record of the models predicting climate change is uncertain at best. In the mid-1980s, available models were forecasting a 5.2°C (9.4° F) average rise in global temperatures by 2100. By 1992, the IPCC had modified that estimate to a range of 1° to 4.5°C (1.8° to 8.1°F) through 2050. For its second assessment, the group revised its upper bound estimate down to 3.5°C (6.3°F) by 2100.

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[3] IPCC, *Climate Change 1995: The Science of Climate Change*, Working Group 1 (Cambridge, UK: Cambridge University Press, 1996), 6.

[4] S. Fred Singer, "Scrap the Climate Treaty," *The Journal of Commerce* (March 6, 1997).

Scientists who disagree with even these most recent projections argue that the computer models generating these estimates do a poor job of reflecting natural climatic variability.[5] They also cite data from satellites and balloon-borne sensors showing little-to-no climate change since 1979 and little, if any, warming since 1945, even though seventy percent of all manmade greenhouse gases have been added to the atmosphere during the past fifty years.[6] They conclude that there will be warming, but much less than the IPCC predicts, and it will have benign, perhaps even beneficial, consequences.[7]

Dissension within the scientific community is not an excuse for inaction. However, the many unanswered questions surrounding this scientific debate suggest a prudent, measured approach toward abatement is warranted.

The Proposals

The Ad Hoc Group of the Berlin Mandate has waded through emissions control proposals submitted by various countries and has combined them into a negotiating text that will be modified and adopted in Kyoto. Though no firm targets for emissions reductions have been chosen, it is clear that the emissions reductions proposals now under consideration, if adopted, would have a major impact on the global economy during the next several decades. Key points of contention include:

1) Emissions targets and timetables - Proposals range from reducing carbon dioxide emission levels to 1990 levels by 2010 to cutting twenty percent from 1990 levels by 2020. Earlier target dates and deeper emissions cuts will mean more severe economic adjustments.
2) Developing-country exemption - Emissions from non-Annex I countries are expected to surpass Annex I emissions by 2050, yet the Berlin Mandate has decreed that their emissions will be allowed to grow for the foreseeable future. Any plan that exempts developing countries would encourage the migration of energy-intensive production processes to developing countries and would result in little net emissions reduction.

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[5] William K. Stevens, "Warming Skeptic Says It's a Lot of Hot Air,"

[6] Patrick J. Michaels and Paul C. Knappenberger, "The United Nations Intergovernmental Panel on Climate Change and the Scientific 'Consensus' on Global Warming," in John Emsley, Ed., *The Global Warming Debate* (London: The European Science and Environmental Forum, 1996), 165-166.

[7] Some believe that such slightly higher temperatures and carbon dioxide levels will lead plant life and human civilization to thrive. See, for example, Sherwood Idso, "Plant responses to Rising Levels of Atmospheric Carbon Dioxide," in Emsley, Ed., *The Global Warming Debate* (London: The European Science and Environmental Forum, 1996), 28-39; and Thomas Gale Moore, "Why Global Warming Will Be Good for You," *The Public Interest* (Winter 1995), 83-99.

3) Differentiated targets - The European Union expects to reach its target by allowing some members to increases emissions while others reduce theirs. Some countries are arguing that all Annex I countries should have the targets appropriate to their economic profile.
4) Flexible reduction strategies - There are alternatives to achieving a target by a certain date. The United States, for instance, has suggested an approach that would allow for emissions budgets to be achieved over a number of years. Washington has also suggested emissions trading and joint implementation, schemes which would, in essence, enable developed countries to get credit for encouraging "offshore" emissions reductions.

Regardless of which proposal emerges from COP-3, any amendment to the treaty that mandates emissions reductions will ultimately affect the choices of both firms and consumers. Whether Annex 1 governments decide to reduce emissions by implementing tough new standards, typically referred to as command and control measures, or by implementing market-oriented measures, such as carbon taxes or tradable permits, there will likely be a decline in the growth of Annex I GDP. These losses would occur because emissions reduction policies would compel companies to make investments that are more expensive than those that would have taken place in the absence of such policies.

During the past decade, dozens of studies have attempted to estimate the economic costs of mitigation. A clear majority of them conclude that GDP in OECD countries would decline from the levels that would be expected to occur in the absence of mitigation policies.[8] Of the ninety-four studies of individual OECD countries cited in the IPCC's second assessment, only seven show gains to baseline GDP from the reduction of carbon dioxide emissions. All twenty-three global impact studies cited by the IPCC conclude that global output will decline as a result of carbon abatement efforts.[9]

Most of these estimates were derived from top-down models that look at the aggregate macroeconomy as a whole. There have been a small number of bottom-up, energy-based, models as well.

This Study's Contribution

Despite the number of studies already completed, there are a wide range of topics that have not yet received adequate attention. For instance, the effects of mitigation policies on employment, inflation, trade and competitiveness at both

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[8] IPCC, *Climate Change 1995:Economic and Social Dimensions of Climate Change*, Working Group III (Cambridge, UK: Cambridge University Press, 1996), 303-322.
[9] *Climate Change 1995:Economic and Social Dimensions of Climate Change*, 336.

the aggregate and sectoral level have barely been analyzed.[10] In addition, analysts have ignored the potential impact of an ill-conceived, growth-distorting climate change agreement on advanced-country support for free trade. A climate change agreement that results in slower advanced-country growth, higher unemployment, and a sharp rise in developing-country imports could give substantial ammunition to people arguing that trade with developing countries is intrinsically bad.

With this in mind, the Economic Strategy Institute (ESI) has undertaken a bottom-up study that quantifies the potential impact of carbon abatement measures on key U.S. industries, covering both high-tech manufacturing and service sectors. In particular, ESI has focused on the chemical, iron and steel, automobile, air transport, and semiconductor industries. The analysis focuses on the absolute economic impact on those industries, as well as the relative impact that proposed measures would have on their competitiveness and on trade flows.

These industries represent a broad cross section of the U.S. economy. Steel and chemicals are traditional "smokestack" industries. Steel is an important input in a variety of manufactured goods, and it increasingly faces competition from developing countries and transition economies. The U.S. chemical industry is also energy intensive and is dominated by multinational corporations capable of shifting production to developing countries. The automobile and airline industries are less energy intensive, but demand for their end-use products and services will be significantly affected by abatement policies that raise gasoline prices and reduce economic growth. The semiconductor industry, a key player in America's industrial renaissance and high-tech revolution, is not energy intensive but, nonetheless, is a major energy user and uses a greenhouse gas in the production process. The potential impact of abatement policies on this cutting edge industry is particularly worth exploring in view of the expectation that U.S. industry will increasingly move from smokestack to high-tech sectors.

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[10] See, for example, *Climate Change 1995:Economic and Social Dimensions of Climate Change*, 13; and "Research on Linkages between Trade, Environment and Sustainable Development - A Preliminary Note," posted online by the United Nations Department for Policy Coordination and Sustainable Development at gopher://gopher.un.org/00/esc/cn17/1996/backgrnd/research.txt.

Chapter II: Putting U.S. Emissions Performance in Perspective

Since enacting the National Environmental Policy Act in 1969, the United States has played a leading role in addressing global environmental problems.[11] Despite this positive record on environmental issues, the United States this year has come under increasing criticism for its policy toward global climate change.

Specifically, European leaders and environmentalists around the globe have been taking the U.S. government to task for not making more progress toward the goal of reducing U.S. carbon dioxide emissions to 1990 levels by 2000, and for not embracing a European plan to reduce emissions further by 2010. Continental leaders, such as British Foreign Secretary Robin Cook, have criticized Americans for being "...still very much in a culture of large, extravagant private cars and generous consumption of energy as a cheap commodity."[12] Europeans are also fond of pointing out that the United States is responsible for more than one-fifth of global carbon dioxide emissions.

For its part, Europe is portraying itself as the defender of the planet. The European Union as a whole could very well reach its 2000 goal, and European leaders have embraced the goal of cutting emissions fifteen percent below 1990 levels by 2010.

European efforts to caricature the United States as the bad boy of global climate change are misguided, however. The timing of the E.U. cacophony - it began in June 1997 at the G-7 Summit in Denver - suggests it was part of a concerted effort to deflect attention from crawling economies and high unemployment back home. More telling, the data simply do not back European assertions. Though it is true that the United States emits more than twenty percent of the world's carbon dioxide, the United States is responsible for only eighteen percent of total greenhouse gas emissions.[13] Since the United States produces more than twenty percent of the world's economic output, the country's greenhouse emissions per unit of growth are actually better than average.

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[11] Organization for Economic Cooperation and Development (OECD), *Environmental Performance Reviews - United States* (Paris: OECD, 1996), 215.

[12] See, for example, "G-7 Summit Split over Greenhouse Gases," *San Jose Mercury News* (June 21, 1997).

[13] OECD, *Environmental Performance Reviews*, p. 217. Sulfur dioxide and nitrous oxides are also considered greenhouse gases.

The reality, then, is quite different from what E.U. leaders would have us to believe. The United States has done much to reduce greenhouse gas emissions over the years, and other factors, less sensational than the pejorative "extravagant culture," help explain current U.S. emission levels.

Poor Timing

The decision at Rio to base future emissions targets on 1990 emissions levels has placed an added burden on the U.S. economy, making it even more difficult for the United States to keep its year-2000 promise. Saddam Hussein's invasion of Kuwait nudged the U.S. economy into recession in 1990. Since energy use, and thus emissions, tend to ebb and flow in tandem with economic activity, U.S. emissions of carbon dioxide that year were 125 metric tons below 1989 levels and did not surpass 1989 levels until 1993.[14] By contrast, the economies of Japan and Europe were in the midst of expansions that lasted until 1992.[15] Thus, meeting any targets based on 1990 levels will be relatively less taxing for Europe and Japan than for the United States.

In fact, the choice of 1990 as a baseline year has been beneficial to Europe. For example, both Germany and Great Britain will likely attain their targets for 2000. Their success, however, has nothing to do with climate change policies and everything to do with timing.

Germany is receiving credit for emissions reductions occurring in the former East Germany, where coal was the main energy source and energy use was inefficient. Since 1990, the united Germany has been dismantling noncompetitive production facilities in the eastern part of the country, and many of the remaining factories are underutilized.[16] Germany's emissions picture, therefore, has brightened dramatically. In Denver, and at the United Nations meeting on climate change that followed, German Prime Minister Kohl was among those critical of the United States, despite the fact that carbon dioxide emissions in western Germany have actually risen since 1990.[17]

In Great Britain, the story is similar. During the late 1980s, Britain's Conservative government decided to cut back on massive subsidies supporting the country's inefficient mining operations, a decision that had nothing to do with climate

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[14] OECD, *OECD Environmental Data Compendium 1995* (Paris: OECD, 1995), 39.

[15] The United Kingdom is the exception. Its recession also began in 1990.

[16] See, for example, Paul M. Bernstein, W. David Montgomery and Thomas F. Rutherford, *World Economic Impacts of U.S. Commitments to Medium Term Carbon Emissions Limits*, CRA No. 837-06 (Washington, DC: American Petroleum Institute, January 1997), 18.

[17] Jeff Rubin, "A Betrayal of Rio," ABCNEWS.com (June 28, 1997).

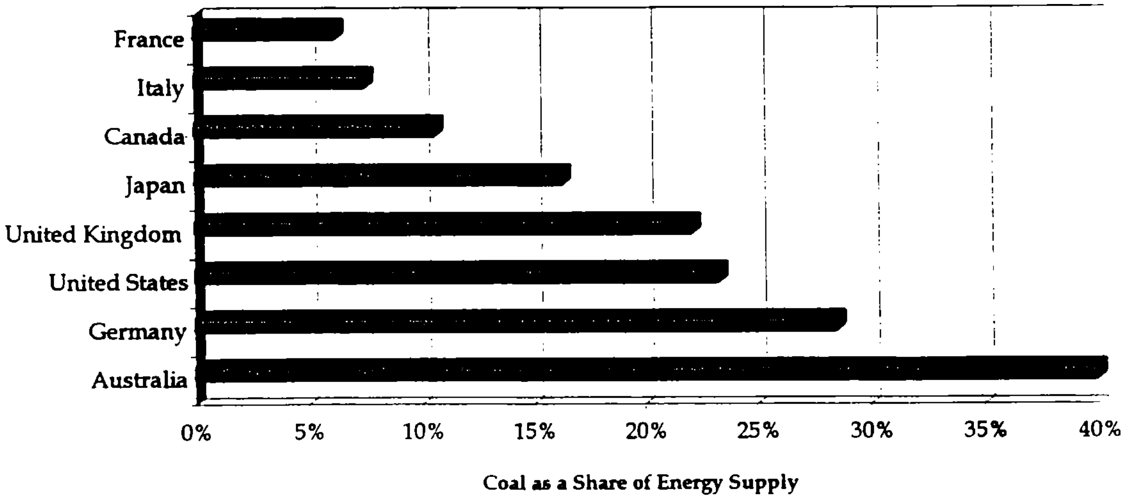
change policies and everything to do with fiscal necessities. As a result, Britain's deregulated electric power generating industry has abandoned coal for cheaper and cleaner natural gas, causing Britain's emissions to plummet. Prime Minister Tony Blair and Foreign Secretary Robin Cook have subsequently voiced the loudest criticism of the United States, which seems ironic in view of the fact that, as shadow trade and industry secretary of the Labor Party, Cook had virulently opposed Conservative efforts during the 1980s and 1990s to reduce coal mine subsidies.

Factor Endowments

It is often said that America's greatest assets are its natural resources and its people. Interestingly, this interplay of people and resources - coal and land, in particular - goes a long way toward explaining current U.S. emissions levels.

The United States, like Australia, has been blessed with large coal reserves. Unlike Great Britain and Germany, where mining has been heavily subsidized and inefficient, U.S. mines are extremely efficient and cost effective. Naturally, the U.S. electric power industry, as well as energy-intensive industries that generate their own power, long ago turned to coal as a primary source of energy. In 1995, the United States supplied more than one-fifth of its total energy consumption and fifty-four percent of its electricity with coal, more than most other advanced economies (see exhibit II.1).

Exhibit II.1
Share of Coal in Total Energy Supply, 1995



Source: International Energy Agency

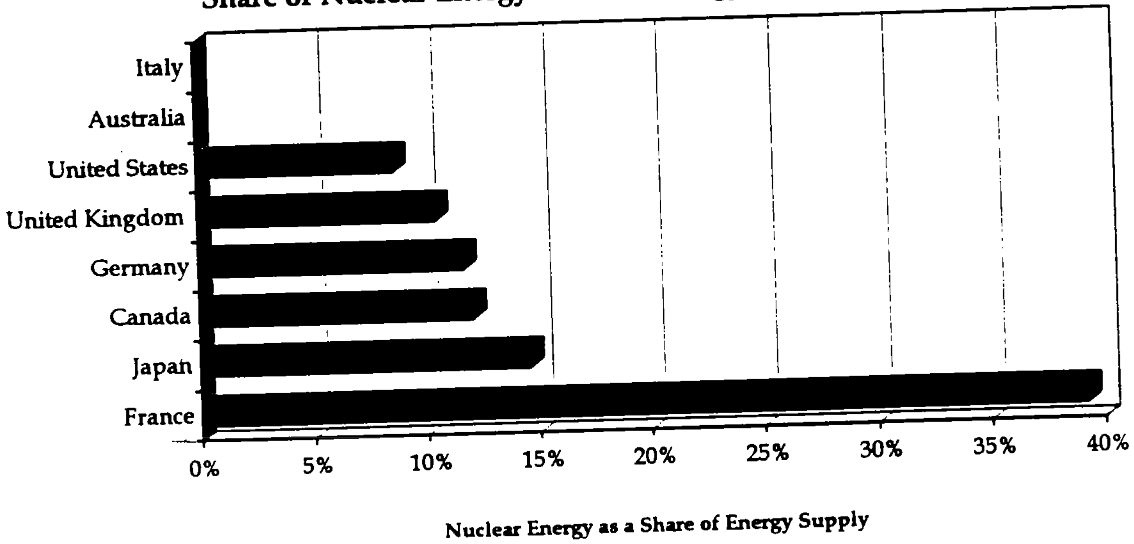
This dependence on coal makes good economic sense, but it increases U.S. emissions levels, because coal is the most carbon-intensive of the fossil fuels. One

Coal: 80% CO2 ... than natural

unit of coal produces about eighty percent more carbon dioxide than does one unit of natural gas, and twenty percent more than one unit of petroleum.[18]

Like other countries, the United States has turned to non-fossil-based energy sources, such as nuclear energy. Due in large measure to protests by environmental groups, however, nuclear energy supplies less than ten percent of U.S. energy consumption, well below penetration levels in France and Japan (see exhibit II.2). In 1980, nuclear energy accounted for about eight percent of France's primary energy supply, versus about four percent in the United States. The nuclear share of French energy is now about forty percent, five times higher than in the United States, and French carbon dioxide emissions from energy use have declined more than twenty percent from 1980 levels. With federal licenses for many U.S. nuclear power plants beginning to lapse, and with deregulation of the U.S. electricity market around the corner, experts predict that the nuclear share of the America's electricity market will be halved in twenty years.[19]

Exhibit II.2
Share of Nuclear Energy in Total Energy Supply, 1995



Source: International Energy Agency

Emissions growth in the United States is also a function of rising U.S. population and employment levels. All other things being equal, a growing population leads to higher energy usage and, thus, to higher carbon emissions. In fact, during the past two decades, global emissions levels have been driven by population growth, but per capita emissions of carbon dioxide have actually been declining (see exhibit II.3).

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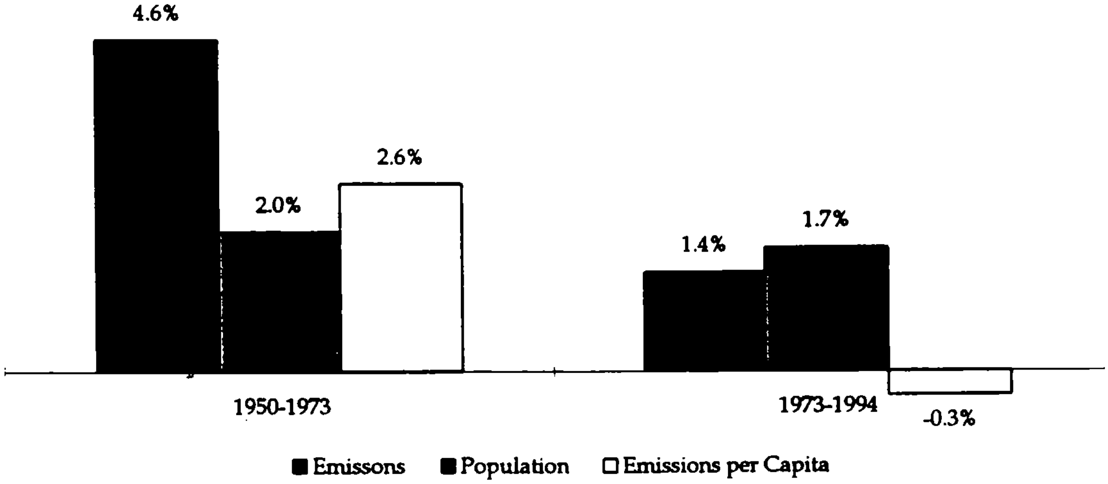
[18] Intergovernmental Panel on Climate Control, *Climate Change 1995 – Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis* (Cambridge, UK: Cambridge University Press, 1996), 14.

[19] Margaret Kriz, "Fuel Fight," *National Journal* (June 7, 1997), 1128.

Exhibit II.3
Annual Changes in Global CO_2 Emissions, Population, and Per Capita Emissions
1950-1974



Thus, looking solely at national emissions growth over time can be deceptive. For instance, the United States is being criticized because it is going to miss its 2000 target by an estimated thirteen percent. Japan, on the other hand, is expected to fall short by only six percent. However, the difference in emissions growth can be explained entirely by differences in population growth. According to the U.S. Bureau of the Census, the U.S. population is expected to expand by 10.7 percent between 1990 and 2000, while Japan's population is expected to advance by only 3.3 percent.[20] In other words, per capita emissions in both countries are expected to rise by roughly 2.5 percent.

The United States' low population density is another reason U.S. emissions levels are relatively high. Exhibit II.4 plots a statistically significant relationship between population density and emissions, as a share of GDP, in nineteen OECD countries. On the graph, these countries are divided into two groups, each with a trend line. Both trend lines have negative slopes, indicating that countries with lower population densities are associated with higher emissions levels.

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[20] National Trade Data Bank, "Total Mid-Year Population & Projections to 2050."

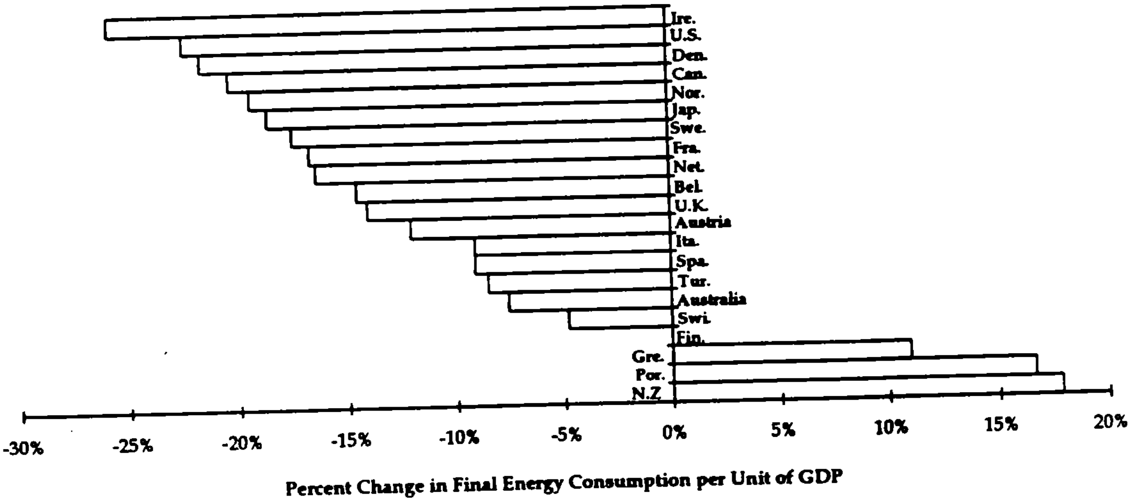
We're Not That Bad

As the Kyoto meeting approaches, critics increasingly will portray the United States as an environmentally unfriendly country. The reality is quite different. Since 1980, U.S. final consumption of energy per unit of output has declined dramatically. The exhibit below indicates that, by this measure, the United States has improved twenty-two percent, more than all but one industrialized country (see exhibit II.7). U.S. emissions intensity, the ratio of carbon emissions to GDP, declined twenty-one percent during the period. Clearly, in the absence of improved energy efficiency, U.S. emissions in 1993 would have been much worse.

Exhibit II.7

Change in Total Final Energy Consumption per Unit of GDP

1980 - 1993



Source: OECD

Even in more recent years, the United States performance has continued to be admirable. From 1990 to 1993, the latest year for which complete OECD emissions data is available, the United States was among eleven OECD countries that reduced emissions levels while increasing economic output (see exhibit II.8). From 1990 to 1995, the United States reduced emissions per unit of output by seven percent, versus a one percent reduction for Canada and a one percent increase for Japan.[24]

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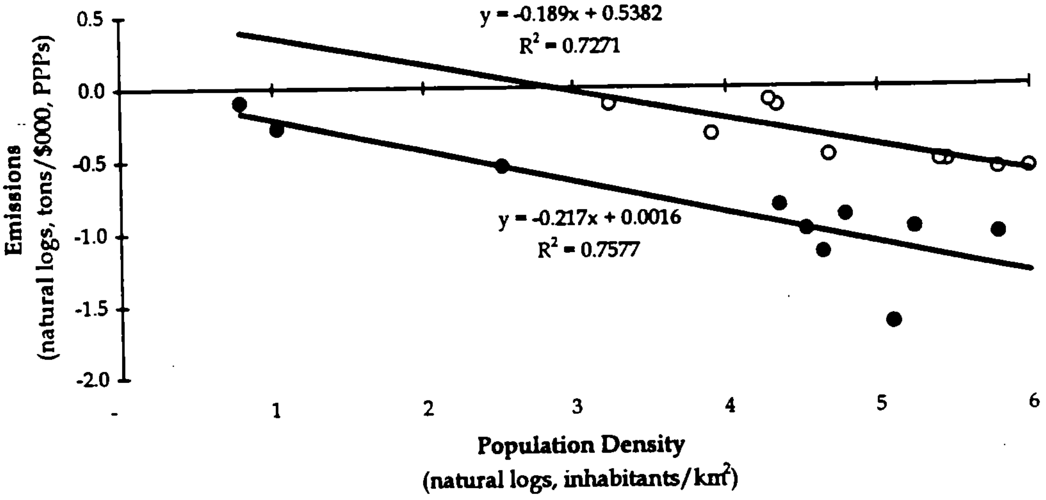
[24] For GDP based on 1991 purchasing power parities, see OECD, *Environmental Data Compendium*. For emissions data, see EIA, *Emissions of Greenhouse Gases in the United States;* Giles Gherson, "PM's Eco-ambivalence," *The Edmonton Journal* (June 27, 1997); and htpp:/www.geic.or.jp/geic-jpinfo.html.

Exhibit II.4
Population Density and Emissions, as a Share of GDP, in Select OECD Countries, 1990



Source: IEA and OECD

It is intuitive that countries with geographically dispersed populations, such as the United States, Canada and Australia, would require more energy than would more crowded industrialized countries. An analysis by the International Energy Agency (IEA) of the OECD supports this interpretation. According to surveys, lower population density within U.S. cities and towns appears to compel Americans to use automobiles for local trips that would be convenient enough for Europeans and Japanese to make by bicycle, foot, or local transit.[21] Lower population density also encourages greater use of air travel and results in greater energy use and emissions in the transport of freight, especially raw materials, because U.S. freight forwarders must ship goods further than do their counterparts in other countries.[22]

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[21] International Energy Agency (IEA), *Indicators of Energy Use and Efficiency*, (Paris: OECD, 1997), 103.

[22] IEA, *Indicators*, 117.

basis, the U.S. record holds up quite well, both in the aggregate and in specific sectors. The analysis in this chapter also indicates that proposals that do not take into account economic growth and population growth discriminate against countries with faster growing economies and populations. This and other shortcomings of existing proposals will be discussed in Chapter III.

Chapter III: Proposals for Kyoto – What's Out There?

Since COP-1 concluded that further measures would be needed to reduce greenhouse gas emissions in developing countries beyond 2000, several countries have tabled proposals and have suggested specific policies. The Ad Hoc Group of the Berlin Mandate is in the process of sifting through the various proposals with the goal of drafting an accord that will be the subject of the Kyoto meeting in December. With December fast approaching, a number of issues remain the subject of intense discussion, and all of them are important to the United States. In the near future, U.S. negotiators will have to take a stand on each of these issues.

Emissions Targets and Timetables

One of the more contentious issues is how deeply, and over what time period, the Annex I countries should cut their carbon dioxide emissions. Earlier target dates and deeper emissions cuts imply more severe economic adjustments for the United States and other developed countries.

The most draconian proposal, proffered by the Association of Small Island States (AOSIS), calls on the Annex I countries to cut their carbon dioxide emissions twenty percent below 1990 levels by 2005. Because it is becoming increasingly clear that most Annex I countries will be unable to cut their emissions to 1990 levels by 2000, this proposal is destined to fail. Earlier this year, the European Union proposed that developed countries cut emissions of a basket of greenhouse gases fifteen percent below 1990 levels by 2010. Though more reasonable than the AOSIS plan, the E.U. proposal is probably unobtainable as well.

Japan, the host of COP-3, has a special interest in seeing negotiations succeed. In August, the Japanese government proposed a two-phase plan that is less taxing than the E.U. and AOSIS proposals. During the first phase, the developed countries would be required to cut annual per capita carbon dioxide emissions to three metric tons per person. During the second phase, average annual emissions from 2010 to 2015 would have to equal the 1990 baseline. In essence, the Japanese proposal delays the Rio goal by fifteen years.

The United States has not yet come out in favor of any specific targets or timetables, but has proposed an "emissions budget" in lieu of a single year target. According to the U.S. proposal, each Annex I country would be allocated an emissions budget, which it would draw down over a given period of time. Any amount not used during the budget period could be used in future budget periods. Conversely, countries could borrow emissions from the future, but would be assessed a penalty.

Today's controversy over targets and timetables exists because Rio set the bar too high.[27] The likely failure of all but two OECD countries to reach their targets indicates that the goal of returning to 1990 emissions levels by 2000, agreed upon in 1992, was ill-conceived. Moreover, Germany and the United Kingdom, the countries with a chance of meeting the 2000 deadline, have benefited from special circumstances (see Chapter III). Eight years is simply not enough time for governments to build a durable political consensus or to make the necessary policy changes, nor is it enough time for consumers and businesses to alter their investment and consumption patterns in a way that would minimize the impact of such policies on economic growth.

Likewise, some other proposals currently before the Ad Hoc Group, if adopted, would fail for similar reasons. Proposals promoting draconian targets even earlier than Rio's less sweeping goals have been achieved have understandably heightened the worries of businesses and their workers alike. More reasonable emissions targets, phased in over a longer period of time, would be more credible, evoke less opposition, and give policymakers time to devise measures to minimize the adverse economic consequences of carbon abatement.

Of course, building a durable consensus on the need for targets and timetables would require unassailable evidence that anthropogenic emissions are indeed responsible for global climate change, and that climate change poses a serious danger to the environment. As long as scientific uncertainty continues to exist, extended timetables are more appropriate.

Developing-Country Exemption

Emissions from non-Annex I countries are growing rapidly and should surpass Annex I emissions by 2020, yet the Berlin Mandate decreed that developing country emissions will be off the table at Kyoto. The rationale for this exemption is straightforward. Increased energy usage typically occurs hand-in-hand with

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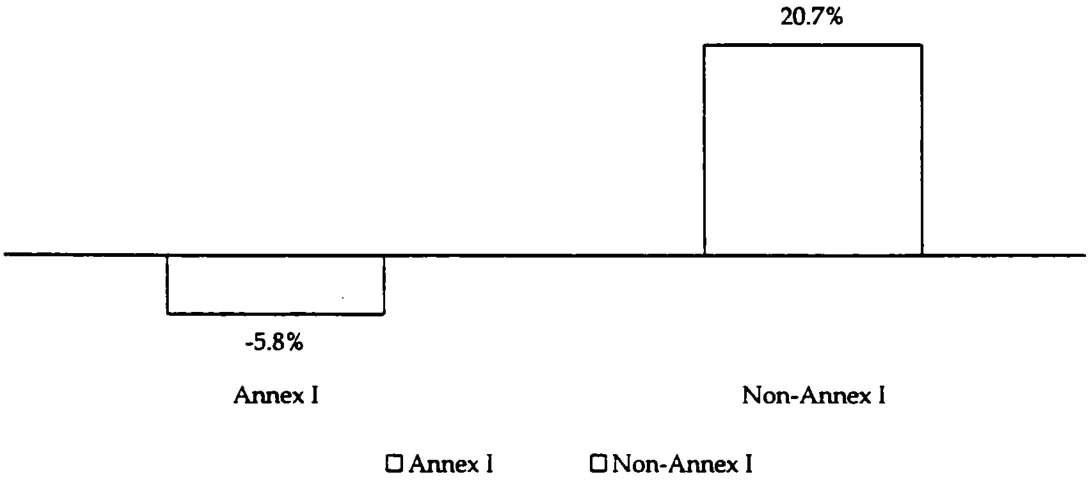
[27] Roger Bate, "Rio Set the Bar Too High," *Wall Street Journal* (), .

economic development. Developing countries argue that limiting their emissions now would hamper their ability to increase living standards.

If the global community is serious about controlling carbon dioxide emissions, however, there is no alternative to bringing the non-Annex I countries into the process as soon as possible. As the figure below demonstrates, these countries' emissions have risen faster between 1990 and 1995 than have Annex I emissions.

Exhibit III.1
Change in Emissions of Carbon Dioxide, 1990-1995
Annex I vs. Non-Annex I Countries



Sources: http://www.eia.doe.gov/oiaf/ieo96/appa1.html; ESI calculations

Though it is true that the emissions levels of OECD countries in Annex I also grew during this period, no one doubts that emissions of developing countries, with their rising populations, growing economies and greater dependence on solid fuels, will surpass those of advanced countries. The implication of this trend is clear. Even if Annex I emissions are kept at 1990 levels, global emissions will continue to grow unless something is done to harness developing-country emissions.

Despite the Berlin Mandate's prohibition of targets for developing-country emissions, the United States has suggested a mechanism that would reduce non-Annex I emissions without stunting growth. Known as "joint implementation," it would allow developing countries, with the help of technology and financial aid provided by an Annex I country, to create emissions reduction credits by undertaking projects that lead to lower emissions. These credits would then be acquired by the Annex I country that helped implement the emissions reducing project.

It should also be recognized that the extraction of commitments from non-Annex I countries has implications beyond the global climate change negotiations. In particular, failure to get non-Annex I countries involved will color U.S. attitudes toward trade deals with developing countries. Securing such deals has been a major trade policy goal of the current administration and many members of Congress, but past debates on the merits of these agreements have been contentious and divisive. Whether it was the hyperbole accompanying the actual debates, or the adverse impact of the peso crisis on the U.S. trade balance with Mexico after the NAFTA, many believe that trade with developing countries has worked against the United States. A Kyoto accord that gives developing countries a competitive advantage over the United States could only inflame these feelings, making support for future market-opening deals less likely.

Differentiated Targets

Some countries, notably Australia, argue that requiring equal emissions reductions among Annex I countries unfairly discriminates against countries with energy-intensive industrial structures and growing populations. Australian officials contend that Annex I countries should have targets appropriate to their economic profiles. The European Union, in fact, which expects to reduce emissions fifteen percent by 2010, has embraced this approach for its members. For example, Great Britain has promised to reduce emissions by twenty percent while Portugal will be allowed to expand its emissions by forty percent. Curiously, the European Union has argued against extending this approach to other Annex I members.

The Australian position makes more sense than the cookie-cutter approach. Given the variations among Annex I economies, it seems unreasonable to expect every country to be able to achieve the same level of reductions over an equivalent period of time. This is especially important for the United States, because, as indicated earlier, the U.S. record in controlling emissions is better than the critics suggest, and also because many of the current proposals would place an unfair burden on the United States. The budgeting idea proposed by the administration, discussed above, takes a small step in the appropriate direction by providing additional flexibility over the "x" percent reduction-by-date-certain approach fashioned at Rio.

Emissions Reduction Strategies

Negotiators are also wrestling over what specific abatement policies or measures, if any, should be included in the document to be considered at the Kyoto meeting. Among the many alternatives are removal of energy and transport subsidies ("no regrets" policies), financial incentives to promote energy efficiency, carbon and energy taxes, energy efficiency standards for traded products, and voluntary public-private agreements.

Washington has promoted the idea of emissions trading among countries, which would enable Annex I countries or their companies to purchase emissions credits from countries that have substantially reduced their emissions. The practical hurdles to creating an emissions trading regime are daunting, however. Emissions trading on a global basis would require some type of centralized monitoring institution and a formula for calculating initial emissions budgets. Obviously, if mandatory reductions come out of Kyoto, it is in the United States' best interest to preserve the flexibility to reduce emissions in the least costly manner.

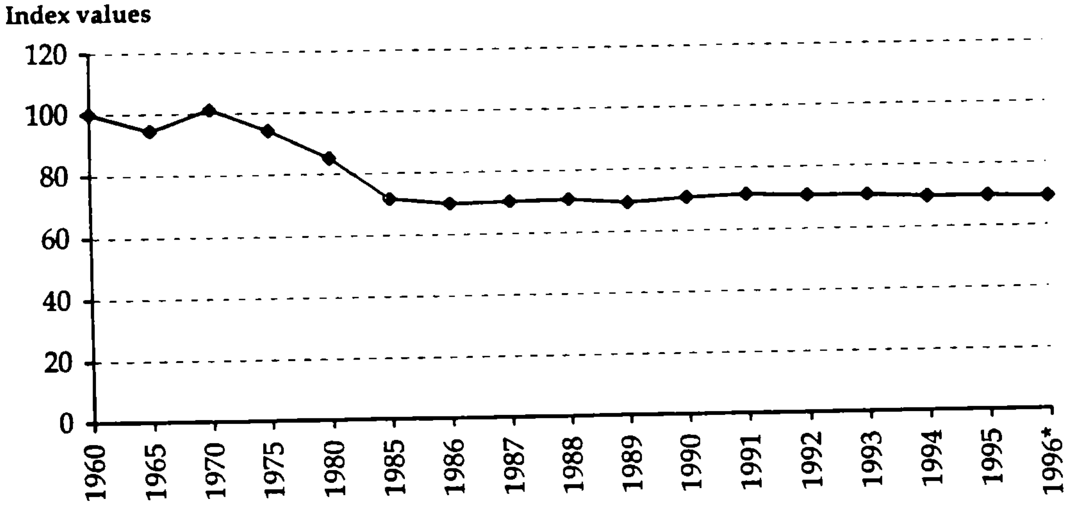
Chapter IV: Measuring the Macroeconomic Impact of Emissions Control

This chapter focuses on the question of how to measure the potential economic impacts of global warming proposals. A careful examination of existing estimates suggest that the short-to-medium-term costs are likely to be much higher than commonly believed. Estimates indicating that the transitional economic costs would be small, and only temporary, are particularly flawed.

How Will The Economy Be Affected?

Almost all manmade CO_2 emissions come from the burning of fossil fuels. Reducing emissions requires reversing the growth of energy consumption, and/or shifting to energy sources that produce less emissions. This could only be accomplished in one of three ways: by improving energy efficiency (i.e., reducing the ratio of energy consumption to GDP), by slowing economic growth (to reduce energy demand), or by developing commercially viable energy alternatives. The more difficult it is to improve energy efficiency or develop fossil fuel alternatives, the greater the slowdown in economic growth needed to achieve any targeted level of energy savings. For example, limiting America's energy consumption in the year 2010 to 1990 levels would require an improvement in energy efficiency of about 2.3 percent per year (the expected trend in real GDP growth) to avoid any adverse effect on real output – a level of improvement far above recent efficiency gains (see exhibit IV.1). In the absence of commercially viable energy substitutes, anything less would mean slower economic growth.

Exhibit IV.1
U.S. Energy Consumption, Real GDP Index, 1960-1995



* Preliminary figure
Sources: U.S. Department of Energy/Energy Information Agency; and *Economic Report of the President 1997*

Theoretically, improvements in energy efficiency can be encouraged through regulatory change or energy taxes. For simplicity's sake, most existing quantitative studies combine all energy conservation measures into an equivalent carbon tax on all fossil fuels.

A tax increase is generally considered more effective, and less costly, than command-and-control regulations because it works through market mechanisms. However, taxes affect the economy in a number of ways and ultimately influence overall economic growth, employment levels, and living standards. The magnitude of these effects are determined by a number of factors, including:

- The sensitivity of energy efficiency to the tax increase. Significant improvements in efficiency through fuel substitution, pure conservation, and modernization, would limit economic costs.
- The impact on U.S. inflation. The level of inflation will be determined by the level of changes in energy prices, and by how these price increases affect other the prices of consumer and capital goods and services.
- The impact on disposable income and corporate profits. The level o disposable income will depend upon the increase in inflation at t

consumer level. Profits will reflect higher production costs of many key industries.

- The effect on financial markets. Financial markets, especially the bond and money markets, respond to the change in inflation. The effects of these changes will be determined by whether, and to what extent, Federal Reserve policy is altered.

- The effect on productivity. Perhaps the most important factor, the impact on productivity will depend on several responses, including the impact of carbon tax increases on the level of saving and investment, the mix between investment designed to conserve energy and investment that might have a larger impact on productivity, and the shifts in the composition of economic activity.

- The effect on U.S. competitiveness. The increase in production costs of energy-sensitive industries caused by higher energy prices; the degree to which costs rise in other countries; and the effect of interest rate changes and other factors on exchange rates will all determine the impact on U.S. competitiveness.

These impacts will then work through the economy altering consumer demand, new investment, trade flows, etc., which, in turn, will bring about changes in output, jobs, and income. In addition, spillovers and multiplier effects will develop. Ultimately, when all of the adjustments take place, a new level of economic activity, and a new trend rate of economic growth, will be reached.

Why Do the Models Vary?

Dozens of quantitative estimates assessing the impact of proposals to reduce CO_2 emissions are now available. All of these estimates have been made with econometric models which, to varying degrees, incorporate variables that measure key aspects and sectors of the economy, and behavioral relationships designed to capture the cause and effect relationships between them. Three types of econometric models have been used in the global warming studies: computable general equilibrium (CGE) models, standard macroeconometric models, and energy-based models.

CGE models generally attempt to determine how price changes will impact the demand and supply for various goods and services, and based on these relationships, the price levels that would result in market clearing. All of these models assume profit maximization by producers, and that consumers maximize their welfare based on some assumed relationship between welfare and present and future consumption. Implied in CGE models is the assumption that individuals and firms respond in an efficient manner to policy actions, and usually, that these responses occur relatively quickly. Unfortunately, these and other simplifying assumptions are probably not realistic over relatively long periods, let alone in the short term. However, short to intermediate term economic effects are perhaps the most important in evaluating different climate protection proposals, both because they are potentially very large and because such effects may reduce political support for continuation of these measures. It is thus not surprising that some, although not all, of the relatively optimistic studies are based on simulations of CGE models.

Macroeconometric models are designed to estimate the **actual** elasticities and sensitivities that underlie economic behavior (unlike CGE models, which frequently assume them), using standard estimation techniques applied to historical data. When used to simulate the impact of policy changes, these models theoretically can depict the actual adjustments that will take place, and the timing of such adjustments.

Standard macroeconometric models are thus more reliable in measuring the short term effects, but nonetheless also contain the potential for sizable predictive errors. This largely reflects such problems as the inability to develop quantitative measures for certain aspects of economic behavior, measurement errors in economic statistics, the limited power of the estimation techniques (which prevent them from perfectly separating the simultaneous influence of many factors), etc., which skew estimates of the key elasticities. These problems can not only undermine their model reliability, but often can cause two models to generate dramatically opposite results.

Finally, the energy-based models used in many of the global warming studies focus on the technological and other changes that are likely in response to energy tax increases, and the likely fuel substitution and other adjustments in various sectors of the economy that are implemented to reduce energy consumption. These technology-based energy models are perhaps the most flawed of all, because the assumptions embodied in them regarding the development of new energy-saving technologies or new energy sources cannot be known with any precision, and because they generally ignore important factors that prevent or delay the implementation of new energy-saving techniques (such as lack of information, high capital costs, risk avoidance, retrofitting, etc.).

The range of predictions of the economic effects of policy actions to reduce greenhouse gas emissions is large, in part because different types of models generally produce different results, and in part because of differences in the structure of models of the same general type. For example, the behavioral relationships within standard macroeconometric models can vary significantl because the models may have been estimated over different historical ti periods, using different data sources and variables, and with different estimati techniques. These factors can cause significant differences in the key coefficier or elasticities from one model to the next. In fact, it is very possible that relationships among some variables may be completely absent in one model, yet may be very significant in another. Thus, no econometric model perfectly captures the structure of the economy of the historical period for which it is estimated. Furthermore, the economy's structure may change, either because of changes in the relationships between some variables, or because new factors may emerge during the forecast or simulation period, both of which can also cause large forecast or simulation errors.

The large variation in the range of predictions among the global warming studies also reflects another factor -- significant differences in the key assumptions that underlie the simulations. All models contain what are called exogenous variables -- factors which measure some aspects of the economy, and which impact other variables embodied in the model, but which themselves are not forecast by the model. Judgments regarding the future of these variables must be made (assumed) before the model can forecast future trends, or simulate the potential impact of any policy change in the future. Generally, these variables are those which are determined by the political process, or for which factors cannot be identified or measured to explain their movement over time.

In the global warming studies, the key assumptions include whether the energy tax increases assumed are recycled back into the economy with offsetting tax cuts; the type of tax cuts assumed; etc. Two models with the exact same structure might forecast different responses to any given global warming proposal because they may be driven by different assumptions made on these and other key exogenous variables.

Why Do Models Underestimate the Economic Cost of Climate Protection?

There is really no way of knowing with any degree of certainty what the transitional and long term costs to the U.S. economy would be from major policy actions designed to reduce CO_2 emissions. The wide range of predictions among available studies is indicative of this uncertainty. However, some of the studies show little, if any, negative impact from energy taxes designed to limit greenhouse gas emissions. ESI believes that several favorable assumptions, and major model omissions, are causing a huge potential understatement of these economic costs in many available studies, even those which do indicate significant effects. These include the following:

- Size of the energy tax increase. As indicated earlier, all of the model simulations begin with an assumption regarding the size of the carbon tax increase that would be needed to reduce CO_2 emissions to a desired level. These assumptions are largely based on elasticities of energy demand, incorporating several estimated responses that are likely to occur if carbon taxes are raised, such as fuel substitution, pure conservation, and the development of alternative fuel sources. However, recent experience has underscored the difficulty of developing new energy sources and technologies which can compete with, and partially displace, fossil fuels within a reasonable period of time (nuclear energy is a case in point). Furthermore, much of the easy energy savings by consumers and businesses occurred in the 1970s and early 1980s. Investments needed to improve fuel efficiency further, will have to be even larger than in the past. This efficiency enhancing investment will divert funds from other uses, dampening productivity growth and/or reducing capacity expansion in many industries.

  Thus, even higher energy prices may be needed to reduce fossil fuel consumption and emissions to desired levels than the general assumption of $100 per ton of carbon. Several other considerations reinforce this conclusion. First, energy prices have in general been very subdued in recent years, after the oil price shocks of the 1970s Spending patterns and investments may have been re-adjusted to thi era of lower energy prices, and relatively large price increases ma now be required to produce meaningful shifts back toward energy conservation. Second, many economic entities may assume that the tax increases will be reversed by future administrations and Congresses, limiting the response to a tax hike even further. Finally, a substantial amount of relatively new equipment is years away from being fully depreciated, and recent purchases of autos, household appliances, and other consumer durables have years of service ahead of them. Encouraging businesses and consumers to replace this equipment much earlier than planned will be difficult. These considerations imply a relatively modest and drawn out improvement in energy efficiency is likely and suggest that a sizable slowdown in economic growth will be needed to meet ambitious emissions targets.

- Revenue recycling. Many simulations assume that higher energy taxes will be recycled back into the economy dollar for dollar through tax cuts, making these levies revenue neutral. It is also assumed that offsetting tax cuts will favor savings and investment, over consumption. Because policies stimulating savings and investme produce higher growth rates in these models, such assumptions bi economic costs estimates downward. It is not clear, however, that taxes will be cut; they may be used to pay for the burgeoning costs of the health care and other federal entitlement programs that will occur as baby boomer retire. Even if taxes are reduced, it is far from certain that the political will exists to reduce them in a way that stimulates savings and investment. It is more likely that any offsetting tax cuts will be designed to restore some or all of the squeeze on consumer income and purchasing power caused by tax-related increases in energy costs. In any case, these models generally overstate the response of saving and investment to tax incentives. As we saw clearly in the 1980s, the effect of so-called supply-side tax cuts on the levels of saving and investment is very low. Thus, the stimulus to economic growth from such tax cuts is likely to be considerably less than many models are forecasting.

- Announcement effect. Several studies assume that merely announcing an agreement to reduce emissions will encourage consumers and businesses to improve energy efficiency, thereby reducing the potentially adverse tax-related economic effects. However, there is absolutely no evidence that this will occur, nor any acceptable historical precedent.

- Benefits. Many studies have factored in sizable economic benefits from the assumed reduction in energy use and the slowing of the global warming process. These benefits include a reduction in health care costs because of cleaner air, higher crop yields, and more stable weather patterns. These benefits are generally super-imposed on the model results, with very little empirical support. Though there will be some benefits, history has shown that they could take decades to appear, and are likely to occur well after the negative impact of global-warming related tax increases is felt.

- Other countries. Some studies assumed joint implementation, which would allow the so-called Annex I countries to acquire emissions credits for helping underdeveloped countries to curb their energy consumption. Obviously, such an assumption lowers the estimated costs to the U.S. economy because it spreads the burden of reducing CO_2 emissions across more countries, and mitigates the adverse effects on U.S. competitiveness. However, it is far from clear that such an arrangement is workable, let alone effective. Thus, there is a clear downside risk in this assumption, with very little on the up side.

- Production shifting. Optimistic predictions, in particular, fail to address the effect of energy tax increases on U.S. competitiveness, or, if they do, understate such effects. However, as will be seen in Chapters V and VI, production costs in many U.S. industries will rise substantially, putting those industries at a huge competitive disadvantage. This is likely to have a drastic effect on U.S. trade flows. Moreover, greater mobility of capital and technology in recent decades, and the proliferation of developing country policies that demand investment as a prerequisite for market access, are likely to lead to significant shifts in production to locations outside the United States.

- Interest rates. Most of the model simulations that predict slightly negative, or even positive, impacts from higher energy taxes in the long run, also expect significantly lower real interest rates in the future. This results from a direct assumption that the Federal Reserve will ease monetary policy, and/or from interest rate equations within these models that predict a decline in long term and money market rates. However, both are highly questionable. First, energy tax increases will significantly increase the overall rate of inflation, at least in the short to intermediate term -- the amount of added inflation will depend on the size of the tax increase, the time period over which it i phased in, and possible spillovers into wages and other prices. It i unlikely that real, market-based, interest rates would decline und these conditions, at least until markets can determine the amount of added inflation that would occur. Second, the Federal Reserve likely will raise interest rates to prevent inflation from spiraling out of as it did after the oil shock in the early 1970s. Furthermore, a strong case can be made that the U.S. economy is more sensitive to nominal and real interest rates than in the past because of the increased use of variable rate mortgages. Now, when interest rates rise, these mortgages (which now account for almost 50 percent of all home mortgages) are re-priced upward, which raises monthly payments, squeezes discretionary purchasing power, and reduces consumer spending. Thus, consumers could experience a double whammy if energy taxes are raised substantially: purchasing power would be squeezed both by higher costs for energy and other goods and services, and by higher mortgage rates. In short,, if real interest rates do not decline as much as forecast, the effect on the economy would be far larger than the optimistic scenarios are currently suggesting.

Regulation versus price impact. Virtually all the economic impact stud assume the imposition of a carbon tax in order to permit mode

However, mandated industry emissions targets or other regulations could also be used to reduce U.S. energy consumption. Because command-and control-solutions are generally less efficient than market-based solutions, models based on a carbon tax are really depicting a best case scenario, because at least some regulatory solutions are likely to be imposed.

The Administration's Analysis – a Reality Check

The administration is on record as supporting strong measures to reduce CO_2 emissions in the years ahead because of its assumption that global warming is a serious environmental issue that must be addressed as soon as possible. As part of their efforts on this issue, the administration has formed an Interagency Analytical Team (IAT) to study the economic effects of global climate change policies. The task force used a group of economic models of the type discussed earlier to make these assessments, with the starting point that carbon taxes would be increased by about $100 per ton of carbon, which allegedly would lead to a reduction in greenhouse gas emissions in 2010 to 1990 levels.

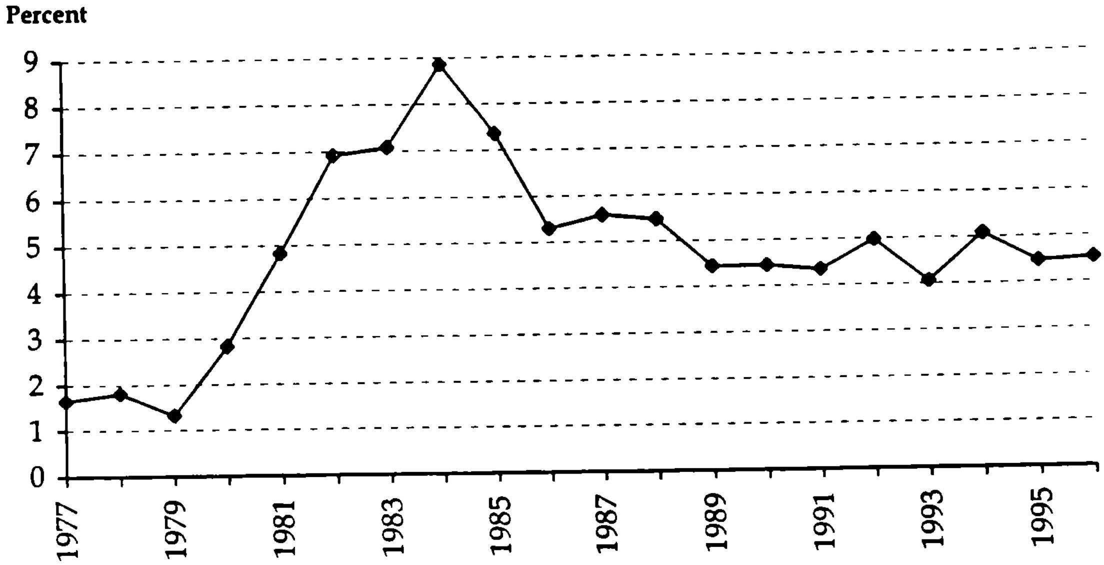
The simulations commissioned by the IAT essentially predict that only a very small loss in the level of economic output (less than 1 percent) would occur within the first ten years after the tax increases are enacted, and that output will then return to the assumed base case, or to even higher levels, within a few years thereafter. In addition, their results indicate that the use of cross border trading of emissions rights could prevent most of these very modest transitional economic losses.

However, there are several major flaws in the administration analysis, most of which, as discussed earlier, also account for the likely understatement of the economic costs in many of the published studies. These include the following:

- The IAT simulations include the assumption that the announcement of an agreement among countries to reduce CO_2 emissions will by itself produce a 25 percent increase in the rate of improvement in energy efficiency, based on the assumption that consumers and businesses will respond immediately to the prospect of higher carbon taxes, or a carbon permit fee, by adjusting their spending and capital decisions even before these fees are implemented. This is highly questionable at best and, while the administration did not provide simulation results without such an assumption, it is clear that the negative impact on jobs, income, and output would be considerably larger. The announcement effect is also supposed to encourage a speed-up in R&D to expand the search for new energy-related technologies, again a dubious assumption.

- The IAT simulations factor in a two hundred basis point decline in real long term interest rates, to almost 2 percent, level, a unseen in many decades (see exhibit IV.2). This is a heroic assumption, because, i anything, new taxes and cost increases that threaten to push up the rate of inflation frequently raise real interest rates.

Exhibit IV.2
Real Long-Term U.S. Interest Rates, 1977-1996



Source: Economic Report of the President 1997

- The IAT also included benefits from reducing target emission levels through non-carbon emission reductions. The administration task force study indicates that taking into account the costs associated with such reductions would increase the economic impact by at least 25 percent, but this was not factored into the simulations.

- The auctionable, tradable permit system assumed in some of the simulations did not include an estimate of the potentially large costs associated with the development, implementation, and monitoring of the program.

While these are the most grievous sources of understatement, the IAT analysis suffers from other shortcomings. It does not take into account the adverse effects on U.S. competitiveness and potential shifting of production by producers in the United States; the drag on productivity of a likely shift in the mix of investme spending toward energy conservation and away from more productive uses;

the incorporation of tax offsets which supposedly will accelerate economic growth by stimulating savings and investment.

A recent simulation made with the WEFA model, one of the oldest and most respected macroeconomic models now in use, illustrates how much greater the economic cost could be if more realistic assumptions are used. The WEFA simulation results indicate that:

- A carbon tax of $200 per metric ton would be required to meet the 2010 emissions target.
- This would raise gasoline prices by nearly $0.50 per gallon.
- Home energy costs would rise by more than $1,200 each year.
- U.S. GDP would decline by $228 billion (more than 2.5 percent) from the base case forecast.
- GDP would remain substantially below the base case for at least 25 years after the enactment of the tax.
- million jobs would be lost.
- The U.S. trade deficit would jump sharply.
- The growth in real income over an extended period would fall by 15 percent.

In short, by assumption and by omission, the administration's analysis biases the results towards minimizing the economic costs in both the short and long term. In fact, with more realistic assumptions, a simulation with one of the models used in the administration analysis shows much more severe economic impacts that are in line with the results of the WEFA study.

The 1970s Experience

It is thus increasingly clear that the economic costs associated with climate protection could be very substantial, far greater than the estimates that are currently available. These conclusions are reinforced by an examination of U.S. and global economic performance following the oil shocks of the 1970's. For example, the large oil price increases following the embargo in the early 1970s produced one of the deepest recessions in the United States since World War II (see exhibit IV.3).

Exhibit IV.3

Postwar Recessions

Peak-to-Trough Declines in Real Chain-Weighted GDP

Recession Period	Percent Decline in GDP
1969-70	0.7
1974-75	3.1
1980	2.5
1981-82	3.0
1990-91	2.0

Furthermore, average economic growth in the United States since 1973 has l about a percentage point lower than it was in the prior 13 years (see exhibit [illegible]). This accumulates to a difference of about 20 percent in the level of real GDP by the end of 1989, relative to the level which would have occurred if the historical growth rate had continued. The slowdown in the rate of increase in industrial production was even larger. And much of the differential in growth reflects differences in the rate of increase in productivity, and not simply population or other demographic factors. While it is clear that not all of this decline in growth can be attributed to the energy price shocks, it does call into question those studies that suggest that the maximum impact on the <u>level</u> of GDP after extremely large carbon tax increases would be on the order of 1 percent or less.

It is also worth noting that both productivity growth and overall economic growth decelerated dramatically in most other industrialized countries as well after the huge spike in oil prices in the 1970s (see exhibit IV.4). Again, while this is not conclusive by itself, it does suggest that the "not to worry" attitude, based on currently available studies of the economic effects of global warming measures, can result in a sense of complacency that will be harmful to U economic interests.

Exhibit IV.4
Average Growth Rates of Real GDP
1960-1973 and 1973-1989

	1960-1973	1973-1989
United States	3.95%	2.42%
European Union	4.68%	2.27%
OECD	4.82%	2.63%
OECD Europe	4.67%	2.31%
Japan	9.57%	3.84%

Note: EU, OECD and OECD Europe refer to 1991 membership

Source: OECD

Quite the opposite, these carbon tax increases are likely to cause a sizable recession and/or dramatically slow economic growth over a relatively long period of time, put U.S. industry at a significant competitive disadvantage in world markets, push up the trade deficit, lower living standards, and raise unemployment. This is reinforced by the fact that the increases in energy prices that are likely in the years ahead in response to carbon tax appears relatively close to those which occurred in the 1970s and early 1980s (see exhibit IV.5)

Exhibit IV.5
Changes in Real U.S. Prices of Various Energy Sources, 1973-1987
Versus Expected Changes Due to a Carbon Tax

	1973-1987	1994-2010
Oil	67%	70%
Natural Gas	223%	45%
Coal	24%	198%

Sources: Derived from data in Gary W. Yohe, *Climate Change Policies, Living Standards, and Real Wage Growth*; Argonne National Laboratory, *The Impact of High Energy Price Scenarios on Energy Intensive Sectors: Perspectives from Industry Workshops*; and ESI Calculations.

Chapter V: Impact of a Potential Carbon Tax on the Chemical and Steel Industries

This chapter examines the impact of a potential carbon tax on the chemical and steel industries. Both sectors are big users of energy, consuming more energy per unit of output than all other manufacturing industries on average. That being the case, any increase in fuel prices brought about by a carbon tax or its equivalent would significantly raise their manufacturing costs, leading to higher-priced outputs. Because the outputs of these industries are key intermediate inputs in other industries, manufacturing costs for a host of products would rise as well. The ripple effect would have profound implications for the international competitiveness of the United States, especially if similar measures are not undertaken by developing countries.

Chemicals

The chemical industry (SIC 28) is one of the United States' most important and competitive manufacturing industries. In 1995, it logged $362 billion in shipments, employed almost 840,000 individuals, and recorded a trade surplus of $21 billion (see exhibit V.1).

The industry is also a major user of energy. According to the Chemical Manufacturers Association, energy expenditures in 1995 totaled $26 billion.[28] Considering that producers in the United States face strong competition from producers in both developed and developing countries, it is clear that a carbon tax would have an adverse impact on the U.S. industry's output and competitiveness.

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[28] Swift, 4.

Exhibit V.1
Output, Employment and Trade of the U.S. Chemical Industry, 1995

	Units	Chemicals	Share of Total Manufacturing
Output			
Shipments	$ bil.	362	10.1%
Value added	$ bil.	196	11.5%
Employees	thou.	839	4.5%
Trade			
Exports	$bil.	59	12.1%
Imports	$bil.	38	6.1%
Balance	$bil.	21	NA

Sources: Bureau of the Census, and International Trade Administration

Energy Use Issues

Treatment of Feedstock

The chemical industry is an energy-intensive industry. Its energy intensity, 21,000 BTUs (British thermal units) per dollar of value added, is seventy-five percent higher than that of the manufacturing sector as a whole.[29] In addition, chemical producers use fossil fuels as a raw material (feedstock). Of the $26 billion spent on energy in 1995, roughly half served as feedstock in the production process. Since feedstock is not burned, it is not an immediate source of carbon dioxide emissions. Thus, a carbon tax or any other carbon abatement measure that does not distinguish between feedstock and power uses of fossil fuels would essentially double the impact on the chemical industry's energy costs without appreciably reducing carbon emissions.

Few Cheap Alternatives Exist

A carbon tax is expected to reduce greenhouse gas emissions by raising energy prices for fossil fuels. Higher prices, in turn, would encourage firms and individuals to use less energy and to use cleaner fossil fuels. Chemical firms, for instance, would reduce their energy dependence by increasing production of less energy-intensive products, by developing new technologies that require less fossil fuel, or by switching to less carbon-intensive energy sources.

Neither of these remedies would be cheap, or easy. It is generally acknowledged that the marginal cost of improving energy efficiency rises as an economy becomes more energy efficient. That is, incremental increases in energy efficiency

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[29] Energy Information Administration, *Manufacturing Consumption of Energy in 1991* (Washington, DC: U.S. Government Printing Office, December, 1994), 97.

become progressively more expensive to achieve. In fact, advocates of aggressive emissions reduction strategies argue that, because a high share of U.S. electricity is generated from coal-fired power plants, emissions reduction in the United States will be relatively inexpensive.

Although fuel switching may be an option for some utilities, its potential is limited for the U.S. chemical industry. Only about ten percent of the industry's energy needs are supplied by high carbon-content solid fuels, and reliance on energy from distillate and residual fuel oils has already been reduced by seventy-three percent since 1974. Natural gas, the cleanest burning fossil fuel, already accounts for sixty percent of chemical industry energy consumption (see exhibit V.2).

Exhibit V.2

U.S. Chemical Industry's Energy Consumption, by Fuel Source

1974 and 1990

	1974		1990	
	trillion BTUs	share	trillion BTUs	share
Distillate fuel oil	120	4.2%	13	0.5%
Residual fuel oil	165	5.8%	64	2.4%
LPG	3	0.1%	3	0.1%
Natural gas	1,635	57.6%	1,637	60.6%
Coal	205	7.2%	269	10.0%
Coal & breeze	6	0.2%	3	0.1%
Electricity	437	15.4%	485	18.0%
Other	266	9.4%	226	8.4%
Total	2,837	100.0%	2,700	100.0%

Source: Chemical Manufacturers Association

Change Will Take Time

The chemical industry would be able to make some adjustments to the rising fuel costs ushered in by a carbon tax, but those adjustments would take time. Higher energy prices would encourage companies to make energy-saving capital investments. Given the new energy price levels, firms would minimize production expenditures by substituting capital expenditures for energy expenditures. Since a chemical plant's economic life is ten to twenty-five years, and sunk costs are high, companies would be unlikely to abandon existing plants right away. Instead, they would choose to retrofit existing facilities and to adjust the level of employment until a new plant is built. Since retrofitting can not provide the energy efficiency of a new plant, the full impact of a carbon tax on energy usage and emissions would not be felt for twenty or more years. This suggests that the ten-to-fifteen-year targets envisioned by parties to the Convention on Climate Change are inappropriate for the chemical industry.

Competitiveness Issues

A Truly Global Industry

The chemical industry is one of the world's most fiercely contested sectors, with competitors in both advanced and developing countries. The United States is the largest national producer of chemicals, recording $362 billion in sales during 1995. Turnover was $255 billion in Japan and $120 billion in Germany during the same period, and the European Union, if considered as a whole, had sales of nearly $450 billion in 1995. Together, the United States, Japan, and the European Union were responsible for seventy-three percent of global chemical sales. Non-OECD chemical production is significant as well. Asia (excluding Japan), Latin America, and central and eastern European countries accounted for twenty percent of global turnover in 1995 (see exhibit V.3).[30] In this environment, it is clear that price increases induced by a carbon tax on U.S. and other OECD producers would alter the distribution of global production.[31]

Exhibit V.3
Global Chemical Sales, by Region, 1995

	Share	Value
Annex I	84%	1,234
European Union	32%	475
USA	25%	362
Japan	17%	250
Other Western Europe	2%	29
Central and Eastern Europe	4%	59
Other Annex 1	4%	59
Non-Annex I	16%	235
Asia	12%	177
Latin America	4%	59
Total	100%	1,471

Source: European Chemical Industry Council

The Relocation Decision

That the United States is a major chemical producer is no accident. The country possesses abundant human capital, competitive supplier industries, domestic

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[30] *Facts and Figures – The European Chemical Industry in a Worldwide Perspective* (Brussels: European Chemical Industry Council, 1996), 7.

[31] Central and Eastern European countries are considered part of Annex I, but it is not yet clear that they will be forced to adhere to any targets coming out of Kyoto.

supplies of key raw materials, and high levels of domestic chemical demand. Low energy prices, therefore, are only a partial explanation for the U.S. industry's competitiveness. The industry has enough advantages to ensure its survival, even if carbon taxes are applied only on Annex I countries.

That being said, a carbon tax in Annex I countries would clearly damage the U.S. chemical industry's competitiveness, and would encourage manufacturers in the United States to locate a larger share of their facilities overseas. According to a study performed by Argonne National Laboratory, in the event of a carbon tax, energy prices faced by chemical manufacturers in the United States would increase substantially more than energy prices in Europe, in both relative and absolute terms.[32]

Producers in the United States also would be hurt vis-a-vis the developing world. There is already substantial non-Annex I production capable of reaping substantial price advantages from a carbon tax on developed countries.

Production shifting is made more likely by competitive dynamics within the industry. The chemical industry is dominated by multinational corporations. Foreign chemical manufacturers, primarily European, have a strong U.S. presence; United States chemical firms have global production networks as well. In 1994 (the latest year for which data is available), value added by foreign affiliates of U.S. multinational chemical manufacturers totaled $56 billion, almost fifty percent of the value added by their U.S. parents.[33] In short, both U.S. and foreign multinationals have the ability to expand their oversees facilities if conditions warrant.

Evidence suggests that location decisions by the chemical industry are, in part, determined by energy costs. Within the United States, for example, the production of energy-intensive chemical products has gravitated toward regions with natural gas production. As a result, chemical manufacturers' energy costs for natural gas and electricity are lower than the U.S. average.[34]

Such production shifting can also occur across countries. Production of energy-intensive chemicals, such as ethylene derivatives, has already begun gravitating toward the Middle East, where energy prices are even lower than they are in the United States. Because the location of chemical production is clearly sensitive to

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[32] Dan Steinmeyer, "The Chemical Industry in the USA – The Role of Energy and the Impact of Energy Price Increases," in Ronald J. Sutherland, ed., *The Impact of High Energy Price Scenarios on Energy Intensive Sectors: Perspectives from Industry Workshops* (Argonne, Illinois: Argonne National Laboratory, July 1997), CH-44-45.

[33] See Bureau of Economic Analysis, *U.S. Direct Investment Abroad – 1994 Benchmark Survey, Preliminary Results* (Washington, DC: U.S. Government Printing Office, January 1997).

[34] Steinmeyer, CH-37-38.

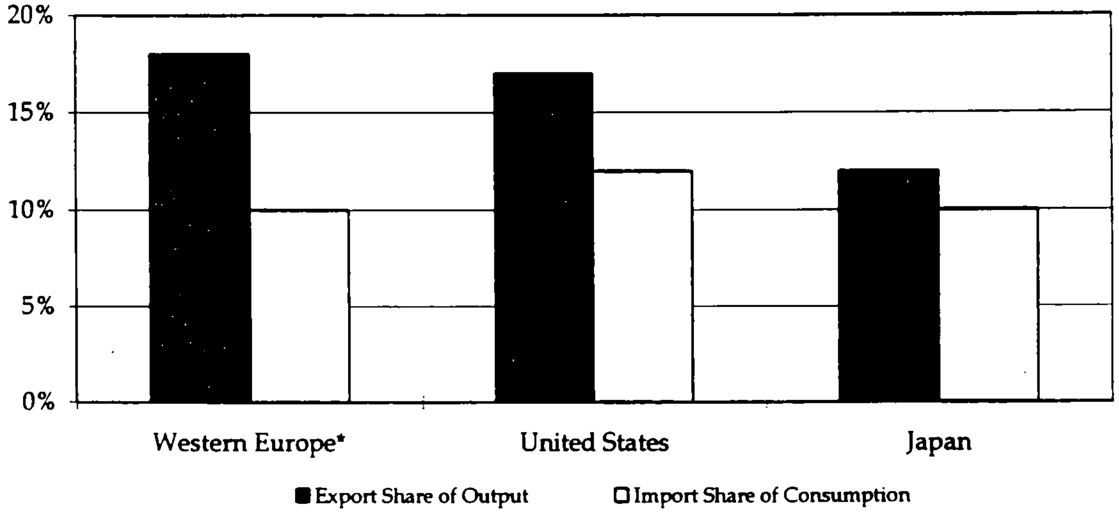
energy costs, an energy tax would cause more U.S. chemical manufacturers, over time, to relocate more of their manufacturing operations overseas than would otherwise be the case.

International Trade

The chemical industry has been a bright spot in the generally dismal U.S. trade picture. It is one of the few manufacturing sectors consistently producing trade surpluses. Yet, given the current competitive realities, it seems a foregone conclusion that a carbon tax affecting only Annex I countries would lead to a higher trade deficit for the U.S. chemical industry.

If measured in terms of import share, the U.S. market is the most open among major chemical producers. The United States has a higher import ratio than either Europe or Japan, and exports less of its output than does Europe (see exhibit V.4).

Exhibit V.4
Chemicals Trade of Western Europe, the United States, and Japan, 1995



Source: European Chemical Industry Council

Despite facing higher energy costs, the European industry is extremely competitive in international markets. E.U. exports to Asia (excluding Japan) reached $22.8 billion in 1995, $8 billion more than U.S. exports to the region. Europe also exported $1.5 billion more to Japan than did the United States. The U.S. industry, however, exported $4 billion more to Latin America than Europe did. Europe's performance is remarkable in light of the fact that its energy costs are significantly higher than U.S. costs (see exhibit V.5).

Exhibit V.5
Energy Prices Faced in Europe, Japan, and the United States, 1994

	Natural Gas*	Heavy Oil*	Coal*	Electricity**
United States	3.07	2.44	1.29	4.7
OECD Europe	4.03	3.37	3.68	7.5
Japan	12.3	4.46	1.69	17.3

*Dollars per million BTUs

**Cents per kilowatt hour

Source: International Energy Agency

European trade competitiveness is explained, in part, by lower labor costs. According to OECD statistics, labor costs in the E.U. chemical industry in 1995 were about twenty percent lower than they were in Japan and the United States. For their part, major producers in developing Asia and Latin America face substantially lower costs than do advanced country producers. In 1993, Korean labor costs in the industry were fifty-four percent lower than European costs, and Mexican costs were even lower.[35]

The impact on trade in U.S. chemicals would be large for two reasons. First, unlike production, trade is concentrated in energy-intensive products. U.S. chemical production is split roughly even between high energy-intensive products, such as inorganic and organic chemicals, plastics, and agricultural chemicals, and low energy-intensive products like pharmaceuticals (see exhibit V.6). European production is slightly weighted toward less energy-intensive goods.

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[35] *Facts and Figures*, 54.

Exhibit V.6
U.S. and E.U. Product Mix, Ranked by Energy Intensity

	Energy Intensity*	U.S. Product Mix**	E.U. Product Mix
High Energy-Intensive Subsectors			
Inorganic chemicals	18%	7%	8%
Organic chemicals	12%	21%	15%
Plastic materials and synthetic resins	8%	17%	18%
Agricultural chemicals	8%	6%	5%
Total	NA	51%	46%
Low Energy-Intensive Subsectors			
Chemicals not elsewhere classified	4%	7%	12%
Soaps, detergents, cleaners, etc.	1%	14%	12%
Paints, varnishes and allied products	1%	5%	6%
Drugs	1%	23%	23%
Total	NA	49%	53%

*Energy Cost divided by value added; calculated with 1995 U.S. data.
**U.S. data is disaggregated on an SIC basis

Sources: U.S. Bureau of the Census, U.S. International Trade Administration, European Industry Council, and ESI estimates.

U.S. trade, on the other hand, is weighted in favor of high energy-intensive products. In 1995 and 1996, high energy-intensive chemicals accounted for seventy-one percent of U.S. chemical exports and sixty-five percent of chemical imports.[36] The two-year U.S. trade surplus in these products was $31 billion, which is equivalent to eighty-four percent of the combined chemicals trade surplus in 1995 and 1996. Because U.S. production costs for these products would be hardest hit by a carbon tax, the likely outcome of a tax would be to lower exports and raise imports in the one manufacturing sector where the United States currently runs a substantial trade surplus.

The geographic composition of U.S. trade flows also suggests that a carbon tax on Annex I countries would adversely affect the U.S. trade balance in chemicals. The U.S. chemicals industry registered only a small trade surplus of $0.43 billion with Annex I countries in 1995.[37] In contrast, the U.S. chemicals surplus with developing countries was $20.9 billion in that same year (see exhibit V.7). A carbon tax levied only on industrial countries would therefore have a much

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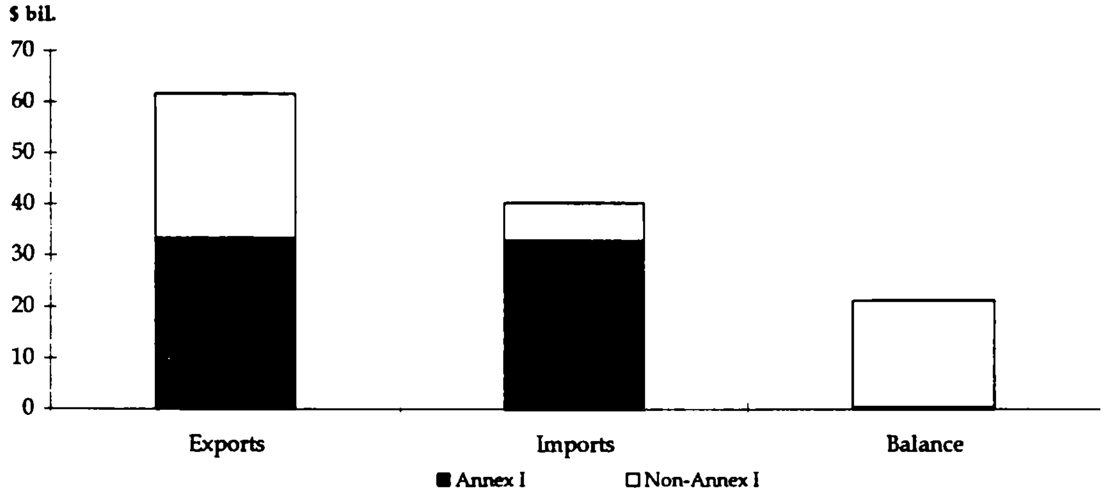
[36] The chemicals trade figures in this paragraph are based on the 1987 SIC definition of the chemical industry. This allows for a direct comparison with the value-added and energy data needed to calculated U.S. energy intensities in the chemical industry.

[37] The chemicals trade figures in this paragraph are based on the SITC Rev. 3 definition.

larger impact on U.S. trade with developing countries than it would on U.S. trade with Annex I countries, and it would almost certainly result in a lower trade surplus with developing countries. The small surplus with Annex I countries could disappear, due to Europe's labor cost advantage in this industry and due to the lower expected increase in European natural gas prices.

Exhibit V.7
U.S. Chemicals Trade with Annex I and Non-Annex I Countries, 1995



Source: U.S. Bureau of the Census, Foreign Trade Division

Impact of a Carbon Tax on the Chemical Industry Output and Trade

In order to quantify the impact of a $100 per ton carbon tax on U.S. chemical industry output and trade flows by 2010, ESI used a partial equilibrium model based on the following assumptions:

- The 2010 GDP would decline 1.5 percent below baseline GDP. Most estimates predict a decline in the range of 0.5 to 1 percent, but those models assume that abatement policies would be phased-in beginning in 1990. The shorter phase-in period now being envisioned should result in a greater decline from baseline GDP than what has been predicted by earlier models. Moreover, as discussed in Chapter IV, several other factors have biased previous estimates downward as well. Thus, the 1.5 percent decline used here is conservative.
- There would be a $100 per ton carbon tax. Such a tax would result, on average, in a hundred percent increase in the energy prices faced by the U.S. chemical industry.
- There would be a carbon tax of similar magnitude for other Annex I countries. This is a simplifying assumption; fuel prices would likely rise more in Japan, less in Europe.

- Energy intensity would range from 3.5 percent of shipments (includes a feedstock exemption) to seven percent of shipments (no feedstock exemption).
- The price elasticity of demand would be minus 0.11. This is a weighted average of price elasticities for five major product categories.
- The income elasticity of demand would be 1.43. This is a weighted average of income elasticities for five major product categories.
- Export and import elasticities would be minus one and one, respectively.

The results, summarized below (exhibit V.8), imply a decline in output ranging from $16.1 to $22.3 billion, and a decline in the U.S. trade surplus ranging from $4.6 to $9.3 billion. On the trade front, the beneficiaries would be European producers, whose energy costs would rise less than U.S. energy costs, and producers in developing countries.

Exhibit V.8
Chemical Industry Output and Trade
Estimated Impact of a $100 per Ton Carbon Tax by 2010

	Base Case	**Carbon Tax**			
		With exemption		Without exemption	
		Value	*% change*	*Value*	*% change*
Domestic Demand	459.57	448.15	-2.5%	446.56	-2.8%
Shipments	487.32	471.26	-3.3%	465.04	-4.6%
Exports	79.15	76.31	-3.6%	73.47	-7.2%
Imports	51.40	53.20	3.5%	54.99	7.0%
Trade Balance	27.75	23.11	-16.7%	18.48	-33.4%
Exports as a Share of Output	16.24	16.19	-0.3%	15.80	-2.7%
Import Penetration	11.19	11.87	6.1%	12.31	10.1%

Source: ESI Estimates

Steel

The steel industry (SIC 331), despite falling on hard times during the early 1980s, remains an important and growing industry in the United States. Dismissed as an also-ran only a decade earlier, the industry shipped $74.6 billion of product in 1995 and employed 224,300 people. Though many experts consider the industry to be the low-cost producer for the U.S. market, imports continue to supply a significant portion of domestic demand, and the U.S. trade deficit in steel is about $10 billion (see exhibit V.9).

Exhibit V.9
Output, Employment and Trade of the U.S. Steel Industry, 1995

	Units	Steel	Share of Total Manufacturing
Output			
Shipments	$ bil.	75	2.1%
Value added	$ bil.	29	1.7%
Employees	thou.	224	1.2%
Trade			
Exports	$bil.	5	1.1%
Imports	$bil.	14	2.3%
Balance	$bil.	-9	NA

Sources: Bureau of the Census, and International Trade Administration

The steel industry has all the characteristics of an industry that would be hit hard by carbon abatement policies. Like chemical producers, steel makers are major energy users and face substantial competition from developing countries. One important difference between the two sectors is the steel industry's dependence on coal, the fossil fuel that will experience the largest price increase as a result of carbon abatement policies. Thus, the impact on the steel industry will be even more severe than on the chemical industry.

Energy Use Issues

Extremely Energy-Intensive Production

Steel production is one of the most energy-intensive manufacturing operations. In 1991, the latest year for which detailed energy consumption data is available, the industry required 108,000 BTUs per dollar of value added, nine times higher than the average for all U.S. manufacturing and five times higher than the chemical industry average.[38] Steel manufacturers also face substantial, indirect energy expenditures as well, due to the transportation requirements of both the traditional integrated mills and the newer minimills, which require large quantities of coal and scrap metal, respectively. This high level of energy dependence ensures that carbon abatement policies that rely on energy price hikes to reduce consumption would raise steel prices significantly.

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[38] *Manufacturing Consumption of Energy in 1991*, 97.

Bifurcated Industry

The steel industry consists of two types of companies: integrated mills, which typically produce steel with "blast furnace/basic oxygen furnace" technology, and the so-called minimills, which produce steel with "electric arc furnace" technology and scrap metal. These technologies have different energy needs. Coal is the primary energy source of the integrated mills, while electricity is the main source of minimill power.

Because coal prices are expected to increase more than electricity prices in the event of a carbon tax, the energy prices faced by minimills should rise by less than those faced by the integrated companies. According to R.J. Fruehan's analysis for Argonne National Laboratory, the minimills' energy cost advantage, currently $10 per ton, could rise to more than $50 per ton by 2010.[39] Thus, carbon abatement policies that placed taxes or other restrictions only on advanced countries would not only favor foreign producers at the expense of domestic ones, but would also favor minimills over the integrated firms. However, the decline of integrated producers in the United States would result in higher prices for scrap steel, which would further hurt minimills' price competitiveness vis à vis producers in developing countries.[40]

Potential for Improvement Is Limited

The improvements in energy efficiency that carbon taxes are expected to promote will be hard to realize in the steel sector, for three reasons. First, as with chemicals, steel makers already have improved their energy efficiency dramatically. Consumption of energy has declined by forty-five percent during the past two decades, while value added has increased by seventy percent. Second, the potential for fuel switching within the industry is limited. Despite the increasing prominence of the minimills, coal remains the dominant source of energy in the industry (see exhibit V.10), and, unfortunately, there are few feasible alternatives to coal and coke in the steel making process. Technologies that rely on natural gas are available but, even if these are used, the resulting savings would still leave the integrated producers uncompetitive. Third, there are certain minimum energy requirements for certain steel making processes that, according to one expert, will be approached around 2010.[41] In short, dramatic improvements in steel industry energy efficiency are unlikely.

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[39] R. J. Fruehan, "The Effect of Increased Energy Prices on the Steel Industry," Ronald J. Sutherland, ed., *The Impact of High Energy Price Scenarios on Energy Intensive Sectors: Perspectives from Industry Workshops* (Argonne, Illinois: Argonne National Laboratory, July 1997), ST-38.

[40] Fruehan, ST-30.

[41] Freuhan, ST 30-34.

Exhibit V.10
U.S. Steel Industry's Energy Consumption By Fuel Source, 1991

	trillion BTUs	share
Natural gas	421	24.6%
Coal	841	49.1%
Coke & breeze	243	14.2%
Electricity	144	8.4%
Other	65	3.8%
Total	1,714	100.0%

Source: Department of Energy/Energy Information Agency

Competitiveness Issues

A Significant Developing-Country Presence

As in the chemical industry, both advanced and developing economies maintain steel industries with internationally competitive companies. However, the developing countries play a more important role in steel than they do in chemicals, in large measure because many developing-country governments view the development of a domestic steel industry as an important component of industrial policies to promote high value-added manufacturing. In 1995, the non-Annex I countries accounted for thirty-two percent of crude steel output and, in 1996, the Chinese steel industry replaced Japan's as the world's largest. The United States is the third largest national producer (see exhibit V.11).

Exhibit V.11
Global Production of Crude Steel, by Region, 1995

	Share	Value
Annex I	68%	501
European Union	21%	156
USA	13%	94
Japan	14%	102
Other Western Europe	2%	14
Eastern Europe & Former Soviet Union	15%	113
Other Annex 1	3%	24
Non-Annex I	32%	231
Asia	22%	163
Latin America	5%	35
Total	100%	732

Source: International Iron & Steel Institute, http://www.amm.com/ref/0123ch2.htm

Relocation Decision

The United States steel industry has been a net recipient of foreign investment. In other words, foreign steel manufacturers have invested more in the United States than U.S. steel makers have invested abroad. This pattern would likely be reversed if the burden of carbon dioxide reduction were to fall solely on the shoulders of advanced countries.

The U.S. steel industry historically has focused on serving demand in the U.S. market with domestic production. Export sales have been limited to less than ten percent of total shipments, one third of which typically go to Canada, and direct investment in foreign countries (FDI) has been miniscule. U.S. steel firms, therefore, are far less "multinational" than their counterparts in other U.S. manufacturing industries. In the chemical industry, for example, foreign affiliates of U.S. multinationals register forty-four cents in sales for every dollar in U.S. parent companies sales. For steel, that ratio is 0.06 to one. In contrast, foreign participation in the U.S. steel market is rather high. Foreign-owned manufacturers in the United States accounted for roughly twenty-five percent of industry-wide value added in 1995.

Because foreign companies operating in the United States are more internationalized than are their U.S. competitors, they would be able to shift production more quickly from their U.S. facilities to take advantage of price differentials arising from a discriminatory carbon tax. Moreover, they would likely choose developing-country locations for their future mills, in order to skirt the tax's competitive consequences. At the same time, U.S. steel firms would be more likely to invest overseas, particularly in non-Annex I countries. The bottom line: inward FDI would likely stagnate or reverse, while outward FDI would increase.

International Trade

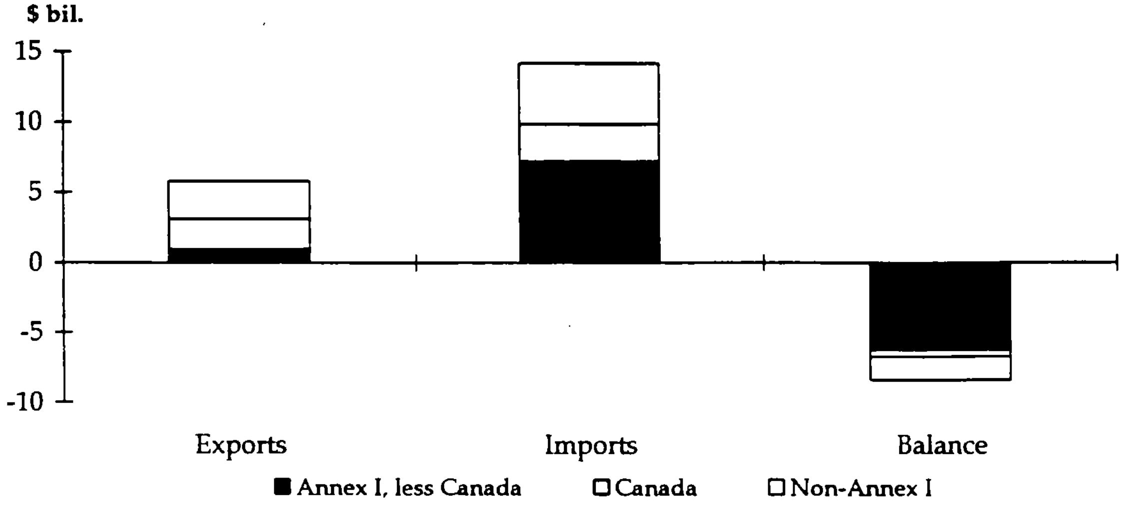
The United States remains a net importer of steel, but the picture has improved markedly since the mid-1980s, when import penetration in value terms approached twenty percent. Import penetration in 1995 was still a high seventeen percent and, with domestic capacity expected to increase in the near future, that figure is expected to remain relatively stable.

A steel industry burdened by a carbon tax would be an entirely different story, however. With energy prices faced by the industry likely to rise by more than a hundred percent, the impact on American steel's international competitiveness would be devastating, especially for the coal-reliant integrated mills. The integrated firms could either shut down entirely, leaving the field to imports and domestic minimills; abandon the most energy-intensive processes and import semi-finished product from developing countries; or invest in developing countries. Either way, U.S. value added and employment in the industry would decline. True, U.S. foreign direct investment in manufacturing tends to be "market seeking" and, more often than not, produces trade surpluses for the United States, but outward FDI resulting from a carbon tax would also be cost-driven and, thus, would enlarge the U.S. trade deficit in steel.

The composition of U.S. steel trade implies that a carbon tax would stifle U.S. competitiveness in developing countries, the very markets where U.S. exports are currently competitive. The United States does export more to Annex I countries, but most of this trade flows to Canada. If Canada is excluded from Annex I exports, U.S. steel exports are actually higher to the developing world than to other advanced countries (see exhibit V.12). The U.S. import market is currently dominated by Annex I product, but a carbon tax would tip the scales in favor of the developing countries. Brazil, Mexico, South Korea and South Africa, which currently export a combined $3.2 billion to the United States, as well as China, would be the big winners.

Exhibit V.12

U.S. Steel Trade with Annex I and Non-Annex I Countries, 1995



Source: U.S. Bureau of the Census, Foreign Trade Division

Impact of a Carbon Tax on Steel Industry Output and Trade

In order to quantify the impact of a $100 per ton carbon tax on the U.S. steel industry's output and trade flows by 2010, ESI used a partial equilibrium model based on many of the same assumptions used in analyzing the chemical industry. Differences include:

- The $100 per ton carbon tax would result, on average, in a 120 percent increase in the energy prices faced by the U.S. steel industry.
- The energy intensity would be fifteen percent of shipments.
- The price elasticity of demand would be minus 0.96. This is an average of various elasticities from two different studies.[42]
- The income elasticity of demand would be 1.035. This is an average of the high-end and low-end estimates of an industry study.[43]
- The import elasticity would be 0.94. This is taken from a recent ITC study.[44]

The results, summarized below (exhibit V.13), imply a $19 billion decline in U.S. industry shipments from base levels, a $3.7 billion dollar increase in the steel trade deficit, and a rise in import penetration, by value, to twenty-four percent. The integrated producers would bear the brunt of this adjustment, because the price of coal would rise more than the price of electricity, the minimills' main energy source.

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[42] See Stephen H. Karlson, "Modeling Location and Production: An Application to U.S. Fully Integrated Steel Plants," *The Review of Economic and Statistics* (1982); and John S. Hekman, "An Analysis of the Changing Location of Iron and Steel Production in the Twentieth Century," American Economic Review (March 1978).

[43] See Hekman, 124-132.

[44] Kenneth A. Reinert and Clinton R. Shields, *Estimated Elasticities of Substitution of a North American Free Trade Area*, U.S. ITC Staff Research Study No. 19 (Washington, DC: U.S. International Trade Commission), 29-41.

Exhibit V.13
Steel Industry Output and Trade
Estimated Impact of a $100 per Ton Carbon Tax by 2010

	Base Case		**Carbon Tax**			
	Value ($ Bil.)	*Mil. Metric tons*	*Value* ($ Bil.)	*% change*	*Mil. Metric tons*	*% change*
Domestic Demand	99.96	125.0	84.28	-15.7%	98.9	-21%
Shipments	88.3	105.0	69.0	-21.9%	73.0	-30%
Exports	6.3	7.6	5.1	-18.0%	5.6	-26%
Imports	17.9	27.6	20.4	14.3%	31.5	14%
Trade Balance	(11.6)	(20.0)	(15.3)	31.6%	(25.9)	30%
Exports as a Share of Output (Percent)	7.1	7.2	7.4	5.0%	7.7	7%
Import Penetration (Percent)	17.9	22.1	24.2	35.5%	31.9	44%

Source: ESI Estimates

Key Points

It is clear that both the chemical and steel industries would be hit hard by a carbon tax, especially if it were levied only on Annex I countries. The industries would no doubt survive, but they would survive with lower levels of output and, consequently, employment, and with more of their energy-intensive manufacturing processes occurring overseas.

The trade losses in both sectors would be concentrated in trade with developing countries, major export markets for both industries. The chemical trade surplus with non-Annex I countries, which accounts for nearly all the surplus in this sector, could decline by almost $9 billion if there is no feedstock exemption. In steel, the deficit with developing countries, currently much smaller than the deficit with Annex-I countries, would increase substantially.

Because competitors in Europe and Japan would also face energy price increases, the competitive impact among developed countries should be less dramatic. Prices of natural gas and coal, the primary energy sources for the chemical and steel industries, respectively, could be expected to rise less in Europe than in the United States or Japan, giving manufacturers in Europe a slight competitive advantage.

Moreover, those who expect a carbon tax to induce rapid gains in energy efficiency in these industries would be disappointed. Both sectors have already increased energy efficiency markedly since the mid-1970s through incremental technical innovations and, in the case of chemicals, through changes in product mix. Given higher marginal costs for future improvements, the long depreciation periods of these industries' capital stock, and the incremental nature of technical progress, rapid gains by 2010 are probably not achievable.

Chapter VI: Impact of a Carbon Tax on Autos, Air Transportation, and Semiconductors

The impact of a carbon tax would by no means be confined to the traditional smokestack manufacturers, such as chemicals and steel. Less energy-intensive manufacturers, and even service industries, would also be affected. This chapter examines the potential impact of such a tax on two of the less energy-intensive manufacturing industries, automobiles and semiconductor, and on air transportation services. The ripple effect of higher chemical and steel prices would be felt in these sectors, raising the cost of end-use products and services and thereby dampening demand.

Automobiles

The automobile industry (SIC 371), which employed 1.5 million people in 1995, is different from chemicals and steel in several ways. For instance, most of its output is sold directly to consumers, not to other industries. Moreover, the actual process of manufacturing a vehicle consumes little energy relative to chemicals and steel. Nevertheless, a carbon tax would have a substantial impact on this industry's costs, because it is a major consumer of energy-intensive intermediate goods, such as plastic, steel, and aluminum. Also, consumer demand for automobiles could be dramatically affected by the twenty-six-cent increase that a carbon tax is expected to add to the price of gasoline.

The industry's vital statistics are shown in exhibit VI.1.

Exhibit VI.1
Output, Employment and Trade of the U.S. Automobile Industry, 1995

	Units	Autos and Parts	Share of Total Manufacturing
Output			
Shipments	$ bil.	326	9.1%
Value added	$ bil.	105	6.2%
Employees	thou.	1,544	8.2%
Trade			
Exports	$bil.	50	10.2%
Imports	$bil.	105	16.8%
Balance	$bil.	(56)	NA

Sources: Bureau of the Census, and International Trade Administration

Energy Use Issues

Indirect Effect is Key

The car industry's energy intensity, the best measure of its direct energy usage, is well below the manufacturing average of 12,000 BTUs per dollar of value added. In 1991, the production of finished vehicles consumed 2,300 BTUs per dollar of value added. By itself, this low intensity suggests that manufacturing costs would barely be affected by a carbon tax.

Direct energy costs are only part of the picture, however. The cost impact of a carbon tax would be driven, in large measure, by rising costs of energy-intensive intermediate inputs. In fact, the automobile industry's importance to the U.S. economy stems largely from its role as a major purchaser of goods and services from other industries. For instance, in 1987, the last year for which detailed U.S. input and output (I-O) tables were published, the vehicle industry (SIC 3711, which excludes parts) purchased four dollars in inputs for every one dollar of value added, compared to a 0.79 ratio for U.S. industry as a whole. The parts industry (SIC 3713-5) purchased $1.62 in inputs per dollar of value added.[45] A large share of these inputs (e.g., plastics, aluminum, and steel) are energy intensive. As exhibit VI.2 shows, the direct impact of a doubling of energy prices on the value of vehicle shipments would be less than the indirect impact of higher energy costs on just a few major inputs.[46]

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[45] See "Benchmark Input-Output Accounts for the U.S. Economy, 1987," *Survey of Current Business* (March 1994), 73-115.

[46] The indirect impact measured here only considers three commodities in addition to energy and, thus, understates the actual indirect impact of an energy tax on automobile industry costs.

Exhibit VI.2
Estimated Direct and Indirect Effects of a 100 Percent Increase in Energy Costs
Passenger Cars and Trucks (SIC 3711)

	Impact	Units
Rise in direct energy cost	1,132	$ million
Rise in cost of plastic, steel, and aluminum consumed directly by SIC 3711	129	$ million
Rise in cost of vehicle bodies, part, and accessories inputs (SIC 3713-5) due to consumption of energy, plastic, steel, and aluminum	1,345	$ million
Total	2,606	$ million
Memorandum:		
Total output of SIC 3711	134,115	$ million
Direct impact as a share of output	0.8	percent
Indirect impact as a share of output	1.10	percent

Sources: Bureau of Economic Analysis and ESI estimates

Behavior of End-Users Will Also Be Affected

A carbon tax would raise not only manufacturing costs, but also the cost of operating a vehicle. According to recent analyses by the administration and others, a $100 per ton carbon tax would translate into a gasoline tax of at least twenty-six cents per gallon. As exhibit VI.3 indicates, a tax of that magnitude would increase the cost of operating a vehicle by thirteen percent. The total price increase to consumers (operating costs plus depreciation plus other costs) would be about 5.5 percent.

Exhibit VI.3
Estimated Impact of a Carbon Tax on Operating and Ownership Costs

Per Mile* Cost of Ownership without a Tax ($)

	Gas & oil	Operating costs	Depreciation	Other	Total
Small	0.056	0.095	0.184	0.105	0.384
Mid-sized	0.066	0.108	0.218	0.121	0.447
Large	0.077	0.121	0.253	0.139	0.513
Light trucks	0.074	0.118	0.228	0.154	0.500

Per Mile* Cost of Ownership with a Tax ($)

	Gas & oil	Operating costs	Depreciation	Other	Total
Small	0.068	0.107	0.193	0.105	0.405
Mid-sized	0.080	0.122	0.229	0.121	0.472
Large	0.093	0.137	0.265	0.139	0.542
Light trucks	0.089	0.133	0.240	0.154	0.526

Cost of a Tax

	Gas & oil	Operating costs	Depreciation	Other	Total
Small	20.8%	12.3%	5.0%	0.0%	5.4%
Mid-sized	20.8%	12.7%	5.0%	0.0%	5.5%
Large	20.8%	13.2%	5.0%	0.0%	5.6%
Light trucks	20.8%	13.1%	5.0%	0.0%	5.4%

*Assumes that direct and indirect effects of higher energy costs on manufacturing costs raises automobile prices 5 percent above their baseline levels; based on 15,000 miles of driving per year.

Sources: Automobile Association of America and ESI estimates

It is naturally to be expected that consumers at the margin would respond to higher costs by driving less, by purchasing smaller cars and/or by postponing vehicle purchases. These behavioral changes would result in lower levels of output and employment in the industry.

Energy Efficiency Has Already Improved Substantially

As has been the case with chemicals and steel, the U.S. automobile industry has already taken major steps to increase energy efficiency and, by extension, to reduce carbon emissions. The figures are striking. Since 1974, the fuel economy of new cars has more than doubled, while light truck fuel economy has increased by fifty-five percent. In 1992, average fuel consumption per vehicle had dropped 106 gallons below 1975 levels. These gains were made possible, in large part, by technological improvements and by reductions in the length, weight and engine size of typical vehicles.

Further increases in fuel efficiency will result from additional technological breakthroughs, such as electric cars and other forms of low- and zero-emissions vehicles. Both U.S. and non-U.S. manufacturers already are making impressive strides toward bringing such products to market. Given this situation, it is unclear how a carbon tax, which would reduce available funds for investment in research and development, could hasten this beneficial development.

Competitiveness Issues

The Global Picture

The automobile industry is dominated by companies in advanced countries. In 1995, Annex-I countries produced eighty-one percent of all vehicles (see exhibit VI.4) The United States is the largest national producer, followed by Japan.

Developing-country industrial policies, foreign direct investment, and increased wealth in developing countries are causing increased production levels in non-Annex I countries. Though production in these countries is substantial, only cars from South Korea, Mexico, Malaysia, and Yugoslavia have made inroads into advanced-country markets.

Exhibit VI.4
Global Production of Automobiles, by Region, 1995

	Share	Units
Annex I	81%	43,046
Western Europe	30%	16,075
USA	22%	11,904
Canada	4%	2,391
Japan	19%	10,197
Eastern Europe & Former Soviet Union	4%	2,074
Other Annex 1	1%	405
Non-Annex I	19%	10,291
Asia	12%	6,353
Latin America	6%	3,062
Africa and Middle East	2%	877
Total	100%	53,338

Source: Automotive News *1997 Market Data Book*

Relocation Decision

Annex I automobile companies have already made substantial investments in non-Annex I markets but, in most cases, production at these facilities is for the "local" market. Since final vehicle assembly in most advanced-country markets takes place in the country where cars are consumed, and because energy intensity of the assembly function is low, increased production shifting by vehicle makers, as opposed to parts makers, is unlikely.

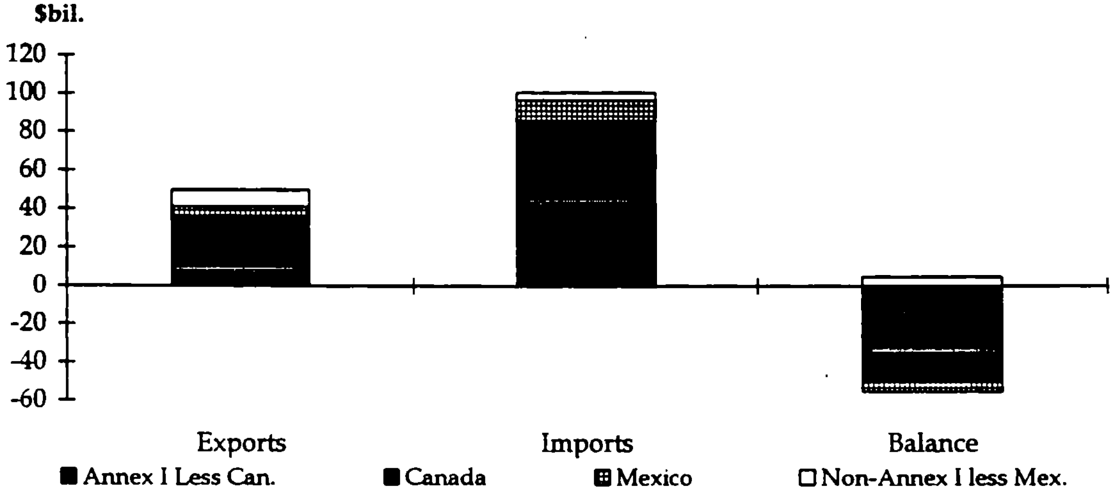
Parts makers in the United States, however, face a different set of pressures, due to their greater consumption of energy-intensive inputs. Higher energy prices would likely increase the speed at which parts production would be localized in Mexico, especially for cars aimed at the local market. In order to remain competitive in Mexico, U.S. parts producers would likely be forced to increase their FDI there.

The need to remain competitive with parts made in other developing countries would also encourage U.S.-based parts makers to increase their FDI in developing countries. The main competition would come from Korea. Korean vehicle makers traditionally have relied heavily on foreign-made parts and components. In order to lessen this dependence, the Korean government is nurturing domestic parts producers with the aim of eventually becoming a net exporter of parts. A carbon tax that gave Korean producers a greater price advantage over parts makers in developed countries would do much to advance this goal, particularly in other non-Annex I markets. This price advantage would also help secure markets in the Annex I countries of Eastern Europe and the former Soviet Union, where Korean firms are investing heavily in automotive capacity.

International Trade

As illustrated in exhibit VI.5, U.S. automotive trade is dominated by Annex I countries. Canada plays an especially prominent role, both as an export market and an import source. The deficit with Canada would probably not change much in the event of a carbon tax, because the U.S. and Canadian industries are highly integrated.

Exhibit VI.5
U.S. Automotive Trade with Annex I and Non-Annex I Countries, 1995



Source: Bureau of the Census, Foreign Trade Division

On the other hand, the deficit with the rest of Annex I would probably rise. U.S. firms produce more of the larger, non-luxury cars and light trucks than do foreign nameplates. Sales of these larger vehicles would be hit harder by a carbon tax than would either small cars or luxury cars. Thus, sales of North American products should decline disproportionately more than sales of imported vehicles (see exhibit VI.6). Japanese and South Korean nameplates would benefit most from these changing preferences. Korean companies, of course, would also have the added competitive advantage of being located in a non-Annex I country.

Exhibit VI.6
U.S. Vehicle Market, by Size and Import Share, 1995

	Total Units Sold	Market Share	Import Share
Small	2,338,612	15.5%	22.0%
Mid-sized	4,190,978	27.7%	10.4%
Large	932,174	6.2%	0.0%
Luxury	1,173,234	7.8%	47.8%
Truck	6,481,357	42.9%	6.5%

Source: American Automobile Manufacturers Association

The FDI flows described above, as well as South Korea's price advantage borne of its non-Annex I status, would both tend to increase the U.S. deficit with non-Annex I countries. Because increased FDI to Mexico would be cost driven, parts exports would fall and imports would rise, adding to an already large automotive deficit with Mexico. The small surplus that the United States has with other developing countries, $4.7 billion in 1995, would likely become a deficit as U.S. exports to developing countries were replaced with local parts production, and competitive parts imports from South Korea and other developing countries expanded.

In sum, a carbon tax would hurt the competitiveness of U.S. motor vehicles vis à vis Japan, thereby increasing the already huge bilateral automotive deficit; expand imports from developing countries, especially from Mexico and Korea; reduce U.S. exports of parts and components to developing countries; and hurt U.S. parts manufacturers' chances of exporting to the markets of Eastern Europe and the former Soviet Union.

Impact of a Carbon Tax on Motor Vehicle Industry Output and Trade

Estimating the impact of a $100 per ton carbon tax on the vehicle industry is complicated by the fact that the impact of a carbon tax on both vehicle and gas prices would lead a significant number of people to purchase mid-size vehicles instead of light trucks. To get an idea of the potential impact that this forced change in preferences would have on U.S. output, ESI has illustrated the potential impact on U.S. vehicle output and trade if just ten percent of light truck purchasers opted to buy a mid-sized vehicle instead of a light truck.

The basic model has similar assumptions to those used in the models for the chemical and steel industries. Differences include:

- The $100 per ton carbon tax would translate into a $0.26 per gallon gasoline tax, about a twenty-one percent increase from current price levels.
- The compound growth rate of vehicle demand in the base scenario would be equal to 0.7 percent annually.
- A price elasticity of demand would be minus 0.25, because most of the substitution caused by higher prices occurs within the industry.
- The income elasticity of demand would be 1.08.[47]
- The import elasticity would be 0.98, taken from a recent ITC study.[48]

The results imply a six percent drop in shipped units, declining vehicle exports, a seven percent increase in import penetration, and a six percent increase in the trade deficit, in unit terms (see exhibit VI.7).

Exhibit VI.7
Motor Vehicle Industry Output and Trade
Estimated Impact of a $100 per Ton Carbon Tax by 2010

	Base Case	Carbon Tax	
Domestic Demand (Units)	16,783.36	16,280.7	-3.0%
Shipments (Units)	12,861.8	12,115.1	-5.8%
Exports (Units)	1,381.2	1,328.7	-3.8%
Imports (Units)	5,302.8	5,494.4	3.6%
Trade Balance (Units)	(3,921.6)	(4,165.6)	6.2%
Exports as a Share of Output (Percent)	10.7	11.0	2.1%
Import Penetration (Percent)	31.6	33.7	6.8%

Source: ESI Estimates

Though significant, these results actually understate the impact that the carbon tax would have on the U.S. auto industry. In dollar terms, the impact would be much larger for two reasons. First, the shift away from light trucks and large-sized passenger vehicles, which together account for more than half of U.S.

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[47] Lawrence Horowitz, "The Impact of Carbon Taxes on Consumer Living Standards," in Charles E. Walker, ed., *An American Perspective on Climate Change Policies* (Washington, DC: American Council for Capital Formation, February 1996), 145.

[48] Kenneth A. Reinert and Clinton R. Shields, 29-41.

vehicle demand, would result in less per-car sales revenue for U.S. firms. Second, this shift would result in more imports, because the import share of the light-truck/large-car market is substantially lower than it is for mid-sized cars. Exhibit VI.8 illustrates this impact, based on a ten percent shift from light trucks and large vehicles to mid-sized cars, and assuming a $10,000 premium for larger cars. This shift would translate into higher imports, lower domestic production, and a $9 billion decline in U.S. revenue.

Exhibit VI.8
Potential Impact of a Shift in Vehicle Purchases toward Mid-Sized Cars

Base case

	Total (units)	Imports (units)	Domestic (units)	Domestic Revenue ($thou.)
Light trucks + large vehicles	8,694,498	463,222	8,231,276	230,475,729
Mid-sized vehicles	4,653,261	485,004	4,168,257	75,028,626
Total	13,347,760	948,227	12,399,533	305,504,355

With 10 percent shift toward mid-sized cars

	Total (units)	Imports (units)	Domestic (units)	Domestic Revenue ($thou.)
Light trucks + large vehicles	7,825,049	416,900	7,408,148	207,428,156
Mid-sized vehicles	5,522,711	575,626	4,947,085	89,047,531
Total	13,347,760	992,526	12,355,233	296,475,687

Change from base case

	Total (units)	Imports (units)	Domestic (units)	Domestic Revenue ($thou.)
Light trucks + large vehicles	(869,450)	(46,322)	(823,128)	(23,047,573)
Mid-sized vehicles	869,450	90,622	778,828	14,018,905
Total	-0-	44,300	(44,300)	(9,028,668)

Base case assumes a compound annual growth rate of 0.7 percent, import share in 2010 the same as in 1995, and per-vehicle revenue of $28,000 for light trucks and $18,000 for mid-sized cars.

Source: ESI estimates

Air Transportation

The airline industry (SIC 45) does not generally come to mind when one thinks of global climate change. Yet, the effects on this industry of a carbon tax, or other mitigation strategy that relies on higher energy prices, would, in many ways, parallel the effects on the automobile industry. The air transportation industry would be hurt not only by the general decline in aggregate demand that a tax would cause, but also by higher aircraft costs, higher fuel costs, and increases in other travel-related expenses, which would impact the frequency of travel in general.

The airline industry is a major employer, responsible for more than a million jobs in the U.S. alone. Its value added is also about seventy-five percent higher than the steel industry's value added (see exhibit VI.9)

Exhibit VI.9.
Output, Employment and Trade of the U.S. Airline Industry, 1995

	Units	Air Transportation Services	Share of Total Transportation Services
Output			
Value added*	$ bil.	51	22.9%
Employees	thou.	1,068	27.4%
Trade			
Exports	$bil.	19	17.4%
Imports	$bil.	14	16.3%
Balance	$bil.	5	NA

* Value added is for 1994.

Sources: Bureau of the Census, and International Trade Administration

Energy Use Issues

Direct Fuel Costs Are High

Though the air transportation industry does not manufacture anything, it is a major energy user. At 0.25 to one, its ratio of energy use to value added is about twice as high as that of the chemical industry. Furthermore, fuel costs make up twenty-to-thirty percent of the direct operating costs for most major airlines (see exhibit VI.10). Since direct operating costs typically account for thirty-to-forty percent of total airline costs, every ten percent rise in the price of fuel is accompanied by a subsequent one percent increase in total costs. Moreover, a carbon tax would come on top of the user fees that airlines already pay, and on top of the so-called ticket tax that was enacted as part of this year's budget accord.

Exhibit VI.10
Energy Expenditures as a Share of Direct Operating Costs, 1995

	Fuel Oil ($ bil.)	Fuel Costs as Share of Total Direct Operating Costs
Air Canada	328.7	30.5%
Air France	736.7	25.9%
Lufthansa	819.0	24.2%
JAL	1,303.2	28.1%
British Airways	943.1	29.0%
American	1,482.3	24.1%
Northwest	1,031.5	28.8%
United	1,583.5	24.4%

Source: ICAO

Indirect Energy Use Is Substantial As Well

Like the motor vehicle industry, the air transport industry also purchases energy-intensive products. Its major input, of course, is aircraft, and aircraft prices would be sure to rise if an energy tax were implemented, because their major material inputs include aluminum, steel, plastic, and rubber. Those inputs alone account for about seven percent of the value of aircraft shipments. Consequently, a fifteen percent rise in the price of those products would increase aircraft prices by about 1.1 percent. Also, the increase in direct energy costs to aircraft manufacturers would increase aircraft prices by another one percent. Given that prices for products such as metal working machinery and other capital equipment would rise as well, the total price effect of direct and indirect energy use would likely be in the neighborhood of four-to-five percent. Unless aircraft manufacturers replaced their domestic production with imports from non-Annex I countries, airlines would have to pay higher prices for their planes. The cost of these extra expenditures would ultimately be borne by consumers.

Higher Ticket Prices and Lower Incomes Would Mean Fewer Travelers

As in the case of automobiles, consumers affected by slowed income growth and by the higher prices resulting from a carbon tax would change their behavior. Specifically, travelers sensitive to shifts in price and income would either use less costly forms of transportation, downsize their vacations by flying closer to ho put more effort into tracking down discounted flights, or choose not to trave all. As exhibit VI.11 indicates, fliers are especially sensitive to changes in income. For airline services, a one percent decline in income translates into a 1.63 percent decline in expenditures on air travel, over the long run.

Exhibit VI.11
Long-Term Income Elasticities for Selected Consumption Categories

	Income Elasticity
Airline service	1.63
Other durable goods	1.51
Furniture and appliances	1.28
Other non-durables	1.23
Motor vehicles and parts	1.08
Financial services	0.89
Clothing and shoes	0.86
Electricity	0.82
Natural gas	0.70
Medical services	0.61
Gasoline	0.60
Food and beverages	0.54
Telephone service	0.36
Housing	0.17

Source: DRI

Competitiveness Issues

The Global Picture

OECD countries dominate airline services, accounting for seventy-three percent of scheduled passenger kilometers worldwide (see exhibit VI.12). The United States, generally considered to have the most competitive airline services sector, is the largest national market within this group of countries. The market share of carriers based in the United States and other Annex I nations would likely be even higher if trade in airline services were as open as trade in goods. However, governments in both OECD and non-OECD countries closely regulate access to their domestic markets.

Exhibit VI.12
Global Scheduled Passenger Kilometers Performed, by Country, 1995

	Share	Passenger Kilometers Performed (millions)
OECD	73%	1,602.6
United States	39%	853.4
Germany	3%	62.2
France	3%	66.9
United Kingdom	7%	152.5
Japan	6%	130.0
Other	15%	337.6
Non-OECD	27%	607.1
China	2%	54.2
Singapore	2%	45.4
Russia	3%	61.0
Brazil	2%	34.3
Argentina	1%	11.9
Other	18%	400.3
Total	100%	2,209.7

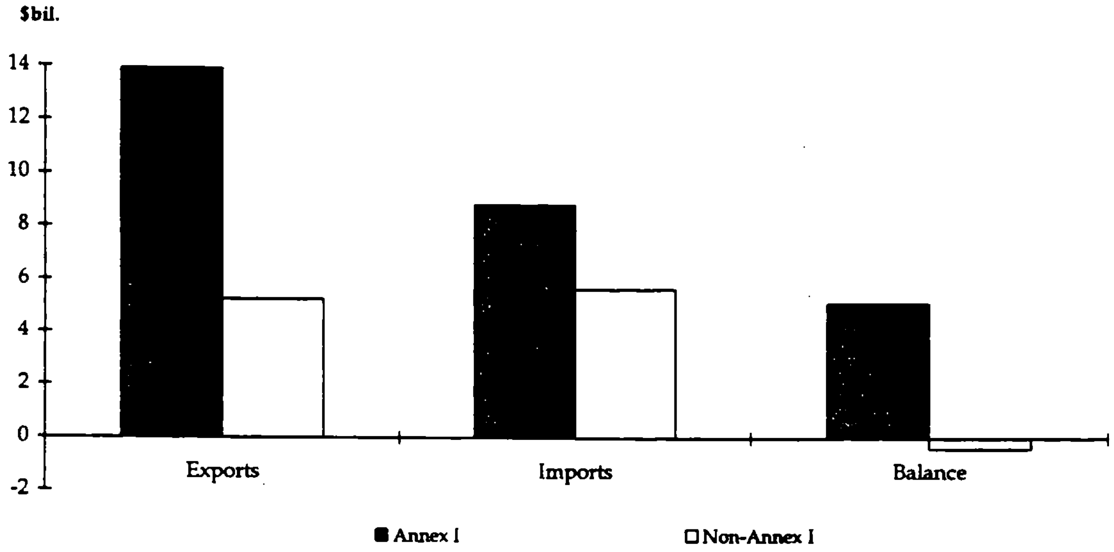
Source: International Civil Aviation Organization and ESI Calculations

International Trade

Unlike the industries previously covered, the competitiveness impact of a carbon tax would likely be slight in the case of the airline industry, especially if it is applied "at the pump." Most major competitors are from Annex I countries, and carriers from developing countries flying to and from the United States would likely have to purchase at least some of their fuel in the United States. Likewise, U.S. carriers flying to developing countries could purchase fuel for their return trips in the developing countries, thereby avoiding the tax on at least one leg of their journey.

A system could be devised, however, that would allow carriers from non-Annex I countries to receive a tax rebate on fuel purchased in developed countries. Under such a scenario, Annex I carriers, including those from the United States, would be at a competitive disadvantage and would likely lose international customers to developing-country airlines. The United States is already running a deficit in passenger airline services trade with developing countries, and this shortfall would likely expand if abatement policies were shouldered solely by advanced-country airlines (see exhibit VI.13 below)

Exhibit VI.13
Passenger Airline Services Trade with Annex I and Non-Annex I Countries, 1995



Source: Bureau of Economic Analysis

The competitiveness effect of a carbon tax on the U.S. airline services industry, therefore, would depend on how the tax was implemented. The impact of a tax without a rebate system would likely be small, but a tax that discriminated against Annex I countries would damage their carriers' competitiveness. Unfortunately, since price-sensitive international travelers would simply shift to non-Annex I carriers, the discriminatory tax would have no impact on energy consumption or, by extension, on global carbon emissions.

Impact of a Carbon Tax on Airline Services Industry Revenue and Trade

ESI has attempted to estimate the potential effects of a carbon tax on airline revenue, using a methodology and assumptions similar to those used for the previously discussed industries. Though current uncertainty surrounding the cross-border implementation of a carbon tax makes any effort to quantify its impact on trade purely speculative, ESI has also included a small trade effect. Assumptions specific to airline services include:

- A $100 per ton carbon tax would translate into a $0.34 per gallon increase in finished aviation fuel costs.
- Domestic demand for, and imports of, airline services would expand three percent per year through 2010 in the base scenario.
- Airline services exports would expand six percent per year, due to increased economic growth in, and travel to and from, developing countries.
- Price elasticity of demand would be minus one.
- Income elasticity of demand would be two.[49]
- Export and import elasticities would be minus one and one, respectively.

The results, shown in exhibit VI.14, imply a 6.5 percent revenue decline from the base scenario, driven primarily by a decline in domestic demand for airline services. The trade impact would be smaller than it would be in the other industries examined, but the U.S. airline services surplus would still decline 8.5 percent below baseline levels.

Exhibit VI.14
Airline Services Industry Revenue and Trade
Estimated Impact of a $100 per Ton Carbon Tax by 2010

	Base Case	Carbon Tax	
	Value	*Value*	*% Change*
Domestic Revenue ($ bil.)	140.0	131.4	-6.2%
Total Revenue ($ bil.)	163.4	152.8	-6.5%
Exports ($ bil.)	45.8	44.5	-3.0%
Imports ($ bil.)	22.5	23.1	2.8%
Trade Balance ($ bil.)	23.3	21.4	-8.5%
Export Receipts as a Share of Revenue (Percent)	28.1	29.1	3.8%
Import Penetration (Percent)	16.1	17.6	9.5%

Source: ESI Estimates

The impact of a decline in airline travel on the domestic economy would be much larger if a less efficient mechanism for reducing carbon emissions were employed. For instance, the Campbell Aviation Group has estimated that the direct, indirect, and induced effects of keeping the industry's fuel consumption at 1990 levels could have a negative economic impact on the United States amounting to $770 billion by 2010.

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[49] This elasticity is higher than the one in exhibit VI.11, reflecting the increasing sensitivity of air travel to income fluctuations.

Semiconductors

The semiconductor industry (SIC 3674), after almost succumbing to the onslaught of predatory Japanese dumping during the mid-1980s, has been a driving force in the high-technology revolution that has helped to remake the U.S. economy during the 1990s. Industry shipments in 1995 totaled $65.6 billion, a whopping 120 percent increase over 1991 shipments. Semiconductor manufacturers employed 193,400 people in high-value-added jobs in 1995. The value added per employee was a staggering $265,000 per person. However, despite obvious U.S. competitiveness in this sector, the United States ran a trade deficit of more than $16 billion (see exhibit VI.15).

Exhibit VI.15.
Output, Employment and Trade of the U.S. Semiconductor Industry, 1995

	Units	Semiconductors	Share of Total Manufacturing
Output			
Shipments	$ bil.	65.6	1.8%
Value added	$ bil.	51.3	3.0%
Employees	thou.	193.4	1.0%
Trade			
Exports	$bil.	22.4	4.6%
Imports	$bil.	38.9	6.2%
Balance	$bil.	(16.5)	NA

Sources: Bureau of the Census, and International Trade Administration

At first glance, the semiconductor industry does not seem to fit the profile of an industry that could be damaged by deliberations in Kyoto. It is certainly not a smokestack industry. Its expenditures on electricity in 1995 amounted to only 0.8 percent of value added. Rising production costs resulting from an energy tax, therefore, would have only a very small impact on the price of the average semiconductor.

In this case, however, first impressions are deceiving. Semiconductors are essential components in a wide and increasing range of consumer and capital goods. A drop in demand induced by an energy tax, therefore, would substantially affect semiconductor sales. Moreover, perflourocarbons (PFCs), manmade greenhouse gases that will be discussed at the Kyoto meeting in December, are an integral part of the semiconductor manufacturing process.

Energy Use Issues

Microprocessors Versus DRAMs

The industry's low energy intensity is somewhat misleading, because it lumps together different products having vastly different energy intensities. While energy costs, as a share of revenue, are low for high-margin products such as microprocessors, they are high for low-margin products such as dynamic random access memory chips (DRAMs). DRAM imports are already substantial, especially from developing-country producers, but some U.S. producers are extremely competitive, recording profits even though memory prices have declined precipitously during the past eighteen months. An energy tax applied only on Annex I countries would put U.S. DRAM manufacturers at a severe competitive disadvantage, perhaps completing the job begun by Japanese dumpers during the 1980s.

No Substitute for Perflourocarbons

Though the attention in Kyoto will be focused heavily on CO_2, PFC mitigation strategies likely will be a topic of discussion as well. Given the key role of PFCs in the manufacturing process, rushed and ill-conceived efforts to limit PFC use in Annex I countries would have a chilling effect on semiconductor manufacturing in the United States.

Perfluoroethane serves as a purging agent in the production of semiconductors. The process results in emissions of PFCs (gases usually associated with aluminum smelting) and sulfur hexafluoride. Because there are currently no substitutes for perfluoroethane in the manufacturing process, any usage limits, or taxes to produce an equivalent reduction, would raise domestic manufacturing costs dramatically. Obviously, such a development would give producers in non-Annex I countries a major advantage.

The U.S. semiconductor industry has been proactive in its efforts to reduce PFC emissions. Individual companies have signed a memorandum of understanding with the Environmental Protection Agency, committing them to work toward emissions reduction. SEMATECH and individual companies have undertaken major research efforts aimed at finding a commercially viable alternative to perfluoroethane.

Current and Past Developments Offer Long-Term Energy Savings Potential

The rapidly growing capabilities and falling prices among the semiconductor and other high-tech industries, such as computers and telecommunications, have led to increased consumption of these products. Concurrently, increased manufacturing activity in these sectors has led to higher levels of U.S. energy consumption and, by extension, greater greenhouse gas emissions. On the other hand, these high-tech industries may actually lead to less energy consumption in the long run, as teleconferencing, telecommuting, and e-mail reduce energy consumption associated with travel and postal services. Efforts to harness high-tech industries through higher energy taxes, or other policies, risk a slowdown in the pace of technological change, thus delaying the advent of energy-saving technologies that would produce lower levels of greenhouse gas emissions in the long run.

Competitiveness Issues

The Global Picture

Annex I producers, particularly those based in the United States and Japan, account for the vast majority of global semiconductor sales. Producers based in other Asia-Pacific countries, such as South Korea, have made impressive strides during the 1990s, with market share tripling between 1990 and 1995 (see exhibit VI.16) Asia-Pacific producers are especially strong in DRAM production, and industrial policies in several countries throughout the region are aimed at developing indigenous semiconductor industries. The goal of Korean industrial policy is to shift the country's product mix away from DRAMs and toward microprocessors and other products currently produced in the United States.

Exhibit VI.16
Global Semiconductor Market Share, by Region of Capital Affiliation
1990 and 1995

	1990 (percent)	**1995** (percent)
Annex I	96.1	87.9
United States	38.6	39.8
Japan	46.3	39.5
Europe	11.2	8.6
Non-Annex I	3.9	12.1
Asia-Pacific (excl. Japan)	3.9	12.1

Source: ESI, *Prospects for U.S.-Japanese Semiconductor Trade in the 21st Century*

The Relocation Decision

Semiconductor manufacturers based in the United States, Japan, Europe and Korea have been active foreign investors. The U.S. market is home to Japanese, European, and Korean-owned firms, and U.S.-based firms have production outlets throughout the world. Though much of this cross-investment has been market seeking, cost-driven FDI has also occurred. Major producers long ago relocated low-value-added, labor-intensive functions to lower-wage countries. In short, the semiconductor industry is mobile and sensitive to cost differences across countries.

As a production site, the United States now has enough advantages to ensure a viable domestic industry, even in the face of energy taxes. Yet, a tax levied only on Annex I countries would provide a powerful incentive for Annex I producers to shift production of low-margin, energy-intensive products like DRAMs to countries exempted from a carbon-based energy tax. All other things being equal, a tax on Annex I countries would result in less FDI in the United States and more U.S. FDI in non-Annex I countries than would otherwise be the case.

International Trade

Despite its competitiveness, the United States is a net importer of semiconductors.[50] Japan is the largest national source of U.S. imports, followed by Korea, Malaysia, Taiwan, and Singapore - all non-Annex I countries. In fact, the majority of U.S. semiconductor imports come from non-Annex I countries (see exhibit VI.17).

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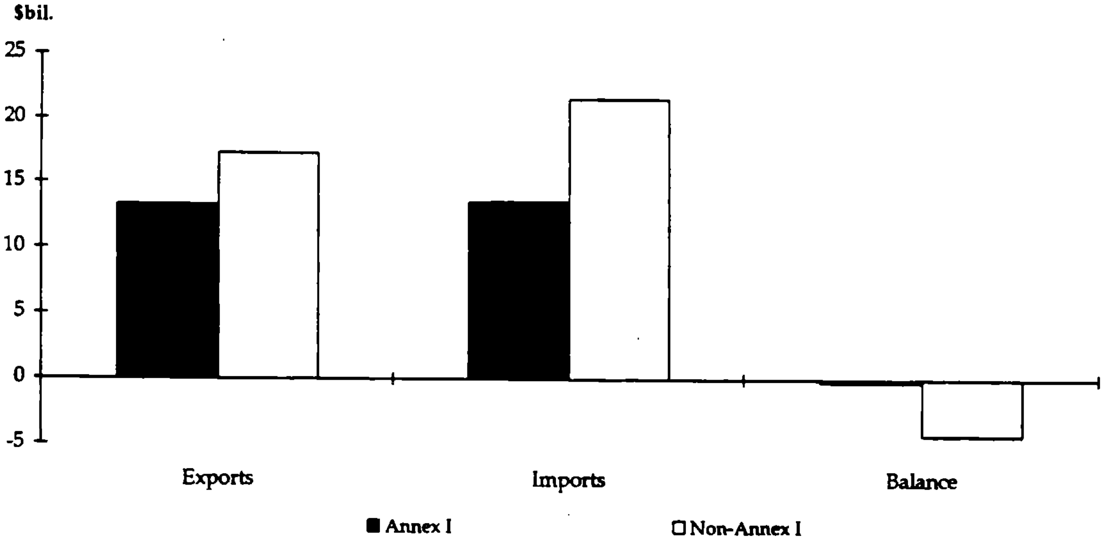
[50] Statistics offer a somewhat confusing picture of semiconductor trade. According to the SIC-based trade numbers, the U.S. deficit in "semiconductors and related devices" was 16.5 percent in 1995. According to SITC-based trade statistics, the U.S. deficit in "integrated circuits" was only $4.5 billion in 1995. The country-by-country discussion in this section is based on SITC definitions.

Exhibit VI.17
U.S. Semiconductor Trade with Annex I and Non-Annex I Countries, 1995



Note: Trade figures based on SITC Rev. 3 classification
Source: Bureau of the Census, Foreign Trade Division

An energy tax on Annex I countries clearly would aggravate the U.S. trade shortfall, for three reasons. First, the change in FDI flows resulting from a carbon tax would lead to more production in non-Annex I countries and less production in the United States than would otherwise occur. Second, producers based in Korea and other developing countries would gain a cost advantage in DRAMs and other low-margin products, potentially rendering U.S. makers of these products uncompetitive. Third, the lower rise in European electricity prices would encourage U.S. producers to service a greater share of European demand with their production facilities on the continent. Because manufacturers in Japan and the United States are expected to face similar increases in electricity costs, the overall impact on competitiveness between the two should be relatively minor.

Furthermore, erosion of the U.S. balance of trade with developing countries would be magnified greatly if advanced countries were burdened by PFC restrictions. Such restrictions would make the addition of capacity in the United States nearly impossible and would compel U.S.-based makers to shift even more production to developing countries, in order to serve rapidly growing U.S. semiconductor demand. PFC policies that undercut U.S. competitiveness would be a boon to DRAM producers in Korea and Taiwan with high capacity levels. Because production would merely be shifting, this U.S. "sacrifice" would produce no net, global change in PFC emissions levels.

Impact of an Energy Tax on Semiconductor Industry Output and Trade

In addition to estimating the effect of a $100 carbon tax, ESI has attempted to capture the impact of restrictions or tax increases on PFCs. Assumptions for these estimates include:

- The $100 per ton carbon tax and PFC mitigation policies would translate into an average five percent increase in semiconductor prices.
- Domestic demand for semiconductors in the base scenario would rise seven percent per year from 1995 levels.
- Due to U.S. competitiveness in high-value-added product lines, U.S. semiconductor exports would rise seven percent per year, versus a five percent growth rate for imports.
- A low price elasticity of minus 0.2 would reflect the paucity of substitutes for semiconductors.
- A high income elasticity of 1.75 would reflect the high and growing semiconductor content of durable consumer and capital goods, which generally have higher than average elasticities.
- Export and import elasticities of minus 1.2 and 1.2, respectively, would be slightly higher than average, reflecting the fact that a high proportion of U.S. semiconductor trade would occur with developing countries and would be price sensitive.

The potential impact on the semiconductor industry of a combination of energy tax and PFC mitigation policies would be even larger, in percentage terms, than the impact on the auto industry (see exhibit VI.18). Shipments in 2010 would be down eight percent from base levels, while exports would fall six percent and imports would expand 5.8 percent. The trade deficit would be $8.4 billion higher than would otherwise be the case.

Exhibit VI.18
Semiconductor Industry Output and Trade
Estimated Impact of a $100 per Ton Carbon Tax and PFC Restrictions by 2010

	Base Case	**Carbon Tax**	
	Value	*Value*	*% change*
Domestic Demand ($ bil.)	226.7	218.5	-3.6%
Shipments ($ bil.)	207.5	191.0	-8.0%
Exports ($ bil.)	61.8	58.1	-6.0%
Imports ($ bil.)	80.9	85.6	5.8%
Trade Balance ($ bil.)	-19.1	-27.5	43.9%
Exports as a Share of Output (Percent)	29.8	30.4	2.1%
Import Penetration (Percent)	35.7	39.2	9.7%

Source: ESI Estimates

Key Points

The automobile, airline services, and semiconductor industries in the United States, like their smokestack brethren, can expect significant declines in output and competitiveness if U.S. negotiators agree to an energy tax aimed at constraining U.S. emissions to 1990 levels, especially if steps are not taken to constrain developing-country emissions. The potentially large impact on the automobile industry is not surprising, because the cutting of energy consumption due to automobile use is a major goal of proposals now on the table. The potentially large effects on airline services and semiconductors, however, is surprising, as well as alarming, because these industries have been considered to be the engines of a "new" U.S. economy driven by services and high-tech manufacturing. The bottom line? A carbon-based energy tax levied only on advanced countries would deal a very hard blow to just about all sectors of the U.S. economy.

Contrary to popular perceptions, U.S.-made autos and parts, like U.S.-made chemicals and steel, compete relatively well in developing-country markets, a situation that a carbon tax would almost certainly alter. By 2010, U.S. trade balances in the auto, airline, and semiconductor sectors would deteriorate sharply, driven mainly, but not exclusively, by trade with non-Annex I countries. Ironically, even the "new economy" sectors of airline services and semiconductors ran trade deficits with developing countries in 1995, and they would run even larger deficits by 2010 if a discriminatory energy tax were to become reality. Such developments could only poison American popular attitudes toward trade with developing countries, thus undercutting decade-long efforts to open those markets through bilateral and multilateral negotiations.

At present, promising efforts to reduce greenhouse gas emissions are ongoing in the auto and semiconductor industries. To penalize them with a tax on energy would hamstring those activities, because lower sales revenues and higher operating costs inevitably translate into less R&D expenditures. In this sense, many of the mitigation options aiming to shunt energy consumption back to 1990 levels by 2010 are misguided.

Chapter VII: Conclusions and Recommendations

In summary:

- Evidence that man-made greenhouse gases will raise temperatures significantly in the decades ahead is ambiguous. While computer models project such a trend, actual satellite data does not conform to the projections and indicates there has been little, if any, global warming since World War II even though most of the man-made greenhouse gases now in the atmosphere have been added since that time. Further, the likely consequences of warming are a matter of dispute among scientists.

- Contrary to much popular commentary and assertions by other governments, the U.S. record on emissions is quite good. In fact, most of the increase in emissions in the United States since 1990, the baseline in many emission reduction proposals, reflects population growth and the strong economic expansion following the recession that occurred in 1990, rather than declining energy efficiency. Indeed, U. S. final consumption of energy per unit of output has actually declined sharply since 1990, even more rapidly than in most other countries.

- The most rapidly growing rates of emissions are occurring in developing countries. Indeed, their emissions are so large and growing so rapidly that any projected reduction by industrialized countries would be overwhelmed by developing countries 'emissions if they are not parties to any agreement.

The economic costs associated with current emission reduction proposals are likely to be large, and to extend over a long period. Advocates of emissions control measures are using flawed models and assumptions which dramatically understate these effects. Most significantly, carbon taxes and other measures designed to reduce emissions will put U. S. companies across a wide range of industries at a severe competitive disadvantage in global markets, especially relative to those countries that may be exempt from emissions control, or that don't live up to commitments that they might make in Kyoto. This will put huge upward pressure on the already large and rising U.S. trade deficit, and will be at cross purposes with current trade policy initiatives which are designed to open foreign markets and reduce the U.S. trade imbalances. U.S. consumers would also be hurt -- higher energy costs, rising overall inflation, and higher interest rates would squeeze real income and purchasing power, and significantly reduce living standards for several decades at least.

The United States government, therefore, should be extremely cautious in dealing with the Kyoto agenda. In particular, it should not agree to proposals being made by other countries for mandatory reduction of emissions to 1990 levels by the year 2010. This would require increases in energy efficiency between now and 2010 that are virtually impossible. The only way to achieve that target would be to reduce the growth in energy consumption that results from higher levels of economic activity, thus dramatically slowing economic growth.

Nor should the United States enter into any agreement that excludes developing countries. Because the easiest and least costly emissions reductions can be achieved in developing countries, the U.S. should encourage cooperative arrangements, technology transfer and low cost finances for installation of up to date equipment in these areas. For example, a leaking gas line in the Ukraine was recently made 100 percent cleaner through the addition of joint strapping to stop the leaks. These kinds of simple inexpensive measures in countries that have not already attacked the easy problems would be a much better cost/benefit profile than draconian measures in the United States where efficiency has already been much improved.

Finally, if the Kyoto convention is really serious, it might consider cooperative financing by all attendees of a Manhattan type of project to achieve the kind of massive increases on energy efficiency that will be necessary to reduce emissions without reducing the world to poverty.

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DRAFT --May 30, 1997

Economic Effects of Global Climate Change Policies

Results of the Research Efforts of the

Interagency Analytical Team

June 1997

Executive Summary

Using a group of economic models with different strengths and weaknesses, the Administration's Interagency Analytic Team has analyzed the economic effects of policies to limit emissions that lead to changes in global climate.

The starting point for this analysis was a scenario in which carbon emissions in the year 2010 were reduced to their 1990 levels. This starting point was selected because it was presented in previous Administration analyses of the issue and because it has been the subject of numerous analyses by academic researchers. Cross-border trading of emissions rights (or permits) was then allowed to reduce transitional economic losses created by such a policy. This is particularly true in the short term. A dramatic acceleration of technological progress also has made the potential to reduce further economic losses, if it can be achieved, but over a longer time period. The economic losses are also reduced by policies that use any resulting revenues for the Federal budget deficit reduction or other policies, which favor investment and long-term growth.

The starting point scenario would raise the implicit price of carbon in the economy by about $100 per ton of carbon. (Actual household burdens would be somewhat offset by conservation and presumed subsequent efficiency improvements.) These higher energy costs would produce GDP losses, at peak, between 0.2 percent and 1.0 percent of GDP. The economy would thereafter bounce back, or in the worst case stabilize, so that it would soon reach its pre-policy growth path. Thus, the losses of economic output resulting from such a policy are real, but relatively small and transient. These losses are disproportionately greater for stricter targets and disproportionately smaller for more lenient ones. However, if international permit trading were established it would moderate the losses to GDP. The maximum effect on GDP under international permit trading is about half of that under no trading.

While the economy-wide losses are small, some sectors bear large burdens, particularly energy producers. Energy-intensive industries also face greater losses. But there is no evidence of a wholesale "capital flight" from the United States resulting from an emissions reduction policy. Moreover, some industries expand as the economy undergoes the adjustment to a world with fewer carbon emissions.

Introduction

In June 1996, the Department of Energy (DOE) and the Environmental Protection Agency (EPA) sponsored a joint workshop where more than 50 experts from inside and outside the government made presentations on technical issues associated with our emissions trends and capability to reduce emissions trends in the next century. As a part of that workshop, the Interagency Analytical Team (IAT) released what were then preliminary results on the economic effects of emissions reduction proposals.

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

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

Model Selection

The first task that the IAT confronted was to review the analytic "toolbox" to assure that it had all the tools necessary to specify the economic effects of a broad range of climate change proposals. At the time, the IAT relied primarily on the Data Resources, Inc. (DRI) macro model to measure economic effects. After this reevaluation of our modeling needs, it was apparent that the complexity of the analysis would require a broader range of analytical tools.

At a public meeting last November, the IAT announced the selection of three models for its analysis. It decided to continue to use the DRI model, but also included two additional models: the Second Generation Model (SGM) and the Markal-Macro model. Each of these three models met the criteria of being available in the public sphere; being well documented; having a track record of analysis in the climate change area; being widely understood within the energy-environment community; and bringing a unique capability to the IAT's work. Used separately, but in concert with each other, they provide the broad analytical capability needed to examine the many complex economic effects of potential global climate change policies.

The DRI model is a large disequilibrium model of the domestic economy that is particularly well suited to identify transition issues based on short-run behavior embedded into a long-run model. The DRI macroeconomic model is linked to energy, regional, and industry sub-models so that macroeconomic effects of policies are translated into the effects on specific industries and regions of the country. The link to energy sub-models provides specific detailed information about the interaction of the energy sector with the rest of the economy.[1] The DRI model also includes the interaction of the financial markets with markets for goods and services and enables the analysis of the interaction of fiscal and monetary policy with the rest of the economy.

The SGM model is a computable general equilibrium good at identifying an economy's long-term trends in response to climate policies. As such, it is particularly good at describing the economy's long-term path while not as good at describing short-term transition issues. In this sense, its strengths and weaknesses are counterpoised to those of DRI. International in scope, SGM also provides detail for 12 global regions that allows the IAT to examine the effects of permit trading and joint implementation. SGM assesses the impacts of greenhouse gas emissions policies on economic growth, consumption, and energy.

The DRI model and SGM can be thought of as lying at opposite ends of an axis that measures time horizons. A second dimension of the climate change problem concerns the role of technology. Both DRI and SGM allow technological progress to move forward in response to the parameters of their models. But given the unpredictable character of innovation, the IAT concluded that a second approach would be helpful. The Markal-Macro model consists of an integrated energy supply and demand modeling system (Markal) and a macroeconomic model (Macro) useful for translating technological assumptions into economic outcomes.

The Markal-Macro model is particularly useful in answering the question, "How do we get there from here?" Markal-Macro identifies optimal, under perfect foresight, for achieving and quantified goal. Markal-Macro allows the user to control technology innovation and diffusion and its cost to the user in order to determine the levels of energy efficiencies that might be expected from a long-term policy announcement. This model also allows us to understand the implications of technology and its interaction with the economy, and helps us determine whether expected energy efficient technologies hold the key to continued economic growth.

The DRI model and the SGM model in some sense provide notional brackets for estimates of the economic effects of carbon-limiting policies. The DRI model is focused on short-term transitions and measures the economy in quarters. In some sectors, the DRI model has forward-looking behavior, but it is structured to examine the effects of short-term changes in the economy, and is often held to overstate the transitions created by broad, secular changes in the economy (and, as will be discussed below, might overstates subsequent economic improvements as well). The SGM model focuses on long-term transitions and measures the economy in five-year intervals. Thus, it risks racing past short-term transition issues, while identifying the economy's ultimate destination.

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[1] The majority of the DRI results reported by the IAT use DRI's own Energy sub-model. In a limited number of cases. DOE's National Energy Modeling System (NEMS) has been also used been used in conjunction with the DRI model to analyze various sensitivities.

The Base Case

The domestic energy and emissions baseline forecasts were taken from the Energy Information Administration's 1997 Annual Energy Outlook (AEO97). The DRI baseline is DRI's own October 1996 long-term forecast, adjusted in part for the Climate Change Action Plan (CCAP). It is very similar to the AEO97 forecast, but not specifically calibrated to it. The international baseline forecast was taken from the International Energy Agency's World Energy Outlook, except for the baseline forecast of the Former Soviet Union (FSU), which came from World Bank projections. The IAT then imposed, as best possible, consistency across the models with regard to projections of baseline GDP, total energy consumption, and carbon emissions. Once these were calibrated into the 3 models, the models solved for energy prices by fuel type. Thus, the baselines of the three models are consistent, but not identical.

Tables 1 and 2 summarize the IAT baseline. In the baseline, U.S. economic growth is projected to slow over the next several decades, as the retirement of "baby boom" workers slows labor force growth and reduces the economy's potential growth rate. Energy demand therefore grows somewhat more slowly than it now does. Energy intensity, measured as energy use per dollar of GDP (the E/GDP ratio), is a key ingredient in the AEO97 forecast, because it measures the growing efficiency with which the economy uses energy. In the 1970s and 1980s, the E/GDP rate of decline averaged almost 2 percent annually--1.5 percent due to price effects and 0.5 percent due to non-price effects. Moderate price increases and the growth of more energy-intensive industries in the late 1980s led to a stabilization of energy intensity. The baseline projection used for this study incorporates a 1.0 percent annual reduction in energy consumption per unit of real output, which is taken from the EIA's Annual Energy Outlook. With these improvements included, energy demand grows at an annual rate of about 0.8 percent over the period from 1995 to 2020, tailing off at the end of the period as does economic growth.

Carbon emissions in the baseline are projected to increase by about 1.2 percent a year through 2010, and by 0.6 percent annually from 2010 to 2020, reaching 1805 million metric tons in 2020. In 1990, the year most frequently used in the international negotiating process as the reference level of carbon, carbon emissions were 1,340 million metric tons, 22 percent below EIA's projection for 2010 and 36 percent below DRI's projection for 2020.

Table 1: IAT Domestic Baseline

	Year							Average Annual Growth Rate (percent) [1]					
	1990	1995	2000	2005	2010	2015	2020	90-95	95-00	00-05	05-10	10-15	15-20
Population													
DRI-DRI Energy	250	263	276	287	299	311	323	1.0	0.9	0.8	0.8	0.8	0.7
AEO97 (NEMS) [2]	250	264	276	287	299	311	n/a	1.0	0.9	0.8	0.8	0.8	n/a
SGM	250	263	276	287	299	311	323	1.0	0.9	0.8	0.8	0.8	0.7
Markal-Macro	250	263	276	287	299	311	323	1.0	1.0	0.8	0.8	0.8	0.8
GDP (Billion 1992$)													
DRI-DRI Energy	$6,139	$6,743	$7,515	$8,320	$9,163	$9,996	$10,670	1.9	2.2	2.1	1.9	1.8	1.3
AEO97 (NEMS)	$6,139	$6,739	$7,544	$8,390	$9,185	$9,880	n/a	1.9	2.3	2.1	1.8	1.5	n/a
SGM	$6,139	$6,739	$7,544	$8,390	$9,185	$9,880	$10,591	1.9	2.3	2.1	1.8	1.5	1.4
Markal-Macro	$6,139	$6,739	$7,549	$8,384	$9,198	$9,880	$10,498	1.9	2.3	2.1	1.9	1.4	1.2
OMB [3]	$6,142	$6,721	$7,470	$8,343	$9,225	$9,929	$10,581	1.8	2.1	2.2	2.0	1.5	1.3
Total Energy Consumption (Quads) [4]													
DRI-DRI Energy	82.6	88.9	95.9	101.0	105.3	107.4	108.9	1.5	1.5	1.0	0.8	0.4	0.3
AEO97 (NEMS)	83.7	90.0	97.9	103.4	107.9	110.9	n/a	1.5	1.7	1.1	0.9	0.5	n/a
SGM	81.2	90.6	96.0	102.0	107.0	110.3	113.0	2.2	1.2	1.2	1.0	0.6	0.5
Markal-Macro	83.7	90.9	98.0	103.7	107.8	110.7	115.3	1.7	1.5	1.1	0.8	0.5	0.8
Energy Intensity (TBtu/$92GDP)													
DRI-DRI Energy	13.5	13.2	12.8	12.1	11.5	10.7	10.2	-0.4	-0.7	-1.0	-1.1	-1.3	-1.0
AEO97 (NEMS)	13.6	13.4	13.0	12.3	11.7	11.2	n/a	-0.4	-0.6	-1.0	-1.0	-0.9	n/a
SGM	13.2	13.5	12.8	12.2	11.6	11.2	10.7	0.4	-1.0	-1.0	-1.0	-0.9	-0.9
Markal-Macro	13.6	13.5	13.0	12.4	11.7	11.2	11.0	-0.2	-0.8	-1.0	-1.1	-0.9	-0.4
Minemouth Coal Price ($95/ton)													
DRI-DRI Energy	$23.92	$18.45	$15.28	$14.41	$13.76	$13.16	$12.70	-5.1	-3.7	-1.2	-0.9	-0.9	-0.7
AEO97 (NEMS)	$19.88	$18.83	$18.38	$17.47	$16.92	$15.46	n/a	-1.1	-0.5	-1.0	-0.6	-1.8	n/a
SGM	$19.88	$19.45	$18.48	$17.30	$16.47	$15.73	$14.96	-0.4	-1.0	-1.3	-1.0	-0.9	-1.0
Markal-Macro	$19.88	$18.83	$17.37	$16.39	$15.90	$16.39	$16.14	-1.1	-1.6	-1.2	-0.6	0.6	-0.3
World Oil Price ($95/Barrel)													
DRI-DRI Energy	$25.23	$17.14	$16.18	$18.93	$21.24	$22.86	$23.95	-7.4	-1.1	3.2	2.3	1.5	0.9
AEO97 (NEMS)	$24.87	$17.26	$18.20	$19.72	$20.41	$20.98	n/a	-7.0	1.1	1.6	0.7	0.6	n/a
SGM	$24.87	$17.26	$18.20	$19.72	$20.41	$20.98	$21.57	-7.0	1.1	1.6	0.7	0.6	0.6
Markal-Macro	$24.87	$17.26	$18.59	$19.75	$20.29	$21.05	$22.20	-7.0	1.5	1.2	0.5	0.7	1.1
Natural Gas Price (wellhead $95/Mcf)													
DRI-DRI Energy	$1.81	$1.46	$1.87	$2.15	$2.42	$2.54	$2.65	-4.2	5.1	2.8	2.4	1.0	0.9
AEO97 (NEMS)	$1.97	$1.61	$1.82	$1.94	$2.01	$2.13	n/a	-4.0	2.5	1.3	0.7	1.2	n/a
SGM	$1.97	$1.99	$2.07	$2.10	$2.16	$2.11	$1.97	0.2	0.9	0.2	0.6	-0.5	-1.4
Markal-Macro	$1.71	$1.55	$2.22	$2.28	$2.46	$2.77	$2.97	-1.9	7.4	0.5	1.6	2.4	1.4
Gasoline Prices ($95/Gal) [5]													
DRI-DRI Energy	$1.40	$1.21	$1.20	$1.26	$1.31	$1.37	$1.40	-2.9	-0.1	1.0	0.8	0.8	0.4
AEO97 (NEMS)	$1.34	$1.15	$1.19	$1.21	$1.22	$1.17	n/a	-3.1	0.8	0.3	0.1	-0.7	n/a
SGM	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Markal-Macro	$1.34	$1.15	$1.34	$1.39	$1.40	$1.41	$1.44	-3.0	3.1	0.7	0.1	0.1	0.4
Carbon Emissions (MMTC) – Total													
DRI-DRI Energy	1338	1413	1516	1612	1693	1767	1805	1.1	1.4	1.2	1.0	0.9	0.4
AEO97 (NEMS)	1339	1424	1543	1639	1722	1799	n/a	1.2	1.6	1.2	1.0	0.9	n/a
SGM	1350	1480	1550	1637	1729	1808	1871	1.9	0.9	1.1	1.1	0.9	0.7
Markal-Macro	1338	1459	1574	1674	1741	1806	1914	1.7	1.5	1.2	0.8	0.7	1.2

1 Growth rates are calculated from non-rounded levels. 2 AEO97 projections extend only to 2015. 3 Office of Management and Budget fiscal year 1998 assumptions. 4 SGM projections do not include geothermal, wind, biomass waste, and other municipal waste. 5 The SGM model does not include gasoline.

Table 2: IAT International Baseline Average Annual Growth Rates (percent)

	Real Economic Growth (GDP)			Energy Growth (Quads)			Emissions Growth (MMTC)		
	1990-00	2000-10	2010-20	1990-00	2000-10	2010-20	1990-00	2000-10	2010-20
Australia	2.8	2.8	2.6	2.1	1.5	0.9	2.0	1.5	0.9
Canada	2.6	2.5	1.2	1.7	1.0	0.4	2.2	1.4	0.7
China	8.4	7.5	5.8	3.9	2.8	2.1	3.8	2.8	2.2
Former Soviet Union	-3.5	4.6	4.2	-3.5	1.8	1.2	-4.0	1.8	1.2
Eastern Europe	-4.5	4.2	4.3	-3.0	1.3	1.2	-3.5	1.3	1.2
India	4.1	4.5	3.9	3.9	3.3	3.1	4.1	2.1	3.3
Japan	2.1	1.7	0.9	2.2	0.9	0.1	2.1	0.9	0.1
Korea	5.0	5.9	4.4	4.0	3.1	2.4	2.6	3.3	2.9
Mexico	4.0	4.0	3.2	4.2	2.9	2.3	4.2	2.9	2.4
Western Europe	2.3	2.5	2.4	1.5	1.4	0.6	1.2	1.4	0.6
United States	2.1	2.2	1.4	1.7	1.1	0.6	1.4	1.1	0.8
Rest-Of-World	3.6	3.4	3.0	3.0	2.0	2.0	3.0	2.2	2.2

The Analytical "Starting Point"

The IAT began its analysis of emissions reductions policies by examining one core emissions reduction scenario. Then we explored the economic effect of changes to this scenario. The central policy modeled -- the "starting point" scenario -- is aimed at reducing carbon and other greenhouse gas emissions by stabilizing them at 1990 levels. The "starting point" scenario pursues those reductions by issuing tradable emission permits at the earliest point of energy production or when imported into the United States. The policy is announced in 2000 and its restrictions are phased-in over a ten year period, so that the policy takes full effect in 2010. The permits are initially auctioned so that all revenues generated through permits would be recycled through the economy through deficit reduction. The initial discussion of the "starting point" scenario assumes no international cooperation. An option incorporating international trading is discussed once the dynamics of the no trading "starting point" scenario have been established.

Estimates of reductions of non-carbon emissions, such as methane and forest carbon sinks, are obtained from engineering estimates outside the models. Early in the process, the IAT estimated a strike-price for these sources of $70 per ton (which turned out to be low). Appendix Table A shows baselines for, and the quantities of emissions obtained from, these non-carbon sources at this price. These carbon tons were subtracted from the emissions targets being modeled. But the cost of obtaining them was not factored back into the models and, is therefore missing. While the engineering estimates are uncertain, the cost of abating non-carbon sources could increase the estimates of economic effects by as much as 14 percent.

The "starting point"scenario was employed as an analytical starting point for this analysis primarily because it has already been the subject of much attention within the analytical literature. Most analysts of climate change policies have used an emissions freeze in the year

2010 at 1990 levels as their framework. The IAT, therefore, used this scenario in order to facilitate comparisons of its work to that of other researchers.

Industry and regional effects, as presented here, show only the effects of the climate change policy on the industry's output (shipments plus inventory change). We considered this our first step in understanding the likely sectoral consequences of emissions reductions.

The "starting point" scenario incorporates a slight improvement in energy intensity (E/GDP) over the EIA/AEO baseline, which declines by 1.0 percent per year. This improvement could come about because the climate change policy undertaken generates foreseeable increases in the future price of energy, or because of the implementation of the Climate Change Action Plan (CCAP), or other policies. The prospective "announcement effect," therefore, is what allows the model to distinguish between a change in future policy regarding carbon emissions and an exogenous shock, such as the two oil price increases in the 1970s. This leads to somewhat faster rate of diffusion of energy efficient technologies and a higher rate of innovation through R&D in anticipation of future higher energy prices. The IAT assumes an improvement in energy-intensity of 0.25 percent so that the total annual change in the ratio of energy to GDP is 1.25 percent per year. A faster technology alternative is also investigated. (More detail on energy-efficient technology improvement is provided later in this paper.)

Unless otherwise stated, the tables and figures that follow were derived using the DRI model and using the "starting point" scenario, which does not incorporate international emissions trading. These estimates, therefore, will be at the high end of the likely range, due to both model structure and the absence of trading.

"Starting Point" Results

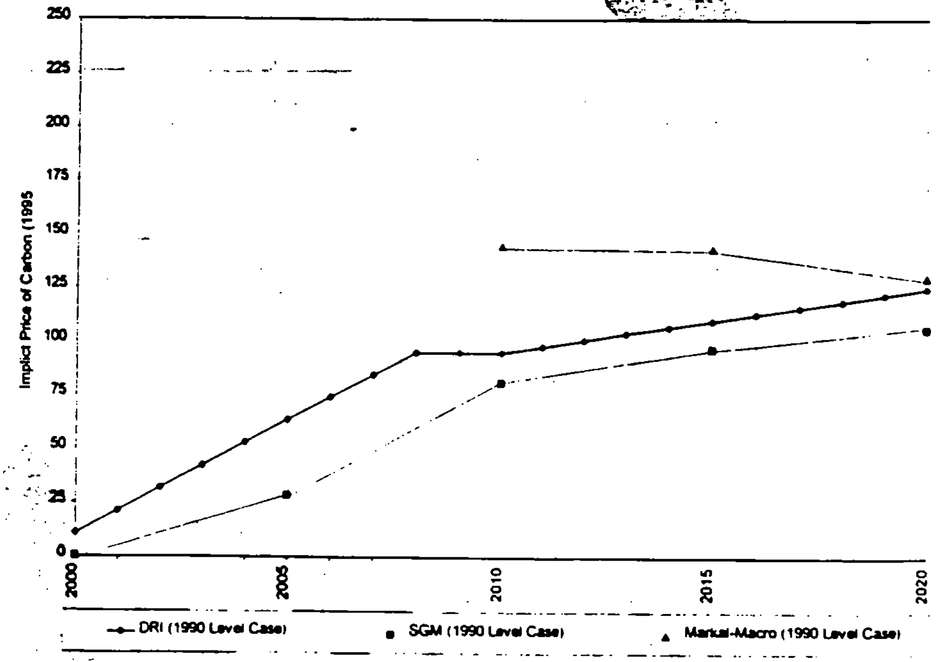
Estimates of permit prices are around $100 per ton of carbon in 2010 and rising slightly thereafter, and are consistent across models. While the three models used for this analysis vary in structure and often in terms of macroeconomic outcomes, they generate fairly consistent results as to the implicit price of carbon in the economy. Table 3 presents the results obtained by the three models for the value of a permit to emit a ton of carbon. Figure 1 shows the path for the value of carbon in these models. All of these estimates pertain to the "starting point" option in which emissions are frozen at their 1990 level in 2010 and thereafter.

Table 3: The Implicit Price of Carbon (1995$) in 2010 and 2020
1990 Level Case, No International Trading

	2010	2020
DRI-DRI Energy	95	125
SGM	81	106
Markal-Macro	145	130
NEMS	n/a	n/a

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP. SGM permit prices are calculated using the rate of change in carbon to GDP (C/GDP), which incorporate emission rates by the different fuel types. NEMS estimates are forthcoming.

Figure 1: Price Path of the Implicit Price of Carbon (1995$)
1990 Level Case, No International Trading



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP. SGM permit prices are calculated using the rate of change in C/GDP. SGM and Markal-Macro models use data and generate results in five year intervals.

The DRI model concludes that an implicit price of $95 (1995$) per ton of carbon in 2010 would result in stabilization. The Markal-Macro model estimated $145 (1995$) while the SGM model predicted about $81 (1995$), in 2010.[2] A permit price of $100 per ton is the equivalent of a price increase of 26 cents per gallon of refined petroleum product, $1.49 per thousand cubic feet of natural gas, $52.52 per ton of coal, and 2 cents per kilowatt hour of electricity produced.

Meaning $100 increase right?

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[2] The higher permit price from the Markal-Macro model reflects, in part, differences in model structure, but results mostly from differences in the calibrations of baseline emissions.

[illegible] how much would [illegible] prices [illegible] on percentage basis?

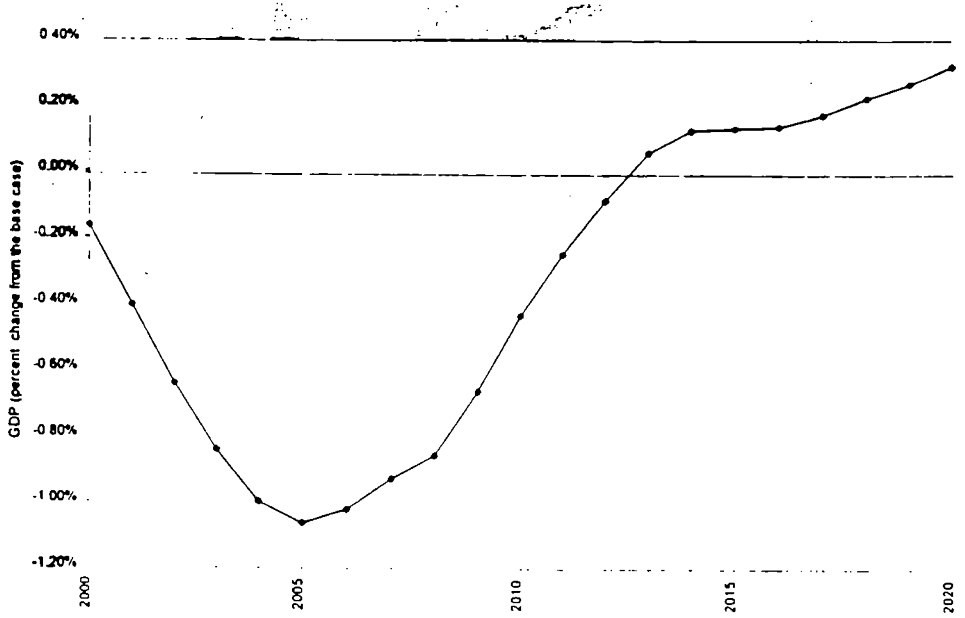
What is price per ton of carbon [illegible] in base case? [illegible] is [illegible] per ton [illegible]

The models also agree that this implicit price of carbon grows somewhat over time. This reflects the fact that the 1990 emission ceiling becomes a progressively more binding constraint over time, given projected growth in base case emissions. By the year 2020, the implicit price of carbon rises to $125, $106 and $130 per ton (1995$) in the DRI, SGM, and Markal-Macro models, respectively.

Emissions reductions lead to small reductions in short-term economic growth (GDP), but growth later appears to recover. The burden of reducing carbon and other greenhouse gas emissions leads to short-term reductions in economic growth as measured by GDP. These reductions, however, are not large and, in many instances, are recovered in later years.

Results from the DRI model are presented in Figure 2. The results indicate that there is an initial GDP loss as the emission-limiting policy begins to be phased in. These losses cumulate to a peak loss of about one percent of total economic output in the year 2005 -- that is, the economy's growth slows until the size of the economy is, at worst, about one percent smaller in that year when compared to the base case. After 2005, the economy actually grows faster than it would have absent climate change policy and starts to make up the lost ground. By the year 2013, the economy is back to the point at which it would have been had no policy been enacted. In subsequent years, the economy improves slightly compared to the "no policy" base case--this differential reaches 0.3 percent by 2020, the last year of the model run.

Figure 2: DRI-DRI Energy 1990 Level Case,
No International Trading--Gross Domestic Product

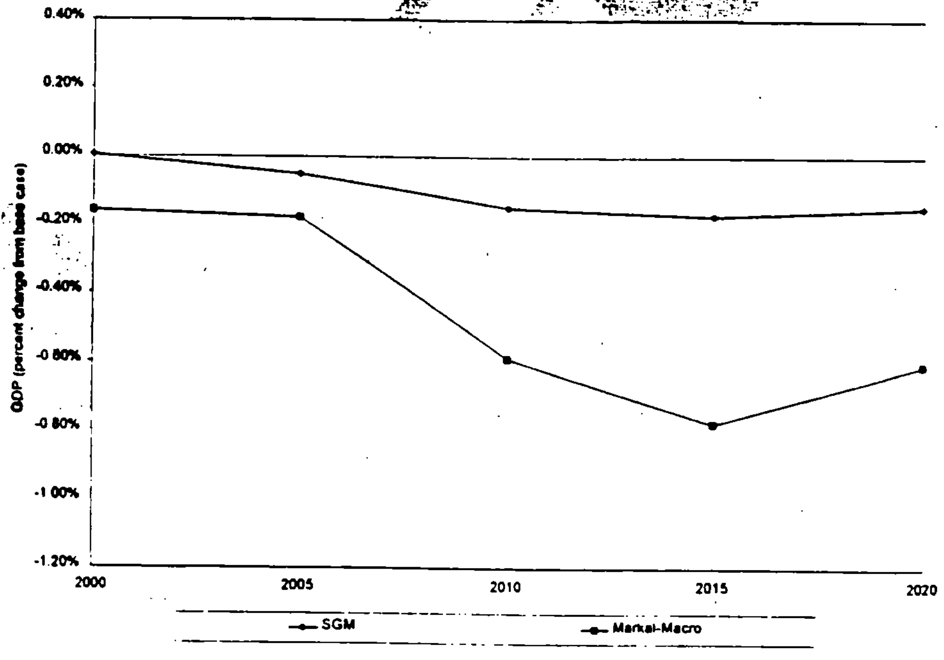


Note. Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP

This improvement occurs in the DRI model because the emissions reduction policies modeled have some effects that favor savings and investment at the expense of consumption. If the Federal government auctions off emissions permits, it acquires the wherewithal to reduce the deficit (or retire debt) and, in effect, increase the nation's savings. This allows the cost of capital to fall and favors investment. The marginal profitability of investment also rises under these policies because new investment allows firms to neutralize higher energy costs. In effect, capital is a long-term substitute for energy and is favored after a transition period. Thus, the cost of investment falls and the incentive to invest is strengthened. This faster rate of investment (discussed in greater detail below) gives the economy a newer and larger capital stock: as a result the economy's ability to grow improves until it actually reaches a modestly higher growth path in the years following the transition.

Figure 3 shows comparable results for the SGM and Markal Macro models. In contrast to the DRI model, which focuses on short-term transition issues and may, therefore, tend to produce larger estimates of GDP losses, the SGM and Markal-Macro models move quickly through these issues and focus on longer-term prospects. The SGM model estimates peak losses for the economy of 0.17 percent of GDP in 2015, but the economy then stabilizes through 2020.

Figure 3: SGM and Markal-Macro 1990 Level Case
No International Trading, Gross Domestic Product



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in C/GDP.

The Markal-Macro simulation results show a reduction in GDP of 0.60 percent from baseline in 2010 in the stabilization case. GDP remains below baseline levels throughout the forecast horizon. The GDP impact profile reflects the model structure, which represents the base case solution as a set of optimal energy use and technology choices given fuel prices, technology characteristics, and discount rates. Since a carbon constraint limits the use of fuels and technologies that would otherwise be chosen, projected GDP must fall. Moreover, since the balance between investment and consumption is optimized within each case considered, economic welfare cannot be increased by an investment-oriented revenue recycling scheme. Consequently, although investment will adjust, the maximization of economic welfare under a carbon constraint does not lead to higher GDP in the future years in the Markal-Macro model.

The models used by the IAT offer a similar picture in some regards--all show initial losses in aggregate economic output that are not very large (even the DRI peak loss is spread over five years). But they also differ in predictable ways, given their structure. A recent analysis by Dr. Robert Repetto and Dr. Dunkin Austin of the World Resources Institute examined 162 analyses of climate change policy and found that model structure can account for two-thirds of the difference in results, if environmental benefits are ignored.[3]

Disequilibrium macro models, such as DRI, tend to identify deeper transitional losses and steeper transitional rebounds. Computable general equilibrium models, such as SGM, see more sanguine short-term effects and see the economy stabilizing after a more frictionless adjustment. The SGM model, however, is less flexible than some computable general equilibrium model because it does not allow instantaneous shifts in capital. The SGM model maintains vintaged capital stock in the electricity sector and retires old electricity related capital only when it cannot cover operating expenses or reaches its fixed lifetime. This feature allows the analysis to incorporate the costs of reallocating capital stock.

Which, then, is right? DRI's transitional losses may be overstated, but so would be the rebound and the shift to a higher growth path it estimates for later years. SGM and Markal-Macro probably understate the transitional problem, but also avoid the later-year growth surge that DRI sees as driven by higher levels of investment. The models probably serve as brackets for the range of reasonable estimates of the economic effects of an emissions freeze at 1990 levels in 2010 and thereafter.

Unemployment and Inflation. The effect of the emissions stabilization policy results in approximately a 0.2 percentage point increase in the unemployment rate from 2001 through 2011, with a peak increase of about 0.4 percentage points in 2015, as estimated using the DRI model. The unemployment rate first rises as GDP falls, but then returns to its pre-policy level by 2012, as shown in Figure 4. The inflation rate increases by about 0.3 percentage points until 2009, measured by the annual rate of change in the Consumer Price Index (CPI). The annual rate of change in the CPI declines by about 0.1 to 0.2 percentage points per year for 2010 through 2020, as shown in Figure 5.

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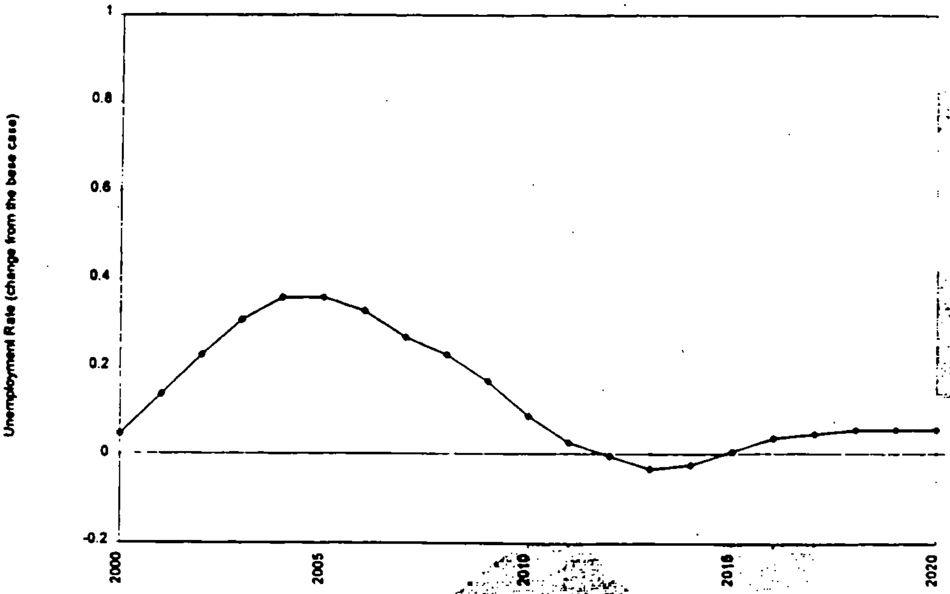
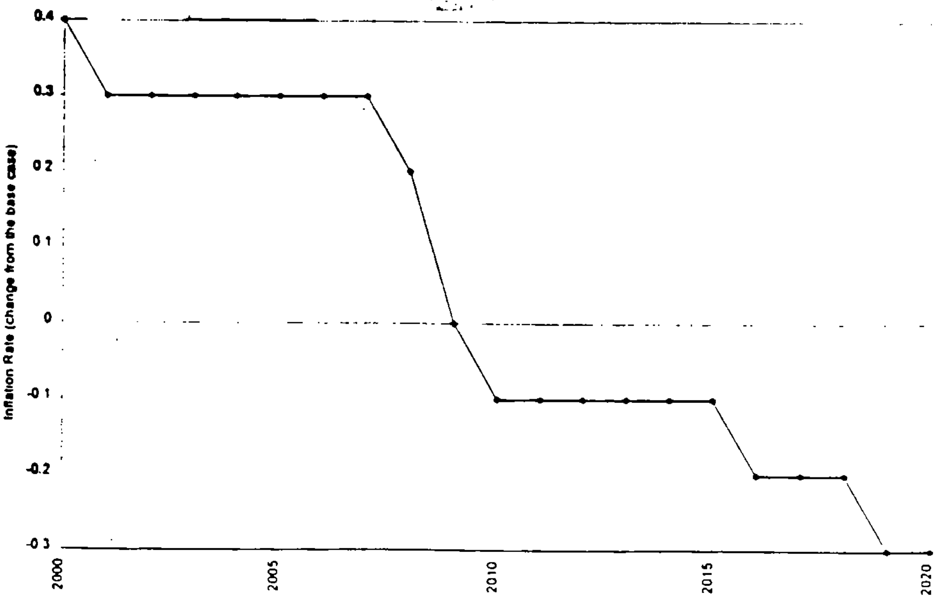
[3] Repetto, Robert and Dunkin Austin. "The Cost of Controlling CO2 Emissions: A Guide for the Perplexed." *World Resources Institute* (Forthcoming).

Figure 4: DRI-DRI Energy 1990 Level Case, No International Trading--Unemployment Rate



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 5: DRI-DRI Energy 1990 Level Case, No International Trading--Inflation Rate

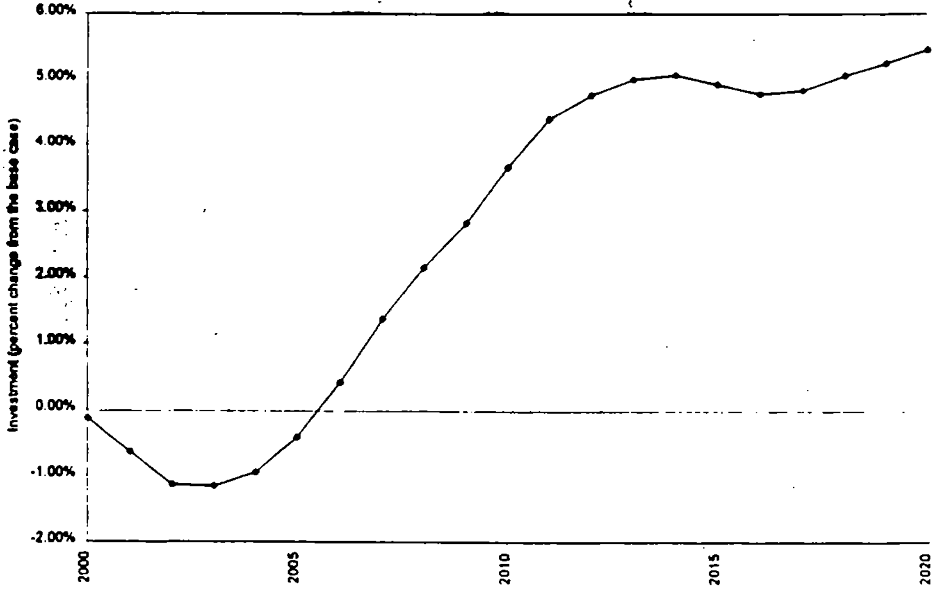


Note. Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP

Investment policies are key to getting the economy back on track. In the baseline forecast, slow labor force growth of 0.8% per year leads to slow potential GDP growth, which results in slow capital stock turnover. The slower rate at which the capital stock is renewed is of direct consequence to mitigating carbon and other related emissions, since improvements in energy-efficiency or carbon-abating technologies generally must be embodied in the capital stock in order to be effective. Thus, any global climate change policy, to be effective, must focus on investment at the expense of consumption. The deficit reduction policy option, one of the several revenue recycling options examined, promotes savings, which boosts this investment.

The DRI model suggests that investment under a climate change policy scenario begins to exceed investment in the baseline by 2006, as seen in Figure 6. By the time the policy is fully implemented in 2010, investment exceeds the baseline by about $50 billion (1992$), with this difference rising to about $100 billion in 2020. Personal Consumption Expenditures (PCE), on the other hand, remain below the baseline level throughout the forecast period, so that PCE drops by about $80 billion in 2008, as seen in Figure 7. After the trough in 2008, PCE gradually moves toward baseline by 2020.

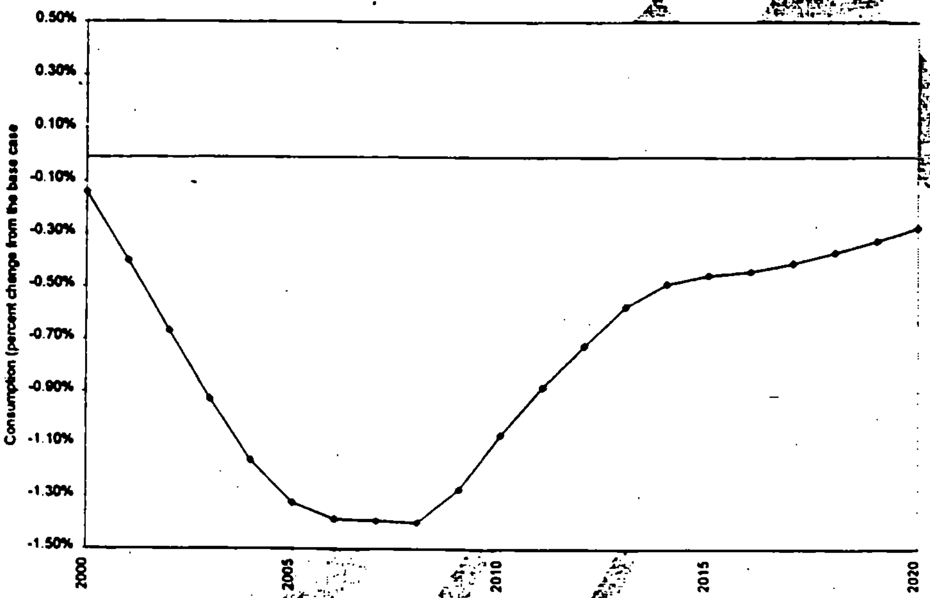
Figure 6: DRI-DRI Energy 1990 Level Case, No International Trading--Investment



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

The faster rate of investment drives the rebounding of real economic growth in the later years of the model simulation. But it should be noted that consumption does not rebound in the same manner, although it does recover from its peak losses, as seen in Figure 7. But consumption can be taken as the measure of economic activity that is closer to consumer "welfare" than total GDP, which includes investment, because consumption includes all activities that are of direct consequence to households. Thus, while increases in investment drive the economy's growth path back to and perhaps even above its original trend, it does so by diverting resources away from uses that allow consumers to enjoy them directly in the short term.

Figure 7: DRI-DRI Energy 1990 Level Case, No International Trading–Consumption



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

The paths of consumption and investment following the imposition of a climate change policy depend critically on assumptions regarding the manner in which revenue flows related to the allocation of emissions permits are managed and the conduct of monetary policy by the Federal Reserve. These sensitivities are discussed in a later section.

Among fuels, demand for coal bears the brunt of greenhouse gas stabilization The reduction in energy-related greenhouse emissions in the 2010 time frame will require a combination of three types of energy system changes: increased end-use efficiency, reduced end-use activity, or fuel-switching towards an increased market share of low- and no-carbon fuels in the energy mix. Increased end-use efficiency or reduced end-use activity tends to lower the demand for all fuels, while fuel-switching favors low- and no-carbon fuels, such as natural gas and renewable energy, relative to coal. The three models used by the IAT place different emphasis on these three strategies, with corresponding differences in projected fossil fuel impacts.

Table 4 presents the effects of carbon-limiting policies on the economy's energy consumption and fuel mix. Using the DRI model, total energy consumption falls from 105 quadrillion Btus (quads) in the base case in 2010 to a level of 88 quads under the policy, a reduction of 16 percent in that year. By 2020, energy consumption in the economy has declined by 20 percent, from 109 quads to 87 quads, when compared to the base case for that year. The table shows comparable results using the Markal-Macro model, when the 1990-level emissions freeze produces a decline in projected energy consumption of 14 percent in 2010 and 16 percent in 2020. SGM model results are similar to both the DRI and Markal-Macro results; energy consumption drops by 15 percent in 2010, and 20 percent in 2020.

Table 4: Effects of Carbon Stabilization on Energy Consumption and Fuel Mix (quadrillion Btus)

	1990	2010		2020	
	Actual	Base case	1990 Level Case, No International Trading	Base case	1990 Level Case, No International Trading
DRI-DRI Energy					
Total U.S. Energy Consumption	84.3	105.3	88.2	108.9	86.7
Natural Gas	19.3	27.4	22.9	29.8	24.9
Oil	33.6	41.1	35.6	44.1	37.4
Coal	19.0	24.3	17.2	25.8	15.2
SGM					
Total U.S. Energy Consumption	84.3	107.0	91.4	113.0	90.0
Natural Gas	19.3	33.2	33.1	37.7	36.7
Oil	33.6	36.5	33.1	39.0	34.0
Coal	19.0	23.9	11.3	25.8	8.5
Markal-Macro[1]					
Total U.S. Energy Consumption	84.3	107.8	92.6	115.6	96.7
Natural Gas	19.3	29.0	30.7	35.1	36.7
Oil	33.6	43.4	37.9	45.0	40.1
Coal	19.0	22.5	9.4	24.6	4.7
NEMS					
Total U.S. Energy Consumption	n/a	n/a	n/a	n/a	n/a
Natural Gas	n/a	n/a	n/a	n/a	n/a
Oil	n/a	n/a	n/a	n/a	n/a
Coal	n/a	n/a	n/a	n/a	n/a

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP. SGM uses a similar rate of change in C/GDP. 1. Under the Markal-Macro results, the increase in the use of renewable energy sources, such as wind, account for the difference the total U.S. energy consumption and the sum of the component fuels. NEMS estimates are forthcoming.

DRI, Markal-Macro, and SGM demonstrate that dampened energy consumption and reduced carbon emissions are concentrated in coal use. As seen in Table 5, DRI results show that about 57 percent of the total emissions reductions in 2010 result from reduced demand for coal, 30 percent from oil, and 13 percent from natural gas. By 2020, 65 percent of emission reductions are generated from reductions in demand for coal. This translates to a 25 percent total emission reduction for coal in 2010 and a 36 percent reduction in 2020. Markal-Macro produces somewhat similar results: it shows that about 57 percent of total emissions reductions in 2010 occur due to reduced coal use; and 16 percent due to reduced oil use; while natural gas consumption is 5 percent above the base case. By 2020, coal accounts for about 80 percent of emissions reductions. The SGM model results are also similar; i.e., coal is responsible for 80 percent of emissions reductions in 2010 and 2020.

The different spread of percent of total emissions reductions by fuel occurs because renewable energy sources and increases in the consumption of natural gas play important roles in the Markal-Macro and SGM models. It is also true because DRI's model sees strong transportation demands and more limited technological prospects for serving it, while transportation choices do not take into account price expectations. This is in contrast to DRI's treatment of the utility sector, which is relatively forward looking when examining fuel choices.

Table 5: 1990 Level Case, No International Trading—
Percent of Total Emissions Reduction by Fuel

	2010	2020
DRI-DRI Energy		
Natural Gas	13	8
Oil	30	28
Coal	57	65
SGM		
Natural Gas	0	3
Oil	18	18
Coal	82	79
Markal-Macro		
Natural Gas	-5	-4
Oil	16	15
Coal	57	80
NEMS		
Natural Gas	n/a	n/a
Oil	n/a	n/a
Coal	n/a	n/a

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP. NEMS estimates are forthcoming.

On the demand side, according to DRI, about 46 percent of total emission reductions in 2010 come from the electric sector due to fuel switching and decreases in demand for electricity, 26 percent come from reduced demand for transportation and 19 percent come from reduced demand by the industrial sector, as shown in Table 6. The commercial and residential sectors contribute a combined 8 percent to the total of emissions reductions. The corresponding estimates obtained from the Markal-Macro model show that electricity uses account for 40 percent of total reduction in emissions, and transportation, industrial, and residential and commercial uses for 16 percent, 17 percent, and 15 percent, respectively.

Table 6: 1990 Level Case, No International Trading
Percent of Total Emissions Reduction by Demand Sector

	2010	2020
DRI-DRI Energy		
Residential	5	4
Commercial	3	2
Industrial	19	21
Transportation	27	25
Electricity	46	47
SGM		
Residential	n/a	n/a
Commercial	n/a	n/a
Industrial	n/a	n/a
Transportation	n/a	n/a
Electricity	n/a	n/a
Markal-Macro		
Residential and Commercial	15	15
Industrial	17	22
Transportation	16	17
Electricity	40	53
NEMS		
Residential	n/a	n/a
Commercial	n/a	n/a
Industrial	n/a	n/a
Transportation	n/a	n/a
Electricity	n/a	n/a

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP. SGM uses a similar rate of change in C/GDP. SGM does not generate data by demand sector. NEMS estimates are forthcoming.

Thus, across models and when viewed from different perspectives, the majority of reductions in emissions obtained under the broadest strategies comes from reducing utility consumption of coal. Reducing coal use under utility boilers is generally the largest, cheapest option to reduce carbon emissions in the economy. This is accomplished through better operating rates and through the substitution of gas-fired combined-cycle units for coal-fired units. The implicit price of carbon obtained in most model runs is usually the one that accomplishes this transition in electricity baseload. The range of carbon values -- generally about $100 per ton in the no trading cases -- is as high as it is because most coal-fired units are fairly old and already fully amortized. Thus, their product costs mainly consist of fuel and operating and maintenance expenses but not capital costs. The price of coal, therefore, must rise considerably to make coal-fired electricity more expensive on the margin than electricity generated by a new gas-fired plant that entails new capital costs.

International trading of carbon permits among the Annex I countries leads to sizable reductions in costs needed to stabilize emissions. The discussion so far has centered on the how the U.S. economy reacts when the United States independently reduces emissions. However, establishing an international market to trade emissions permits is a preferred to unilateral action that has been proposed by the United States for inclusion in a multinational agreement. The purpose of such a market would be to increase the efficiency and lower the cost of reducing global emissions by giving all emitters the incentive to search for least-cost solutions across national boundaries.

In brief, under a system of tradable permits, a country could either reduce emissions domestically or purchase additional emissions "rights" (i.e., permits) from other countries. Countries with opportunities to reduce emissions that cost less than the going permit price would have an incentive to reduce emissions and sell their "right to emit" for cash. Countries that had only high cost options to reduce emissions (that is, reduction options that cost more than the permit prices) could purchase emission permits. The forces of supply and demand would set the permit price and the market incentives would push the trading group, as a whole, to institute the least cost emissions reductions first. As a result, it costs less for the trading group, as a whole, to reach the target emissions levels, than it would for each country unilaterally to reduce its emissions to the target levels. Such a policy, of course, raises a variety of legal and institutional questions regarding how it would be implemented with certainty. These issues are not addressed here: instead, the simple assumption is made that the policy works as intended and least-cost approaches to abating carbon are identified and traded.

Using the SGM model, the IAT modeled two international trading scenarios. In the first, it examined the affects of establishing a permit market among the United States, Canada, Western Europe, Eastern Europe, Japan, the Former Soviet Union (FSU), and Australia (collectively known as Annex I countries under the Climate Convention). In the second scenario, it examined the effects of Joint Implementation, that is, establishing a wider permit market that includes the rest of the world. These scenarios are compared to a scenario in which each of the Annex I countries independently implemented our "starting point" scenario for stabilizing carbon emissions; that is, stabilizing emissions at 1990 levels in 2010 with a ten year phase in, where revenues are used to reduce the deficit, and under the assumption of moderate technological change (i.e., a 0.25 percent increase over the baseline in the annual increase in energy or carbon efficiency).

International emissions trading calls into question one of the basic assumptions regarding international compliance when performing the estimates. This concerns the case of the FSU. The "starting point" case assumes that all countries are restricted to their 1990 emissions level before they trade. The FSU nations, however, will have emissions below their 1990 levels for years to come. Thus, under this rule, they would be able to sell to other nations their "right to emit" up to their 1990 levels, but would not have to perform any actual emissions reductions. Thus, emissions trades would not result in "corresponding reductions" in annual emissions.

The IAT performed its analysis both with and without "corresponding reductions." The case without "corresponding reductions" allows the FSU to sell emissions rights up to its 1990 base. The case with "corresponding reductions" does not allow these trades. Instead the IAT specified that if a nation's emissions were below their 1990 level in the base case, its baseline for the purposes of trading was shifted down from the 1990 level to whatever the nation's actual emissions would be. For example, the FSU had carbon emissions of 1050 million metric tons (MMT) in 1990, and is projected to have emissions of 836 MMT in 2010. Their baseline in

2010, therefore, is 836 MMT, even though it is lower than the 1990 level. Thus, any tons "sold" from the FSU in these simulations represent actual emissions reductions. The results obtained using the SGM model appear in Tables 7a and 7b.

Under the Annex I trading scenario, the United States, Canada, Western Europe, Japan, and Australia each bear real costs for emissions reduction. The losses experienced by the different nations reflect the economic assumptions made for them (which are presented earlier in this report, in Table 2) and their energy policies to date. Japan, for example, is projected to have relatively slow economic growth and already has relatively high energy prices and an extensive nuclear program. Thus, it is not projected to have strong growth in emissions over the next few decades. Japan has a high implicit price of carbon ($268 per ton) as shown in Table 8. Western Europe fares somewhat worse than the United States, since its economic growth is projected to be stronger, and its energy policies have already been raised.

Table 7a: SGM 1990 Level Case--GDP Impacts to Annex I Countries
No Trading vs. Annex I Trading,

	No Trading					Annex I Trading (With Corresponding Reductions)				
	2000	2005	2010	2015	2020	2000	2005	2010	2015	2020
Australia	0.0%	-0.2%	-0.5%	-0.4%	-0.2%	0.0%	-0.1%	-0.3%	-0.2%	-0.1%
Canada	0.0%	-0.4%	-1.1%	-1.1%	-1.1%	0.0%	-0.1%	-0.4%	-0.3%	-0.2%
Eastern Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.3%
Former Soviet Union	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%	0.6%	0.5%
Japan	0.0%	-0.2%	-0.6%	-0.4%	-0.3%	0.0%	-0.1%	-0.2%	-0.1%	-0.1%
Western Europe	0.0%	-0.2%	-0.7%	-0.4%	-0.2%	0.0%	-0.1%	-0.3%	-0.2%	-0.1%
United States	0.0%	-0.1%	-0.2%	-0.2%	-0.2%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in C/GDP.

Table 7b: SGM 1990 Level Case--GDP Impacts to Annex I Countries
No Trading vs. Annex I Trading

	No Trading					Annex I Trading (With out Corresponding Reductions)				
	2000	2005	2010	2015	2020	2000	2005	2010	2015	2020
Australia	0.0%	-0.2%	-0.5%	-0.4%	-0.2%	0.0%	0.0%	-0.1%	-0.2%	-0.1%
Canada	0.0%	-0.4%	-1.1%	-1.1%	-1.1%	0.0%	0.0%	-0.2%	-0.2%	-0.2%
Eastern Europe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.7%	0.5%
Former Soviet Union	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.5%	0.5%
Japan	0.0%	-0.2%	-0.6%	-0.4%	-0.3%	0.0%	0.0%	-0.1%	-0.1%	-0.1%
Western Europe	0.0%	-0.2%	-0.7%	-0.4%	-0.2%	0.0%	0.0%	-0.2%	-0.2%	-0.1%
United States	0.0%	-0.1%	-0.2%	-0.2%	-0.2%	0.0%	0.0%	-0.1%	-0.1%	-0.1%

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in C/GDP.

GDP losses in Canada are the most severe among the Annex I countries. Canada is already less carbon intensive, but not as energy efficient as other Annex I countries. For example, Canada's carbon to population ratio is about 17 percent below that of the United States, while its energy to GDP ratio is about 46 percent higher. Canada also relies more heavily on non-carbon sources of energy, such as hydroelectrical generation, making emissions reductions more difficult to come by.

Table 8 shows the implicit price of carbon by country without trading, trading with Annex I countries, and with Joint Implementation with the developing countries. The United States shows smaller output losses than Japan or Western Europe predominantly because it has more "cheap" carbon-abating opportunities. Thus, it is somewhat easier for the United States to reach emission targets than other regions, which have already "picked the low fruit."

Table 8: Implicit Price of Carbon (1995$) Under Annex I Trading and Joint Implementation--SGM 1990 Level Case

	2010					2020				
	No Trading	Annex I Trading		Joint Implementation		No Trading	Annex I Trading		Joint Implementation	
		with CR	without CR	with CR	without CR		with CR	without CR	with CR	without CR
Australia	132	56	23	20	9	126	50	35	16	12
Canada	222	56	23	20	9	252	50	35	16	12
China	•	n/a	n/a	20	9	•	n/a	n/a	16	12
Former Soviet Union	0	56	23	20	9	0	50	35	16	12
Eastern Europe	0	56	23	20	9	0	50	35	16	12
India	•	n/a	n/a	20	9	•	n/a	n/a	16	12
Japan	268	56	23	20	9	257	50	35	16	12
Korea	•	n/a	n/a	20	9	•	n/a	n/a	16	12
Mexico	•	n/a	n/a	20	9	•	n/a	n/a	16	12
Western Europe	130	56	23	20	9	139	50	35	16	12
United States	82	56	23	20	9	107	50	35	16	12
Rest of World	•	n/a	n/a	20	9	•	n/a	n/a	16	12

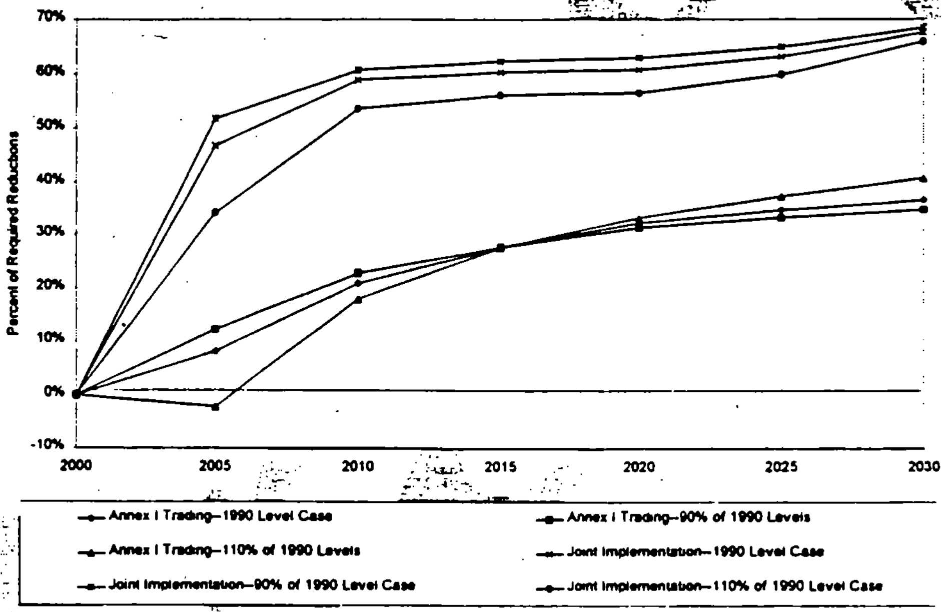
Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in C/GDP. • indicates the cell is blank because the country is a non-Annex I country. CR=corresponding reductions.

Under Annex I trading with "corresponding reductions," the implicit price of carbon falls dramatically--to $56 in 2010 and $50 in 2020. All countries gain through these lower permit prices, because as a whole they achieve stabilization at 1990 levels more cheaply. The source of these cheap emissions is the FSU and the Eastern European nations. The implicit price of carbon falls because it is cheaper for all of the industrialized nations to pay for carbon abatements in those nations (due to lax environmental standards and slow economic growth) than to pursue domestic options only. These nations gain as they become emissions permit sellers under Annex I trading. If "corresponding reductions" are not required, the FSU would be allowed to sell permits up to its 1990 level further depressing the price to $23 per ton in 2010 and $35 in 2020.

Under Annex I trading with "corresponding reductions," the United States purchases 72 million metric tons of permits from the FSU and Eastern Europe in 2010 at a cost of $4 billion ($95), which offsets $5 billion of abatement expenditures within the United States. U.S. purchases of permits abroad increases to 157 million metric tons of permits in 2020 at a cost of $7.8 billion, which offsets $12.2 billion of cost increases that would have occurred domestically if the U.S. did not participate in international trading.

Joint Implementation with developing countries reduce the costs of permit prices even further. Joint implementation -- emissions trading on a global scale -- reduces the permit price further, to $20 in 2010 and $16 in 2020 (with corresponding reductions). If corresponding reductions are not required the implicit price of carbon falls to $9 in 2010 and $12 in 2020. Under this broader market for tradeable emissions permits the FSU and Eastern Europe lose their monopoly on permit sales. Specifically, Joint Implementation encourages China and India to reduce their use of coal and enter the market as emissions permit sellers. As shown in Figure 8, imports of carbon permits are greater under Joint Implementation than under Annex I trading.

Figure 8: U.S. Imports of Carbon Permits Under Alternate Mitigation Targets--Annex I Trading and Joint Implementation

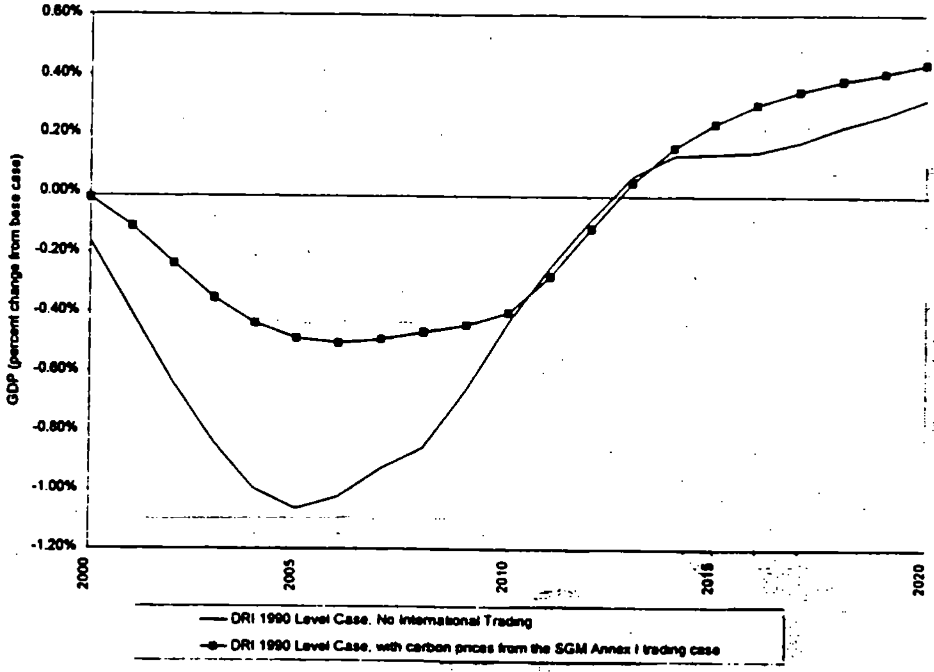


Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in C/GDP.

Using the SGM implicit carbon prices from Annex I trading to simulate macroeconomic conditions for the DRI Model moderates the short-term economic effects of emissions reductions. The IAT incorporate Annex I implied permit prices estimated by the SGM model under permit trading, with corresponding reductions into the DRI model. For in 2010 SGM's Annex I trading implicit price of carbon estimate ($56) was incorporated into the DRI model.

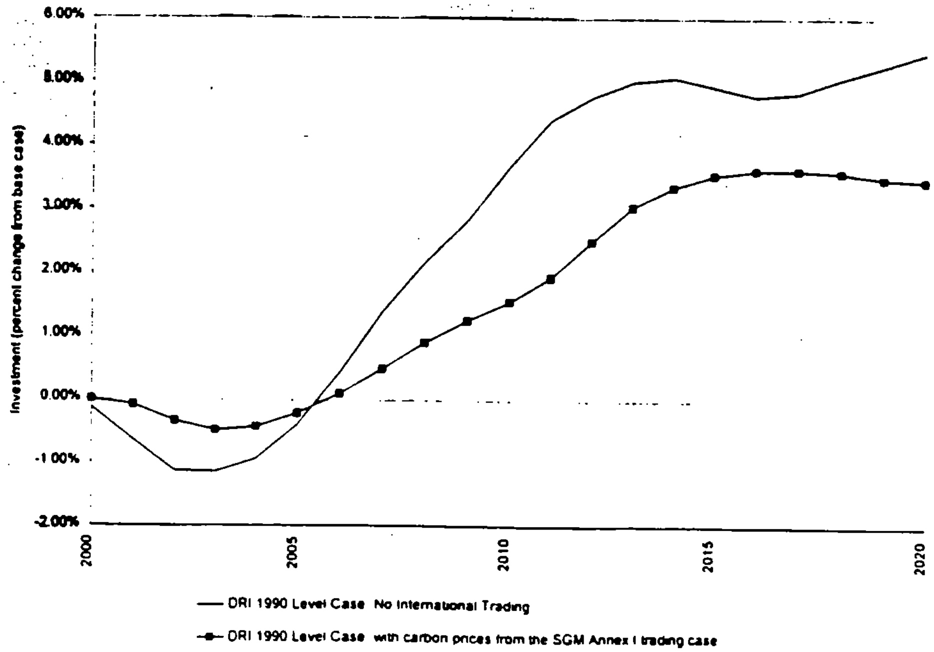
The results from the DRI model using the SGM permit trading implied permit prices are represented in Figures 9, 10, and 11. As shown in Figure 9, the maximum effect on GDP is less than half, 0.5 percent less than the baseline in 2006 compared with about one percent in 2005. The lower permit prices also has a somewhat dampening effect on the increase in investment under the no trading case, but shows a much improved effect on the impact on consumption, a -0.7 percent change in 2010 compared with a -1.4 percent change in 2008, and reaches the baseline consumption estimates in 2018.

Figure 9: DRI-DRI Energy 1990 Level Case with and without Annex I Trading--GDP



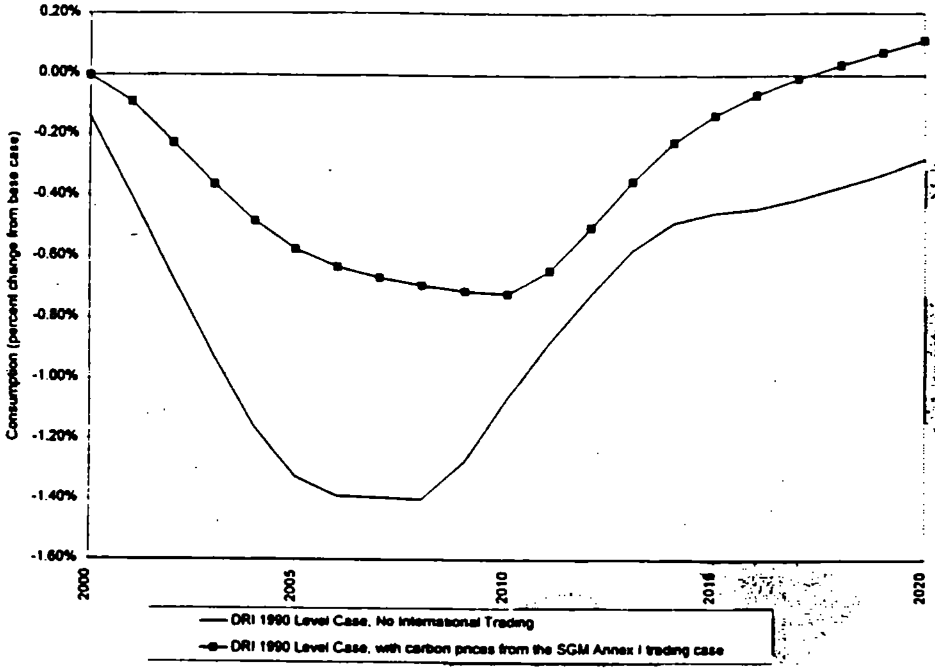
Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 10: DRI-DRI Energy 1990 Level Case with and without Annex I Trading--Investment



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 11: DRI-DRI Energy 1990 Level Case with and without Annex I Trading--Consumption



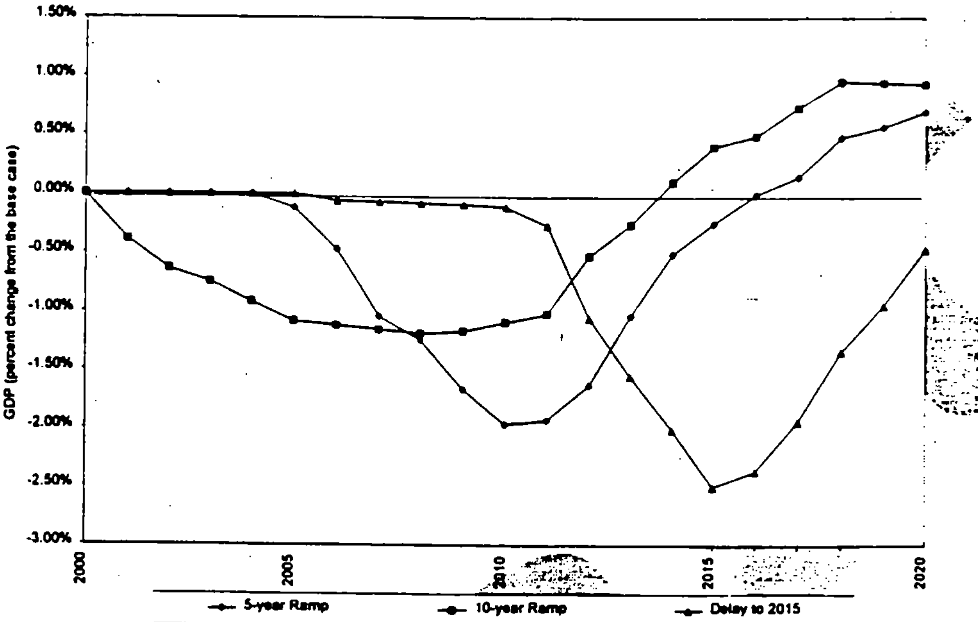
Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Important Sensitivities

The following represents a number of variations from the "starting point" scenario that the IAT analysts examined to address a number of factors that will influence the climate change policy process. These include the effects of: (1) timing, including different transition periods to full implementation and delaying implementation; (2) lower or higher emission level targets; (3) different revenue recycling options, including comparing the deficit reduction case with scenarios where revenues are distributed to consumers, distributed to business, and a combination of both consumers and business; (4) policy announcement on the rate if technological innovation and diffusion as well as the steps needed to achieve a higher level of innovation and diffusion; (5) other collateral environmental benefits; and (6) international trade; and (7) Federal Reserve reaction assumptions in the DRI model.

Increasing the implementation period from 5 to 10 years dampens the negative effects on GDP Delaying implementation until 2015 does little to improve GDP effects. The IAT examined differing effects on GDP of a 5-year and a 10-year implementation period for the "starting point" scenario with the NEMS model. These results are shown in Figure 12. A 5-year ramp-up between 2005 and 2010 results in a maximum output loss in 2010 that is 65 percent greater than that associated with a ten year ramp-up and a return to the baseline two years later. Thus, shorter transition periods result in a more pronounced economic cycle in response to policy--a sharper downturn and deferred recovery.

Figure 12: NEMS 1990 Level Case, No International Trading--Sensitivity to the Length of the Implementation Period and to Implementation Timing



Note: These simulations were conducted using DRI and the NEMS Energy Model and they do not conform in detail to those conducted using DRI and the DRI Energy Model. 5-Year and 10-Year Ramp to 1990 Levels in 2010; 1990 Levels in 2015 using a 5-Year ramp-up. Revenues are used for Federal deficit reduction, assuming 1.25 percent annual decrease in E/GDP.

Figure 12 also shows the result of delaying the implementation by 5 years, to 2015 combined with the shorter 5-year ramp-up period. GDP effects for the delayed case are less severe in the initial period, but become greater than either the 5-year or 10-year ramp-up to stabilization in 2010.

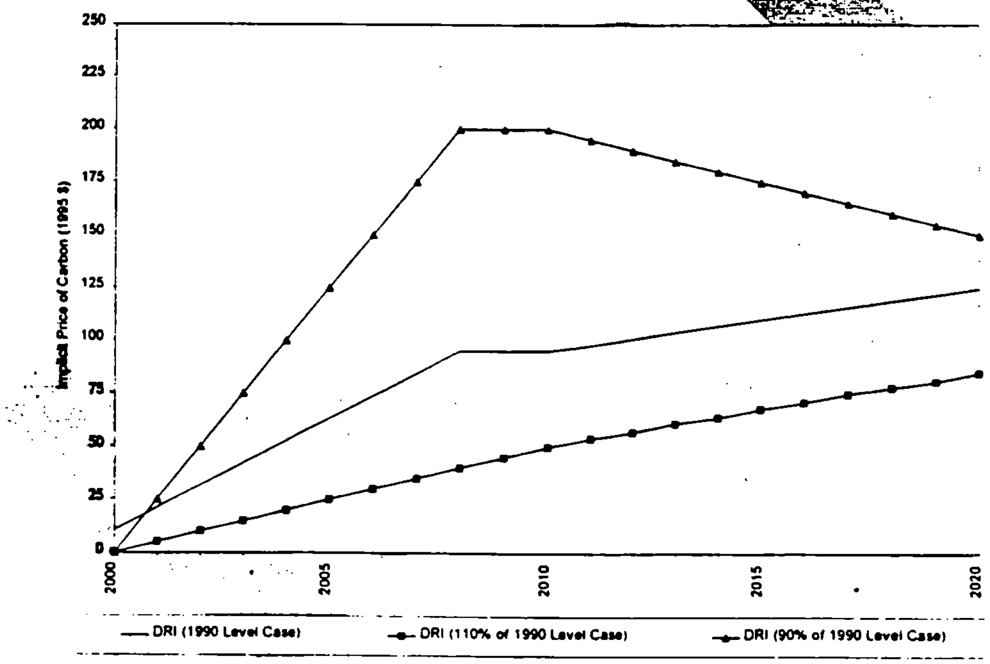
Raising or lowering emission targets lead to obvious results--more stringent emission targets lead to greater economic losses while less stringent ones have less severe impacts The three models were used to analyze how changes in the level of emissions affect the implicit price of carbon. If the emission target for the year 2010 and beyond is raised (made less severe) to a level equal to 110 percent of the 1990 emissions level (that is, to a target of 1,472 million tons as opposed to 1,338 million tons), then the DRI model estimated that the implicit price of carbon drop almost by half -- to about $50 per ton of carbon, while the SGM model dropped from $81 to $37. The very large decline in the implicit price of carbon reflects the fact that additional emissions reductions are progressively harder to find. On the other hand, a more stringent target, one that freezes emissions at 90 percent of their 1990 level in the year 2010 and beyond, leads to an implicit price of carbon of $200 per ton in 2010 and $150 per ton in 2020, according to the DRI model. The SGM model estimated that the implicit price of carbon would be $145 and $183 in 2010 and 2020, respectively. The implicit price of carbon generated by Markal-Macro for the 90 percent of the 1990 level case with no international trading would be $187 and $207 in 2010 and 2020, respectively. Table 9 and Figures 13 and 14 describe the sensitivity of these results using DRI, SGM, and Markal-Macro.

Table 9: Sensitivity of the Implicit Price of Carbon to the Stringency of the Emissions Target No International Trading

	2010	2020
DRI-DRI Energy		
Carbon Emissions 90% of 1990 Level Case	200	150
Carbon Emissions 110% of 1990 Level Case	50	85
SGM		
Carbon Emissions 90% of 1990 Level Case	145	183
Carbon Emissions 110% of 1990 Level Case	37	56
Markal-Macro		
Carbon Emissions 90% of 1990 Level Case	187	207
Carbon Emissions 110% of 1990 Level Case	101	93

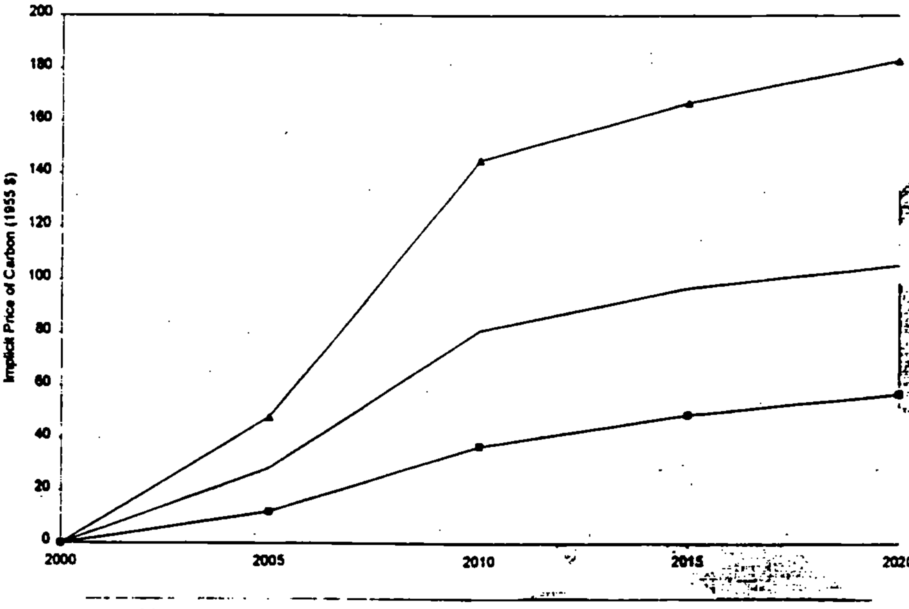
Note: 10 year phase-in with revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP. SGM uses a similar rate of change in C/GDP.

Figure 13: DRI-DRI Energy No International Trading--Sensitivity of the Implicit Price of Carbon to the Stringency of the Emissions Target



Note: 10 year phase-in with revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 14: SGM No International Trading--Sensitivity of the Implicit Price of Carbon to the Stringency of the Emissions Target



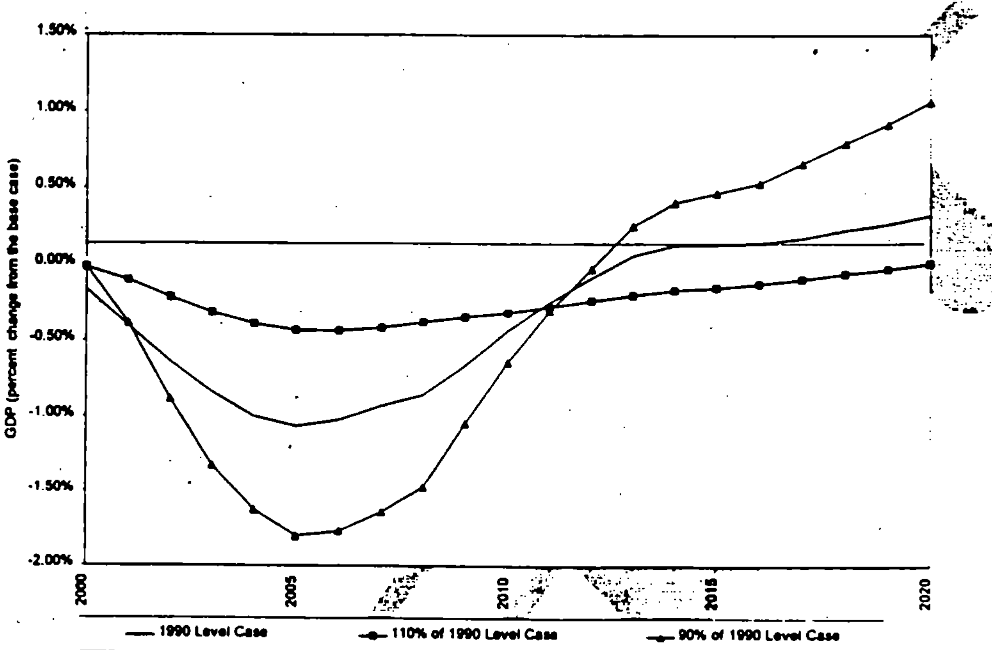
Note: 10 year phase-in with revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in C/GDP.

In 2020, permit prices rise to about $85 compared with the $125 permit price under stabilization. Using the DRI model, an emissions target of 90 percent of 1990 level results in an implicit price of carbon of $200 per ton in 2010 and $150 in 2020. Unlike in the other cases, the implicit price of carbon falls after 2010. This is because the initial price increase is large enough to set in motion a series of capital stock improvements, particularly in utilities, that reduce the ongoing level of emissions by enough to allow the implicit price to fall in the future. Thus, this result is predicated on the idea that future price expectations could be wrong. In fact, if decision makers had perfect price expectations, the implicit price of carbon would lie somewhere between these two values over the period.

It is no surprise that the 90 percent of 1990 emissions case results in a more severe decline of GDP in the transition period. But what is surprising, and questionable, is that this scenario also has a greater long-term potential for economic recovery. As shown in Figure 15, GDP declines to a peak loss of 1.9 percent below the base case in 2005. It recovers to the base case level in 2013 and increases to 1.0 percent above the base case in 2020. The long-term rebound effect results from a greater amount of revenue used for deficit reduction (or debt retirement), which pushes interest rates down substantially and drives up investment. The magnitude of this result is questionable.

The DRI model, as discussed, is prone to depicting large effects of interest rates on investment. Thus, when confronted with a very large implicit price of carbon and, in turn, large amounts of forced saving, either through deficit reduction or by grandfathering these new property rights to firms, it produces much higher levels of investment and a higher long-term growth path. The reality is probably more moderate at both ends. In essence, this case appears to tax the ability of the model to manage these revenue flows.

Figure 15: DRI-DRI Energy No International Trading--Sensitivity of GDP to the Stringency of the Emissions Target



Note: 10 year phase-in with revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

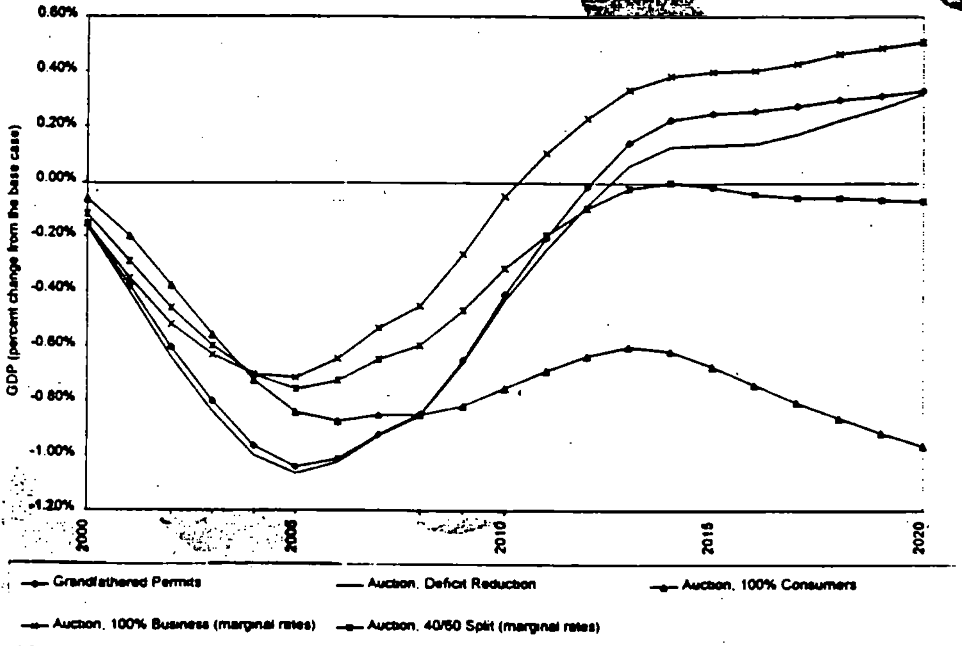
The portion of total emission reductions from coal and oil in both the 90 percent and 110 percent of 1990 Level Case, No International Trading, increases only slightly--about 5 percentage points--while total emission reductions from natural gas change significantly. In 2010, under stabilization, about 13 percent of total emission reductions are from natural gas. Under a 10 percent increase in the target (that is, a target of 90 percent of 1990 emissions), about 9 percent of total emission reductions are from natural gas. This occurs because the substitution of gas for coal in electric utilities is not enough to achieve the bulk of the 90 percent (more stringent) target. Additional emissions reductions must be found, which forces the burden to be spread more evenly among fuel types and sectors.

Adopting a revenue recycling option that favors capital formation leads to less impact on the economy during the transition and greater returns to the economy in the long term. The IAT looked at a number of revenue recycling policies in addition to the deficit reduction case. These options are depicted in Figure 16. These include:

- "grandfathering" permits to producers, meaning that every carbon-emitter would be given sufficient permits to allow them to emit at their 1990 level. The permits allowing them to do so would then be traded freely, allowing a least-cost response to the problem to emerge;

- a 100 percent recycling of any revenues from permit auctions to consumers through a reduction in the personal income tax;
- a 100 percent return to business through a reduction in the marginal rates of the corporate income tax; or
- a 40/60 split to consumers and businesses, in proportion to their shares of energy use, through tax rate reductions.

Figure 16: DRI-DRI Energy 1990 Level Case, No International Trading--Sensitivity of GDP to Revenue Recycling Options



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Assuming a 1.25 percent annual decrease in E/GDP.

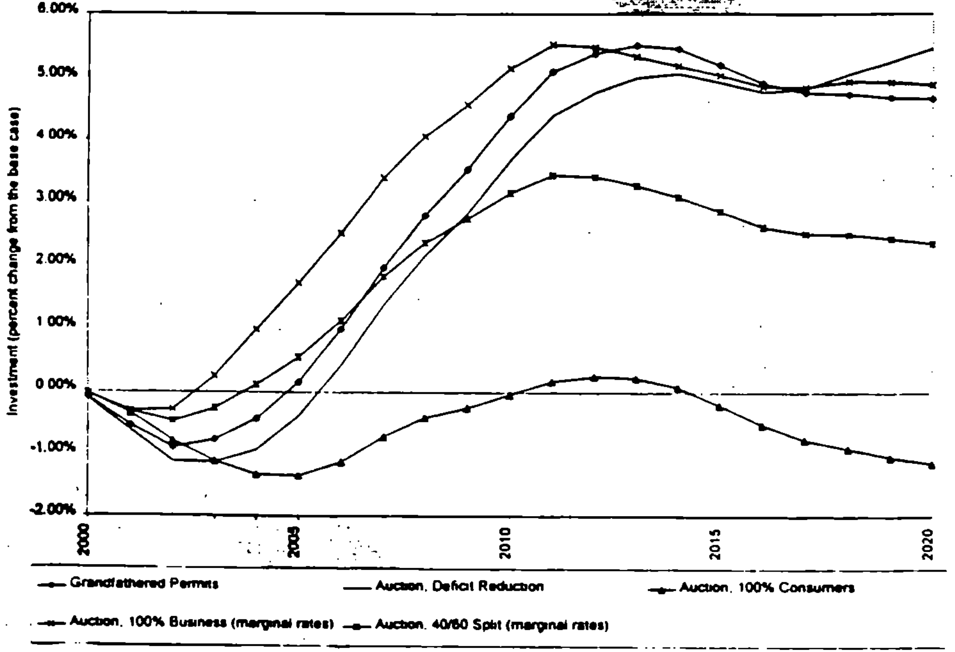
According to the IAT analysis, the revenues generated from the implementation of this policy have the most positive effect when returned through either the deficit reduction plan, grandfathered permits, or to business through lower taxes. Revenue recycled to consumers, in either case, result in a greater and longer-term reductions in GDP, when measured against the baseline, but would have correspondingly lower impacts on consumption.

The revenue recycling options that lead to better economic outcomes are all those associated with greater investment and capital formation. Deficit reduction leads to lower interest rates, which lowers the cost of capital and facilitates investment. Recycling revenues to companies has the effect of increasing savings through apparent profits and provides the wherewithal for greater investment spending. Similarly, grandfathering permits to producers allows them to "assetize" their right to produce emissions. This allows firms to realize gains on this "right" and again provides the wherewithal to invest.

Peak GDP losses during the transition period are less severe for the 100 percent to business and 40/60 split when accomplished through reductions in the marginal tax rates, (about 0.7 percent in 2005), compared with the other recycling options, (between 0.8 and 1.0 percent in that year).

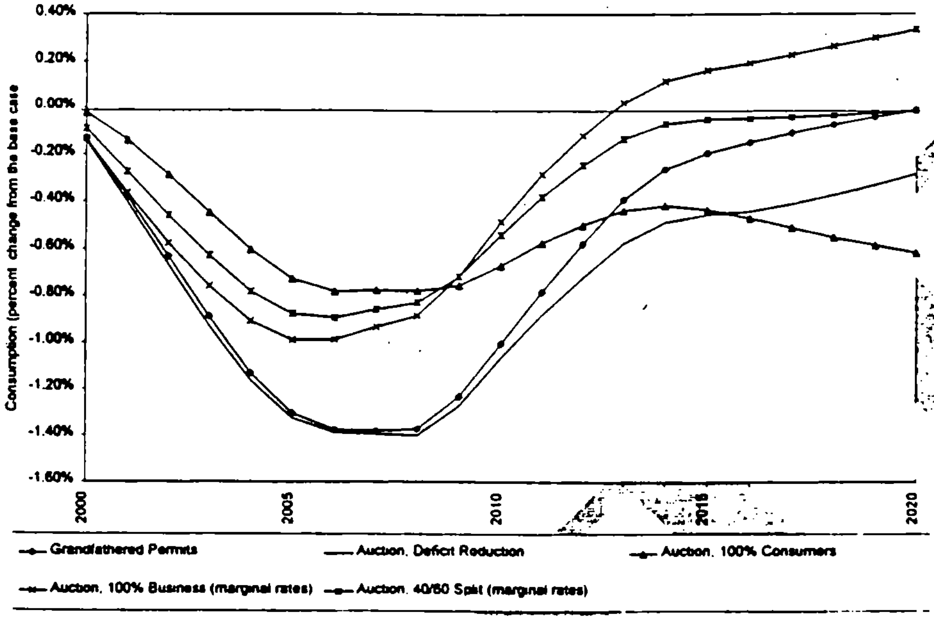
Figures 17 and 18 demonstrate the effects of revenue recycling on investment and consumption, in relation to the effect on GDP, as shown in the previous figure. As these figures show, the key to economic recovery among the revenue recycling options is to improve investment in the economy.

Figure 17: DRI 1990 Level Case, No International Trading--Sensitivity of Investment to Revenue Recycling Options



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Assuming a 1.25 percent annual decrease in E/GDP.

Figure 18: DRI-DRI Energy 1990 Level Case, No International Trading-- Sensitivity of Consumption to Revenue Recycling Options

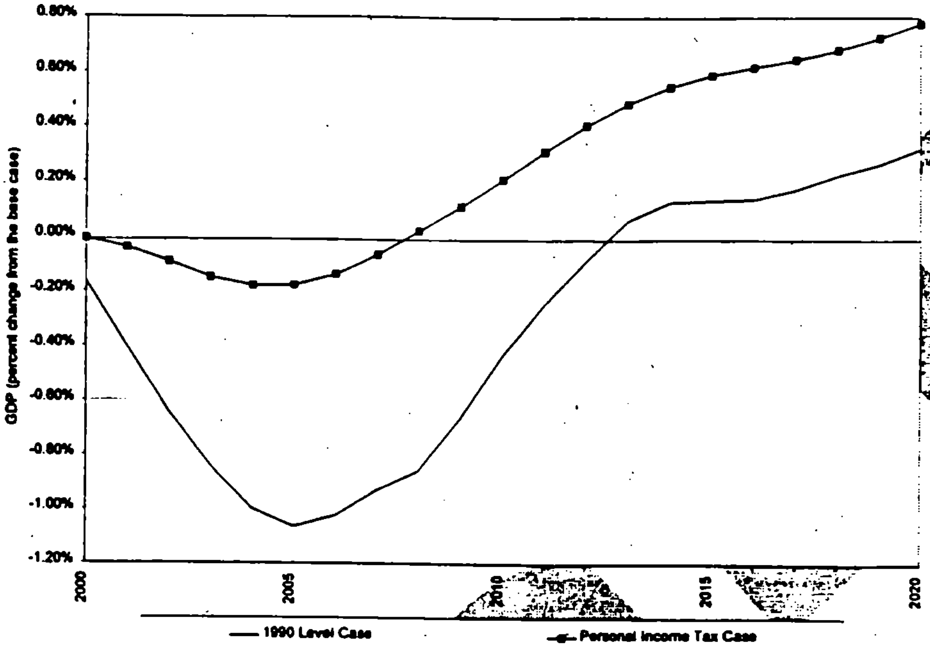


Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Assuming a 1.25 percent annual decrease in E/GDP.

But the economic effects of these recycling options must be separated from the economic effects of carbon limitations *per se*. That is, economic analysis can make the case -- and models are often structured to demonstrate -- that reducing taxes on capital could improve long-term economic performance. In order to separate these effects, the 1990 emissions freeze accompanied by the use of any permit auction revenues to reduce the deficit was compared to a conventional increase in the personal income tax to achieve a comparable level of deficit reduction.

An increase in the personal income tax results in smaller economic losses and a more prompt economic rebound than a "deficit-equivalent" carbon reduction policy, as shown in Figure 19. Thus, while revenue recycling options can affect significantly the outcome of a carbon-reduction policy, the gains they create are unrelated to carbon reduction itself.

Figure 19: DRI-DRI Energy, No International Trading–Comparison of GDP, Recycling Revenue Recycling through Deficit Reduction and a Personal Income Tax Increase



Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Assuming a 1.25 percent annual decrease in E/GDP.

Technological progress can be very helpful, especially in the long term. In its analysis of technology, the Markal-Macro model was used to determine whether higher levels of energy to GDP (E/GDP) savings are realistic. This analysis assumed two benchmarks for technological progress. In the first, the annual steady-state improvement in the economy's efficient use of energy was increased from the level of 1.0 percent in the AEO97 projections (found in the "no policy" base case) to a level of 1.25 percent. In the second case, this improvement in energy efficiency was increased to 1.75 percent. These two benchmark levels were obtained by examining the historical record and engineering estimates of potential technical progress. The point of the analysis was then to determine not only what effect technical progress might have on the economic effects of climate change policy, but also whether these rates were themselves technically feasible.

According to results from the Markal-Macro model, an improvement in the energy intensity of 0.25 percent annually, or a total annual decline of 1.25 in energy per unit of real output, can be achieved without great difficulty using both off the shelf technologies as well as new technologies that are near commercial viability. For example, such an improvement can be produced if the "hurdle rates" – that is, the premium that households and firms appear to place in their discount rate when considering energy-efficiency investments -- declines by 81 percent. For example, the discount rate households use when considering installing better insulation would have to fall from 46 percent to 23 percent). Thus, this improvement can be achieved through diffusion practices even without assuming a higher rate of innovation and technological progress. In fact, some analysts believe that the enactment of the CCAP gets us to the 1.25 annual reduction.

The Markal model demonstrates that the higher technological case -- an increase in the annual rate of improvement in energy-efficiency of 1.75 percent -- is more difficult to achieve. Specifically, this higher level of energy savings cannot be achieved through better diffusion of best technical practices alone. Thus, new innovation must occur if we are to move beyond the 1.25 case. To achieve the 1.75 case, a new set of advanced energy efficiency technologies was added to the pool of technologies. These are part of the DOE research portfolio. Some of these technologies are aggressive in their scope: For example, the average fuel efficiency of new cars entering the vehicle fleet in the year 2020 is 33 miles per gallon in the 1.25 case, but rises to 55 miles per gallon for new cars entering the vehicle fleet in the 1.75 case. They were all deemed viable in an outside peer-review of the DOE program. The IAT will be circulating the technological assumptions necessary to achieve this 1.75 benchmark in a separate paper.

Rather than use the specific technological assumptions developed in Markal, the IAT represented technological progress in the DRI model by targeting a 1.75 percent annual rate of energy improvement in the economy for supply and end-use technologies in all sectors. For residential and commercial sector space heating/cooling and water heating, DRI assumed improved performance and cost characteristics for various heating and cooling equipment types and allowed the model to choose the optimal technologies. The model selects equipment based on life-cycle cost estimates, which include a "first-cost bias" that weights up-front capital costs more heavily than future fuel costs. This is comparable to the higher discount rates used in Markal.

For all other residential and commercial sector energy end-uses, the DRI model uses estimates of the average efficiency of all new and retrofit equipment purchases to determine fuel use requirements. These average efficiencies were increased to reflect improvements to technology performance and higher rates of diffusion for more efficient technologies. No changes were made to the rates of capital stock turnover and replacement.

Table 10 summarizes the effects of higher technological progress (that is, the 1.75 percent annual rate versus the 1.25 annual rate) on the economic effects of carbon-limiting policies. As seen, higher rates of technological progress can dramatically cut the implicit price of carbon and the associated transitional GDP losses. In the IAT "starting point" case (assuming 1.25 percent annual efficiency improvements), the implicit price of carbon in the three models is $95, $81 and $145 per ton in 2010 and $125, $106 and $130 per ton in 2020, for DRI, SGM, and Markal-Macro respectively. In the more advanced technology case, the implicit price of carbon is $88, $53, and $77 per ton in 2010 and $30, $51, and $35 per ton in 2020, for DRI, SGM and Markal-Macro respectively.[4]

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[4] SGM applied the rate of carbon-efficiency for purposes of modeling technological improvement in energy-efficiency because it is easier for SGM to manage C/GDP than E/GDP. Carbon to GDP is an equally appropriate target and the differences in the results of the two specifications is not large.

Table 10: Sensitivity of Implicit Price of Carbon (1995$) to Rate of Technological Change --1990 Level Case, No International Trading

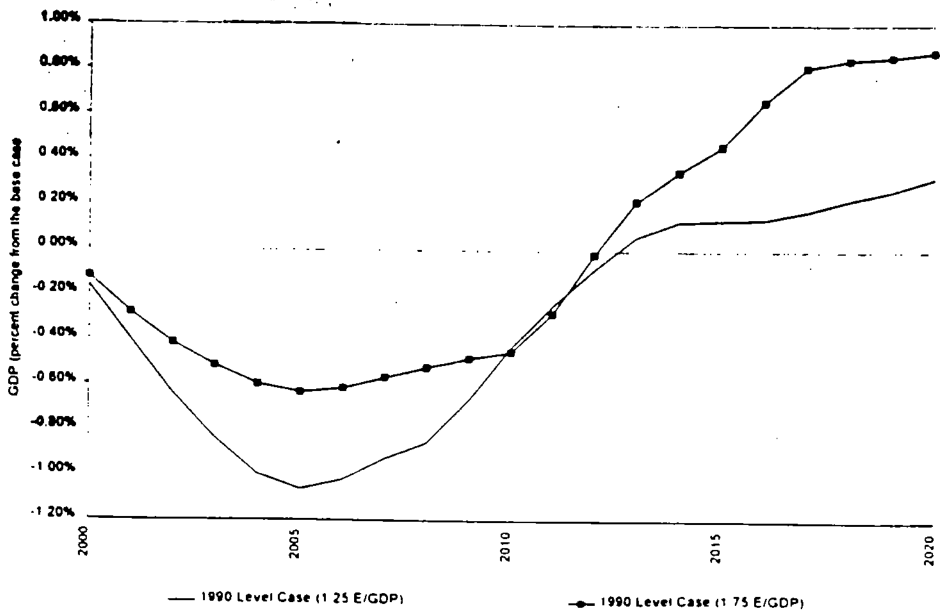
	2010		2020	
	1.25 Case	1.75 Case	1.25 Case	1.75 Case
DRI-DRI Energy	95	88	125	30
SGM	81	53	106	51
Markal-Macro	145	77	130	35

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues used for deficit reduction. DRI permit prices are generated using the annual rate of change in E/GDP. SGM uses a similar rate of change in C/GDP.

The peak GDP losses change accordingly, as shown in Figure 20. Using the DRI model, the peak output loss of -0.6 percent occurs in 2005, and the economy reaches its pre-policy growth path by 2012. The economy's shift to a higher growth path is also more pronounced, but here the result is more believable, because it is achieved through technological progress rather than revenue recycling that raises savings and fosters investment (in fact, the level of revenue recycling falls dramatically along with the implicit price of carbon).

The risk, however, is that these output gains may be somewhat overstated, because they do not account for the cost of the investments needed to reach the higher rate of technological progress. For example, firms will have to perform R&D that might distract them from other R&D tasks. If other R&D in the economy fell as energy- and carbon-related R&D was performed, overall productivity could drop and offset the economy's potential growth elsewhere. Alternatively, firms might increase total R&D effort, but leave the economy with fewer resources to do other things. While it is likely that these effects are second-order when compared to the effects of the improvement in carbon-related efficiency, they are still absent from the analysis.

Figure 20: DRI-DRI Energy 1990 Level Case, No International Trading--Sensitivity of GDP to the Rate of Technological Progress



Note. Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in Revenues used for deficit reduction

These results indicate how important technological progress especially in the long term. A substantially higher rate of technological progress will improve short-term results. But it is capable of moving the analysis significantly once its effects are allowed to accumulate.

Reducing carbon emissions would also reduce other pollutants leading to direct economic benefit. The release of CO_2 is inherent in the activity of burning fossil fuel under current technologies. When CO_2 emissions in the utility, industrial boiler, and transportation sectors are reduced--either by using less fuel or by altering the mix of fuels--emissions of nitrogen oxides (NO_X) and sulfur dioxide (SO_2) are also reduced. In the atmosphere, NO_x and SO_2 react with ammonia to form ammonium nitrate and ammonium sulfate--significant components of fine particulate matter ($PM_{2.5}$), which may cause significant respiratory health problems and mortality.[5]
To investigate this effect, the NEMS model was used to estimate SO_2 and No_x emissions from electricity generation. When emissions are frozen at 1990 levels without trading, NEMS estimates decreases in utility NO_x and SO_2 emissions of 60 percent 47 percent, respectively in 2010.

The NEMS model provided emissions for each of the thirteen NERC regions. These results were then translated into disaggregated county level emissions by calibrating the NEMS results to the county specific data from EPA's National Particulate Inventory. The results were then fed through EPA's climatological regional dispersion model, which calculates the resulting air quality changes for each county. Finally, these results were used to estimate health and welfare effects of air pollution using EPA methodology developed under Section 812 of the Clean Air Act Amendments and reviewed and endorsed by EPA's Science Advisory Board.

Health benefits from reducing utility NO_x and SO_2 emissions in the "starting point" stabilization case include avoided mortality, avoided cases of chronic bronchitis, reduced acute bronchitis, fewer upper and lower respiratory symptoms, and a decline in lost work days. The results are very sensitive to the value attributed to avoided mortality, here estimated at $5 million per episode. When monetized these benefits could have a mean value of over $4 billion per quad of coal based energy generation. Assuming the estimated 7 quad reduction found by DRI (in Table 4), this would yield benefits of about $30 billion.

NOTE TO READERS: The IAT has not yet quantified the NO_x and SO_2 emission reductions from the industrial and transportation sectors or estimated the reduction in emissions of other criteria air pollutants--e.g., carbon monoxide and volatile organic compounds.

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[5] This analysis assumes that no new regulations to control criteria air pollutants would be implemented at he Federal or state level. It is important to note that actions are being considered at the Federal and state levels, including proposed new National Ambient Air Quality Standards, the Clean Air Policy Initiative, and new State Implementation Plans, that could reduce NO_x and SO_2 emissions from utilities over the next decade independently of controlling CO_2 emissions.

The losses experienced by the United States by handicapping energy-intensive industries in international trade need not be large. There is widespread and legitimate concern that forcing an implicit energy price increase on U.S. producers will disadvantage them substantially through trade, particularly with those countries outside of Annex I that might not be subject to the same emissions limits. The IAT used the DRI model to examine the overall trade implications of such a possible energy price differential. Industry trade results are discussed in the Industry Results section of this report.

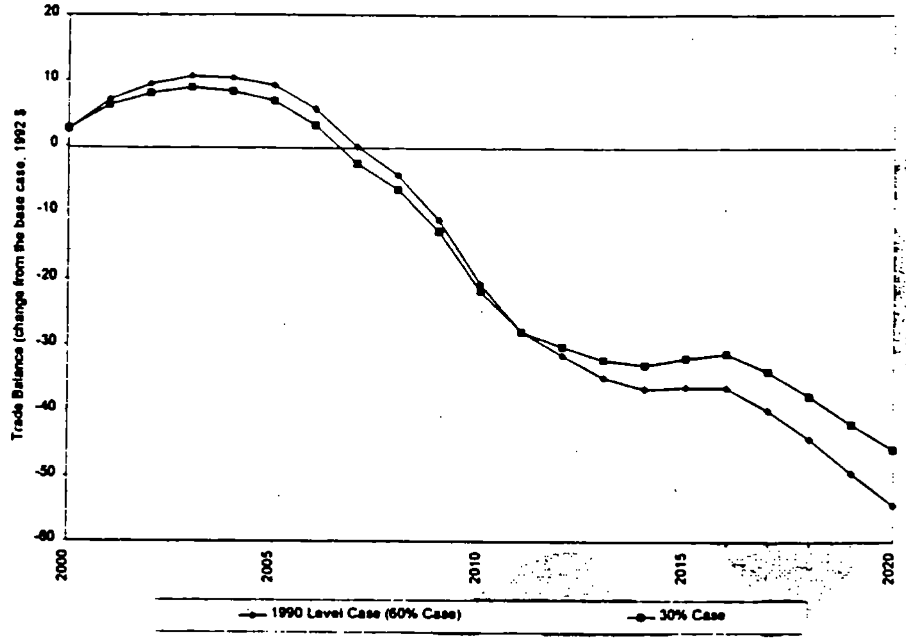
The DRI model examines overall trade effects by assuming a rate at which producers who export to the U.S. experience cost increases. In the aggregate, about 60 percent of imports of manufactured goods come from Annex I countries that will also experience higher implicit carbon prices (and, therefore, energy prices). The DRI model, therefore, assumes that manufactured imports, in general rise by an average of 60 percent of the full cost increase experienced by U.S. manufacturers.

This assumption, however, can be criticized as being too favorable to U.S. producers. If exporters from non-Annex I countries do not experience the cost increase that Annex I producers do, then they will no doubt substitute their production for Annex I production. Given this likely switching of export sources, the DRI model was also run with the assumption that foreign producers experience a cost increase equal to, on average, 30 percent as opposed to 60 percent of the U.S. cost increase.

Figure 21 presents the results under these two cases. The effect of the carbon-limiting policy on trade is depicted in these runs as surprisingly small. Some of the change in trade flows is reconciled in the DRI model by allowing the exchange rate to move, but as seen in Figure 22, the anticipated changes in the exchange rate themselves are not large and do not vary between the two assumptions. The small differences are not necessarily counterintuitive. There are already substantial energy price differences and differing environmental restrictions among trading nations that are larger than the price increase that results from the policies considered here.

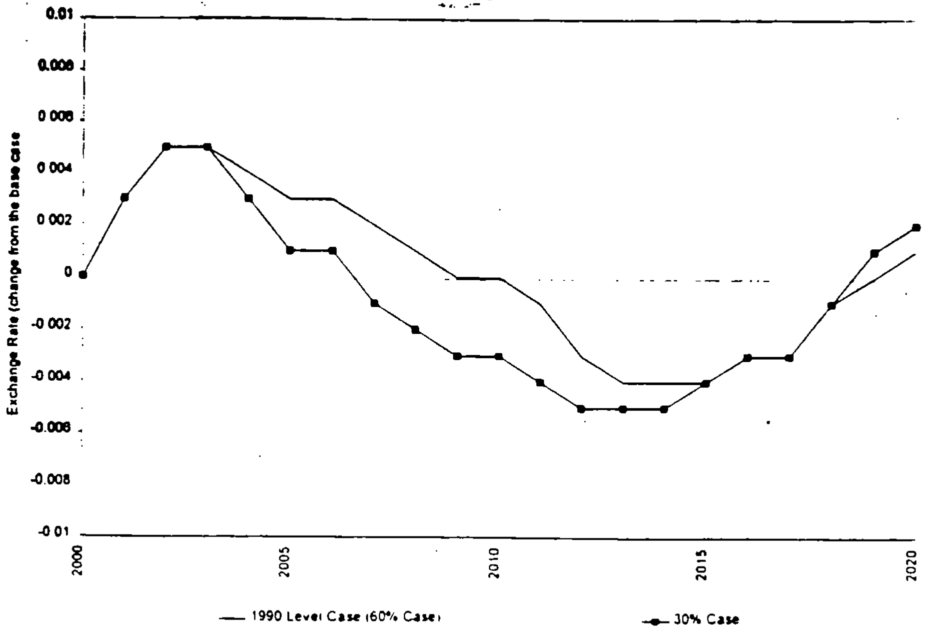
This aggregate treatment does not capture the effects that might be borne by specific industries due to their varying energy intensities. This more detailed examination is presented in Table 13, in the section on industry effects

Figure 21: DRI-DRI Energy 1990 Level Case, No International Trading--Sensitivity of the Trade Balance to International Price Ratio Assumptions



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 22: DRI-DRI Energy 1990 Level Case, No International Trading--Sensitivity of the Exchange Rate to International Price Ratio Assumptions



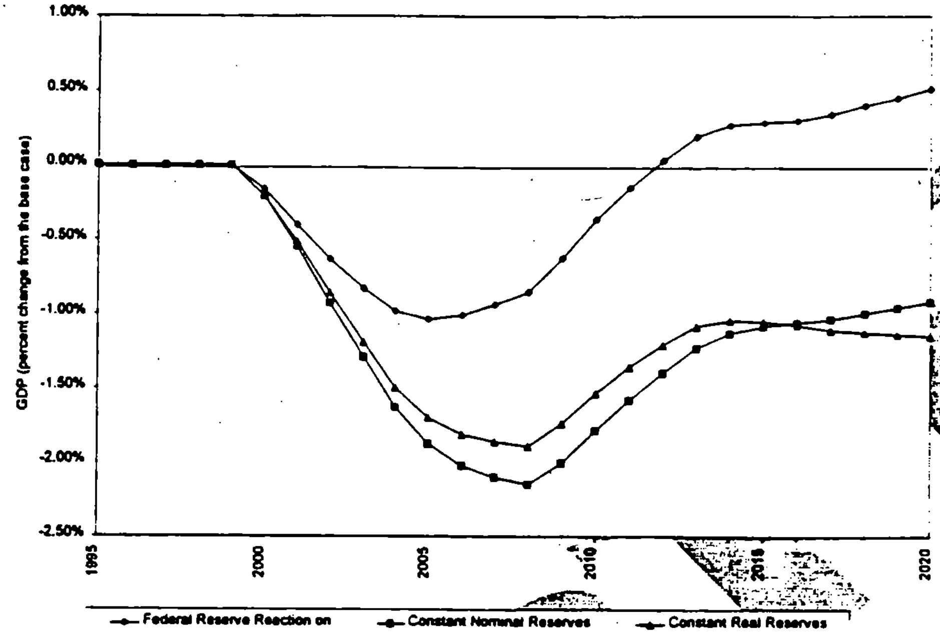
Note: Emissions stabilized at 1990 levels in 2010 Revenues used deficit reduction and assuming a 1.25 percent annual decrease in E/GDP

Alternative views about Federal Reserve policy can yield significantly different results. The Federal Reserve reaction function in the DRI model is an empirically derived estimation of likely Federal Reserve policy responses to changes in price inflation and the unemployment rate, among other variables. It is seen by DRI as the best proxy for Fed decisions in the model simulations. In essence, the reaction function will abate unemployment unless doing so would lead to high rates of inflation. This reaction function was used in the analysis as the default setting for the assessment of the alternative target profiles and implementation strategies. This section reports on a set of sensitivity analyses which consider different Federal Reserve actions: maintaining *nominal* non-borrowed reserves at baseline levels, and a case where *real* non-borrowed reserves are held at baseline. As can be seen from Figure 23, the effects of the alternative monetary policy assumptions are substantial.

If the Federal Reserve maintains nominal reserves at baseline, the size of the GDP loss is approximately doubled, from a 1 percent peak loss when the reaction function is on to just over 2 percent peak loss when more restrictive policies are pursued. There is essentially no difference between holding nominal non-borrowed reserves constant and holding real non-borrowed reserves constant. (The level of non-borrowed reserves in the banking system is an important Federal Reserve policy. If the Fed chooses to hold nominal reserves constant, then the funds that banks have to lend goes down when inflation rises. If real reserves are held constant, banks can lend more if prices go up.)

The sensitivity cases presented here, however, focus only on using the collected funds to reduce the federal deficit. The lower deficit (or greater surplus) makes it easier for the Fed to ease credit conditions without making inflation worse (indeed, as shown in Figure 5 inflation subsides by 2009 and inflation thereafter is lower than in the base case).The Federal Reserve can therefore do much to ease the economic transition in such an environment. But, the impact of the Federal Reserve reaction function fundamentally depends on how revenue recycling policy affects price inflation and the unemployment rate. In cases where price inflation remains high and unemployment losses are lower, the reaction function would ease credit conditions at a slower rate, and the divergence between the reaction function results and the nominal reserves at base case may be much smaller.

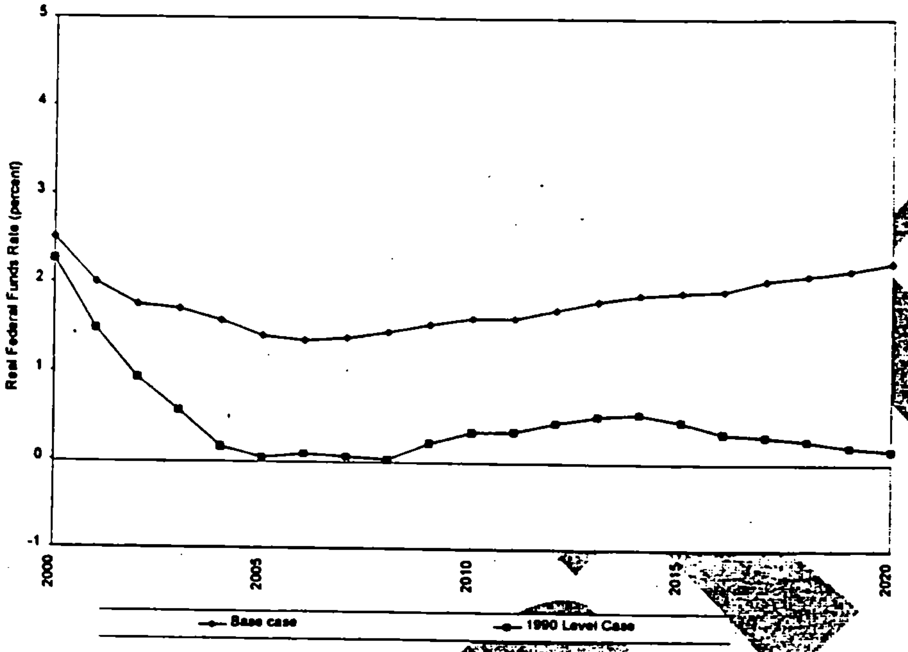
Figure 23: DRI-DRI Energy, No International Trading-- Sensitivity of GDP to Federal Reserve Policy Assumptions



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

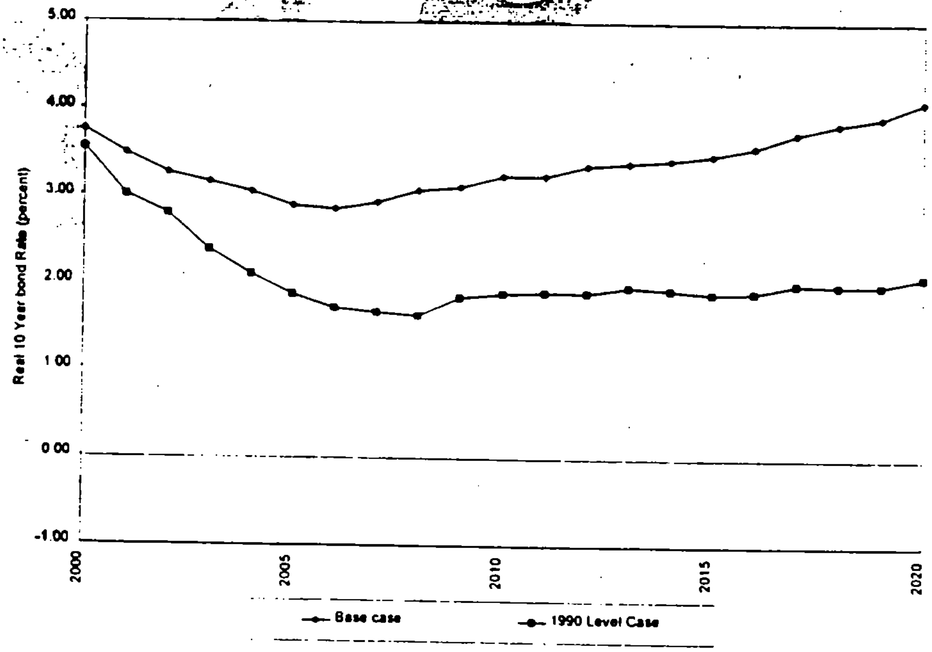
Figures 24, 25, and 26 show projections of the Federal Funds Rate, the 10-year Long Term Bond Rate, and the Federal Deficit/Surplus, respectively, from the DRI model with the Federal Reaction Function used in the analysis of the 1990 Level Case, No International Trading ("starting point"). These results show how important the treatment of revenue flows is in the DRI model. Substantial declines in the deficit (these runs were produced before the agreement to balance the budget in 2002 was achieved in May) allow interest rates to fall, which is the key to the economy's investment response.

Figure 24: DRI-DRI Energy 1990 Level Case, No International Trading– Real Federal Funds Rate



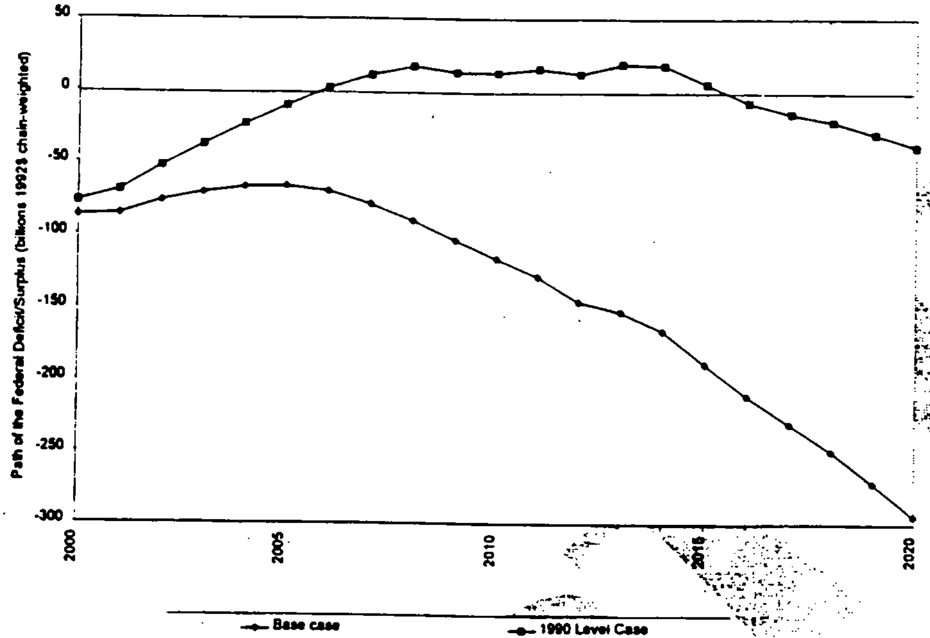
Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 25: DRI-DRI Energy 1990 Level Case, No International Trading– Real 10 Year Long-Term Bond Rate



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP

Figure 26: DRI-DRI Energy 1990 Level Case, No International Trading--Path of the U.S. Federal Deficit/Surplus



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

The results presented in the sections below on "Industry Results" and "Regional and Employment Effects" do not include cross-border emissions trading. The IAT is in the process of generating industry and regional results based on using implicit carbon prices from SGM Annex I trading results to simulate macro economic conditions for the DRI model, which will extend the final section of the core results to the industry and regional levels.

Industry Results

Using the DRI model. the IAT examined both the industry impacts and the impacts to regional employment associated with carbon-limiting policies. Regional impacts are discussed in the next section of the report. Table 11 provides impacts to the energy producing industries and to industries that are considered to be energy intensive. Table 12 lists the industries with the greatest increase from base case output and the largest decline from base case output in 2010.

Different energy models place different emphasis on three strategies for coping with energy price increases. with corresponding differences in projected fossil fuel impacts. These strategies include increased end-use efficiency. reduced end-use activity, or fuel-switching towards an increased market share of low- and no- carbon fuels. Increased end-use efficiency or reduced end-use activity tends to lower overall fuel demand. while fuel-switching favors low- and no-carbon fuels, such as natural gas and renewable energy, relative to high carbon fuels such as coal.

The DRI energy model results (reported here) emphasize improved efficiency and reduced end-use activity. In this model, stabilization reduces the use of all fossil fuels (coal, oil, and natural gas) relative to baseline levels. In contrast, for example, the NEMS results rely more heavily on fuel switching opportunities in the utility and transportation sectors, as well as efficiency improvements in cars. The NEMS stabilization runs show greater reductions in coal use than the DRI runs, but natural gas use actually increases relative to baseline due to fuel switching and a higher level of end-use energy demand.

Table 11: DRI-DRI Energy 1990 Level Case, No International Trading Impact on the Output of Energy Producing Industries and Energy Intensive Industries (percent change from the base case)

	2010		2020	
	No trading	With International Trading	No trading	With International Trading
Energy Producers				
Electric Utilities	-11.6%	n/a	-17.7%	n/a
Petroleum Refining	-8.8%	n/a	-9.3%	n/a
Coal Mining	-25.9%	n/a	-39.3%	n/a
Natural Gas	-19.9%	n/a	-18.2%	n/a
Gas Utilities	-11.4%	n/a	-10.9%	n/a
Crude Petroleum	-11.8%	n/a	-12.4%	n/a
Fuel Oil	-13.6%	n/a	-16.7%	n/a
"Pipelines. ex. Natural Gas"	-7.8%	n/a	-8.0%	n/a
Energy Intensive Industries				
Food and Kindred Products	-0.9%	n/a	0.2%	n/a
Chemical and Allied Products	-1.9%	n/a	-1.6%	n/a
Petroleum and Coal Products	-9.2%	n/a	-10.0%	n/a
Stone. Glass. and Clay Products	0.8%	n/a	2.3%	n/a
Paper and Allied Products	-0.6%	n/a	0.4%	n/a
Primary Metals	-1.0%	n/a	-1.0%	n/a

Note: Emissions stabilized at 1990 levels in 2010 with a 10 year phase-in. Revenues are used for Federal deficit reduction. assuming a 1.25 percent annual decrease in E/GDP. Estimates for the international trading scenario are forthcoming.

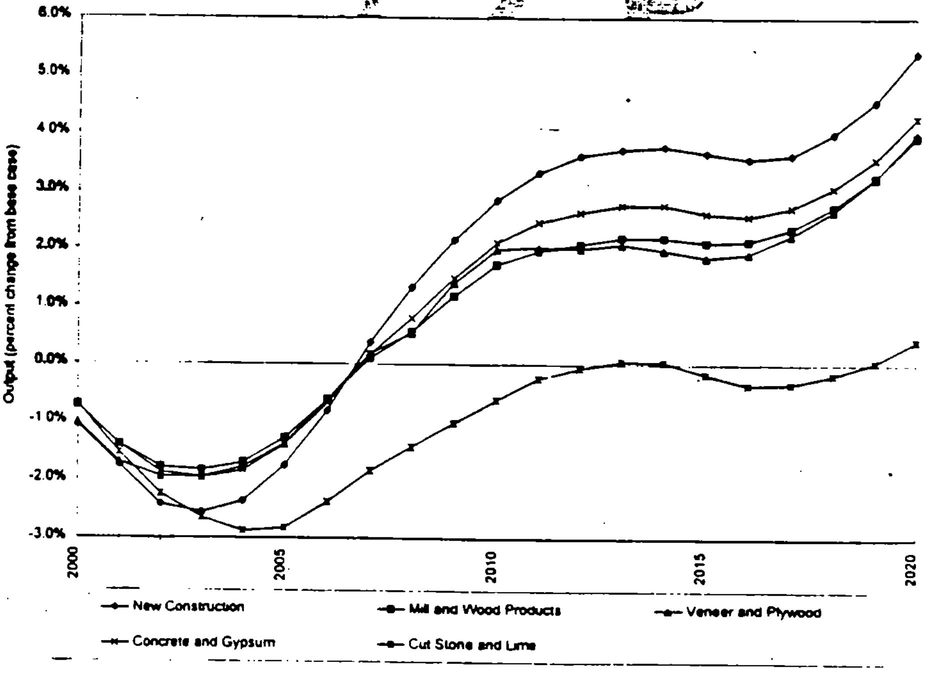
Energy intensive industries are put at a disadvantage by higher implicit prices for fossil fuels following the imposition of policy. This occurs because they are displaced through trade -- an effect that DRI depicts as relatively minor -- or because the composition of the economy's output changes in favor of less energy-intensive goods and services. These composition shifts drive the industry results. For some industries, however, composition may shift in favor of energy intensive industries because the economy's composition shifts from consumption to investment. which calls up a different mix of goods itself.

For example, a number of energy intensive manufacturing and construction sectors benefit in the long-term by the stimulus to investment created by the reduction of the deficit. Table 12 shows that 6 of the top 10 industries. in terms of output increasing above the base case. are directly or indirectly related to construction. which reflect the increase to the investment component of the economy. Figures 27 and 28 show the short-term output losses and the long-term output gains of a number of these industries.

On the other hand, industries whose production is used primarily for consumption, particularly energy products such as petroleum and coal, but also including paper, chemicals, and food and kindred products, continue to show losses in annual output. The energy producing industries show losses in output from between 8 percent for pipelines and 26 percent for coal mining. Consumer non-durable goods producing industries show losses of output that ranges from 1 percent for food processing to 10 percent for rubber and plastic footwear. In the longer-term, other than the energy producers, the consumption-oriented industries are expected to just about reach their output levels in the baseline.

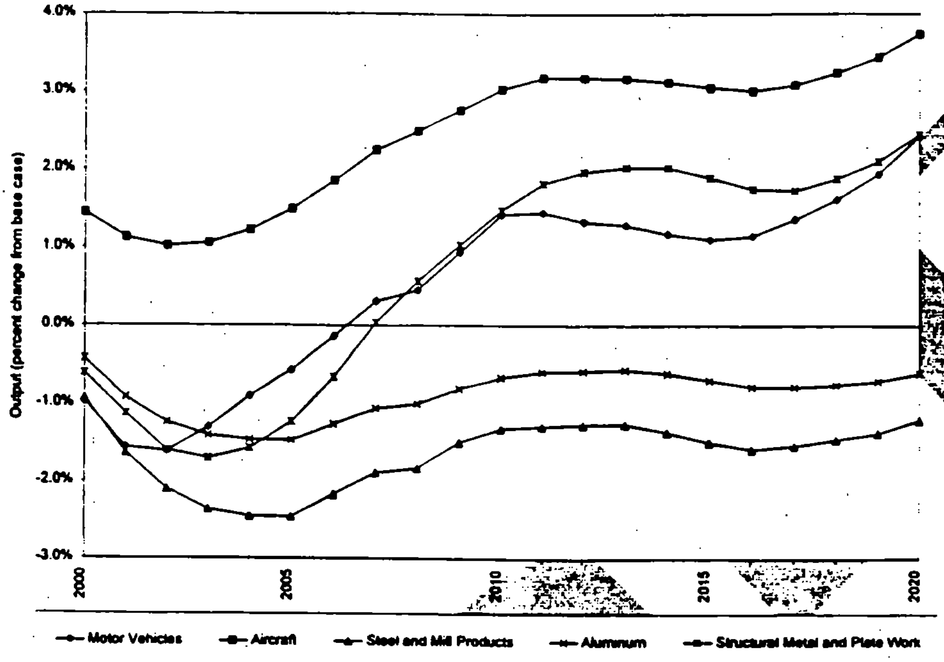
This mix effect is particularly and obviously important for energy producers. The DRI model suggests output of petroleum products will decline by 9 percent in 2010 and in 2020, when compared to the base case. As seen in Table 12, coal production in the United States will be 26 percent lower in 2010 and 39 percent lower in 2020 when compared to its projected levels in the base case.

Figure 27: DRI-DRI Energy 1990 Level Case, No International Trading--Output in Key Industries--New Construction, Mill and Wood Products, Veneer and Plywood, and Concrete and Gypsum



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Figure 28: DRI-DRI Energy 1990 Level Case, No International Trading--Output in Key Industries--Motor Vehicles, Steel and Mill Products, Structural Metal and Plate Work, Aircraft, Aluminum



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Mining (including coal, oil, and natural gas extraction) employment would be 6 percent and 7 percent lower, respectively, in 2010 and 2020: these declines are lower than output losses because productivity in the industry is generally anticipated to improve and the nation's coal mix is projected to shift to more productive coal reserves. These employment losses are particularly severe in the east and west south central regions.

Electric utilities experience smaller percentage reductions in output, but their losses are larger in dollar terms. Utility output declines by about $30 billion in 2010 and $52 billion in 2020 when compared to the base case. Petroleum refining and coal mining also experience larger losses than other energy-related industries on a dollar basis.

Table 12: DRI-DRI Energy 1990 Level Case, No International Trading Impacts on the Output of Selected Industries (percent change from the base case)

	2010	2020
Industries with the Largest Percent Increase in Output		
Aircraft	3.0	3.7
Truck Trailers	3.0	3.7
New Construction	2.8	5.4
Truck and Bus Bodies	2.7	3.5
Partitions and Fixtures	2.5	3.9
Lawn and Garden Equipment	2.3	3.3
Elevators and Materials Handling Equipment	2.3	2.8
Structural Metal Products	2.2	2.9
Concrete and Gypsum	2.1	4.3
Plumbing and Heating Equipment	2.1	4.0
Packaging Machinery	2.1	2.7
Industries with the Largest Percent Decline in Output*		
Rubber and Plastic Footwear	-10.3	-3.9
Nonferrous Metals	-3.2	-5.4
Household Audio and Video Equipment	-3.2	-6.1
Chemical and Fertilizer Mining	-3.1	-3.3
Watches and Clocks	-2.8	-4.9
Iron and Ferroalloy Ores	-2.6	-2.8
Other Leather Goods	-2.5	0.4
Nonferrous Wire and Cable	-2.5	-2.8
Misc. Nonferrous Ores	-2.3	-3.7
Industrial Organic and Inorg. Chemicals	-2.2	-2.1
Computers	-2.1	-6.1

Note: Emissions stabilized at 1990 levels in 2010. Revenues used for deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.
* Excluding energy producing sectors.

As discussed earlier, the DRI model found that the effect of a carbon-limiting policy on international trade is relatively small across all industries. However, as Table 13 shows, the trade impact on some specific industries are relatively large. For example, imports by the cement industry increase by 13 percent and exports are off by 3 percent, a net trade loss of 16 percent. Steel imports increase by almost 7 percent while its exports are cut by about 1 percent, a net trade loss of about 7 percent. On the other hand, fuel oil imports decline by about 39 percent, while exports increase by about 1 percent, a net trade gain of 40 percent. Imports for the industries listed in this table generally increase, while exports decline slightly.

Table 13: DRI-DRI Energy, 1990 Level Case, No International Trading Effects on Exports and Imports in 2010 (percent change from base case)

	Imports	Exports
Paper and Allied Products		
Pulp Mills	0.9%	0.1%
Paper and Paperboard Mills	2.3%	-0.5%
Paperboard Boxes and Containers	1.6%	-0.2%
Paper Coating and Laminating	1.2%	0.1%
Sanitary Paper Products	0.8%	0.3%
Chemical and Allied Products		
Industrial Inorg. and Organic Chemicals	3.6%	1.0%
Fertilizers	5.3%	-2.0%
Pesticides and Agr. Chemicals	0.2%	0.4%
Petroleum and Coal Products		
Petroleum Refining	-7.7%	0.5%
Fuel Oil	-38.6%	0.6%
Stone, Glass, and Clay Products		
Cement	13.3%	-2.8%
Concrete and Gypsum	5.3%	-0.2%
Cut Stone and Lime	7.4%	-1.1%
Primary Metals		
Steel and Mill Products	6.6%	-1.4%
Iron and Steel Foundries	2.7%	0.0%
Iron and Steel Forgings	3.6%	-0.1%
Aluminum	3.8%	-0.5%
Transportation Equipment		
Truck and Bus Bodies	3.4%	0.1%
Truck Trailers	4.7%	0.0%
Motor Vehicles	3.1%	-0.1%
Motor Vehicle Parts and Accessories	1.4%	-0.1%
Aircraft	3.0%	3.7%
Aircraft and Missile Engines and Parts	1.5%	2.5%
Computer and Electronic Equipment		
Computers	2.7%	-0.8%
Computer Peripheral Equipment	2.3%	-0.2%
Semiconductors	0.3%	-0.6%

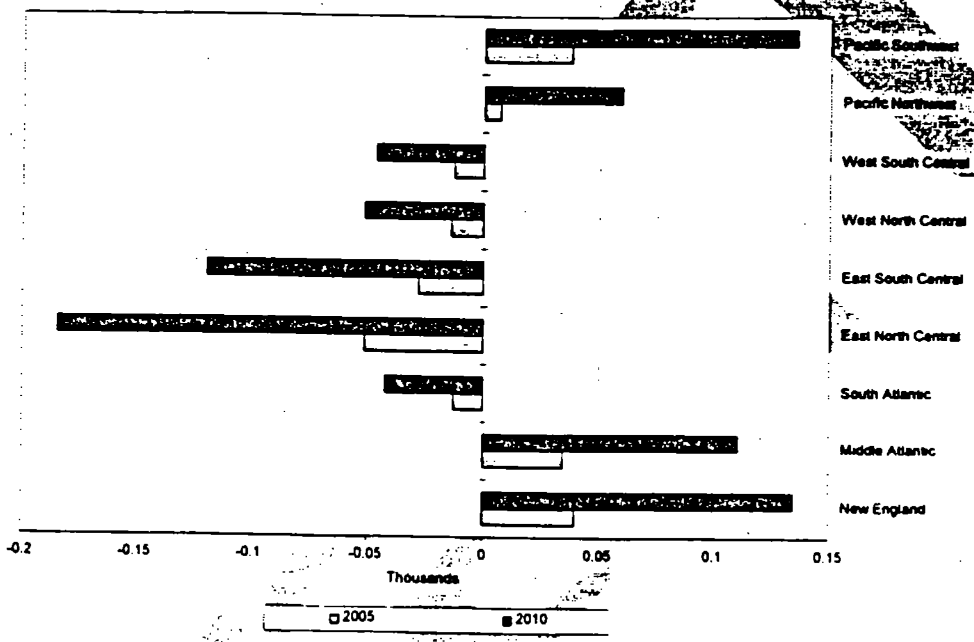
Note: Emissions stabilized at 1990 levels in 2010. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Regional and Employment Effects

The effects of climate change policy on the various regions of the country are shown in Table 14. In general, states in the East North Central, East South Central, and West North Central regions will have proportionally greater losses in population, 150-, 125-, and 75-thousand, respectively, nd employment, 210-, 165-, and 125-thousand, respectively, than the other regions of the country. See Figures 29 and 30. Total non-farm employment loss due to the climate change policy is about 900 thousand in 2005 compared with the baseline total non-farm employment of

135.3 million in that year. In 2010, total non-farm employment loss due to the climate change policy is only 400 thousand, compared with the baseline total non-farm employment of 140.9 million, as the economy starts to recover. The New England, Middle Atlantic, and the Pacific Southwest are expected to show long-term gains in population of 125-, 110-, and 130 thousand, respectively, and in employment of 125-, 45-, and 65-thousand, respectively, because of climate change policy implementation.

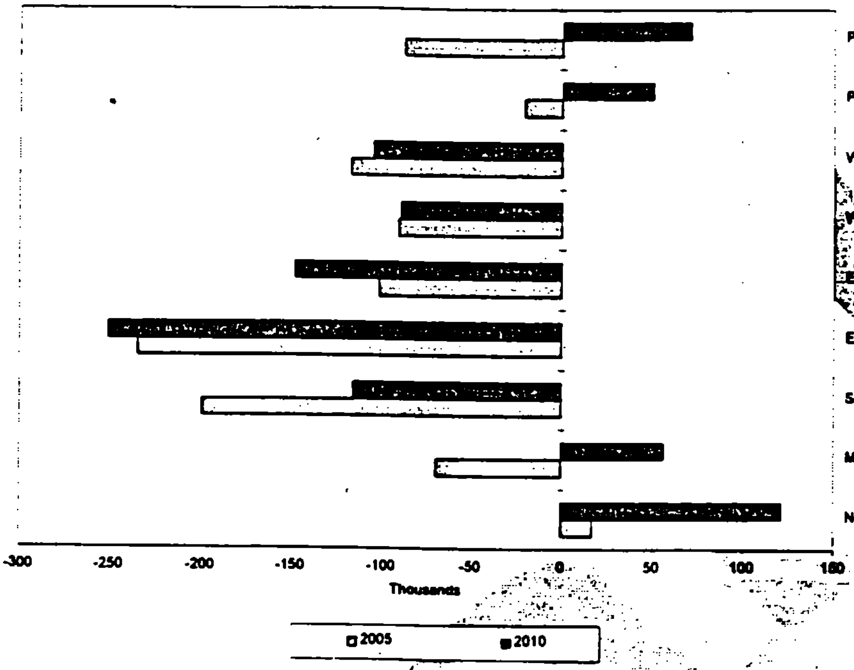
Figure 29: DRI-DRI Energy 1990 Level Case, No International Trading-- Population by Region (change from the base case)



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

The key to the regional effects relies on how revenue raised through permit sales is recycled to the economy. In the policy reviewed for regional effects, revenues are used to reduce the Federal budget deficit, which supports savings and, thus, increases investment. The climate change policy favors those states where production in industries support investment in structures and capital goods equipment, and of course, those areas of the country that are not as dependent on fossil fuel production. The climate change policy's effects are mitigated in those regions whose mix of industries favor investment goods industries and where the levels of industry production are large and can absorb the losses in production in industries that produce consumer goods.

Figure 30: DRI-DRI Energy 1990 Level Case, No International Trading–Total Non-Farm Employment by Region (change from the base case)



Note: Emissions stabilized at 1990 levels in 2010. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

As shown in Table 14, although the West South Central region is expected to have the greatest losses in fossil fuel employment, about 15 thousand in 2010, this represents only about 6 percent of its total mining employment in that year. On the other hand, the East South Central Region is expected to lose about 8 thousand in 2010, but this represents about 22 percent of its total fossil fuel employment in the same year.

Table 14: DRI-DRI Energy 1990 Level Case, No International Trading Regional Impacts

Year	New England	Middle Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Pacific North-west	Pacific Southwest
Disposable Income, % change from the base case									
2005	0.9	0.4	-0.1	-0.4	-0.5	-0.7	-0.2	0.3	0.3
2010	1.9	0.7	-0.1	-1.1	-1.3	-1.2	-0.4	1.1	0.6
2020	2.9	0.9	0.1	-1.4	-1.5	-1.9	-0.7	1.4	0.7
Total Non-farm employment, % change from the base case									
2005	0.3	-0.4	-0.8	-1.0	-1.3	-0.9	-0.8	-0.4	-0.4
2010	1.7	0.3	-0.4	-1.1	-1.8	-0.8	-0.7	0.8	0.3
2020	2.7	0.5	-0.2	-1.1	-1.7	-0.9	-0.8	1.1	0.5%
Mining, Oil, and Gas Employment, % change from the base case									
2005	0.4	-8.5	-8.3	-5.9	-10.9	-0.8	-1.4	-2.1	-0.9
2010	4.4	-10.9	-11.6	-7.8	-20.5	1.0	-6.4	-1.1	0.8
2020	9.0	-14.0	-15.6	-6.2	-27.8	4.3	-4.8	-8.3	0.6
Population, change from the base case (millions)									
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.1	0.1	0.0	-0.2	-0.1	-0.1	-0.1	0.1	0.1
2020	0.3	0.2	0.0	-0.3	-0.2	-0.1	-0.1	0.1	0.2
Manufacturing Employment, change from the base case (thousands)									
2005	9.6	1.7	-32.5	-77.1	-24.7	-19.5	-21.5	-1.0	-0.6
2010	26.5	21.7	-28.4	-116.1	-32.5	-28.3	-28.5	6.7	17.3
2020	36.9	13.9	-33.8	-142.5	-32.7	-35.3	-41.8	7.3	23.9
Transportation, Communication & Utilities, change from the base case (thousands)									
2005	1.7	-4.1	-12.1	-15.5	-4.9	-8.1	-8.7	-1.6	-6.5
2010	5.7	-2.9	-16.5	-25.9	-9.4	-13.5	-14.9	0.3	-5.5
2020	8.4	-4.8	-18.1	-31.8	-10.0	-16.1	-17.9	0.4	-5.4

Note: Emissions stabilized at 1990 levels in 2010. Revenues used for Federal deficit reduction and assuming a 1.25 percent annual decrease in E/GDP.

Appendix Table A: Assumptions Regarding Non-Carbon Greenhouse Gases (million metric tons of carbon equivalent)

	1900	1995	2000	2005	2010	2015	2020
Baseline Emissions							
CH4	169	178	150	152	152	154	155
HFC PFC	24	n/a	42	69	91	115	133
N2O	37	34	31	32	34	36	37
Sinks	-136	-128	-121	-120	-119	-111	-103
Total	95	n/a	102	133	158	194	223
Cost Effective Reductions in Emissions (assuming an implicit price of carbon of $70 per ton)							
CH4					27	29	29
HFC PFC					51	75	110
N2O					4	[illegible]	4
Sinks				7	15	15	15
Total Reduction					97	123	159
Emissions with Cost Effective Reductions							
CH4	169	178	150	152	125	126	126
HFC PFC	24	n/a	42	69	40	41	23
N2O	37	34	31	32	30	31	33
Sinks	-136	-128	-121	-120	-134	-126	-118
Total Other Gas Emissions	95	n/a	102	133	61	71	64
Reductions Below 1990 Levels					34	23	31

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

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Draft Protocol to the Framework Convention on Climate Change

As released by the Department of State, Bureau of Oceans and International Environmental and Scientific Affairs, January 28, 1997.

January 17, 1997

U.S. DRAFT PROTOCOL FRAMEWORK

(submitted without prejudice to ultimate form of agreement)

The Parties to this Protocol,

Have agreed as follows:

Article 1
Definitions

For purposes of this Protocol:

1. "The Convention" means the United Nations Framework Convention on Climate Change done at New York on 9 May 1992.

2. "Party" means Party to this Protocol.

3. "Greenhouse gas" means any greenhouse gas for which a global warming potential is set forth in Annex C of this Protocol.

4. "Tonne of carbon equivalent" means one metric tonne of carbon, or a quantity of one or more other greenhouse gases equivalent to one metric tonne based on the global warming potentials set forth in Annex C of this Protocol.

5. "Net anthropogenic emissions" of greenhouse gases is the calculated difference between emissions by sources and removals by sinks.

6. [other definitions to be developed or cross-referenced to the Convention as necessary]

Article 2
Emissions Budgets

1. Each Annex A and Annex B Party shall ensure that its net anthropogenic emissions of greenhouse gases do not exceed its emissions budget for any applicable budget period, as specified in this Article.

2. For each Annex A and Annex B Party, its emissions budget shall be denominated in tonnes of carbon equivalent emissions allowed and shall equal:

(a) the tonnes of carbon equivalent emissions it is allowed under paragraph 3 or 4 below, plus
(b) any tonnes of carbon equivalent emissions allowed that are carried over from a prior

budget period under paragraph 5 below, plus
(c) up to [percent] of the tonnes of carbon equivalent emissions allowed under paragraph 3 or 4 below, such as may be borrowed from the subsequent budget period under paragraph 6 below, plus
(d) any tonnes of carbon equivalent emissions allowed that are acquired from another Party under Article 6 (International Emissions Trading) or Article 7 (Joint Implementation), minus
(e) any tonnes of carbon equivalent emissions allowed that are transferred to another Party under Article 6 (International Emissions Trading).

3.

1. (a) For the first budget period, [20 through 20], each Annex A Party shall have a number of tonnes of carbon equivalent allowed equal to [a percentage of] its net anthropogenic emissions of tonnes of carbon equivalent in 1990, multiplied by [the number of years in this budget period].
(b) For the second budget period, [20 through 20], each Annex A Party shall have a number of tonnes of carbon equivalent emissions allowed equal to [a percentage equal to or less than the percentage in subparagraph 3(a)] of its net anthropogenic emissions of tonnes of carbon equivalent in 1990, multiplied by [the number of years in this budget period].
(c) [possible subsequent budget period(s)]

4. For the budget period [20 through 20], each Annex B Party (see Annex B for States included) shall have a number of tonnes of carbon equivalent emissions allowed equal to [options for Annex B Parties include: budget periods, baseyears, and/or percentages different from those applicable to Annex A Parties].

5. At the end of a budget period applicable to a Party, any amount by which the Party's emissions of tonnes of carbon equivalent is under its emissions budget for that period may be carried over and added to its emissions budget for the next budget period.

6. At the end of a budget period applicable to a Party, any amount of tonnes of carbon equivalent emissions allowed that is borrowed from the subsequent budget period shall be subtracted at a rate of [1.2:1] from the subsequent budget period.

7. [Provision requiring control of greenhouse gases not listed in Annex C.]

8. Any State not listed in Annex A may, in its instrument of ratification, acceptance, approval or accession, or at any time thereafter, notify the Depositary that it intends to be bound by obligations of Annex A Parties. It will then be an Annex A Party. The Depositary shall inform the other signatories and Parties of any such notification.

9. Any State not listed in Annex A may, in its instrument of ratification, acceptance, approval, or accession, or at any time thereafter, notify the Depositary that it intends to be bound by obligations of Annex B Parties. It will then be an Annex B Party. The Depositary shall inform the other signatories and Parties of any such notification.

Article 3
Measurement and Reporting

1. Each Annex A and Annex B Party shall have in place by [the first year of its first budget period] a national system for the accurate measurement of anthropogenic emissions by sources, and removals by sinks, of greenhouse gases.

2. For the purposes of implementing paragraph 1 and promoting comparability, consistency, and transparency, the Parties shall, not later than their second Meeting, decide on minimum standards for the measurement of anthropogenic emissions by sources, and removals by sinks, of greenhouse gases.

3. Each Annex A and Annex B Party shall put in place, if it has not already done so, national compliance and enforcement programs relevant to its implementation of the obligations under this Protocol.

4. Each Annex A and Annex B Party shall submit to the Secretariat, as part of its communication under Article 12 of the Convention, information on its implementation of this Protocol, including policies and measures it is taking to meet its obligations in Article 2. Such submission shall be in accordance with guidelines which the Parties adopt at their first Meeting, taking into account any relevant guidelines adopted by the Parties to the Convention. Such submission shall also contain the following information:

(a) once the obligation in paragraph 1 above becomes effective, a description of the national measurement system that it has in place;

(b) once the obligation in paragraph 1 above becomes effective, the results of its national measurement system;

(c) a quantitative projection of its net anthropogenic emissions of greenhouse gases through the budget periods; and

(d) a description of relevant national compliance and enforcement programs it has in place pursuant to paragraph 3 above, as well as a description of their effectiveness, including actions taken in cases of non-compliance with national law.

5. In addition to the information required to be submitted under paragraph 4, each Annex A and Annex B Party shall submit to the Secretariat, on an annual basis and in accordance with the guidelines referred to in paragraph 4, its current calculation corresponding to each of the subparagraphs in Article 2.2 and its remaining emissions budget for that budget period. With respect to any tonnes of carbon equivalent emissions allowed that are acquired or transferred under Articles 6 or 7, the Party shall specify the quantity, Party of origin or destination, and the relevant budget period.

6. The first of the submissions referred to in paragraph 5 shall be part of a Party's first communication that is due after the Protocol has been in force for that Party for two years. The frequency of subsequent submissions shall be determined by the Parties.

7. Information communicated by Parties under this Article shall be transmitted by the secretariat as soon as possible to the Parties and to any subsidiary bodies concerned.

8. Without prejudice to the ability of any Party to make public its communication at any time, the secretariat shall make information communicated by Parties under this Article publicly available at the time it is submitted to the Parties.

Article 4
Review and Compliance Process

1. In addition to the review of communications conducted under Article 10.2(b) of the Convention, the Meeting of the Parties shall consider the information submitted by Annex A and Annex B Parties under Article 3 in order to assess those Parties' implementation of their obligations.

2. Reviews will be conducted by expert review teams, which will be coordinated by the secretariat and composed of experts selected from those nominated by Parties and, as appropriate, by intergovernmental organizations.

3. Reviews will be in accordance with guidelines to be adopted by the Meeting of the Parties. These guidelines shall, inter alia, provide for how information will be made available to the public and define mechanisms by which observers and the public may

provide comments, supplemental data or other information to facilitate and improve reviews. The guidelines shall be periodically reviewed by the Parties for appropriate revision.

4. Review teams will review all aspects of a Party's implementation of this Protocol, including the likelihood that a Party will achieve its emissions budgets obligations. They will prepare a report assessing a Party's implementation of its obligations, identifying any areas of apparent non-compliance, as well as potential problems in achieving obligations. Reports will be provided to a Meeting of the Parties.

5. Based on such reports, a Meeting of the Parties may make recommendations to a Party. In such case, the Party shall review its implementation, take appropriate action, and report back to the next Meeting of the Parties on its action.

6. There would also be provisions setting forth various consequences for non-compliance with obligations, as determined by a Meeting of the Parties. Consequences would correspond to the type, degree, and frequency of non-compliance. Some would be automatic, while others might be discretionary. Examples of consequences could include, e.g.:

(a) denial of the opportunity to sell tonnes of carbon equivalent emissions allowed through international emissions trading and/or joint implementation;

(b) loss of voting rights and/or other opportunities to participate in processes under the Protocol.

Article 5
Advancement of the Implementation of Article 4.1 of the Convention

Recognizing the progress that has been made to date in implementing commitments under Article 4.1 of the Convention:

1. The Parties reaffirm their commitments under Article 4.1 of the Convention and the need to continue to advance the implementation of such commitments.

2. Each Party shall strengthen its legal and institutional framework to advance the implementation of its commitments under Article 4.1 of the Convention.

3. Each Party shall take measures to facilitate investment in climate-friendly technologies.

4. Each Party shall report, as part of its communication under the Convention, on how it is promoting public education and participation in the development of climate change policy.

5. Each Party that is neither in Annex A nor Annex B shall identify and implement "no-regrets" measures for mitigating net anthropogenic emissions of greenhouse gases, including any identified through the review process under paragraph 7 below. In this regard, each such Party shall also:

(a) quantify the effects of the measures it implements;
(b) evaluate barriers to the adoption of potential measures; and
(c) report to the Secretariat, as part of its communication under the Convention, on the measures it has implemented, plans to implement, and barriers to the adoption of potential measures.

6. Each Party that is neither in Annex A nor Annex B shall submit to the Secretariat, on an annual basis, its inventory of greenhouse gas emissions. Such inventory shall be consistent with any guidelines adopted by the Parties.

7. The Parties shall establish a process for reviewing communications received under the Convention from the Parties identified in paragraphs 5 and 6. The process shall be designed to:

(a) enable the review of the effects of individual measures described in paragraph 5;
(b) assist such Parties in identifying and implementing "no-regrets" measures for mitigating net anthropogenic emissions of greenhouse gases;
(c) seek to identify key sectors and technological options within them;
(d) consider possibilities for promoting voluntary arrangements with industry aimed at identifying and encouraging implementation of "no regrets" measures; and
(e) explore various means through which such Parties could obtain both the know-how and the technology needed to implement options identified.

Article 6
International Emissions Trading

1. An Annex A or Annex B Party that is in compliance with its obligations under Article 3 (Measurement and Reporting) and that has in place a national mechanism for certification and verification of trades, may transfer to, or receive from, any Annex A or Annex B Party, any of its tonnes of carbon equivalent emissions allowed for a budget period, for the purpose of meeting its obligations under Article 2.

2. A Party may authorize any domestic entity (e.g., government agencies, private firms, non-governmental organizations, individuals) to participate in actions leading to transfer and receipt under paragraph 1 of tonnes of carbon equivalent emissions allowed.

3. A Meeting of the Parties may further elaborate guidelines to facilitate the reporting of emissions trading information.

Article 7
Joint Implementation

1. Any Party that is neither in Annex A nor B may generate tonnes of carbon equivalent emissions allowed through projects that meet the criteria set forth in paragraph 2.

2. In addition to any criteria adopted by the Parties to this Protocol, the following criteria shall apply to projects:

(a) Projects must be compatible with and supportive of national environment and development priorities and strategies, as well as contribute to cost-effectiveness in achieving global benefits;

(b) Projects must provide a reduction in emissions that is additional to any that would otherwise occur.

3. [Additional provisions to be added on calculation, measurement, monitoring, verification, review, reporting]

4. Any Party that generates tonnes of carbon equivalent emissions allowed consistent with this Article may:

(a) hold such tonnes of carbon equivalent emissions allowed; or
(b) transfer any portion thereof to any Party.

5. An Annex A or Annex B Party may acquire tonnes of carbon equivalent emissions allowed under this Article for the purpose of meeting its obligations under Article 2, provided it is in compliance with its obligations under Article 3 (Measurement and

Reporting).

6. A Party may authorize any domestic entity (e.g., government agencies, private firms, non-governmental organizations, individuals) to participate in actions leading to generation, transfer and receipt under this Article of tonnes of carbon equivalent emissions.

7. Any Party that is neither in Annex A nor Annex B that generates or acquires tonnes of carbon equivalent emissions allowed under this Article shall notify the Secretariat annually of the quantity, origin, and destination of such tonnes.

Article 8
Science

The Parties shall periodically review this Protocol, and guidelines established thereunder, in light of evolving scientific knowledge related to climate change.

Article 9
Progress Toward Long-Term Goal

The Parties shall cooperate in the establishment of a long-term goal with respect to atmospheric concentrations of greenhouse gases.

Article 10
Meetings of the Parties

1. The Parties shall hold meetings at regular intervals. The secretariat shall convene the first meeting of the Parties not later than one year after the date of the entry into force of this Protocol and in conjunction with a meeting of the Conference of the Parties to the Convention.

2. Subsequent meetings of the Parties shall be held, unless the Parties decide otherwise, in conjunction with meetings of the Conference of the Parties to the Convention. Extraordinary meetings of the Parties shall be held at such other times as may be deemed necessary by a meeting of the Parties, or at the written request of a Party, provided that within six months of such a request being communicated to them by the secretariat, it is supported by at least one third of the Parties.

3. The Parties, at their first meeting, shall:

(a) adopt, by consensus, rules of procedure for their meetings;
(b) [other].

4. The functions of the meetings of the Parties shall be to:

(a) review the implementation of this Protocol, including the information submitted in accordance with Article 3;
(b) periodically review the adequacy of this Protocol;
(c) [other].

5. The United Nations, its specialized agencies and the International Atomic Energy Agency, as well as any State not party to this Protocol, may be represented at meetings of the Parties as observers. Any body or agency, whether national or international, governmental or non-governmental, qualified in fields relating to climate change which has informed the secretariat of its wish to be represented at a meeting of the Parties as an observer may be admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Parties.

Article 11
Secretariat

1. In accordance with Article 8.2(g) of the Convention, the secretariat of this Protocol shall be the secretariat of the Convention.

2. The functions of the secretariat shall be:

(a) ...

Article 12
Subsidiary Body for Scientific and Technological Advice

1. The Subsidiary Body for Scientific and Technological Advice of the Convention shall serve as the Subsidiary Body for Scientific and Technological Advice of the Protocol.

2. When the Subsidiary Body for Scientific and Technological Advice exercises its functions with regard to matters concerning the Protocol, decisions shall be taken only by those of its members that are, at the same time, Parties to the Protocol.

3. When the Subsidiary Body for Scientific and Technological Advice exercises its functions with regard to matters concerning the Protocol, any member of the bureau of the Subsidiary Body for Scientific and Technological Advice representing a Party to the Convention, but, at the same time, not a Party to the Protocol, shall be substituted by an additional member to be elected by and from the Parties to the Protocol.

Article 13
Subsidiary Body for Implementation

1. The Subsidiary Body for Implementation of the Convention shall serve as the Subsidiary Body for Implementation of the Protocol.

2. When the Subsidiary Body for Implementation exercises its functions with regard to matters concerning the Protocol, decisions shall be taken only by those of its members that are, at the same time, Parties to the Protocol.

3. When the Subsidiary Body for Implementation exercises its functions with regard to matters concerning the Protocol, any member of the bureau of the Subsidiary Body for Implementation representing a Party to the Convention, but, at the same time, not a Party to the Protocol, shall be substituted by an additional member to be elected by and from the Parties to the Protocol.

Article 14
Multilateral Consultative Process

[The Parties, at their first Meeting or as soon as practicable thereafter, shall consider the establishment of a multilateral consultative process to promote effective implementation of the Convention.]

Article 15
Dispute Settlement

[silence, with the result that Article 14 of the Convention would apply to this Protocol.]

[in addition, mandatory, binding dispute settlement [with specific consequences flowing from a violation] among Annex A and Annex B Parties, as well as against other Parties as appropriate (e.g., host countries under Article 7)]

Note: this process would be without prejudice to the review and compliance process under Article 4

Article 16
Evolution

The Parties shall adopt, by [2005], binding provisions so that all Parties have quantitative greenhouse gas emissions obligations and so that there is a mechanism for automatic application of progressive greenhouse gas emissions obligations to Parties, based upon agreed criteria.

Views on Certain Final Clauses

Adoption and Amendments of Annexes

Depending upon what type of material is eventually included in annexes, it may not be appropriate to restrict the content of all annexes to "lists, forms and any other material of a descriptive nature that is of a scientific, technical, procedural or administrative character." For any substantive annex, it may not be appropriate to provide for tacit adoption/amendment.

Signature

This provision should state that only Parties to the Convention may be Parties to the Protocol.

Entry into Force

To ensure effective implementation, as well as to minimize the potential "free rider" problem, this provision may need to stipulate an entry into force trigger that requires ratification by States that account for a particular percentage of global emissions of greenhouse gases.

Annex A

This Annex would include the same States as those listed in Annex I of the Convention, plus those that join subsequently pursuant to Article 2.

Annex B

This Annex would include those States not listed in Annex A that indicate before adoption of the protocol that they want to be included in this Annex, plus those that join subsequently pursuant to Article 2.

Annex C

This Annex would list greenhouse gases not covered by the Montreal Protocol, with the exception of gases, or particular sources and sinks, for which there is insufficient knowledge of the GWP or inability to accurately measure emissions or removals. GWPs would be those developed by the IPCC.

[end of document]

FACT SHEET ON SUPPLEMENTAL U.S. CLIMATE CHANGE PROPOSALS

June 1997

In January 1997 the United States submitted a draft text for a legal instrument to address next steps under the United Nations Framework Convention on Climate Change. Several technical elements left undefined in the January submission (principally those relating to compliance issues, and to which gases should be included in an agreement) have been further developed in the attached text; they are described below. The revised U.S. draft protocol proposal containing these new elements will form the basis for the U.S. position in the next session of the Ad Hoc Group on the Berlin Mandate (scheduled to meet in late July). Please call Jonathan Pershing (647-4069) or Linda Strachan (647-3550) of the State Department with any questions.

COMPLIANCE

- The January text created "emissions budgets", with targets based on the total emissions over a period of several years; this revision provides for a penalty to be assessed should a Party exceed its allowed budget.

- The January text created a review process; this revision calls for the review process to build on the existing Convention review mechanism, authorizes the review of any pertinent information, allows for consultations with both the Party and others in the course of a review, calls for the circulation of the completed review to all Parties, and requests the Secretariat to identify any report that requires further consideration.

- The January text provided an option for Parties with budgets to trade emissions; this text limits trading to Parties that have met all obligations pertaining to measurement and reporting of budgets, and that have in place national mechanisms for certification and verification of trades. With respect to a given budget period, it also precludes a Party from trading if it has exceeded its budget, and provisionally limits a Party's ability to trade if its compliance has been called into question.

- The January text provided for Meetings of the Parties; this text also calls for periodic review by the Parties of protocol implementation (including of the review process), requires Parties to implement an appropriate non-compliance regime (including through the development of an indicative list of consequences for non-compliance), and allows the Parties to establish an implementation committee to assist them in carrying out these duties.

ANNEX C: WHICH GASES ARE INCLUDED

- The January text suggested that all gases for which monitoring and measurement procedures are available should be included in the agreement; this revision maintains the broad inclusion of all greenhouse gases, sources, sinks and sectors, and calls upon the Parties to decide on best available methods for measurement, and to propose adjustments to the measurements in cases where best available methods are not used. The revision also calls for periodic updating of measurement methods.

Additional U.S. Proposals

(references are to the original U.S. submission)

Article 1 (Definitions)

- Replace definition 3 ("Greenhouse gas") with the following:

  > "Greenhouse gas" means any greenhouse gas covered in Annex C of this Protocol."

- Replace definition 4 ("Tonne of carbon equivalent") with the following:

  > "Tonne of carbon equivalent" means one metric tonne of carbon, or a quantity of one or more other greenhouse gases equivalent to one metric tonne based on the global warming potentials decided by the Parties in accordance with Annex C of this Protocol.

Article 2 (Emissions Budgets)

- Delete paragraph 7

Article 3 (Measurement and Reporting)

- Replace paragraph 2 with the following:

  > For the purposes of implementing paragraph 1 and promoting comparability, consistency, and transparency, the Parties shall, not later than their first Meeting, decide on agreed best available methods for the measurement by Parties of anthropogenic emissions by sources, and removals by sinks, of greenhouse gases, taking into account the best available methods determined by the IPCC and other expert bodies. They shall also decide on appropriate adjustments to measurements of emissions and removals where agreed best available methods have not been used. The Parties shall periodically update agreed best available methods and adjustments based on evolving scientific knowledge, including advice from the Subsidiary Body for Scientific and Technological Advice referred to in Article 12.

Annex C

- Replace descriptive language with the following:

  > All greenhouse gases, their sources and sinks, with global warming potentials as decided by the Parties at their first meeting (taking into account the IPCC's global warming potentials for 100-year time horizons) and as subsequently updated by the Parties to reflect evolving scientific knowledge.

Additional U.S. Proposals
(references are to the original U.S. submission)

In Article 2 of the U.S. proposal (Emissions Budgets), add a new paragraph 6.bis. as follows:

2.6.bis. At the end of a budget period applicable to a Party, any amount of tonnes of carbon equivalent emissions over its emissions budget shall be subtracted at a rate of [rate greater than that in paragraph 6] from the subsequent budget period.

In Article 4 of the U.S. proposal (Review and Compliance Process), substitute for paragraphs 3 to 6 the following text:

4.3 Reviews will be in connection with the review of communications conducted under Article 10.2(b) of the Convention and will be in accordance with guidelines to be adopted by the Parties at a meeting. These guidelines shall, inter alia, provide for how information will be made available to the public and define mechanisms by which observers and the public may provide comments, supplemental data or other information to facilitate and improve reviews. The guidelines shall be periodically reviewed by the Parties for appropriate revision.

4.4 Review teams will review all aspects of a Party's implementation of this Protocol, including the likelihood that a Party will achieve its emissions budgets obligations. They will be authorized, inter alia, to review pertinent information and consult with the Party in question and others as necessary. They will prepare a report assessing a Party's implementation of its obligations, identifying any areas of apparent non-compliance, as well as potential problems in achieving obligations.

4.5 Such reports will be circulated by the Secretariat to all Parties. In addition, the Secretariat will identify for further consideration any report indicating a question of implementation.

In Article 6 of the U.S. proposal (International Emissions Trading), substitute the following text:

6.1. Except as otherwise provided below, any Annex A or Annex B Party may transfer to, or acquire from, any Annex A or Annex B Party, any of its tonnes of carbon equivalent emissions allowed for a budget period, for the purpose of meeting its obligations under Article 2.

6.2 An Annex A or Annex B Party may not transfer or acquire any of its tonnes of carbon equivalent emissions allowed if it is not in compliance with its obligations under Article 3 (Measurement and Reporting) or if it does not have in place a national mechanism for certification and verification of trades.

6.3 An Annex A or Annex B Party may not transfer in a given budget period any of its tonnes of carbon equivalent emissions allowed if it has exceeded its emissions budget for that period.

6.4 If a question of a Party's implementation of the requirements referred to in paragraph 2 or 3 above is identified by either the review process under Article 4.5 or by the Secretariat under Article 11.2(b):

-- transfers and acquisitions of tonnes allowed (in the case of paragraph 2) and transfers of tonnes allowed (in the case of paragraph 3) may continue to be made after the question has been identified, provided that any such tonnes may not be used by any Party to meet its obligations under Article 2 until any issue of compliance is resolved. Issues of compliance shall be resolved as expeditiously as possible.

6.5 A Party may authorize any domestic entity (e.g., government agencies, private firms, non-governmental organizations, individuals) to participate in actions leading to transfer and acquisition under paragraph 1 of tonnes of carbon equivalent emissions allowed.

6.6 The Parties, at a meeting, may further elaborate guidelines to facilitate the reporting of emissions trading information.

In Article 10 of the U.S. proposal (Meetings of the Parties), for paragraph 4, substitute the following text:

10.4 The Parties:

(a) shall periodically review the adequacy of this Protocol;

(b) shall review the implementation of this Protocol, including the information submitted in accordance with Articles 3 and 5, reports received from the review teams referred to in Article 4, and any other reports and recommendations received from processes under this Protocol;

(c) shall implement an appropriate regime to address cases of non-compliance with obligations under this Protocol, including through the development of an indicative list of consequences, taking into account the type, degree, and frequency of non-compliance;

(d) may establish an implementation committee consisting of a subset of Parties to assist them, including by making recommendations, in carrying out functions referred to in subparagraphs (b) and (c) above.

In Article 11 of the U.S. proposal (Secretariat), for paragraph 2, substitute the following:

11.2 The functions of the secretariat shall be:

(a) to maintain and administer records relating to the accounting of the emissions budgets of Annex A and Annex B Parties, including initial budget allocations, adjustments to budgets consistent with Articles 2, 6, and 7, annual emissions, and remaining budgets in a given budget period;

(b) to facilitate the review of implementation of this Protocol through, <u>inter alia</u>, coordinating the review of Annex A and Annex B implementation; coordinating the reviews under Article 5; identifying for the Parties questions of implementation, including whether individual reports are consistent with reporting criteria; and preparing an annual compilation and synthesis report that contains inventory and budget information, and notes any discrepancies in accounting.

(c) [other].

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