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Testimony of David Gardiner
Assistant Administrator of Policy, Planning and Evaluation, U.S. EPA
before the
Subcommittee on Energy and Power
of the
Commerce Committee
U.S. House of Representatives

June 19, 1996

1. INTRODUCTION

Good Morning, Chairman Schaefer and Members of the Subcommittee. I am David Gardiner, Assistant Administrator of Policy, Planning and Evaluation at the U.S. Environmental Protection Agency. I am pleased to be here today to offer the Environmental Protection Agency's perspective on the Administration process for developing a U.S. position for the international negotiations to prevent dangerous human interference in the climate system.

The Environmental Protection Agency has participated actively in the Administration-wide analytic process for estimating the costs both of taking action to mitigate climate change and the costs of inaction if atmospheric concentrations of greenhouse gases are allowed to increase unabated. The Administration's efforts are contributing to a growing worldwide literature on these complex analytic tasks, and the totality of this research will serve as the scientific and economic foundation for the eventual formulation of a U.S. position.

Three prominent factors have intensified the Administration's recent focus on the problem of human-induced climate change, which has also been labeled "global warming" and the "greenhouse effect".

First, just this past December, the most comprehensive assessment of climate change ever undertaken was completed and released under the auspices of the Intergovernmental Panel on Climate Change (IPCC), a scientific body drawing on the work of 2,500 scientists that was set up by the United Nations to advise world leaders on this critical issue facing our civilization. The IPCC's first assessment in 1990 provided the basis for negotiation of the 1992 Framework Convention on Climate Change, which was signed by over 150 nations at the Earth Summit in Rio de Janeiro. The IPCC's Second Assessment Report constituted a major scientific milestone that advanced the scientific understanding of climate change and reinforced the urgency of further action. I will speak briefly about their findings on human health and the environment in a moment.

A second factor intensifying the Administration's attention to climate change is the accelerating pace of the international negotiation process. The Parties to the 1992 Convention decided in March of 1995 in Berlin to launch a process to define actions to be taken by the industrialized nations -- designated in the Convention as "Annex 1" nations -- in the post-2000 period, and to promote implementation of commitments by all nations. This decision, known as

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the "Berlin Mandate", initiated international negotiations to develop a new legal instrument for adoption in 1997. The U.S. successfully urged the Parties to include in the Berlin Mandate a call for an initial phase of analysis and assessment to inform the negotiation of post-2000 obligations. It is the early lessons of that analytic phase that we are prepared to discuss today. I will not elaborate further on the international process since this will be the focus of Deputy Assistant Secretary of State Rafe Pomerance's testimony today.

A third factor commanding our attention is the evidence that we are not going to be able to fulfill the objective called for in the Framework Convention. That convention obligates the United States and other industrialized nations -- known in FCCC parlance as "Annex 1" nations -- to aim to return greenhouse gas emissions to 1990 levels by the year 2000. In 1993, President Clinton unveiled the Climate Change Action Plan (CCAP), which included over 50 actions intended to bring the U.S. to the emissions level called for by the FCCC. Although the CCAP programs have in fact cost-effectively reduced emissions over the past three years, it now seems likely that the U.S. will fall significantly short of the goal, due to substantial funding cuts by Congress, stronger than expected economic growth, and lower energy prices. A review of the CCAP is being completed for release in the of fall 1996, and will include an update of emission trends, a review of the effectiveness of current actions, and recommendations for additional actions.

In sum, in light of the latest scientific evidence, the accelerating international process and the evident shortfall of our domestic efforts to date to adequately reduce U.S. emissions of greenhouse gases, the Administration is intensifying its efforts to determine the appropriate next steps. We have not yet even settled on a range of options for consideration. Rather we have been analyzing the emissions reduction options advanced by other countries in the negotiating process. We have reached one conclusion, however, and that is that inaction in the face of this threat would be inexcusable. We owe present and future generations a reasoned and attentive response to climate change.

2. EMISSIONS TRENDS

U.S. Emissions Trends: Total U.S. emissions of greenhouse gases were 1,595 million metric tons of carbon equivalent (MMTCE) in 1990, of which 1,336 MMTCE (roughly 84%) resulted from fossil fuel combustion. In 1994, the U.S. emitted 1,666 MMTCE of greenhouse gases (EPA, 1995). Of this total, 85% were carbon dioxide emissions, about 11% were methane, 2% were nitrous oxide, and 2% were from other gases including HFC, PFC, and SF₆. The transportation and industrial sectors of the U.S. economy were responsible for most of the CO₂ emissions, landfills and agricultural production were the greatest sources of CH₄ emissions, and the agricultural sector was the largest emitter of N₂O. Automotive air conditioning was largely responsible for the remaining emissions of HFC-134a.

Without additional policy intervention, U.S. greenhouse gas emissions are expected to rise

by at least 20 percent by 2010. Seventy five percent of the emissions growth will be in the energy sector, mainly in electricity generation and transportation. Emissions of HFCs – substitutes for chemicals being phased out under the Montreal Protocol – are expected to increase substantially.

Global Trends: During the first half of the 1990s, greenhouse gas emissions grew in the U.S. and most of the rest of the world. However, due to the restructuring of the former Soviet Union and Eastern Europe, global emissions have been roughly stable. Nearly all of the countries of the Organization for Economic Cooperation and Development (OECD) are experiencing rising greenhouse gas emissions. The important exceptions are the U.K., where energy sector deregulation is resulting in shifts away from coal and toward natural gas; and Germany, where emissions have fallen due to dramatic emissions reductions in the former East Germany. Projected U.S. emissions growth is expected to be slightly higher than the OECD average. Emissions are expected to grow somewhat more slowly in OECD-Europe and somewhat faster in OECD-Asia, when compared to the U.S.

Over the next century, the bulk of emissions growth will occur in the non-OECD developing countries. While OECD carbon emissions are projected to grow by about 25% over the next 20 years, developing country emissions are projected to more than double. This observation underscores why addressing the climate change problem will require both international cooperation and developed country leadership.

3. SUMMARY OF PRELIMINARY LESSONS FROM ANALYSIS

The Analytic Workshop on June 6-7, 1996 provided the U.S. Government an opportunity to hear more than 50 diverse presentations from a wide range of sources. Today I would like to describe the key preliminary lessons that we derived from analysis conducted by the U.S. Government's Interagency Analytic Team (IAT). I will also cite findings presented by non-governmental participants at the workshop, many of which reinforced those of the preliminary government analysis.

The IAT includes staff analysts from many of the U.S. government agencies that have a role in developing climate change policy, including: the Environmental Protection Agency, the Department of Energy, the Department of Agriculture, the Department of Commerce, Department of Transportation, Department of the Treasury, and the White House Council of Economic Advisors, the Office of Science and Technology Policy, and the Council on Environmental Quality. The IAT has adopted a diversity of perspectives and approaches – from detailed technology assessments to highly aggregated domestic and international macroeconomic modeling exercises – in making progress toward a balanced assessment of the impacts of climate change mitigation policy alternatives.

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I would now like to provide an overview of the seven preliminary lessons from the IAT.

analysis, after which I will offer some elaboration on each one in order. Please note that these are the same lessons embodied in the IAT's paper at the Workshop, though I have rearranged their order to suit the flow of my presentation today.

Lesson 1: Must account for benefits, not just costs of policy action

A balanced assessment of emissions reduction policies should account for the benefits that they would deliver in terms of averting or reducing the economic dislocations that are otherwise projected to occur in a rapidly changing climate. Significant progress needs to be made in estimating impacts and monetizing the range of damages so that the costs of action can be more appropriately compared to the costs of inaction.

Lesson 2: Emissions can be reduced with modest economic impacts, and projections are contingent on policy design and model biases

Modest emissions reductions can be achieved with macroeconomic impacts ranging from mildly negative to slightly positive. All else held equal, more stringent emission reduction targets would generally impose higher costs. The range of analytic results depends on the modeling framework used as well as the type of policy intervention simulated.

Lesson 3: No silver bullet in modeling -- no single number can accurately project impacts

Rigorous assessment of the impacts of greenhouse gas mitigation requires a variety of analytic approaches since no single model is capable of capturing all relevant aspects of the economy. Each approach has its own strengths and weaknesses. Therefore, it is imperative to understand and reconcile insights gained from a diversity of analytic approaches in arriving at an informed and balanced assessment.

Lesson 4: Flexible, phased policies can reduce costs of pursuing emissions reductions

Lower costs are associated with policies that are broad-based, flexible and phased. Such policies can help avoid disruptions such as premature retirement of capital and allow for rational planning by businesses and consumers.

Lesson 5: Technological change offers vast, untapped potential for emission reductions

Technological development and diffusion is critical to addressing climate change. In the short run, we need to understand and overcome the institutional barriers that slow the deployment of cost effective energy-saving technologies. In the longer term, we need to encourage the development and diffusion of new energy-saving and low-carbon technologies

Lesson 6: International cooperation and flexibility can reduce costs

Addressing the climate change problem will require unprecedented international cooperation. Cost-effective global solutions will require flexibility in the timing and location of greenhouse gas reductions, as well as institutions able to accommodate and promote such flexibility.

Lesson 7: Projections of compliance costs ^{can be} ~~tend to be~~ ^{or understated} overstated due to blindspots

In the past, regulatory compliance costs have often been overestimated because of reliance on analytic tools that fail to account for dynamic technological, institutional and organizational innovations. Such responses have greatly reduced compliance costs from original estimates for some regulations, and future analysis needs to consider how to take this potential bias into account. *ON THE OTHER HAND, ANALYTIC TOOLS OFTEN IGNORE STRUCTURAL ADJUSTMENT COSTS CAUSED BY THE DIFFERENTIAL IMPACT OF POLICIES ON EMPLOYMENT AND GROWTH OPPORTUNITIES ACROSS SECTORS.*

4. DISCUSSION OF PRELIMINARY LESSONS FROM ANALYSIS

Lesson #1: Must account for benefits, not just costs of policy action

A balanced assessment of emissions reduction policies should account for the benefits that they would deliver in terms of averting or reducing the economic dislocations that are otherwise projected to occur in a rapidly changing climate. Significant progress needs to be made in estimating impacts and monetizing the range of damages so that the costs of action can be more appropriately compared to the costs of inaction.

This first lesson provides a fundamental point of context for everything that follows. None of the economic models so far employed in the LAT's analysis measure the economic benefits of mitigating greenhouse gas emissions in terms of reduced climate change and other environmental impacts. The estimated costs of achieving emission reductions under various policies have not been systematically compared to the benefits of reduced or avoided climate change impacts. Reducing greenhouse gas emissions can lessen or avoid some of these impacts, but it should also be noted that since most greenhouse gases are long-lived in the atmosphere, past emissions have already committed us to experience some climate change impacts.

Unfortunately, the tools available to estimate the magnitude of specific impacts and convert them to monetized damages are limited at this time, hampering our ability to undertake a more comprehensive cost-benefit assessment of climate change policies. Nevertheless, some impact analyses have indicated substantial possible costs associated with inaction, providing an important context for considering the economic costs associated with policies to reduce greenhouse gas emissions.

As I mentioned earlier, a major significant milestone was crossed this past year. Drawing

on the work of 2,500 scientists from around the world, the Intergovernmental Panel on Climate Change concluded in its Second Assessment Report last December that: "The balance of evidence suggests that there is a discernible human influence on global climate." For the first time, this diverse group of scientists stated their belief that human beings have already begun to disrupt the climate system, a statement that is based on a multiplicity of peer-reviewed studies of empirical observations, statistical models, and advanced climate models.

Global greenhouse gas emissions are projected to increase up to six-fold over current levels by 2100 under the set of possible futures considered in the recent report of the Intergovernmental Panel on Climate Change (IPCC). Under any of the IPCC emission scenarios, the scientists expect that the rate of warming due to human emissions "will probably be greater than any seen in the last 10,000 years."

These impacts include very serious potential repercussions for the well-being of human populations. The IPCC concluded that: "Climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life." Health effects will potentially include increased incidences of illness and death from:

- anticipated increases in the intensity and duration of heat waves that exacerbate cardiovascular and respiratory diseases;
- reduced air quality and increased levels of air borne pollen and spores which exacerbate respiratory disease, asthma, and allergic disorders;
- extended geographic ranges of insects such as mosquitos and other disease-carrying vectors which can increase the populations exposed to diseases such as malaria, dengue and yellow fever; and
- ecological changes that can increase the incidence of cholera, diarrheal and other infectious diseases.

A control strategy to address greenhouse gas emissions would simultaneously reduce atmospheric concentrations of fine particles, NO_x, ozone, and heavy metals including mercury, bringing more immediate local air quality and health benefits. Despite a quarter century of efforts to control these pollutants through other means, health effects from these pollutants are still pervasive. These collateral non-climate benefits should also be considered in a full assessment of climate policy. EPA will be launching additional work to examine, therefore, the economic benefits of co-controlling for local air quality and greenhouse gas mitigation.

Human welfare is also placed at risk by the potential for climate change to adversely impact food production. Studies reviewed by the IPCC indicate that global agricultural production on an aggregate basis would be only moderately impacted by climatic changes projected by General Circulation Models for a doubling of carbon dioxide from preindustrial

levels. However, regional effects will vary widely and some regions could suffer significant reductions in agricultural output. The IPCC concludes that "There may be increased risk of hunger and famine in some locations; many of the world's poorest people -- particularly those living in subtropical and tropical areas, and dependent on isolated agricultural systems in semi-arid and arid regions -- are most at risk of increased hunger."

Studies of agricultural impacts in the U.S. suggest that total U.S. production of agricultural commodities are likely to be changed by only a small percentage as a consequence of climate change. The effects could either increase or decrease total output, depending upon the specific changes in climate that are projected to occur and depending upon how adaptable US agriculture is assumed to be to changes in climate. However, even for optimistic scenarios of agricultural gains in the U.S., it should be noted that the gains are not uniform across the US. Some regions could suffer significant losses as climate change causes geographic shifts in where important crops are grown.

The IPCC estimates that, in response to global climate change, sea level rise will accelerate at two to five times the rate witnessed in the past 100 years. The IPCC's best estimate of global sea level rise by the year 2100 is about 50 cm and their high estimate is nearly 1 meter. The IPCC estimates that a 50 cm rise in sea level would increase the population at risk from storm surges from roughly 45 million at present to over 90 million world wide. An earlier EPA report estimates that a 50 cm rise in sea level would inundate more than 5,000 square miles of dryland and 4,000 square miles of wetlands in the United States alone, if no protective measures are taken. Measures to prevent or limit these losses would cost billions of dollars.

In developing countries, resources to defend against a rising sea will be scarce and costs could represent a substantial portion of their annual GDP. But if no action is taken, millions of people would be displaced from their homes. The IPCC estimates that in Bangladesh and China alone, more than 140 million people could be displaced by a 1 meter rise in sea level. In addition to direct humanitarian implications, the creation of tens of millions of environmental refugees in these and other countries may impose substantial risks to political and economic stability, as well as promote the trans-boundary spread of infectious disease.

Human welfare is also placed at risk by changes in the availability of fresh water that may result from climate change. Relatively small changes in temperature and precipitation -- well within those projected to occur as a result of human-induced climate change -- can be expected to cause large changes in water runoff, affecting the quantity and quality of water supplies for domestic and industrial uses, irrigation, hydropower generation, navigation, stream ecosystems and water based recreation. Some analyses suggest that the frequency and intensity of floods and droughts will increase, but these changes will vary substantially across locations and confidence in predicted changes are low.

The IPCC judges that the areas of greatest vulnerability to changes in water supplies are the arid and semi-arid regions of the world. In some cases these areas coincide with conflict

prone areas which are highly dependent on water originating in areas outside their borders such as Cambodia, Syria, Sudan, Egypt and Iraq.

Because of water scarcity and tensions over its allocation in the arid west of the United States, some experts believe that changes in precipitation and water runoff due to climate change could have important social, political and economic consequences. However, appropriate planning by water management facilities and institutions could help to offset the adverse impacts and lessen the vulnerability of this region of the U.S. to changes in water runoff.

Studies of the long-term effects of climate change from a doubling of carbon dioxide from preindustrial levels reviewed by the IPCC find that one-third of North American forests would undergo major changes. The changes will mean that a large portion of the American landscape will look different, will function differently, and will support very different assemblages of plants and animals than is presently the case. The transformation of America's forests will take decades to centuries to complete. In the intervening period, prior to the introduction and establishment of species that are better adapted to the new climate, forest growth rates may decline in many areas, forested acreage may shrink as a result of forest dieback, and wildlife habitat may be severely disturbed.

Wetlands represent another critical set of ecological systems at risk from climate change. For example, the IPCC found that precipitation changes and salt water intrusion from sea level rise could adversely affect the ecological communities of the Florida Everglades and degrade this critical and unique habitat for many species of wading birds. The wetlands of the prairie pothole region of North America, which supports half the waterfowl population of this continent, could diminish in area and change dramatically in character in response to climate change according to the IPCC. Although not specifically assessed by the IPCC, such changes could be devastating to migratory bird populations and species survival.

Many climate change impacts may translate into direct economic impacts, including but not limited to:

- coastal zone engineering and construction costs in response to sea-level rise;
- exposure of large coastal populations to property and casualty loss due to potential changes in the frequency and intensity of extreme weather events such as hurricanes;
- property and crop damages from changes in flood and drought patterns;
- health and worker productivity impacts due to extreme hot weather events and changes in climate-sensitive disease exposure;
- disruption of agricultural production, which may be significant on a regional basis

even if net effects overall are modest

- and impacts on tourism revenue due to beach loss, impacts on recreational fish species and other ecosystem alterations

Lesson #2: Emissions can be reduced with modest economic impacts, and projections are contingent on policy design and model biases

Modest emissions reductions can be achieved with macroeconomic impacts ranging from mildly negative to slightly positive. All else held equal, more stringent emission reduction targets would generally impose higher costs. The range of analytic results depends on the modeling framework used as well as the type of policy intervention simulated.

In his testimony, Assistant Secretary of Energy Marc Chupka will discuss the quantitative range of macroeconomic effects associated with the emissions reduction targets advanced by other countries, and with various policy mechanisms for pursuing them. He will also discuss the relative strengths and weaknesses of the models used to project the macroeconomic effects.

However, I would like to underscore one lesson that stands out from the particular numbers: the ultimate magnitude and distribution of the economic impacts of climate change policies are contingent on the biases and assumptions of the model being used as well as on the design of the policy. Let me just discuss a few of the factors that can cause substantial swings in the model outputs.

Assumptions Regarding the Responsiveness of Energy Users to Changes in Energy Prices:

How responsive are energy users to changes in energy prices? If consumers and businesses respond very strongly to price signals, then relatively small price increases can produce large changes in energy consumption. Alternatively, if they are not very responsive, then it will take large price hikes to control emissions. Moreover, energy users' responsiveness to price changes is greater in the long term than in the short term, and is greater to price changes that are expected than to those that are unexpected. This suggests that policies that provide advance information about controls and introduce them gradually are likely to be less costly than policies that impose large controls unexpectedly, a point we will come back to.

Academic studies have demonstrated a wide range on energy price responsiveness. Some of these studies suggest that energy users are more responsive to changes in energy prices - they have higher demand elasticities - than is suggested by the DRI Energy Market Model used by the IAT. As a sensitivity analysis, therefore, the IAT replaced DRI's own long-run energy elasticities with average estimates from recent literature reviews. This change in assumption had a dramatic effect, cutting permit prices in half, and reducing the macroeconomic effects of the emissions reduction policies by a corresponding amount.

Other modeling approaches that incorporate a more flexible economic structure will also tend to result in lower energy prices and yield lower macroeconomic impacts to achieve a given emissions reduction target. For example, the DRI model's permit prices fall towards the high end of the range reported in the Stanford Energy Modeling Forum (EMF-12). This suggests that alternative modeling approaches would yield even lower estimates of macroeconomic impacts than those obtained and reported by the IAT.

Assumptions Regarding Energy Prices and Composition of Economic Growth: Control costs are sensitive to assumptions about the magnitude and composition of economic growth that are subject to great uncertainty. If one assumes that future economic growth will occur mainly in sectors that are fossil energy-intensive – such as basic manufacturing – then one will end up with relatively high estimates of the costs of controlling emissions. Alternatively, if one assumes that the composition of the economy will continue to evolve towards the service and information sectors, estimated control costs will be lower.

Similarly, future emissions growth – and thus the amount of emission reduction necessary to meet a specified target – is dependent in part on energy prices. One reason the U.S. has failed to meet its stabilization goal under the President's Climate Change Action Plan is that energy prices are lower than expected. To the extent that fossil energy prices continue to remain low, more emissions reductions will be necessary to meet future emissions targets.

Assumptions Regarding Capital Flows Into and Out of the U.S.: The economic impact of greenhouse gas mitigation in the U.S. is sensitive to what happens in other countries and the response of international capital markets. If all countries undertake mitigation, then capital will flow into those countries for which mitigation is least burdensome. The McKibbin-Wilcoxon G-Cubed Model, presented at the workshop, suggests that, for many mitigation scenarios, control costs are likely to be lower in the U.S. than in many of its industrial competitors. This is because the U.S. has relatively more opportunities than many of its OECD partners to limit its greenhouse gas emissions. Other countries may be less energy dependent than the U.S. is today, but their ability to become yet more energy efficient in the future is not as great as ours. Thus, an international mitigation strategy could result in more capital entering the U.S., stimulating economic growth that would not otherwise occur, and offsetting the direct costs to the energy sector. The analysis also suggests that overall GDP impacts of policies are highly dependent on international flows of financial capital.

Assumptions Regarding the Relative Importance of Energy to Economic Growth: Mitigation costs are sensitive to assumptions concerning the extent to which the overall ability of the U.S. economy to produce goods and services is dependent on energy consumption. The IAT examined the same emissions goal in one economic model using two different representations of this relationship. The economic impacts were substantially larger in one version than in the other. Further research is currently underway to understand the appropriate specification of this relationship.

Assumptions Regarding the Rate of Incremental Technological Improvement in Key Sectors: John Blaney of ICF presented a paper at the Analytic Workshop that demonstrated the sensitivity of cost estimates to assumptions regarding technologies in the electric utility sector. He asserted that relatively small improvements in technology (i.e., natural gas-fired plants) may lead to significant cost reductions. The electric utility sector today accounts for approximately one-third of carbon emissions in the United States. As such, a key determinant of the cost of greenhouse gas mitigation will be ability of the electricity sector to adapt to policy changes and incorporate low- and no-carbon technologies into the generation mix. The ICF analysis was designed, said Blaney, to complement the U.S. Government's macroeconomic analysis by providing a more detailed assessment of the electricity sector impacts of proposals being considered in negotiations under the Berlin Mandate. Using the DRI electricity demand forecast, ICF simulated a number of policy scenarios. In some cases, ICF's IPM model estimated that the cost per ton of reducing carbon emissions in the utility sector was almost 50% lower than the cost reported by the DRI model (DRI \$118/ton; ICF \$80/ton). The most notable difference between these two analyses are the assumptions regarding the future performance of particular technologies in the electric utility sector.

Lesson #3: No silver bullet in modeling -- no single number can accurately project impacts

Rigorous assessment of the impacts of greenhouse gas mitigation requires a variety of analytic approaches since no single model is capable of capturing all relevant aspects of the economy. Each approach has its own strengths and weaknesses. Therefore, it is imperative to understand and reconcile insights gained from a diversity of analytic approaches in arriving at an informed and balanced assessment.

This lesson reinforces Lesson 2, which illustrated the contingent nature of particular economic forecasts and policy analyses. Given that economic projections from the IAT analysis were frequently demonstrated to be, in part, an artifact of the model used to obtain them, it became clear that it would be inappropriate to rely on the findings of any one model or to attribute singular importance to any one number.

Although we have released the IAT's preliminary quantitative results, it is important to understand that non-practitioners of economic modeling tend to attribute more significance to the absolute values of numerical results than do modelers themselves. Aware of the limits of their own methods, modelers tend to focus instead on qualitative lessons for policy formulation, derived from cases where a particular policy design or strategy shows consistently superior results under a variety of modeling frameworks and assumptions. It is important for policy-makers to take this cue from analysts pursuing their area of specialization and to therefore not to attribute greater precision and reliability to model outcomes than do the modelers themselves.

As we move forward in our continuing analysis and policy deliberations, an important question to continue to grapple with is: which aspects of model specification have the greatest

impact on the results, which assumptions are most prone to bias, and how should analysts and policy-makers treat biases identified in the models?

Lesson #4: Flexible, phased policies can reduce costs of pursuing emissions reductions

Lower costs are associated with policies that are broad-based, flexible and phased. Such policies can help avoid disruptions such as premature retirement of capital and allow for rational planning by businesses and consumers.

As noted earlier, it is not only model design that matters but also the selection of which policy instrument to use in pursuing a particular emissions reduction goal. Analysis to date suggests that a well designed implementation policy can substantially reduce or totally offset the costs of greenhouse gas mitigation, potentially yielding net savings due to efficiency gains. While this analysis is still incomplete, it appears that a well-designed policy would include some of the following features:

- **Advance Signals:** Policies that are announced well in advance and implemented gradually will be substantially less costly than policies that impose large controls unexpectedly.
- **Flexibility:** We know from our experience in implementing the Clean Air Act that control strategies that grant sources broad flexibility in meeting desired targets will dramatically reduce costs. A model for this flexibility is the tradable allowances system for sulfur dioxide.
- **Broadly Shared Impacts Across the Economy:** Our studies show that how the cost of emission reductions is shared among energy producers and consumers can be important. An implementation program that places the economic burden solely on fossil energy producers can lead to reduced capital investment within the economy, which ultimately reduces economic growth. When impacts are shared with consumers, this drag on investment can be reduced or eliminated and unimpeded economic growth can continue.
- **Policies to Improve the Operation of Energy Markets:** Given the magnitude of potential emissions reductions that can be realized at a net savings, one must ask why more of these technologies are not now being implemented even in the absence of a control strategy. The reasons include a lack of information on the performance and economics of new technologies, higher up-front costs for the equipment (although lower operating costs), and other institutional problems (e.g., landlords minimize up-front costs and load higher operating costs onto tenants). Many of the programs included in the Administration's current Climate Change Action Plan were designed to address these issues. Such programs help ensure that the vast potential of technology to address the climate problem will be realized.

Lesson #5: Technological change offers vast, untapped potential for emission reductions

Technological development and dissemination is critical to addressing climate change. In the short run, we need to understand and overcome the institutional barriers that slow the deployment of cost effective energy-saving technologies. In the longer term, we need to encourage the development and dissemination of new energy-saving and low-carbon technologies.

A substantial body of literature demonstrates tremendous potential to reduce emissions in the energy sector at a net savings or low cost to the economy. Exploiting these opportunities could result in substantial positive impacts on the economy. These improvements in the economic efficiency of the energy sector would stem, in the relatively short term, from the adoption of existing energy end-use and energy supply technologies. Firms that make an incremental investment in energy efficiency typically enjoy returns substantially higher than the available alternative investments, increasing overall productivity. In the long term, the development and diffusion of new energy-saving technologies could offer further gains.

Most prominent among the studies of emissions reduction potential are the National Academy of Sciences 1991 report, *Policy Implications of Greenhouse Warming* and the Office of Technology Assessment's report, *Changing by Degrees* (OTA, 1991). These studies found that the technologies evaluated had the potential to reduce up to 472-480 million metric tons of carbon at a net economic savings. This represents over a 30% reduction from today's levels of greenhouse gas emissions. Both studies employed engineering cost estimates to calculate the potential of various technologies to reduce emissions in the energy sector. Specific examples of opportunities include the following efficiency improvements: adjustable speed drives for fan motors, waste heat recovery, improved chillers, cogeneration, occupancy sensors, increased residential use of natural gas, comprehensive retrofit measures to existing building shells, and improved fuel efficiency from existing technologies.

Edward Rubin of Carnegie Mellon University sought in his paper for the Analytic Workshop to explain why the technologies evaluated by the NAS study cited were not more readily adopted despite their economic benefits. He suggested that the range of discount rates utilized in the study -- 3-10% -- may not accurately represent consumer behavior. While the Office of Management and Budget indicates that this range is representative of current criteria for public investment in the U.S., Rubin proposed that consumers may have discount rates closer to 30% for these investments. This would imply that consumers are systematically undervaluing the returns from energy saving investments, which would explain in part their failure to adopt these technologies.

Many other studies have come to similar conclusions over the years. For example, the Energy Information Administration, in a report used to develop the 1990 National Energy Strategy, found that energy use in the U.S. could be reduced by 16% and carbon emissions

reduced by 19% compared to baseline projections for the year 2010 while boosting GDP by 0.8%. [*Energy Consumption and Conservation Potential: Supporting Analysis for the National Energy Strategy*]. The study did note, however, that further analysis was necessary to more accurately quantify the macroeconomic impacts like GDP.

A study recently completed by the Environmental Protection Agency using the Energy Information Administration NEMS model confirms and extends the earlier results, finding substantial carbon emissions reductions at net economic savings. The new study focuses on the impact of policies that would resolve market failures in the commercial, residential, industrial, transportation and electric sectors. These policies are based on institutional and organizational change that will unlock profitable opportunities in the energy efficiency market and promote the diffusion of higher efficiency technologies. The EPA analysis found that successful implementation of institutional and organizational change could yield greenhouse gases reductions of up to 39% over baseline 2015 levels (or 21% over 1990 levels) with a positive GDP impact of 0.5%. The institutional and organizational change examined in the EPA study would ensure that households and businesses receive the information, technical assistance, and financing they need to purchase and profit from proven higher efficiency technologies. The institutional and organizational change would also be structured to give equipment manufacturers and building owners the opportunity to capture some of the profit from the higher efficiency technologies, thus stimulating diffusion and innovation.

The Union of Concerned Scientists said in their 1990 report, *America's Energy Choices*, that economically beneficial energy reductions could be achieved. Carbon emissions could be lowered by 31% compared to their reference case at benefit-cost ratio of 2.58 to 1 for the years 1990 through 2030. The American Council for an Energy Efficient Economy said, in *Energy Efficiency and Job Creation*, that their high efficiency scenario would yield significant economic benefits including a 0.7% increase in employment, 0.5% increase in personal income, and a 0.1% improvement in GDP by 2010.

At the recent Analytic Workshop, Stephen DeCanio presented a paper arguing that just as economic growth over the long term is driven largely by the rate of general technological progress, the path of future energy demand depends at least as much on technological advances in energy use and the decisions to adopt advanced technology as it does on the underlying process of macroeconomic growth. He further noted that the models used to project potential impacts of climate change policies are deeply conservative, i.e., they seriously underestimate the potential for the diffusion of better, more energy efficient technology in the energy-using sectors of the economy. Since they limit the potential for technological responses to energy price increases (often modeled through a carbon tax or the auctioning of carbon allowances), macroeconomic and related models show a penalty in the form of reduced economic growth, at least in the short term. Understanding innovation and diffusion of advanced technologies is one of the more difficult questions in economics today, but according to De Canio, we can no longer afford to ignore it in our policy analysis and development.

Mr. Skip Laitner presented a paper at the Analytic Workshop that sought to characterize the "efficiency gap" in the United States. He defined this gap as the disparity between the level of energy efficiency that is now economically possible compared to current practice in how energy is used. A range of studies estimate the "efficiency gap" in the United States at between 14-30%. Mr. Laitner suggested that based upon a greater understanding and appreciation of the "efficiency gap", policy makers could recognize that investments in energy efficiency technologies -- and policies to promote them -- could provide both an important productivity benefit for the economy as well as a reduction in overall carbon emissions.

To illustrate this gap, Mr. Laitner cited a recent, detailed study of the Colorado economy showing that a cumulative investment of \$4.4 billion over 13 years would reduce energy expenditures by \$8.5 billion over the same period [*Colorado's Energy Future: Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy*, by Economic Research Associates, April, 1996]. This would reduce carbon emissions by 17% compared to baseline projections out to 2010. The impacts on gross state product (GSP) would be positive, rising by \$46 million in 2010 and the investments would generate a net gain on the order of 8,400 jobs, with an increase in wage and salary income of about \$171 million. By contrast, Laitner noted, a typical macroeconomic model of the U.S. economy would have projected that the same 17% reduction in carbon emissions would have generated a \$61 million loss in (GSP) for the state.

How can we explain such widely disparate estimates of the impacts of carbon emissions reductions? The difference stems, in part, from an assumption implicit in most models of the economy that all economic agents -- whether firms, households, or governments -- are operating on the "production possibility frontier", that is, that they are already efficient. This efficiency assumption creates the familiar view that there is a tradeoff between environmental protection and economic growth. Yet a range of empirical studies demonstrate that economic actors frequently fail to reach their efficiency frontier, leaving an "efficiency gap" that can profitably be closed.

This closing of the gap would also produce job gains, according to Laitner. Building on a 1992 study by the American Council for an Energy Efficient Economy [*Energy Efficiency and Job Creation*], Laitner estimated that returning carbon emissions to 1990 levels -- amounting to a 23% energy and carbon savings in his scenario -- would lead to a net gain about 1.3 million new jobs. (Estimated from the baseline forecast by the Energy Information Administration in the reference scenario of the 1996 version of Annual Energy Outlook).

Productivity improvements, through efficiency increases and innovation, are the key to successfully competing in a global economy and to breaking the link between greenhouse gas emissions and economic activity. Even outside the energy efficiency literature considered above, recent analysis demonstrates that innovation, in general, drives economic growth and increases employment. Recent studies by the Department of Commerce demonstrate that manufacturing plants that use more advanced technologies -- many of which apply to energy efficiency improvements -- outperform other firms. They are more productive, less likely to close, able to

increase employment more rapidly, and pay higher wages than comparable firms.

Dennis Heydanek, Director of Issues Management at Dow Chemical, presented a paper at the Analytic Workshop describing his company's 53% average return on capital for voluntary environmental improvements, including energy efficiency projects. Through the use of cogeneration for more than 90% of their global productivity capacity, Dow has been able to achieve efficiency gains on the order of 20-40% when compared with the purchase of power from the public utility grid. With the use of cogeneration in the U.S. alone, they claim to have saved enough fuel annually to supply heat and light to 996,000 average households in the U.S., or one percent of all U.S. households. Dow concludes that "the technology is proven across a broad range of economic, legal, and social circumstances, that this technological concept is an excellent means of establishing sustainable efficient infrastructure in developing countries, and that this technology will play an important role in delivering a solid foundation for economic, growth, industrial competitiveness, and "no regrets" investment in climate change solutions".

Jared Blum presented a paper on behalf of the Polyisocyanurate Insulation Manufacturers Association (PIMA), in which he noted that the use of thermal insulation in buildings, homes, and industry has tremendous potential to save energy, save money, and reduce atmospheric pollution emissions. Since the Energy Policy Act of 1992, the number of states which have adopted improved energy standards for new buildings has increased from 15 to 26. These standards largely consist of insulation upgrades in buildings. Since 1991, PIMA claims that "3.9 trillion Btu's of thermal energy have been saved, at a rate of about 861 billion Btu/year, worth a total savings of \$44.2 million for consumers and a reduction of 334,000 tons of air pollution". If the adoption of these standards occurred in the remaining 24 states, they estimate that 5.9 trillion Btus would be saved, annual energy bills would be reduced by \$81 million and 566,000 tons of pollution/year would be avoided.

Mark Menzer of the Air Conditioning and Refrigeration Institute presented a paper showing that replacing older less efficient equipment with new chillers, building owners can save almost \$500 million and seven billion kilowatt hours of electricity in 1999. This seven billion kWh represents the annual electrical needs of 740,000 U.S. households and would avoid emissions of over four million tons of carbon dioxide and of 34,000 tons of sulfur dioxide (equivalent to the annual emissions of one and one-half large coal-fired power plants).

Scott Sklar of the Solar Energy Industries Association said in his presentation at the Analytic Workshop that "The United States can reliably generate U.S. employment in the renewable energy technologies, of which our nation holds both the global technological and commercialization leads, and at the same time substantially reduce greenhouse gas emissions." He noted that this can occur through investment in renewables, which have a higher rate of jobs created per dollar than investments in non-renewables. According to Scott Sklar, one million dollars of investment (1990\$) in biomass electricity can spur the creation of 23.2 jobs, while the same million would create only 4.38 jobs in the coal mining industry or 4.73 in manufacturing. While biomass represents less than one percent of total energy in the U.S., renewables are

predicted to be responsible for nearly half of global power generation by 2040.

Nancy Bacon of Energy Conversion Devices, speaking at the Analytic Workshop on behalf of the Business Council for a Sustainable Energy Future, discussed two, recently improved technologies that she said demonstrate that emissions reductions and economic growth can be simultaneously pursued: electric cars and photovoltaic cells. She said that an efficient, high-powered battery now available has improved the performance of the electric car. One new battery lasts the lifetime of the car, can run 300 miles before being recharged, and allows the car to perform like its gasoline-powered counterpart. However, since it is not being mass-produced, it therefore remains expensive relative to gasoline-powered cars. Photovoltaic cells have similarly undergone significant improvement, allowing them to be smaller, cheaper, and more efficient. In addition, they can now be manufactured in the form of traditional roof shingles; this is both efficient and aesthetically pleasing. As with the new electric cars, Bacon said the market penetration of the PV cells is limited by their relatively high upfront cost due to lack of mass production. Bacon concluded that these technologies have a lot of economic and emissions-reduction potential, but that a joint effort between consumers, government, and business is required to promote them and make them financially attractive.

This discussion highlights some of the exciting potential that exists to reduce greenhouse gas emissions while exploiting untapped opportunities for positive efficiency gains in the economy. A principal question for present and future analysis in climate change mitigation is how policies can best be designed to harness market forces and induce the development and adoption of more efficient technologies.

Lesson #6: International cooperation and flexibility can reduce costs

Addressing the climate change problem will require unprecedented international cooperation. Cost-effective global solutions will require flexibility in the timing and location of greenhouse gas reductions, as well as institutions able to accommodate and promote such flexibility.

Because of the projected growth in greenhouse gas emissions from developing countries, it is essential that these countries control and limit their emissions. However, developed countries and the economies in transition are responsible for the bulk of current and historic greenhouse gas emissions. For this reason, the Parties to the Framework Convention on Climate Change have decided that is appropriate for developed countries to take the lead in controlling greenhouse gas emissions. This does not imply that the U.S. and other OECD countries will continue to bear the costs of limiting greenhouse gas emissions in the long run, only that in the short run, developed countries are expected to take more actions than their developing country peers in controlling emissions.

The U.S. fully expects developing countries to take on more responsibility for controlling

greenhouse gas emissions over time. However, within the context of the climate negotiations, the Administration has found it much more constructive to engage developing countries cooperatively than to continually pressure them into more commitments - a strategy which inevitably leads to demands for new and additional financial and technological transfers. Instead, the Administration's approach has emphasized demonstrating that controlling greenhouse gas emissions is in the economic and environmental self-interest of developing countries. The success of the Administration's strategy is evidenced by the groundswell of climate mitigation activities being undertaken by developing countries.

One notable example is Thailand's demand side management program. EPA invested approximately \$200,000 over 6 years to provide technical assistance to develop and implement the program. The Thai government has invested \$171 million dollars into the pilot project which began in 1993. The program is projected to yield energy savings of 238 megawatts and 1 million metric ton of carbon dioxide per year by 1997.

Lesson # 7: Projections of compliance costs tend to be overstated due to blindspots

In the past, regulatory compliance costs have often been overestimated because of reliance on analytic tools that fail to account for dynamic technological, institutional and organizational innovations. Such responses have greatly reduced compliance costs from original estimates for some regulations, and future analysis needs to consider how to take this potential bias into account. *on the other hand, analytic tools often ignore structural adjustment costs caused by the differential impact of policies on employment and growth opportunities across sectors.*

Most of the modelling approaches used by the IAT have not incorporated the technological innovation response to the policies analyzed, but rather assume a relatively fixed path of technological change. Policies that limit energy use will tend to stimulate research investments that will produce technologies that cannot be predicted in advance but which are likely to reduce the costs of meeting greenhouse gas emission reduction goals.

This potential bias has distorted some previous analyses of the costs of pursuing environmental policies, where the private sector demonstrated a greater than anticipated ability to respond to market-based policy signals with technological innovation that reduced the costs of meeting environmental goals. We can draw lessons from two successful and innovative environmental policies: the acid rain control program and the Montreal Protocol, designed to limit the release of ozone-depleting chemicals into the atmosphere. Experiences with the phase-out of ozone-depleting CFCs and with implementation of the 1990 Clean Air Act Amendments demonstrate that when the government sends a clear signal concerning its environmental goals and preserves operational flexibility for businesses, innovative technologies tend to emerge and costs tend to fall well below early projections.

Sulfur Dioxide Allowance Trading: The price of sulfur dioxide emissions permits under the Acid Rain market trading mechanism has plummeted far below initial estimates,

demonstrating that the projected costs of meeting the goal had been exaggerated. In 1989, industry projected that they would have to pay \$1,500 for the right to emit one ton of sulfur dioxide. Due to such factors as improved methods of blending coal types to meet emission limits and innovations in smokestack scrubber technology, the actual price of a one-ton permit on the Chicago Board of Trade in 1996 is just \$66.

CFC Phase-out: Similarly, the cost of the CFC phase-out have proved to be much lower than initial estimates. During early phases of the analysis, it was not even clear that substitutes for some CFCs would even emerge, so that no cost estimate was possible. In the case of automobile air conditioners, industry analysts initially estimated that retrofits with CFC substitutes would cost between \$800 and \$1500; they are now available at a cost of \$200 to \$800.

A change in greenhouse gas policy would also likely stimulate private sector efforts to develop low-carbon energy technologies. Analyses of proposed climate policies tend to *MISestimate* underestimate these types of dynamic responses because they are difficult to quantify and may be impossible to forecast. Differences between the climate change problem and either acid rain or stratospheric ozone depletion may also limit the transferability of specific lessons from those cases. Nevertheless, the broad lesson is instructive; as discussed above, evaluation of the role of innovation and technological change is needed to provide a more accurate estimate of the potential long-term impacts of climate change policies and any potential bias in current modeling results. *as we have discovered,*

5. CONCLUSION

The U.S. Government recognizes the need for further refinement of its continuing analytic work. The preliminary government analysis I have discussed today, and the recent workshop, together mark the beginning, not the end, of a process of analysis, assessment and development of climate change response strategies. The U.S. Government intends to rely on a range of experts and stakeholders to provide high-quality input on the difficult analytical problems that must be resolved in order to craft a cost-effective and forceful policy capable of preventing dangerous human interference with the Earth's climate.

Thank you, Mr. Chairman, for this opportunity to discuss this critical mission.

dst-It* Fax Note	7671	Date	6/5	# of pages	1
to	RAY PRINCE	From	M. TOMAN		
cc/Dept.		Co.			
home #		Phone #			
fax #		Fax #			



JUNE 5, 1996

C. Martin

MEMORANDUM FOR: RAY PRINCE, CEA

FROM: MIKE TOMAN *MT*

SUBJECT: *File* GOSSIP ABOUT THE ADMINISTRATION'S CLIMATE CHANGE ANALYSIS

or Global Warming

I have had a couple of occasions at recent meetings to talk with some pretty well-connected people outside the government who have some knowledge about the Administration's interagency analysis of the economic impacts of long-term GHG emissions constraints. Since I am not close to the process myself at this point, I have no way to independently judge the veracity of their assertions. However, I know these people to be competent analysts and generally well enough connected to be believable. Their comments suggest that there are some real potential problems with the Administration's analysis, flaws that (again, if these guys are right) could be identified by sharp analysts hostile to the Administration's climate program. There thus seems to be sufficient risk of embarrassment that it might be worth following up on these concerns, assuming that CEA has not been shut out of the process entirely.

The gossip I was privy to did not provide a detailed road map of the potential analytical problems. However, the following points seem to be at issue:

- (1) Why is the Administration relying mostly if not entirely on variants of the long-term DRI model? The essence of the EMF12 process was that models differed considerably in their results, and that the differences were not just the result of parameter values. A macro forecasting model like DRI's will inherently show different responses to GHG control policies and different adjustment costs, especially in the short term (the adjustment costs would likely be higher, it seems to me, than with a GE model that emphasizes changes in resource allocation over spending levels).
- (2) Is the version of the model the Administration is using reliable? There seem to be concerns about the specification of energy demand in the model, but I did not get any details. There also seems to be some real concern about how the costs of carbon taxes in the model are recycled. I know that in earlier studies of the macro effects of energy prices using these models, the economy always could be made to boom with cuts in corporate taxes. I always thought these results were pretty bogus, so if the Administration's analysis is using carbon tax revenues to lower capital taxes, they may be understating the cost of the GHG constraints.

Again, I wish I could be more precise about the concerns; I hope this is helpful.

MARTIN CLIMATE CHANGE
PRI (KL)
Model runs RAY Costs

Stabilization

GDP Impacts (Undiscounted)						Consumption Impacts (Undiscounted)					
2000-2010		2011-2020		2000-2020		2000-2010		2011-2020		2000-2020	
Scenario	\$87 Bill.	%	\$87 Bill.	%	\$87 Bill.	%	Scenario	\$87 Bill.	%	\$87 Bill.	%
1A3	-605.8	-0.78%	1332.9	1.60%	727.1	0.46%	1A3	-519.6	-1.03%	460.7	0.84%
2A1	-513.9	-0.67%	736.3	0.89%	222.4	0.14%	2A1	-788.2	-1.56%	-48.7	-0.09%
2A2	-399.2	-0.52%	-832.5	-1.00%	-1231.7	-0.77%	2A2	-40.8	-0.08%	-147.9	-0.27%
2A3	-74.1	-0.10%	729.6	0.88%	655.5	0.41%	2A3	-155.8	-0.31%	512.8	0.93%
2B1	-429.3	-0.56%	-787.1	-0.95%	-1216.4	-0.76%	2B1	-227.8	-0.45%	-232.5	-0.42%
2B2	-521.7	-0.68%	-2.9	0.00%	-524.6	-0.33%	2B2	-546.0	-1.08%	-149.2	-0.27%
3A3	-228.7	-0.30%	859.5	1.03%	630.8	0.40%	3A3	-274.6	-0.54%	521.4	0.95%
4A1	-659.8	-0.86%	766.9	0.92%	107.1	0.07%	4A1	-917.0	-1.81%	-229.2	-0.42%
4A2	-440.3	-0.58%	-1034.6	-1.25%	-1474.9	-0.92%	4A2	-29.7	-0.06%	-242.1	-0.44%
4A3	-123.5	-0.16%	745.8	0.90%	622.3	0.39%	4A3	-175.2	-0.35%	472.7	0.86%

GDP Impacts (Discounted)						Consumption Impacts (Discounted)					
2000-2010		2011-2020		2000-2020		2000-2010		2011-2020		2000-2020	
Scenario	\$87 Bill.	%	\$87 Bill.	%	\$87 Bill.	%	Scenario	\$87 Bill.	%	\$87 Bill.	%
1A3	-307.2	-0.73%	352.7	1.57%	45.5	0.07%	1A3	-268.1	-0.97%	108.1	0.73%
2A1	-296.9	-0.71%	182.2	0.81%	-114.7	-0.18%	2A1	-411.0	-1.48%	-31.7	-0.21%
2A2	-193.9	-0.46%	-217.6	-0.97%	-411.6	-0.64%	2A2	-11.5	-0.04%	-42.3	-0.28%
2A3	-50.8	-0.12%	187.8	0.84%	137.0	0.21%	2A3	-87.1	-0.31%	125.8	0.85%
2B1	-211.2	-0.50%	-205.9	-0.92%	-417.1	-0.65%	2B1	-104.7	-0.38%	-69.9	-0.47%
2B2	-280.8	-0.67%	-7.2	-0.03%	-287.9	-0.45%	2B2	-277.5	-1.00%	-54.1	-0.36%
3A3	-136.4	-0.32%	225.7	1.00%	89.3	0.14%	3A3	-151.2	-0.54%	127.3	0.86%
4A1	-362.3	-0.86%	190.9	0.85%	-171.4	-0.27%	4A1	-468.7	-1.69%	-81.9	-0.55%
4A2	-214.0	-0.51%	-269.3	-1.20%	-483.3	-0.75%	4A2	-10.5	-0.04%	-64.2	-0.43%
4A3	-70.8	-0.17%	194.0	0.86%	123.2	0.19%	4A3	-95.4	-0.34%	116.7	0.78%

2A3 like Pri B
260 8958

2B1 - Distribute permits to consumers (Free)

2B2 - Distribute permits 60% to Business, 40% to consumers

2A1

2A2

2-A3

Auctioned permits, revenue used for deficit reduction

Auctioned permits, all revenue to consumers in form of lowered income tax (reduces MRT)

Auctioned permits, 60% revenue to Business (reduces MRT) 40% to consumers in form of lowered income tax

File: Global Warming
Greenhouse Gases

C. MARTIN

E X E C U T I V E O F F I C E O F T H E P R E S I D E

25-May-1996 07:39am

TO: (See Below)

FROM: Stephen R. Seidel
Council on Environmental Quality

SUBJECT: Comments on Draft Overview Paper for Analysis Works

NOTE TO: Abe Haspel/ Howard Gruenspecht
Al McGartland
Nancy Kete
Rafe Pomerance
Jeffrey Hunker
David Sandalow
Rosina Bierbaum
Ray Prince

cc: Marc Chupka
David Gardner
Eileen Claussen

RE: Comments on Draft Presentation for Analysis Workshop

The draft government overview paper (version #2) does a good job of pulling together a lot of information, but needs considerable refinement. Most significantly, the paper differs substantively in several key areas from the results and conclusions presented at the February briefing. It also fails to deliver a clear message for the audience.

1. Message -- I thought we had two basic messages to convey: 1. Our analysis shows that projected costs are likely to be substantially less than previous analyses and 2. Our analysis shows that some of the scenarios examined would not substantially harm the economy and there are reasons to believe that this analysis overstates likely impacts. These messages do not come across in the current package. Consider adding an overhead that shows comparison to past studies and explains why cost estimates have come down and adding material on why our modeling is generally conservative and likely overstates costs.

2. CCAP discussion -- generally pretty good, but I would add something positive, e.g., those actions that have been funded are producing and saving economy money while reducing emissions. They just aren't going to deliver enough for the reasons stated. I would discuss the gap qualitatively and not present detailed figures which are still being sorted out.

3. Technological costing studies: In place of the current discussion of the amount of reductions that could be achieved at various dollar amounts, consider stating the amount the studies suggest can be achieved for zero or negative cost and give the quantity needed to stabilize in sat 2010 for context.

4. Macromodeling -- A number of points here

A. The size of the reductions from CCAP (50-60 mmt) seems low for 2010.

B. The discussion on the energy modeling focuses on IDEAS and DRI model. Shouldn't we make it clearer that these models give the highest energy impacts and that other models like the ICF model and the bottom up models, not to mention the analysis that Hoffman is doing with NEMS, give much lower results. In this sense we are using the worst case or at least a conservative energy impact analysis to drive the macromodeling. This does not come across at all.

C. The most significant change since the February briefing package appears to involve a modification in DOE's modeling of the relationship between energy and GDP impacts in the DRI model. This appears to have substantially increased the reduction in GDP. Clearly it would be best if this could be resolved prior to the workshop. If not, we might be better off presenting the DRI model as it stands and identify in additional work this and any other factors that we think need further analysis.

D. We need to give further thought how to present the range of uncertainties for the macromodeling. The implementation issue is one area that we should present, but energy inputs to the model are also uncertain and are not dealt with in our modeling as an area of uncertainty.

E. Should we also be making the point here that these modeling exercises assume a permit system, but that implementation could take any one of a number of forms including sector specific actions, regulations, tax, etc.

5. International Modeling

This is the second major area where the draft paper diverges significantly from the February briefing. The results at that briefing (based on preliminary G-Cubed and Oxford modeling) were GDP impacts for U.S. of stabilization of between +0.4% - -0.8% in 2010, with greater impact on most other OECD countries than the U.S., and no significant leakage to developing countries.

The results in the presentation rely on EMF modeling, show no potential for positive GDP impacts and larger negative ones for the U.S. and conclude that the U.S. will be hit harder than other OECD countries. It also says nothing about leakage. The conclusions as presented are chock full of economics jargon and

appear to be written to obfuscate rather than illuminate.

Why the changes in the modeling presented? Why the changes in the conclusions? This section needs major surgery.

6. Where and when Flexibility

This information will presumably be presented by Edmonds and/or Richels in their presentations. Should we include it in ours given the fact that the "where" includes non-Annex 1 countries and the "when" spans 50 years. While we are very likely to support maximum flexibility in the negotiations, we may be hurting rather than helping our case by presenting flexibility in this extreme scenario.

7. Conclusions:

Should focus on two key points from above:

1. Analysis shows costs are lower than previously estimated
2. Some scenarios can be achieved at relatively minor impact to economy, even assuming conservative assumptions.

Distribution:

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TO: Rosina M. Bierbaum
TO: Raymond Prince
TO: FAX (9482-6055,Jeffrey Hunker)
TO: FAX (9647-0217,Eileen Claussen)

- Macro-models often underestimate response time and costs related to transforming the economy
- Disconnect in paper between statements of differences among models and graphs
- Costs equal around 50% of current pollution abatement expenditures
- Paper attempt to avoid emphasis on costs by advocating dramatic new tax policy which might be just as politically dangerous
- Emphasis should be on emissions trading with banking and borrowing not on reforming corporate tax policy

Yale University

Professor William D. Nordhaus

Department of Economics

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June 3, 1996

Dr. Martin Baily

Member, Council of Economic Advisers

Washington, D.C.

Dear Martin:

I enclose a brief discussion and comparison of the engineering and behavior approaches to estimating the costs of greenhouse gas (GHG) emissions from the most recent comprehensive National Academy of Sciences study of this subject. While there is more recent work, I think this captures the essence of the estimates reasonably well.

The major issues that are not addressed here are the following:

1. The engineering models do not identify the instruments that can be used to capture the low-cost or negative-cost savings in GHG emissions. Hence, while there is little doubt that many low-cost options exist, it is not clear how one exploits them.

2. Because of point 1, the engineering approach tends to "overoptimize." If we use actual instruments to attain the savings, they almost always introduce some inefficiencies. An obvious example is CAFE standards, which save GHG emissions but not at the costs estimated by the engineering

3. Finally, in terms of policy implications, if the low-cost view is correct, then the implication would be that we need less stringent measures to attain the cost-beneficial rate of GHG emissions than if the standard behavior view is correct. The reason is that if there are many low-cost sources of emissions reductions, then the carbon tax or necessary additional reductions would be lower because we can more easily attain the cost-beneficial objective.

Sincerely,

Bill

Price smoothing
Auction over 20 years
trade within
Stock externalities

Institutions
Ocean circulation
Inertia

intergov. panel
climate change
(not great)

Policy Implications of Greenhouse Warming

**Mitigation, Adaptation,
and the Science Base**

Panel on Policy Implications of Greenhouse Warming

Committee on Science, Engineering, and Public Policy

National Academy of Sciences
National Academy of Engineering
Institute of Medicine

NATIONAL ACADEMY PRESS
Washington, D.C. 1992

PART ONE: SYNTHESIS

know more about them before greenhouse warming occurs, at the high end of the range to restrain their greenhouse gas emissions on a global scale, or might fail. In the case of countering the effects, and none of these options are relatively unknowns concerning possible implementation without careful assessments.

Options in the United States

Implementation	Potential Emission ^b Reduction (t CO ₂ equivalent per year)
	900 million ^c
	300 million
to low cost	500 million
to low cost	50 million
to low cost	50 million
	200 million
	1400 million
	200 million
erate cost ^d	200 million
erate cost ^d	1000 million ^e

metric.

CO₂ equivalent

of CO₂ equivalent
equivalent

action assumes 100 percent imple-
mentations and is an optimistic "upper

bound and is controversial. This repre-

sents the possible to determine the amount of

supply options is actually 1700 Mt
are to remove the double-counting
(ing).

MITIGATION

61

TABLE 6.3 Cost-Effectiveness Ordering of Geoengineering Mitigation Options

Mitigation Option	Net Implementation Cost	Potential Emission Mitigation (t CO ₂ equivalent per year)
Low stratospheric soot	Low	8 billion to 25 billion
Low stratospheric dust, aircraft delivery	Low	8 billion to 80 billion
Stratospheric dust (guns or balloon lift)	Low	4 trillion or amount desired
Cloud stimulated by provision of cloud condensation nuclei	Low	4 trillion or amount desired
Stimulation of ocean biomass with iron	Low to moderate	7 billion or amount desired
Stratospheric bubbles (multiple balloons)	Low to moderate	4 trillion or amount desired
Space mirrors	Low to moderate	4 trillion or amount desired
Atmospheric CFC removal	Unknown	Unknown

NOTE: The feasibility and possible side effects of these geoengineering options are poorly understood. Their possible effects on the climate system and its chemistry need considerably more study and research. They should not be implemented without careful assessment of their direct and indirect consequences.

Cost-effectiveness estimates are categorized as either savings (for less than 0, low (0 to \$9/t CO₂ equivalent), moderate (\$10 to \$99/t CO₂ equivalent), or high (>\$100/t CO₂ equivalent). Potential emission savings (which in some cases include not only the annual emissions, but also changes in atmospheric concentrations already in the atmosphere—stock) for the geoengineering options are also shown. These options do not reduce the flow of emissions into the atmosphere but rather alter the amount of warming resulting from those emissions. Mitigation options are placed in order of cost-effectiveness.

The CO₂-equivalent reductions are determined by calculating the equivalent reduction in radiative forcing.

Here and throughout this report, tons are metric.

COMPARING OPTIONS

Table 6.2 shows estimates of net cost and emission reductions for several options. It must be emphasized that the table presents the Mitigation Panel's estimates of the technical potential for each option. For example, the calculation of cost-effectiveness of high-efficiency light bulbs (one of the building efficiency options) does not consider whether the supply of light bulbs could meet the demand with current production capacities. It does not consider the trade-off between expenditures on light bulbs and on health

care, education, or basic shelter for low-income families. Nor does it consider aesthetic issues about different sources of illumination.

Care must be taken in developing such a table because there is some "double-counting" among potential mitigation options. For example, implementation of both the nuclear and the natural gas energy options assumes replacement of the same coal-fired power plants. Thus, simply summing up the emission reductions of all options to give total reduction in emissions would overstate the actual potential. The options presented in Table 6.2 have been selected to eliminate double-counting.

Finally, although there is evidence that efficiency programs can pay, there is no field evidence showing success with programs on the massive scale suggested here. There may be very good reasons why options exhibiting net benefit on the table are not fully implemented today.

Figure 6.3 illustrates the results of different rates of implementation of those options. The many uncertainties in the calculations of both costs and emission reductions have been collapsed into two lines. The line labeled "25% Implementation/High Cost" assumes incomplete implementation of each option (25 percent implementation of feasible opportunities) and the high end of the range of cost estimates for that option (high cost). This line shows a lower bound of what is reasonable to achieve. The line labeled

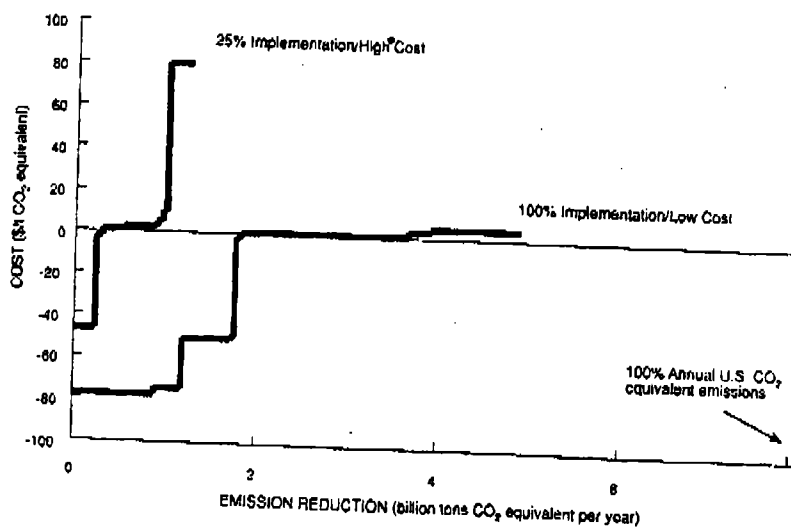


FIGURE 6.3 Comparison of mitigation options. Total potential reduction of CO_2 -equivalent emissions is compared to the cost in dollars per ton of CO_2 reduction. Options are ranked from left to right in CO_2 emissions according to cost. Some options show the possibility of reductions of CO_2 emissions at a net savings. See text for explanation.

MITIGATION

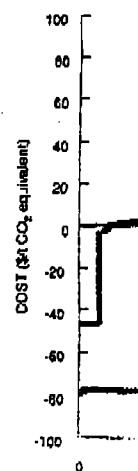


FIGURE 6.4 energy model

"100% Implementation" option (100 percent implementation) estimates for that could be calculate appropriate the scope of and cost results.

As pointed out, modeling some of the "High Cost" energy model States should emissions at

An array of emission and income controls on emission (quotas or efficiency, d

PART ONE: SYNTHESIS

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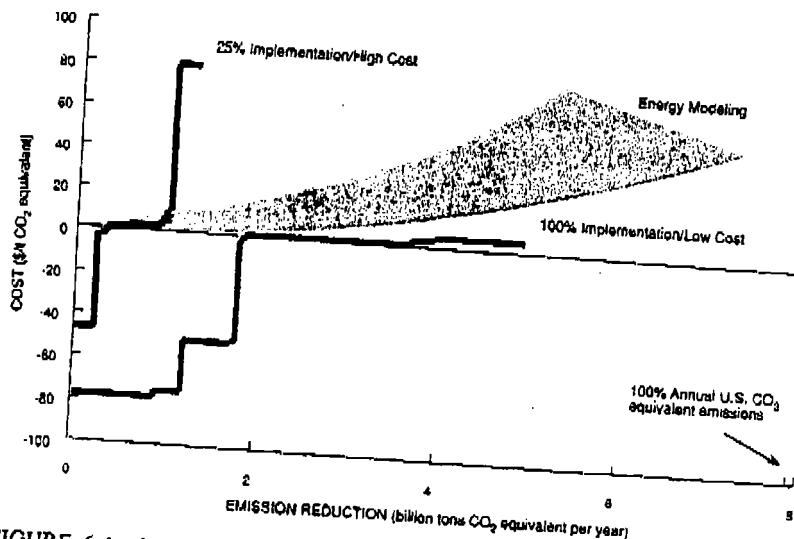


FIGURE 6.4 Comparison of mitigation options using technological costing and energy modeling calculations.

"100% Implementation/Low Cost" assumes complete implementation of each option (100 percent implementation) combined with the low range of cost estimates for that option (low cost). This line indicates the upper bound that could be achieved with all options shown. A complete analysis would calculate appropriate implementation rates for each option. That is beyond the scope of this study. It should be realistic to achieve emission reduction and cost results somewhere between the two lines in Figure 6.3.

As pointed out earlier in this chapter, technological costing and energy modeling sometimes yield different results. For this reason, both are presented in Figure 6.4. The "100% Implementation/Low Cost" and "25% Implementation/High Cost" curves are repeated from Figure 6.3, and the range typical of energy modeling is shown. As can be seen from Figure 6.4, the United States should be able to achieve substantial reduction in greenhouse gas emissions at low cost, or perhaps even a small net savings.

IMPLEMENTING MITIGATION OPTIONS

An array of policy instruments of two different types are available: regulation and incentives. Regulatory instruments mandate action and include controls on consumption (bans, quotas, required product attributes), production (quotas on products or substances), and factors in design or production (efficiency, durability, processes). Incentive instruments are designed to

Implementation/Low Cost

100% Annual U.S. CO₂
equivalent emissions

per)

1 reduction of CO₂-
reduction. Options
Some options show
See text for expla-

Climate Model Paper
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Note

U.S. EPA

401 M STREET, S.W. (MAILCODE: 2111)
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To: Steve Seidel
Rosina Bierbaum
Ray Prince**Date:** June 3, 1996**Fax #:** 456-6546, 456-6025, 395-6853, **Pages:** 23, including this cover sheet.**From:** Daniel R. Abbasi, U.S. EPA**Subject:** Latest draft of USG paper for climate analytic workshop**COMMENTS:**

Attached for your review and comment is the latest draft of the USG paper for the June 6-7 analytic workshop on climate change.

I am still resolving several issues between EPA and DOE, as noted in brackets in the text.

Please call me as soon as possible with any comments: 260-4332. We are aiming to finalize the text by the end of today, if possible. Sorry for the late circulation; I worked with staff throughout last night and into this morning, so it was not available earlier.

Thank you very much.

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June 3, 1996 (1:44pm)

1. INTRODUCTION

International negotiations to address the risk of climate change have been underway for more than seven years. At the Earth Summit in Rio de Janeiro in 1992 -- formally known as the U.N. Conference on Environment and Development -- 154 nations signed the Framework Convention on Climate Change (FCCC). Article Two of the FCCC states its guiding objective: "to stabilize atmospheric concentrations of greenhouse gases at a level that would prevent dangerous anthropogenic interference with the climate system."

The FCCC obligates the United States and other industrialized nations -- known in FCCC parlance as "Annex 1" nations -- to aim to return greenhouse gas emissions to 1990 levels by the year 2000. In 1993, President Clinton unveiled the Climate Change Action Plan (CCAP), which included over 50 actions intended to bring the U.S. to the emissions level called for by the FCCC. Although the CCAP programs have in fact cost-effectively reduced emissions over the past three years, it now seems likely that the U.S. will fall short of the goal by over 100 million metric tons of carbon equivalent (MMTCE), due to substantial funding cuts by Congress, stronger than expected economic growth, and lower energy prices. A review of the CCAP is being completed for release in fall, 1996, and will include an update of baseline trends, a review of the effectiveness of current actions, and recommendations for additional actions.

At the first Conference of the Parties to the FCCC in Berlin in March 1995, the Parties decided that the provisions and goals of the FCCC were not adequate to address the long-term challenges of climate change. They recognized the FCCC commitments as an important first step but noted their silence with respect to emissions after the year 2000.

Accordingly, in the Report of the Conference, dubbed the "Berlin Mandate", the Parties agreed to launch a process to define actions to be taken by the industrialized Annex 1 nations in the post-2000 period, and to promote implementation of commitments by all nations. The U.S. successfully urged the Parties to include in the Berlin Mandate a call for an initial phase of analysis and assessment to inform the negotiation of a Protocol specifying post-2000 obligations. The adopted language follows:

The process will include in its early stages an analysis and assessment to identify possible policies and measures for Annex I parties that could contribute to limiting and reducing emissions by sources and protecting and enhancing sinks and reservoirs of greenhouse gases. (FCCC/CP/1995/7/Add.1)

The U.S. Government is participating actively in the series of international negotiation sessions intended to fulfill the Berlin Mandate and conclude with a legally binding Protocol to

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June 3, 1996 (1:38pm)

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the FCCC in time for signing at the Third Conference of the Parties in Kyoto, Japan in late 1997. Three formal negotiating sessions have been held since the Berlin Mandate was issued at the First Conference of the Parties. In these sessions, a number of countries, as well as multilateral associations of countries, have proposed draft protocols under which the Annex I countries would be required to reduce their emissions by specific amounts by specific years -- goals that have customarily been called "targets and timetables", but have since been technically labeled Quantified Emissions Limitation and Reduction Objectives (QELRO's). In addition to these proposed targets and timetables -- which would by themselves permit Parties to select their own policy instruments for fulfilling the targets -- some countries have also proposed mandatory, internationally coordinated "policies and measures".

The United States Government has to date proposed neither a QELRO for reducing greenhouse gas emissions, nor a specific set of policies and measures. Instead, the U.S. Government is analyzing and assessing the proposals offered by other countries as a critical foundation for its own development of a policy and negotiating position.

This paper is the U.S. Government's first public document describing the partial and interim results of its ongoing analyses of climate change proposals advanced by other countries. The paper presents key findings from our analyses to date, with some reference to analyses by other stakeholders. These findings are being released on a preliminary basis at the U.S. Government's Analytic Workshop on Climate Change on June 6-7, 1996, in order to facilitate maximum feedback by convened experts and stakeholders.

The U.S. Government's Interagency Analytic Team (IAT) responsible for most of the analysis underlying this paper is composed of analysts from many of the U.S. government agencies that have a role in developing climate change policy, including the Environmental Protection Agency, the Department of Energy, the Department of Agriculture, the Department of Commerce, Department of Transportation, Department of the Treasury, and the White House Council of Economic Advisors. The IAT has adopted a diversity of perspectives and approaches -- from detailed technology assessments to highly aggregated domestic and international macroeconomic modeling exercises -- in making progress toward a balanced assessment of the impacts of climate change mitigation policy alternatives.

Among their other limitations, the partial scope of the analyses discussed in this paper should be acknowledged up front. Atmospheric greenhouse gas concentrations are a function both of emissions from a variety of sectors and activities and of available sinks. The U.S. Government continues to maintain that international commitments should be comprehensive, addressing both sources and sinks of all greenhouse gases. However, most of the analyses described in this paper focuses on energy-related greenhouse gas emissions. This focus reflects the availability of modeling tools that can be used to assess the relationships linking energy use and economic performance, as well as the fact that energy-related emissions account for over 86 percent of total U.S. greenhouse gas emissions and 70 percent of global greenhouse gas emissions.

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It bears emphasis that this paper marks the beginning, not the end, of a process of analysis, assessment and development of climate change response strategies. Beyond the June 6-7 Analytic Workshop, many other opportunities will be provided to potentially affected stakeholders to comment on U.S. Government analysis and to submit additional analyses for consideration.

2. PRELIMINARY LESSONS LEARNED FROM ANALYSES

The balance of this paper will discuss the strengths, weaknesses and findings of alternative models that have been enlisted to analyze the economic effects of implementing other countries' proposed climate change protocols. It will offer preliminary numerical results from the models in both textual and graphical form. It should, at this point, be noted that non-practitioners of economic modeling tend to attribute more significance to the absolute values of numerical results than do modelers themselves. Modelers tend to focus instead on qualitative lessons for policy formulation, derived from cases where a particular policy design or strategy shows consistently superior results under a variety of modeling frameworks and assumptions. Accordingly, this section distills key lessons that the U.S. Government has derived on a preliminary basis from its initial analytic work. The lessons follow:

- Rigorous assessment of the impacts of greenhouse gas mitigation requires a variety of analytic approaches since no single model is capable of capturing all relevant aspects of the economy. Each approach has its own strengths and weaknesses. Therefore, it is imperative to understand and reconcile insights gained from a diversity of analytic approaches in arriving at an informed and balanced assessment.
- The overall costs of emissions control depend critically on the stringency of the target and on the structure of the policy.
- Modest emissions reductions can be achieved with macroeconomic impacts ranging from mildly negative to slightly positive. More stringent targets will impose higher costs. The range of analytic results depends on the modeling framework used as well as the type of policy intervention simulated.
- Lower costs are associated with policies that are broad-based, flexible and phased. Such policies can help avoid disruptions and allow for rational planning by businesses and consumers.
- Responsibility for addressing the climate change problem rests on the global community, and will require unprecedented international cooperation. Cost-effective global solutions will require flexibility in the timing and location of greenhouse gas reductions, as well as institutions able to accommodate and promote such flexibility.

- Technological development and dissemination is critical to addressing climate change. In the short run, we need to understand and overcome the institutional barriers that slow the deployment of energy-saving technologies that pay for themselves. In the longer term, we need to encourage the development and dissemination of new energy-saving and low-carbon technologies.
- In the past, regulatory compliance costs have often been overestimated because of reliance on analytic tools that fail to account for dynamic technological, institutional and organizational innovations. Such responses have greatly reduced compliance costs from original estimates for some regulations, and future analyses of climate change policies should take this potential bias into account.
- A balanced assessment of climate change policies must account for the benefits that would accrue from their ability to avert the myriad economic dislocations projected to occur in a rapidly changing climate. Significant progress needs to be made in monetizing the range of impacts so that the costs of action can be compared not to the status quo, but more appropriately to the substantial costs of inaction.

3. BENEFITS OF POLICIES TO REDUCE GREENHOUSE GAS EMISSIONS -- OR THE COSTS OF INACTION

[TEXT ON MONETIZED IMPACTS FORTHCOMING FROM EPA/OPPE]

None of the models discussed in this paper measure the environmental and economic benefits of mitigating emissions in terms of reduced climate change impacts. Because the models do not measure these benefits, the fact that a policy is shown to impose significant costs cannot, by itself, rule out its selection for implementation if the overall benefits of reducing climate change impacts outweighs those costs.

Global greenhouse gas emissions are projected to increase anywhere from two- to six-fold over current levels by the end of the next century (i.e., by the year 2100) under the set of possible "business as usual" futures considered in the recent report of the Intergovernmental Panel on Climate Change (IPCC). Atmospheric greenhouse gas concentrations will ultimately have to be stabilized in order to achieve the FCCC's objective of preventing dangerous human interference with the climate. Even in the "business as usual" IPCC scenarios, the scientists asserted that the rate of warming due to human emissions will be, in their words, "greater than any seen in the last 10,000 years." In other words, since before the first human city was built. Therefore, it will ultimately be necessary to reduce emissions to achieve the goal of the Convention.

The most striking conclusion in the IPCC Second Assessment Report, drawing on the work of 2,500 scientists from around the world, was their consensus finding that: "The balance

of evidence suggests that there is a discernible human influence on global climate." For the first time, this diverse group of highly respected scientists stated their belief that human beings have already begun to disrupt the planet's life-supporting climate system, a statement that is based on a multiplicity of peer-reviewed studies. This finding has reinforced the urgency that Parties attach to additional actions under the Berlin Mandate.

4. GREENHOUSE GAS EMISSION TRENDS

Global Trends: During the first half of the 1990s, greenhouse gas emissions grew in the U.S. and most of the rest of the world. However, due to the restructuring of the former Soviet Union and Eastern Europe, global emissions have been roughly stable. Nearly all of the countries of the Organization for Economic Cooperation and Development (OECD) are experiencing rising greenhouse gas emissions. The important exceptions are the U.K., which is eliminating its inefficient coal production in favor of cheap natural gas; and Germany, which is benefitting from the dramatic cut in emissions in the former East Germany. Projected U.S. emissions growth is expected to be slightly higher than the OECD average. Emissions are expected to grow somewhat more slowly in OECD-Europe, somewhat faster in OECD-Asia.

Over the next century, the bulk of emissions growth will occur in the non-OECD developing countries. While OECD carbon emissions are expected to grow by about 26% over the next twenty years, developing country carbon emissions are expected to double [Energy Information Administration's *International Energy Outlook*, 1996]. This observation underscores why the climate change problem can be solved only through international cooperation, and why U.S. leadership in addressing the issue is critical.

Figure 1: Relative growth within OECD

Figure 2: Long-term emissions trends

U.S. Emissions Trends: Total US emissions of greenhouse gases were 1,595 million metric tons of carbon equivalent (MMTCE) in 1990, of which 1,336 MMTCE. By 1994, the US was emitting 1,666 MMTCE of greenhouse gases. Of this total, 85% were carbon dioxide emissions, about 11% were methane (CH₄), 2% were nitrous oxide (N₂O), and 2% from other gases including the chloroflourocarbons HFC, PFC, and SF₆. The transportation and industrial sectors of the U.S. economy were responsible for most of the CO₂ emissions, landfills and agricultural production were the greatest sources of CH₄ emissions, and the agricultural sector was the largest emitter of N₂O. Automotive air conditioning was largely responsible for the remaining emissions from HFC-134a.

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Without additional policy intervention, U.S. greenhouse gas emissions are expected to rise by at least 20 percent by 2010. Seventy five percent of the emissions growth will be in the energy sector, mainly in electricity generation and transportation. Emissions of HFCs – substitutes for chemicals being phased out under the Montreal Protocol – are expected to increase substantially. Carbon sequestration in American forests is expected to decline.

Figure 3: US Greenhouse Gas Emissions 1990-1995. With baseline projections through 2020

Figure 4: Sectoral Energy-Related U.S. Carbon Emissions 1990-2020

5. DOMESTIC TECHNOLOGICAL COSTING ANALYSES

Past Studies: A number of studies have suggested that greenhouse gas emissions can be reduced significantly at *net economic savings*. Two of the more prominent studies endorsing this conclusion are the National Academy of Sciences (NAS) report, Policy Implications of Greenhouse Warming (NAS 1991) and Changing by Degrees. Steps to Reduce Greenhouse Gases, by the U.S. Office of Technology Assessment (OTA 1991). The NAS study found that 100 to 480 million metric tons of greenhouse gas emissions could be reduced at negative or no cost. The OTA study identified a greenhouse gas emissions reduction potential of up to 472 million metric tons at negative cost or net benefit.

[ADD TEXT ON 1995 EPA STUDY CITED IN CHUPKA TESTIMONY – 330 MMTCE]

[EPA/OPPE WILL ADD TEXT SUMMARIZING NAS AND OTA STUDIES]

To help provide additional insights into individual policies and measures that might be used to reduce emissions, DOE is now completing an update of its 1989 report A Compendium of Options for Government Policy to Encourage Private Sector Response to Potential Climate Change. This update summarizes, on a sector-by-sector basis, the results regarding individual policies and measures to mitigate emissions reported in the literature since issuance of the original report. The report considers the extent to which each of the factors affecting the end-user adoption of relevant technologies are incorporated in the analysis and which appear to be most relevant for successful introduction of measures in each specific sector.

The strength of the technology costing approach is that it demonstrates the extent of

technological opportunities available to save energy and reduce greenhouse gas emissions. The primary weakness of this approach is that it fails to address the institutional and organizational reasons why businesses and consumers do not take full advantage of these obvious opportunities.

[Mark: delete this -- Domestic Institutional, Organizational and Technological Analyses: The large store of potentially profitable energy-saving investments suggests that an effective policy must include the institutional and organizational change necessary to unlock these profitable opportunities and promote the diffusion of higher efficiency technologies. A new EPA study focuses on the impact of policies that would resolve market failures in the commercial, residential, industrial, transportation and electric sectors. The study confirms the findings of earlier reports, finding even greater greenhouse gas emissions reductions at net economic savings.

The study examines institutional and organizational changes that would ensure that households and businesses receive the information, technical assistance, and financing they need to purchase and profit from proven higher efficiency technologies. The institutional and organizational changes would also be structured to give equipment manufacturers and building owners the opportunity to capture some of the profit from the higher efficiency technologies, thus stimulating diffusion and innovation. The study finds that successful implementation of institutional and organizational change could yield greenhouse gases reductions of up to 39% over baseline 2015 levels (or 21% over 1990 levels) with a positive GDP impact of 0.5%.]

Figure 10 (OAR graph labeled 8)

6. DOMESTIC MACROECONOMIC ANALYSES

[DOE TO PROPOSE ADDITIONAL MODIFICATIONS TO THIS SECTION]

Four Emissions Reduction Scenarios: The U.S. Government's domestic macroeconomic analysis has focused almost exclusively on proposals that have already been advanced by other nations in the international negotiating process, including by the Alliance of Small Island States (AOSIS), Germany and the United Kingdom. The four scenarios follow:

- (1) **Stabilization Proposal:** Annex I Parties stabilize emissions at 1990 levels in 2010;
- (2) **United Kingdom Proposal:** Annex I Parties reduce emissions 10 percent below their 1990 levels by 2010;
- (3) **German Proposal:** Annex I Parties reduce emissions 10 percent below 1990 levels by 2005; 20 percent below 1990 levels by 2010;

(4) Alliance of Small Island States (AOSIS) Proposal: Annex I Parties reduce emissions 20 percent below 1990 levels by 2005.

As noted earlier, the U.S. Government does not favor or endorse any of these proposals at this time. Rather, the Government is analyzing their economic consequences for the U.S. and for the rest of the world.

General Outline of Model: The U.S. Government has analyzed the economy-wide impacts of these targets and timetables using two distinct energy models linked to the DRI/McGraw Hill Macroeconomic Model of the U.S. Economy. The analysis assumes that America's OECD trading partners implement similar policies, and that the Federal Reserve reacts to the resulting changes in prices and employment in same way that it has reacted to these changes over the past decade. These models were used to estimate the potential economic impacts for a range of policy scenarios, including impacts on gross domestic product (GDP), consumption, investment, employment, and inflation; as well as regional, industrial, and energy market impacts.

Macroeconomic models have the advantage of representing economy-wide adjustments and responses to policies, particularly business cycle responses. Their weakness is that they do not provide detailed representation of specific markets and specific technologies. Furthermore, their characterization of the long-run determinants of economic growth is relatively limited.

To represent energy markets and technologies, the macroeconomic model is coupled with an energy sector model. The analysts have estimated price increases for the four emission target scenarios using the DRI/McGraw Hill Energy Market Model and the IDEAS model. These models incorporate different assumptions about the price responsiveness in energy demand and different characterizations of energy technologies. These assumptions yield different estimates of the magnitude of changes needed to achieve a given target in the energy sector.

Energy sector models constrain greenhouse gas emissions either by limiting the supply of fossil fuels or by directly increasing their price. Given these constraints, the models forecast changes in fossil fuel energy prices and consumption, and related changes in behavior. In addition, higher fuel prices result in higher revenues that circulate through the economy. These revenues can be redistributed to ameliorate the negative impact of price inflation on economic growth.

Implementation Timing: The analysis assumes that policies are phased in after 2000. Energy prices gradually increase throughout the period, and emissions generally decline to the target by the end of the phase-in (2005 for AOSIS and German proposals; 2010 for all others).

Five Modeled Permit Allocation Policies: For each emission target, the IAT assumed that the government would introduce a tradeable permit system, distributing or selling a fixed number of permits to sell fossil fuels based on their carbon content. Those receiving or purchasing the permits would have the right to sell fuels that contain carbon or to sell their permits. Primary fossil fuel producers would be required to obtain permits reflecting the carbon content of their fossil fuel sales.

A system of marketable tradable permits is considered one of the most cost-effective and flexible policies for reducing emissions. The ability to trade permits in a market assures that permits are put to their highest-value use. Given the limit imposed by the number of permits, fossil fuel consumers can be expected to make the least-cost emission reductions available, thus minimizing overall costs. Another reason why the IAT has analyzed international proposals with a permit trading scheme is that this type of policy readily lends itself to analysis in the available large-scale economic models. However, despite these virtues, the analysis of marketable permit systems should not be taken as an endorsement by the U.S. Government. The U.S. Government continues to examine a variety of options to achieve climate goals.

The IAT examined five very different schemes for allocating the permits to analyze their economic and distributional impacts. The fundamental insight from the analysis is that the economic impacts of mitigation depend to a very great extent on how the permits – and thus the costs – are allocated across different sectors of the economy. If the permits are simply handed out, their allocation creates a type of property right that has value. On the other hand, if the permits were auctioned off by the government, their sale would generate revenues for the government. How the government uses the revenues can have profound impacts on the economy.

The IAT analyzed three distinct auction scenarios to determine the impacts of various mechanisms for redistributing the revenue:

- 1) **Auctioned Permits, Revenues to Consumers Only:** distributing revenue to consumers by increasing the personal income tax exemption;
- 2) **Auctioned Permits, Revenues to Consumers and Business:** sharing revenue between consumers and producers by reducing personal and corporate marginal income tax rates; and
- 3) **Auctioned Permits, Revenues Used to Reduce Deficit:** using the revenue to reduce the Federal budget deficit and retire Federal debt.

In addition, we analyzed two distinct allocation scenarios:

- 4) **Permits Distributed to Consumers:** all permits are allocated to individual households, who in turn sell their permits to primary fossil fuel producers; and
- 5) **Permits Distributed to Consumers and Business:** permits are allocated to both consumer and businesses, based on their historical energy use.

Results of Domestic Macroeconomic Models: Figure 5 shows the GDP impacts from 2000 through 2015 of different levels of GHG emissions abatement. In each case, the target is achieved by auctioning off permits and returning roughly 40% of the revenues to consumers through an increase in the personal income tax exemption and 60% to businesses through a

reduction in marginal corporate income tax rates. The rationale for this approach is that households consume roughly 40% of all energy directly, while 60% of all energy is used by businesses in the production of goods and services.

For all of the targets, the initial effect of the permit and revenue recycling systems is to raise fossil fuel prices, generating a rise in the general price level and reducing demand. In response to inflation, the Federal Reserve Bank restricts the money supply to offset the inflationary impacts of the policy, further slowing the economy. GDP declines slightly in the near term – through at least 2008. However, by reducing business taxes, this permit allocation and revenue recycling system encourages business investment. In the long run, this boosts economic growth. GDP increases above the no-policy case throughout the rest of the forecast period. With more stringent targets, output dips more in the near term but rebounds more strongly in the out years.

Figure 5. Range of GDP impacts relative to the baseline for each scenario -- using the results from the latest DRI model. Permit Auction 40% 60% split.

How do different permit designs affect the economy? Figure 6 illustrates the GDP impact of alternative methods of distributing or auctioning marketable permits and recycling any revenues, using the stabilization target as an example. It is clear that the design of the permit system can significantly influence the GDP impacts of a given target. Every approach causes near term GDP losses as the economy adjusts to higher energy prices. However, the long term impacts depend critically on the permit distribution and revenue recycling scheme. When the revenues from selling permits are distributed to consumers and businesses based upon historical patterns of spending on energy – i.e., 40% to consumers and 60% to producers – higher investment actually raises economic activity above what it would have been without any policy. Alternatively, when the permits (or the revenues from selling permits) are distributed only to households, the economy's aggregate savings are lower. With fewer savings available for investment, GDP is lower even in the later years of the forecast.

These results highlight not only the importance of the permit system design, but the importance of the distribution of the permits or the disbursement of revenues from permit auctions. If the value of permits accrues mainly to households – whose aggregate savings are relatively low – there will not be sufficient investment to offset higher energy prices. In contrast, if the value of permits accrues mainly to businesses – which tend to retain and reinvest profits – there may be enough additional investment to offset the loss of energy inputs. Well-designed policies can thus actually enhance economic activity; while policies that are not targeted to alleviate the impacts of higher energy prices can dampen economic growth.

Figure 6. Comparison of allocation and auction of permits for stabilization scenario.

The IAT used two different versions of the DRI Macro model to project the macroeconomic impacts of greenhouse gas policies. In one – an older version – the economy's productive capacity is determined by the capital stock, the labor force, and the total quantity of energy consumed. In the more recent version, productive capacity (also called "potential GDP") is directly influenced by domestic oil and natural gas production rather than by total energy demand. While this change may seem minor, it has profound impacts on the model's predictions of the impacts of reducing the amount of energy available. Further research is underway to determine which of these approaches is most appropriate, or whether another approach is needed. All of the above results use the most recent version of the DRI model.

Figure 7 Impact of potential GDP stabilization for stabilization scenario.

Figure 7 shows the different GDP impacts, using the two model versions, of a single target and policy: an auctioned permit system with revenues returned to both consumers and businesses. The figure illustrates that the form of this one equation in the model can significantly influence the estimate of the economic impact of a given policy.

Another source of uncertainty is the energy sector impacts of the a marekteable tradeable permit system. The key consequence of the permit system is to raise energy prices by limiting fossil fuel use. How consumers and businesses respond to these price changes is one of the critical determinants of any policy's costs. If consumers and businesses respond very strongly to price signals, then relatively small price increases – and thus relatively low permit prices – will be necessary to achieve a given emissions target. On the other hand, if consumers and businesses are not very responsive to price signals – if they have "low energy demand elasticities" – then it will take large price hikes to achieve the same target.

[DOE PROPOSING TO DELETE REFERENCE TO AVERAGE ELASTICITY DERIVED FROM LITERATURE SURVEY AND SUBSTITUTE MORE CREDIBLE BENCHMARK] The Department of Energy has sponsored research on how consumers and businesses respond to enrgy price increases. The DOE research seems to suggest that energy users are more responsive to changes in energy prices – they have higher demand elasticities – than is suggested by the DRI model.]

As a sensitivity analysis, we replaced DRI's own long-run energy elasticities with average estimates from the Department of Energy literature. This minor change had a dramatic effect on permit prices. In the current version of the DRI model, the value of permits must rise to roughly \$125 per metric ton of carbon in order to stabilize greenhouse gas emissions in 2010. With the higher elasticities, the value of permits had to rise only to \$60 per ton in order to stabilize GHG emissions in 2010. The projected permit prices are shown in Figure 8.

The lower estimate is roughly in line with the average of estimates derived from a large number of economic models in the Stanford Energy Modeling Forum 12. It is also consistent with results obtained from the technology-rich ICF Integrated Planning Model of the electric

utility sector, which projects similar carbon emissions reductions at lower energy price increases than DRI's utility sector model. The IAT will continue to assess this issue so that the best forecast of energy sector impacts from alternative greenhouse gas policies can ultimately be developed.

Figure 8. Price elasticity sensitivity analysis.

The macroeconomic impacts presented here are generally lower than those presented in other studies, even those using the DRI model. For example, when the Electric Research Power Institute (EPRI) examined the same GHG targets using the DRI model, it concluded that the losses in GDP could be quite large – up to 4.3% (see Figure 9).

A crucial questions remains. Why are the U.S. Government's current results so different from the EPRI-sponsored results? There are three major reasons for these conclusions. First, in the U.S.G. analysis, the permit system has been phased in, so as to allow energy users more time to adjust to the policy change. By contrast, the EPRI-sponsored work "shocked" the system by imposing a carbon tax all at once. This greatly increases the GDP impacts. Second, in the EPRI study, carbon tax revenues were recycled only through an increase in the personal income tax exemption – the worst case for GDP. Third, EPRI assumed that the U.S. is pursuing a unilateral emissions reduction strategy, rather than cooperating with the rest of the OECD. Fourth, in the EPRI study, the Federal Reserve was assumed to pursue exactly the same monetary policy that it would have in the absence of the carbon tax. This has the effect of contracting the money supply – and causing output to decline – more than would be the case if the Federal Reserve responded as it normally does.

Figure 9. Comparison with EPRI analysis.

Taking account of the above factors, the U.S. Government's preliminary macroeconomic results show a wide range of impacts on the economy, although the results tend to show smaller impacts on output in the U.S. economy than the results obtained in several earlier studies that purported to show substantial negative impacts. Moreover, as discussed elsewhere in this paper, the impacts depend fundamentally on what kind of policy is implemented; intelligent policy design can dramatically reduce costs. The U.S. Government's analysis indicates that the U.S. economy will continue to grow at a healthy pace through the first decades of the next century under all of the options examined. The IAT is still synthesizing the results of these studies and exploring the how the timing, implementation, and the size of the emissions reductions may explain the range of outcomes.

7. INTERNATIONAL ANALYSES

The IAT is also pursuing a variety of analyses using a diverse set of models of the international economy, including the Oxford and G-Cubed models that are being discussed in separate papers prepared for the June 6-7, 1996 Analytic Workshop. A wide range of results has been obtained, with review and synthesis still pending. It is possible, however, to draw three tentative conclusions.

1. GDP impacts: There may be significant differences across OECD countries in the costs of meeting any specific target. Some countries, such as Germany and the United Kingdom, face special circumstances that will make it relatively inexpensive to reduce emissions during the next decade. Countries expected to grow relatively rapidly, such as Japan, should find it more difficult to meet particular targets. Low-carbon economies such as France, which rely on nuclear power for much of their electricity, will have fewer opportunities to reduce emissions.

2. Carbon emissions leakage: Some analysts argue that if the developed nations constrain the use of fossil fuels in order to reduce greenhouse gas emissions, two confounding effects could lead to an offsetting increase in developing country fuel use and greenhouse gas emissions. First, reduced demand could cause world oil prices to decline, thereby potentially spurring increased oil demand in the developing world. Second, over the longer term, energy-intensive industries facing higher energy prices in developed countries might migrate to developing countries that are not controlling emissions. Taken together, these two influences are called the "leakage effect."

[An increase in emissions in the developing world could eviscerate an emissions program pursued only by developed countries, so that their energy-intensive industries would make a sacrifice with no ultimate benefit. However, the U.S. Government's initial modeling results suggest that although reduced energy demand in OECD countries would lead to lower world oil prices, a decrease in OECD emissions would not be significantly offset by an increase in non-Annex I countries' emissions. Also, the analysis did not find that energy-intensive industries are likely to migrate from industrialized to developing countries as a result of control regimes implemented in the former. These results, however, are preliminary and await more detailed analysis in the future.]

3. "Where" and "When" Flexibilities: Some of the preliminary international results illustrate how both the level, design and timing of commitments could affect the costs of greenhouse gas mitigation. One recent study used four different models to evaluate the extent to which flexibility in the international location and timing of emission reductions should reduce costs. The results suggested that costs of achieving the same cumulative emissions reductions over the next fifty years could be significantly reduced by allowing reductions anywhere in the world and by allowing a slower pace of early emission reductions which are then "made up" with more extensive reductions later. According to this analysis, the cost reduction for locational flexibility alone could be roughly 70 percent, timing flexibility alone 40 percent, and both types

of flexibility together 85 percent. The cost reductions from timing flexibility are significantly reduced as the time horizon over which higher initial emissions must be "made up" is shortened.

These results are very dependent on a number of important assumptions built into the models. The models assume a fixed path of technological development, and do not make allowance for technological developments in response to control regimes. This means that they do not consider the effect of early signals to induce a technological response. Moreover, the models assume perfect foresight, so that economic actors know with certainty what technologies will be available in the future, and what the ultimate emissions limit is. Finally, the analysis assumes that the institutional infrastructure need to undertake emissions trades internationally can be implemented without cost, negotiated effectively, and that no countries will "game" the system. Relaxing any of these assumptions would reduce the gains from "where and when" flexibility.

8. LESSONS FROM PREVIOUS POLICIES

Past practice reveals common biases in the analyses of costs of pursuing control policies. The private sector has demonstrated an ability to respond to market-based policy signals with technological innovation that reduces the costs of meeting environmental and other goals. A change in greenhouse gas policy would also be likely to stimulate a private sector effort to develop low-carbon energy technologies. The U.S. Government recognizes that differences between the climate change problem and either acid rain or stratospheric ozone destruction limit the transferability of lessons from those cases. Nevertheless, insights gained from previous regulatory experiences may be suggestive of analytic biases.

Lessons may be drawn from two successful and innovative American environmental policies: the acid rain control program and the Montreal Protocol, designed to limit the release of ozone-depleting chemicals into the atmosphere. Our experiences with the phase-out of ozone-depleting CFCs and with implementation of the 1990 Clean Air Act Amendments demonstrate that when the government sends a clear signal concerning its environmental goals and preserves operational flexibility for businesses, innovative technologies tend to emerge and costs tend to fall well below early projections.

Sulfur Dioxide Allowance Trading: The price of sulfur dioxide emissions permits under the Acid Rain market trading mechanism has plummeted far below initial industry estimates, demonstrating that the projected costs of meeting the goal had been exaggerated. In 1989, industry projected that they would have to pay \$1,500 for the right to emit one ton of sulfur dioxide. Due to such factors as improved methods of blending coal types to meet emission limits and innovations in smokestack scrubber technology, the actual price of a one-ton permit on the Chicago Board of Trade in 1996 is just \$66.

CFC Phase-out: Similarly, initial industry cost estimates for car air conditioning retrofits of CFC substitutes were between \$800 and \$1,500. These retrofits are now available at a cost of \$200-800.

[OAR MAY ADD ADDITIONAL NARRATIVE ON CFC EXPERIENCE, INCLUDING 2 CHARTS]

Analyses of proposed climate policies may tend to underestimate these types of dynamic responses because they are difficult to quantify. Much better modeling of innovation and technological change is needed. On the other hand, it should also be noted that precisely because they are hard to quantify, the impact of such technological responses on control costs will always be difficult to forecast.

9. THE ROLE OF ADVANCED ENERGY TECHNOLOGIES

[DOE PROPOSES FOLDING THIS SECTION INTO SECTION 8]

One weakness of all of the modelling approaches described above is that they cannot describe the technological innovation response to the proposed policies analyzed in this paper. Policies that limit energy use will tend to stimulate investment in research that will produce technologies that cannot be predicted in advance. The modeling approaches discussed above assume a relatively fixed path of technological change that does not respond to policies.

This analytic blindspot in the models becomes especially important when one considers that over the long term, global energy demand will be driven by expanding economic growth and a rapidly growing population. These factors drive current projections of ever increasing greenhouse gas emissions. Ultimately, it is difficult to envision how humanity can meet the twin goals of raising global living standards and reducing energy-related emissions without developing advanced energy technologies.

Both government and the private sector have legitimate, complementary roles to play in fostering the development of advanced, clean energy technologies. While the private sector should take the lead role in commercial development activities, government-supported energy research can play a complementary role in overcoming market failures that lead to systematic underinvestment in research and development activity.

For the climate change issue, electricity and transportation fuels and technologies are of particular importance. A wide variety of projections show electricity generation and transportation to be the major sources of growth in energy-related emissions in throughout the world over the foreseeable future. Recent activities at the National Renewable Energy Laboratory -- focusing on biofuels, wind and solar energy -- are excellent examples of the types of research and development that can help provide attractive long-run answers to the challenge of

emissions mitigation.]

10. NEXT STEPS: FROM ANALYSIS TO POLICY

While a significant amount of analysis has been conducted to date, much remains to be done. Among the remaining questions to be addressed over the next several months are:

- How can a policy best be designed to harness market forces and induce technological change?
- How can improved performance be stimulated in renewable energy and energy efficiency?
- How can the impacts of proposed policies be effectively specified with regard to sectors and regions?
- How can the employment impacts, both positive and negative, of policy options best be assessed, both in the aggregate economy and in specific sectors?
- What are the proper criteria for selecting between alternative policy mechanisms and implementation strategies?

The United States is committed to ensuring that the process of developing and negotiating further commitments, and advancing those already made, is based on a solid analytical foundation. Analysis and assessment is helping to guide the way toward an appropriate level of commitment and, equally or more important, toward a structure of commitments and domestic implementation approaches that will cost-effectively meet our environmental goals.

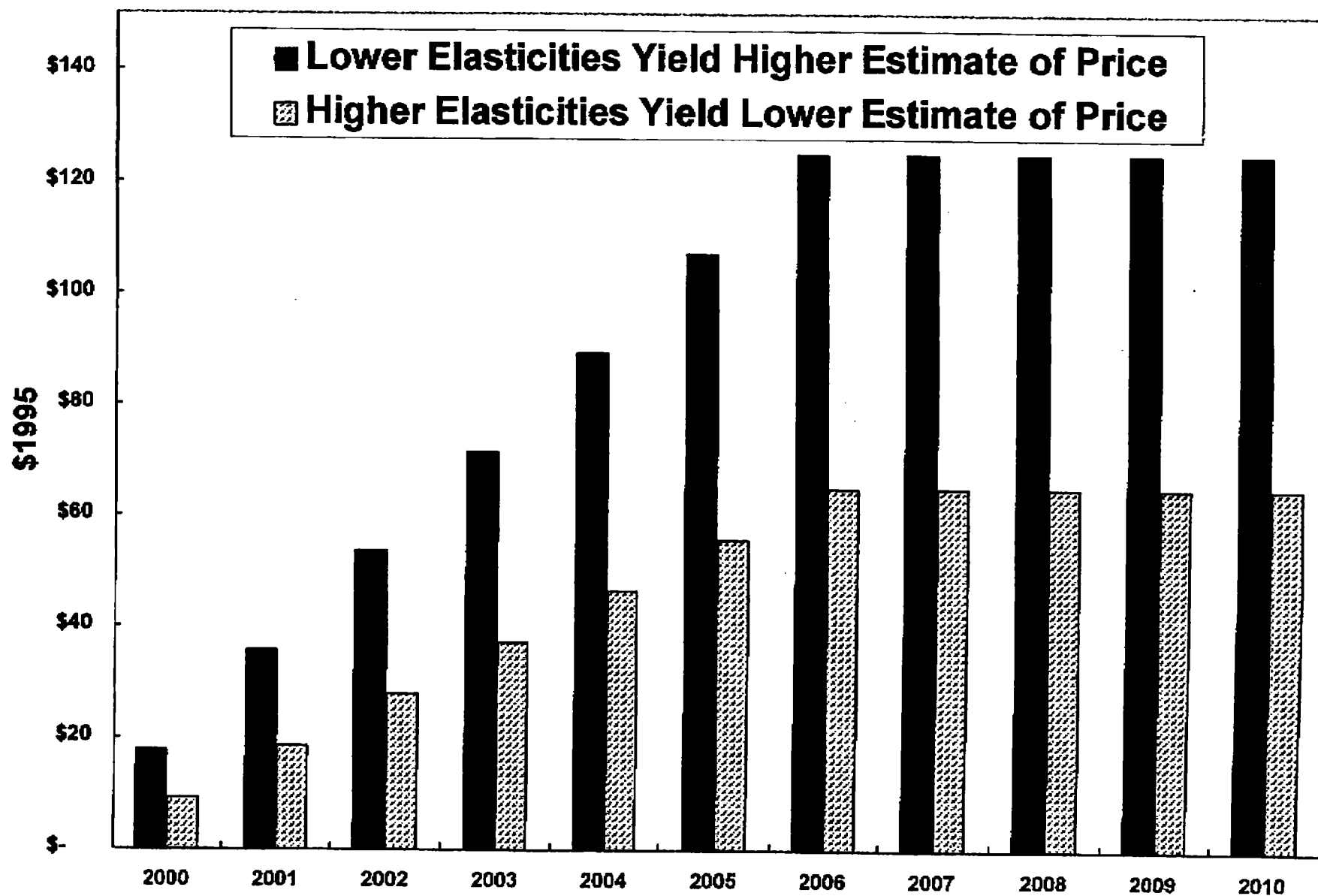
Analysis and assessment together constitute an evolutionary process that informs policy development. Together, these two functions account for the costs and benefits -- both economic and environmental -- associated with alternative policy strategies. Analysis provides a neutral picture of the range of possible outcomes that would result from implementation of alternative domestic and international policies. Assessment, by contrast, weighs the range of analytic results and identifies those that are most plausible. Policy development then formulates positions based on the conclusions of the assessment process.

The U.S. Government is presently focused on analysis -- gathering the set of policy-relevant results from analysts inside and outside of the Government. The Analytic Workshop on June 6-7, 1996 is a significant milestone in the analytic phase, in that it will provide the U.S. Government an opportunity to hear more than 50 diverse presentations from a wide range of sources. Over time, the balance of U.S. Government activities will shift to a greater emphasis on

assessment, i.e., the consideration of which analytical results are most plausible and which should receive the most consideration in the policy development phase.

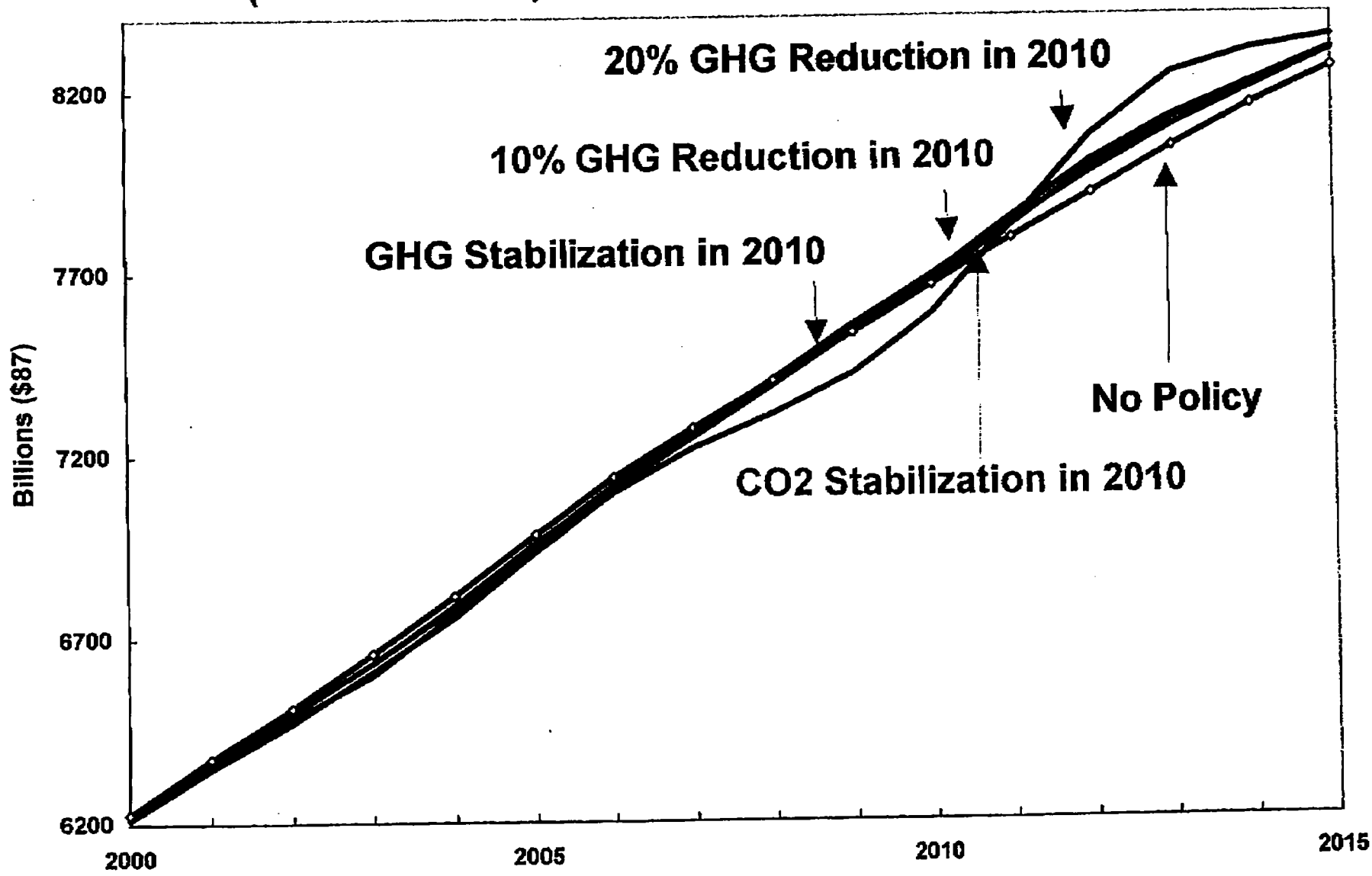
The U.S. Government recognizes the need for further refinement of its continuing analytic work. This paper marks the beginning, not the end, of a process of analysis, assessment and development of climate change response strategies. The U.S. Government intends to rely on a range of experts and stakeholders to provide high-quality input on the difficult analytical problems that must be resolved in order to craft a cost-effective and forceful policy capable of preventing dangerous human interference with the Earth's climate.

Permit Price Needed to Stabilize GHG Emissions in 2010



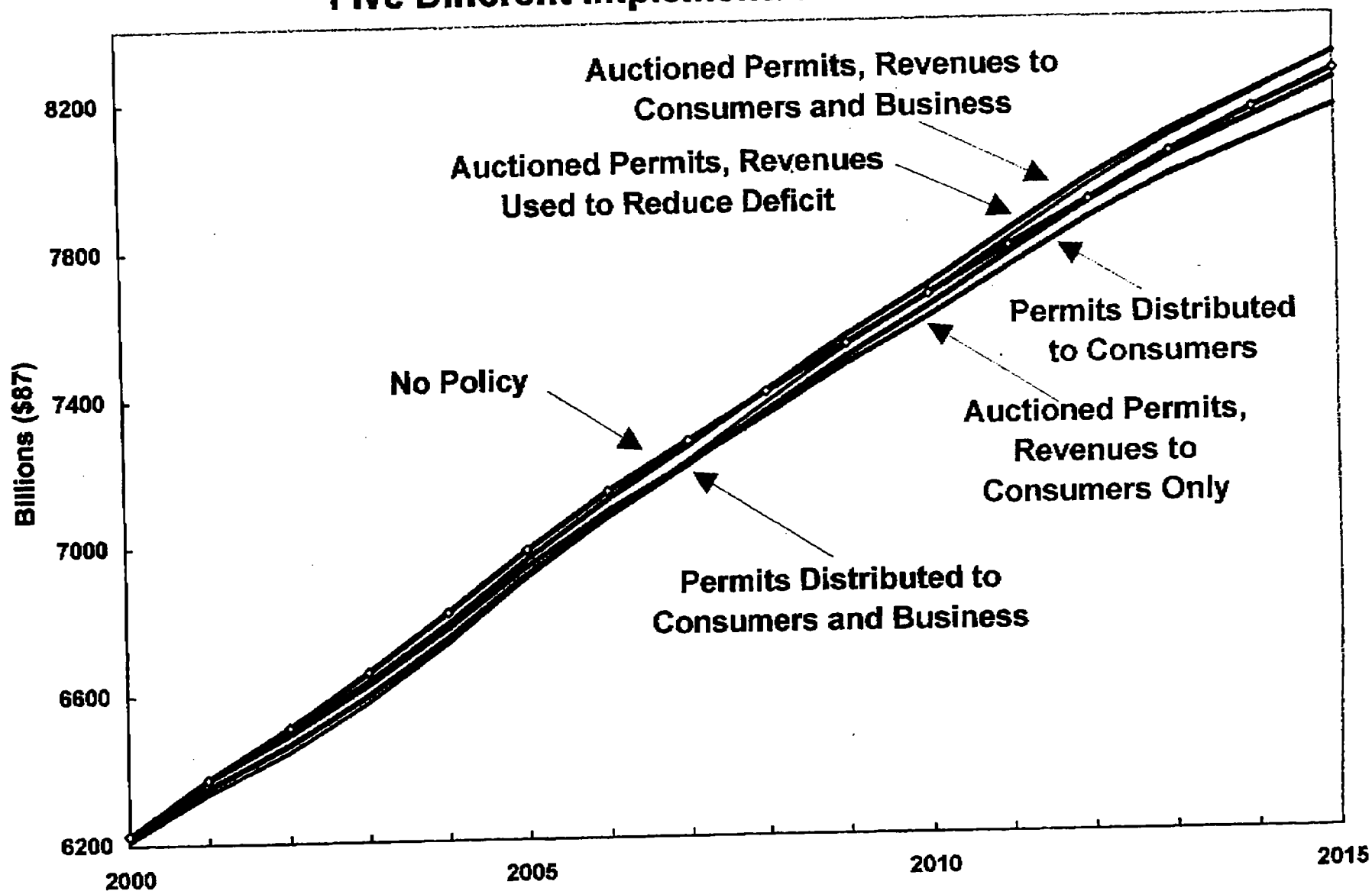
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GDP Impact of Different GHG Targets (Permit Auction, Consumer/Business Recycling)



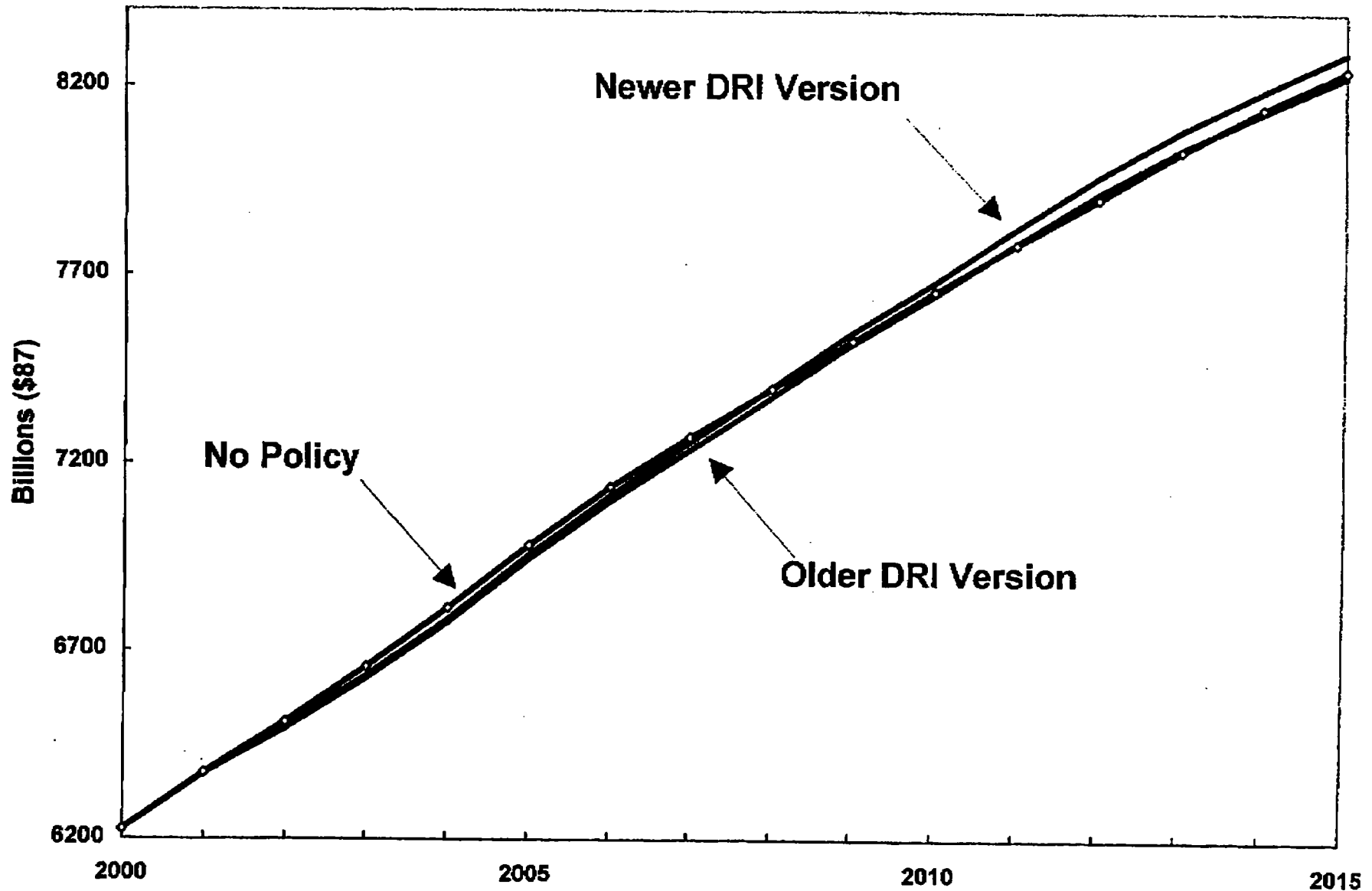
GDP Impact of GHG Stabilization in 2010

Five Different Implementation Policies



GDP Impact of GHG Stabilization in 2010

Different Model Versions w/ Permit Auction, 60/40



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Presentation/Paper On Climate Analysis
Annotated Outline

Note: This outline is intended to serve as the basis of both the presentation and a brief paper to be provided to conference participants. The paper and presentation versions would be very close, except that the paper version would include an up-front executive summary that includes main findings from the agreed presentation.

A. Introduction

1. The Administration recognizes the importance of analysis and assessment as a guide to next steps under the Climate Convention. The United States delegation was instrumental in writing analysis and assessment into the Berlin Mandate in April 1995, and we have been actively involved in the analytic process since that time. The United States has supported, and continues to support, a wide range of analysis and assessment, including work presented by the U.S. delegation at AGBM-2 and at the AGBM-3 workshops.
2. Analysis and assessment is an evolutionary process. Today, we would like to survey some of the preliminary analysis that is being considered by policymakers as the U.S. negotiating position is developed. We are sharing this information to allow for review and feedback from the public.
3. We are undertaking further analysis to assess the impacts of proposed options on regions and sectors, other implementation strategies, and specific policies and measures.
4. This presentation will not consider damages that might result from inaction in the face of the threat of climate change, some of which have already been touched on earlier this morning. As we have heard, climate change could lead to important environmental and human health damages over the next century. Besides ameliorating these impacts, actions to reduce greenhouse gas emissions can also achieve substantial ancillary environmental benefits.

B. Outline of Today's Presentation

1. This presentation provides an overview of the following topics:

- Factors affecting projected emissions levels in 2000 and beyond; developments since CCAP
- Technological costing analyses of emission reduction opportunities
- Analysis of several proposals that have been discussed in the AGBM using macroeconomic modeling tools
- Results from international modeling using computable general equilibrium models and other tools, for U.S. and the world as a whole, including consideration of flexibility
- The role of technological progress and related issues

*Martin and
Alicia This is
the version of the
5/24/96
Climate model paper
that caused the
big last week's*

Ray

*Fig 1, 2, 3
are based on
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Figure 4
is based on
Various KLE
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2. The analyses presented here today focus primarily on the limitation of energy-related greenhouse gas emissions. This focus reflects the availability of modeling tools that can be used to assess the relationships linking energy use and economic performance, as well as the fact that energy related emissions account for over ____ percent of total U.S. greenhouse gas emissions. It should not however, be construed as indicating a change in the Administration's view that commitments and policies should consider all greenhouse gases.

3. This presentation necessarily covers a lot of ground quickly, and many of the issues raised here will be addressed in much greater detail in breakout sessions today and tomorrow. We believe that the breakout presentations will help to clarify some of what we present now.

C. Factors affecting emissions projections since publication of CCAP and CAR

1. The October 1993 Climate Change Action Plan (CCAP) was projected to return greenhouse gas emissions to the 1990 level by 2000. CCAP estimated the necessary reduction to return emissions to 1990 levels to be 109 MMTCE. This amount, when subtracted from the emissions baseline developed at that time for use in the plan, was believed sufficient to return U.S. emissions of greenhouse gases to their 1990 levels by the year 2000.

2. The Administration is gratified by the progress of the CCAP initiatives that are now underway. We recognize that many of you here today are active participants in voluntary initiatives. Many of our programs are meeting their milestones. For example, Green Lights now has over ____ partners, and the Climate Challenge program now actively involves over ____ utilities, which together account for over ____ percent of total power generation.

3. The Climate Action Report, issued in October, 1994, indicated that emissions were growing faster than assumed in the original CCAP. More recent data confirm this trend. Work underway to review the CCAP indicates that despite the considerable progress that CCAP has made to date, it is unlikely that the original CCAP will achieved its desired aim, and suggests the likelihood of significant emissions growth after 2000 without additional action to limit emissions.

4. Greenhouse gas emissions data through 1994 is summarized in the following table. (Table will have a footnote indicating estimate of emissions of energy related carbon in 1995 of 1409 to 1415 MMT).

(1990 vs. 1994 emissions table)

TABLE 1

Discussion of salient points.

-All types of emissions are up.

-1994 figures for methane do not reflect impact of recent landfill rule, which will take effect prior to 2000

5. The key factors leading to the expectation that emissions in 2000 will exceed levels projected in the 1993 Plan include:

Reduced funding for CCAP programs and other legislative action. Congressional appropriations action for Fiscal 1996 sharply reduces funding for some important CCAP programs. For example, DOE programs received only ____ percent of requested funding, with

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reductions disproportionately targeted on programs projected to result in near-term reductions. EPA was provided with only ___ percent of requested funding. Other important legislative action includes reductions in energy efficiency and conservation programs included in the baseline, elimination of federal speed limit authority, and appropriations riders limiting program activities such as the promulgation of appliance standards.

Revised economic assumptions. Most notably, actual and projected energy price trends have been lower than the CCAP assumptions and economic growth has been somewhat stronger than previously projected. Moreover, while the projected output mix has shifted towards less energy-intensive sectors, the rate of reduction in industrial energy intensity has been slower than projected in the CCAP.

Revised estimates of program effectiveness based on experience to date and revised assumptions. Most notably, an increased role now projected for natural gas in electricity generation reduces the emissions reductions associated with increased electricity conservation.

Higher non-energy related greenhouse gases. Higher projected emissions of halogenated greenhouse gases, including newly identified gases, and revisions in baseline estimates of carbon forest sequestration.

5. An updated projection of greenhouse gas emissions that reflects all of these factors, many of which were the subject of appropriations bills in the late spring of this year, is now in preparation and should be available in the fall.

[An initial guess/estimate of likely emissions trends under current policies is provided in Figure x:

"Gap" figure from Feb 15 briefing, with appropriate revisions.]

Figure a

[NOTE: A decision on whether to include this figure, which implicitly defines an estimate of the "gap," will depend on a judgment as to whether it is desirable to provide a numerical gap estimate at the time of this briefing. The previous qualitative discussion under item 4. above was purposely designed so as not to include a gap estimate in accord with previous direction. If we do want to include this figure, we will have to look very carefully at the energy numbers, which differ between DOE and EPA.]

It should be noted that any projection of emissions, even for a period as short as 5 years, is necessarily uncertain. However, a review of projections of energy use and related emissions indicates the widespread belief among independent forecasters that, absent significant mitigation actions, energy-related greenhouse gas emissions are expected to grow.

(U.S. energy sectors chart from 2/15/96 Briefing)

Figure b

5. Using a similar approach, we can put the U.S. situation into perspective by comparing projected trends for energy-related carbon for major world regions, notably the Annex I countries that are the focus of negotiations for further commitments under the Berlin Mandate. This comparison suggests the following:

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-the countries of the former soviet union and eastern Europe, which are transitioning to market based economies, emissions are projected to grow from current levels. However, emissions have fallen sharply since 1990, and are projected to remain below the 1990 level through 2010.

-within the OECD group, energy-related emissions in North America are projected to grow more rapidly than emissions in OECD Europe, but less rapidly than emissions in the OECD Pacific area, which is dominated by Japan.

-emissions of countries outside Annex I are projected to drive the growth in world emissions. Reduction of greenhouse gas emissions is a global issue that will ultimately have to be addressed on a global basis.

(International comparisons slide from 2/15/96 Briefing)

Figure c

D. Technological Costing Studies

1. Technological costing studies represent the emission reduction potential and the costs (or savings) of technological investments and changes in the way in which energy is used to provide services.

2. Results from a recent EPA study identify up to 330 MMTCE that can potentially be reduced at zero or negative cost. Examples of options included at this level include: transportation sector improvements in light duty trucks and vehicles, residential sector shell improvements and electric appliances, and commercial sector electric conservation measures. Recognizing that some of these opportunities are already being pursued under CCAP, while others could only be realized over an extended period of time, the technologies identified in these studies have the potential to make a substantial contribution towards meeting our carbon reduction objectives. A sense of their importance is reflected in the fact that the total identified potential exceeds the estimated reductions of between 200 and 300 MMT that are required to stabilize carbon dioxide emissions at 1990 levels in 2010.

(Insert Engineering Cost Chart from 2/15/96 briefing)

Figure d

3. These EPA results are consistent with earlier engineering cost studies done by the National Academy of Sciences (Policy Implications of Greenhouse Warming, 1991) and the Office of Technology Assessment (Changes by Degrees: Steps to Reduce Greenhouse Gases, 1991). The NAS study showed a reduction potential of between 100 to 480 million metric tons of carbon at negative or no cost. The OTA study identified reduction potential of up to 472 million metric tons of carbon at negative cost or net benefit.

4. There are several reasons why the technologies identified as promising in these studies have not significantly penetrated the market. These include: high first cost (up-front cost), apparent consumer discount rates in excess of those used in engineering calculations, consumer preferences for other features (such as acceleration performance in motor vehicles), lack of consumer information about technologies and high transaction costs.

5. Many of the initiatives included in the Administration's current Climate Change Action Plan are designed to address some of the impediments to more widespread adoption of emissions-saving technologies, while leaving the final choices to American consumers and businesses. The results of these programs, if adequately funded, will provide insight into how much of the identified emission reduction potential can be realized.

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E. Macroeconomic Modeling of Reduction Costs

1. The analysis team addressed the economy-wide costs of meeting various emission targets by using inputs developed from detailed energy sector models to drive business cycle models that capture the short-term behavior of the economy. These models were used to estimate impacts on GDP, consumption, and employment, as well as sectoral impacts for various policy scenarios.

2. Scenarios considered in the macroeconomic modeling were based on proposals made by various parties in the negotiations. The scenarios addressed include:

Continuation of stabilization aim: extend the existing aim of stabilizing emissions at the 1990 level to 2010

UK idea: reduce CO2 emissions 10 percent below the 1990 level by 2010

German proposal: reduce CO2 emissions 10 percent below the 1990 level by 2005; continue reduction to 15-20% below the 1990 level by 2010. Our modeling analysis applies the 20 percent level.

AOSIS proposal: reduce CO2 20 percent below the 1990 level by 2005.

3. For purposes of our analysis, we allowed for a phase-in of policies over a period beginning in 2000 and extending through each proposal's target year (2005 for AOSIS and German, 2010 for all others). Under this approach, emissions generally approach the targeted level from above. For example, emissions in the stabilization case remain above the 1990 level until 2010 -- as illustrated in Figure e

(Insert schematic picture of scenarios)

Figure e

4. In addition to the scenario and phase-in schedule considered, there are several key issues that affect the macroeconomic modeling results:

Size of Emissions Reduction. The analysis assumes some reduction in the size of the required carbon reduction due to either CCAP programs or excess emissions reductions for other greenhouse gases that can be credited against reductions otherwise required in the energy sector.

The size of the assumed "credit" from CCAP or other programs falls within a range of 50 to 60 MMT in 2010, about 20 percent of the reduction otherwise required for stabilization of energy-related CO2 emissions.

Energy Modeling. Two different energy models, IDEAS and DRI, were used to generate inputs for macroeconomic modeling. These models incorporate different views regarding the magnitude of changes needed to achieve a given emissions level in the energy sector, reflecting different degrees of price responsiveness in energy demand and different specifications of opportunities for technology switching on the supply side in response to a need for reduced emissions. These energy models, which share the perspective that shifts away from carbon intensive fuels will engender positive costs, contrast with technological costing analyses discussed in the previous section.

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Implementation. The macroeconomic analysis assumed that reductions in emissions were achieved using a tradable allowances system. Several different variants were modeled to account for a variety of possibilities. One case considered was a system like the sulfur dioxide tradable allowances scheme under the Clean Air Act of 1990, in which the permits are awarded directly to users without charge. Another was a case in which permits were auctioned off, like the recent spectrum allocations auction by the Federal Communications Commission. In both cases, different distributions of permits or auction revenues among firms and consumers were considered. Implementation turns out to have important implications for the economy.

Energy's Role in Determining Productive Capacity. While nearly all long-run economic models applied to this problem explicitly account for energy's role in determining potential output, macro modeling practice over the past two decades has varied on this issue. Although this issue is not particularly significant for most economic modeling applications, it is central to the consideration of carbon reduction policies that directly affect the energy sector. Our analysis considered alternative assumptions in this area.

5. Given the potential number of permutations involved, it is clearly impractical to address all cases in this overview. However, we can illustrate some key results.

Figure 1 highlights the sensitivity of estimated GDP impacts in the stabilization scenario to assumptions about implementation, the size of the required reduction in emissions, and the role of energy in determining potential output.

The upper curve, in which emissions stabilization actually increases output after a brief downturn, reflects an implementation through auctioned permits in which 60 percent of permit revenue is returned to business in the form of marginal tax rate reductions. This redistribution of income towards business favors investment, leading to a larger capital stock that allows output to exceed baseline levels under a model specification in which limitations on energy use do not "pull in" the economy's production function.

The lower curve reflects an implementation in which permits are awarded directly to consumers in order to maintain income distribution in the economy near to baseline levels and in which the restrictions on level and mix of energy use needed to meet the stabilization objective lower the productivity of other factors. The absence of an investment boom sparked by income redistribution, and the increasing drag on the productive capacity caused by an ever-increasing gap between unconstrained energy choices and those needed to meet the stabilization goal, lead to an outcome in which output remains below baseline for an extended period.

To provide an indication of how the results vary across policy scenarios, Figure 2 illustrates the range of GDP impacts, relative to baseline (no controls), using the implementation approach and potential GDP specification consistent with the lower curve for stabilization in Figure 1.

More stringent emissions reduction goals have larger output effects in both the short and long term. The short term result is driven by the larger shock, while the long term effect reflects the direct and indirect effects of energy restriction on potential output.

Figure 3 parallels Figure 2, this time using the same specification of implementation and potential GDP used to generate the upper curve in Figure 1. The pattern of short term reductions in output followed by subsequent increases over baseline output levels is again reflected.

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The short term effects are similar to those in Figure 2. However, more stringent targets actually lead to higher long-run output levels. This result occurs because there is a larger stimulus to investment with more stringent goals due to the rebate of permit action revenues through reduced corporate tax rates. The marginal corporate tax rate in 2010 in the baseline (____%) is reduced to ____% in the stabilization case and ____% under the German proposal.

6. GDP is not, of course, the only indicator of economic impacts. Changes in employment, consumption, sectoral output patterns, and other macroeconomic indicators are also important. Policies that also change the income distribution can have important effects on these issues. We expect that the breakout presentations will touch on these issues.

7. So, what insights can we take away from our initial macroeconomic analyses.

Under either set of implementation and modeling assumptions, scenarios that require abrupt adjustments for compliance, such as the AOSIS proposal, are likely to disrupt the economy in the short term.

Even under implementation and model specification assumptions that do not lead to a rapid turnaround in the initial downturn in output, our preliminary results indicate somewhat lower GDP impacts than some previous studies. This outcome reflects not only differences in the assumed size of the reduction required and the phase-in schedule for reductions, but also modeling choices reflecting the likely requirement for parallel emissions mitigation activities within the economies of many of our most important trading partners, and assumptions about the response of the monetary authority.

Under implementation and modeling assumptions conducive to a rapid turnaround in output following an initial output, emissions limitation can raise gross output.

Clearly, all of these issues merit increased attention as analysis continues, and results obtained to date cannot be considered as definitive.

Finally, economic analyses suggesting that there are costs to reducing emissions do not, of course, imply mitigation should not be pursued -- benefits, in terms of direct environmental improvement and the contribution towards continued progress towards further emissions reductions on a global scale are also an important consideration.

F. International modeling results

1. International economic models can be used to explicitly consider the effects of emissions limitation obligations affecting several countries or regions -- for example, Annex I parties or OECD countries. There are two main types of international models -- computable general equilibrium (CGE) energy-economic models and macroeconomic models. CGE models are designed to estimate long-term changes in economic growth due to proposed policies, and in general do not estimate adjustment costs. Macro models, as considered in the previous section, can be used to trace short and medium term business cycle dynamics, and are most useful for examining economy-wide adjustments to economic shocks.

2. The Administration has actively supported both types of modeling efforts. Both DOE and EPA have been actively involved in the work of the Stanford Energy Modeling Forum, which has completed one study and has two more underway, and have also supported other modeling studies. You will be hearing several presentations from this body of analysis later this afternoon.

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3. One group of studies within the current Stanford Energy Modeling Forum project has developed estimates of GDP impacts for a variety of emissions objectives for OECD countries, including two of those considered above -- stabilization of emissions at the 1990 level and reducing emissions 20 percent below the 1990 level by 2010.

Figure 4 illustrates estimates from 3 participating models for economic impacts in the U.S. and in other OECD countries. Two of the models show higher economic impacts in the U.S. than in other OECD regions, while the third, in which absolute impacts are much larger, shows the opposite result, paralleling efforts to develop the "G-cubed" modeling effort by McKibben and Wilcoxon.

4. The results presented above are for the costs of meeting goals for each OECD region that do not allow for flexibility in where or when emissions reductions are made. Analysis using these models has shown that costs of achieving the same cumulative emissions reductions in the period between now and 2050 could be significantly reduced by allowing for these types of flexibility.

Averaging across all the models, the cost reduction for where flexibility alone (global joint implementation) is 70 percent, when flexibility alone is 40 percent, and both types of flexibility together is 85 percent. We note that the cost-reduction benefits of when flexibility are significantly reduced as the time horizon over which higher initial emissions must be "made up" is shortened.

5. While generalization across multiple models is perilous, it is probably reasonable to note that the weakest link in international models developed to date is their representation of the effect of emissions reduction policy on competition in energy intensive industries. (In fact, the representation of industrial energy use and its responsiveness to policy change is a weak point even in domestic modeling.)

To address this concern, we are undertaking a study exploring the sensitivity of energy-intensive industries to significant shifts in energy prices within the world economy. This effort will provide some initial insights and help in setting the research agenda for further analysis of this important topic.

6. A much larger group of models participating in various EMF studies have considered the economic implications of emissions stabilization for the United States. These models report a wide range of results, reflecting not only differences in the assumed costs of control, but also differences in the emissions baseline. Differences in assumed baselines are important because they directly affect the size of the adjustment in private behavior needed to reach a given emissions objective.

Figure 5 (EMF baseline picture)

7. There is also some interesting preliminary work going on outside the EMF projects using the Oxford Economic Model, an international macroeconomic modeling tool and G-cubed, a new CGE model. You will be hearing more about ongoing work on these projects later this afternoon. There are many challenges to this work most notably in setting the energy inputs -- how large of a policy intervention is needed in each country to reach an emissions objective.

At this point, the work we have seen is only suggestive of some preliminary insights about international linkages. Some of the relevant insights are:

Baseline energy prices, energy intensities, and energy consumption levels within national economies can have a significant impact the effectiveness of a carbon limitation policy and its absolute and relative economic impact across countries.

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In terms of effectiveness, a higher baseline energy price translates into a smaller change in end-user behavior resulting from a policy involving a given implicit carbon value.

In terms of economic impact, a higher the baseline energy price and lower baseline energy intensity translates into a lower inflationary impact resulting from a reduction policy involving a given implicit carbon value.

Given that proposals under evaluation are based on 1990 emissions, baseline emissions growth determines the size of the "emissions gap" that policy must be called on to close.

The United States has lower baseline energy prices, but higher baseline energy intensities, than most other OECD countries. As noted in the discussion of emissions trends, most estimates forecast baseline U.S. emissions growth falling between that of European developed countries on the low end and Japan on the high end.

G. Potential Biases in Model Results

1. In considering the results from modeling studies, policymakers need to consider whether the methodologies used result in biased estimates of costs. In discussions surrounding the costs of greenhouse gas mitigation, the possible relationship between policy and technological advance has received considerable attention as a possible source of bias.
2. Several observations suggest that the cost estimates from macroeconomic models may be overstated. For example, the private sector may do a better job in finding better and cheaper solutions than either the government or modelers. Moreover, the change in relative prices with the implementation of greenhouse mitigation policies will increase the payoff from investments in the development of low-emitting technologies. A change in policy may also result in new institutional arrangements that address existing barriers in ways that cannot now be imagined -- just as the "hub and spoke" system arose from airline deregulation.
3. Experience with other environmental regulations demonstrates that implementation costs can be overestimated. Two recent examples include the costs of retrofitting car air conditioners to use substitutes for CFCs and the costs of sulfur dioxide allowances under Title IV of the 1990 Clean Air Act.
4. However, other observations suggest that we should not count a repetition of these developments. Unlike some environmental technologies, energy efficiency and renewable technologies are not unexplored territory. Federal expenditure in these areas since 1978 is over \$17 billion (\$1994). Further efficiency and renewable technology development is stimulated by tax credits, substantial private spending, and regulatory requirements. Economic models also assume continued technical progress.
5. As to the issue of whether models overstate or understate costs, two other considerations are also potentially important. First, modeling exercises typically assume steadily rising real oil and gas prices. Continuation of flat real oil and gas prices, consistent with long run experience over the past 50 to 100 years, would increase baseline demand for energy and lower the assumed future cost of conventional energy forms, both of which raise mitigation costs. Second, although models generally assume economically efficient implementation, typical regulatory programs often achieve reductions at a significant cost premium over modeled emission tax or allowance systems.

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6. How consideration of the full set of these factors might affect our interpretation of modeling results is an issue that will require further work.

H. Conclusion

(NOTE: some of this material could be reconstituted as an Executive Summary for a the paper version.)

1. The United States delegation was instrumental in securing a role for analysis and assessment in the Berlin Mandate, and we have been actively engaged in the analytic process since that time. Our presentation provides an insight into some of the analytical approaches and preliminary results being considered by the Administration.
2. We are actively pursuing analysis, which we view as an evolutionary process. It should be noted that there is virtually unanimous recognition among national delegations and stakeholder groups participating in the negotiating process that the United States is far ahead of other countries in both the depth and breadth of its analysis. Nonetheless, we recognize the need for, and intend to support additional analyses, as well as refinements of the work that will be discussed today. In light of the Berlin Mandate schedule, this further analysis will need to proceed in tandem with the negotiating process.
3. Current preliminary analyses that are being considered by Administration policymakers suggest the following findings:

U.S. greenhouse gas emissions in 2000 are likely to exceed their 1990 level.

The technological costing perspective identifies a significant potential for emissions reductions at low or no cost within the U.S. economy. Factors relevant to decisionmakers that are not accounted for in such analyses and barriers that can be addressed by policy may both have a role in limiting adoption of identified measures and technologies. The Climate Change Action Plan targets some of the apparent barriers.

Macroeconomic modeling of the U.S. economy suggests that carbon reduction impacts on gross economic output are highly dependent on implementation and modeling assumptions. However, our preliminary analysis shows lower economic impacts than several widely-cited studies using comparable modeling tools.

- The AOSIS proposal, which involves sharp reductions in fossil fuel use over a very short time period, would have a significant adverse effect on U.S. economic performance.
- The economic costs of limiting emissions depend significantly on the assumed baseline emissions path, the phase-in schedule, the implementation approach, and the role of energy in determining the economy's productive capacity.

International modeling studies, involving both equilibrium and business cycle models, also suggest that emissions limitation will reduce gross economic output.

- There is a wide range of results across different studies.

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--Allowing for flexibility in where and when reductions are made can significantly lower the costs of reaching a cumulative emissions objective. (There may, however, be significant institutional challenges in securing an agreement that exploits this insight.)

--Relative impacts are highly dependent on assumptions made regarding the size of the intervention needed to meet emissions objectives in different countries and differences across economies in the transmission of inflationary impacts.

Finally, all modeling studies are subject to competing claims regarding the over- or underestimation of costs.

--Recognizing that these claims merit further attention, there is no clear evidence as to which arguments are stronger in the present context.

While a significant amount has been accomplished to date, much remains to be done. Our analysis priorities include further work in the following areas:

- assessing economic impacts on sectors and regions
- continuing analysis of mechanisms and implementation strategies
- addressing the potential role of policies to induce more rapid technological advance
- evaluating the potential to improve performance in renewables and energy efficiency
- refining domestic analyses, including the consideration of additional modeling tools

TABLE 1

U.S. Greenhouse Gas Emissions 1990 and 1994

	1990	1994
Energy-Related CO ₂	1345*	1396**
International Bunker Fuel	-20.8 (est.)	-23 (est.)
Adjustments and Other Sources	27.2	27.6 (est.)
Methane ***	191	180
Nitrous Oxide***	36.7	39
HFC/PFC and Other Gases***	25.2	40
Forest Carbon Sequestration	-125	-130?
Total Net Emissions***		

* Revised figure: CCAP figure was 1338 MMT. Includes international bunker fuels.

** Note 1995 energy-related CO₂ emissions are estimated at 1408 MMT.

*** Calculated in carbon-equivalent terms based on latest Global Warming Potentials (GWPs) estimated by the IPCC.

Figure a**DRAFT II**

**Baseline U.S. Greenhouse Gas Emissions
increase by 22% in 2010 from 1990 levels.**

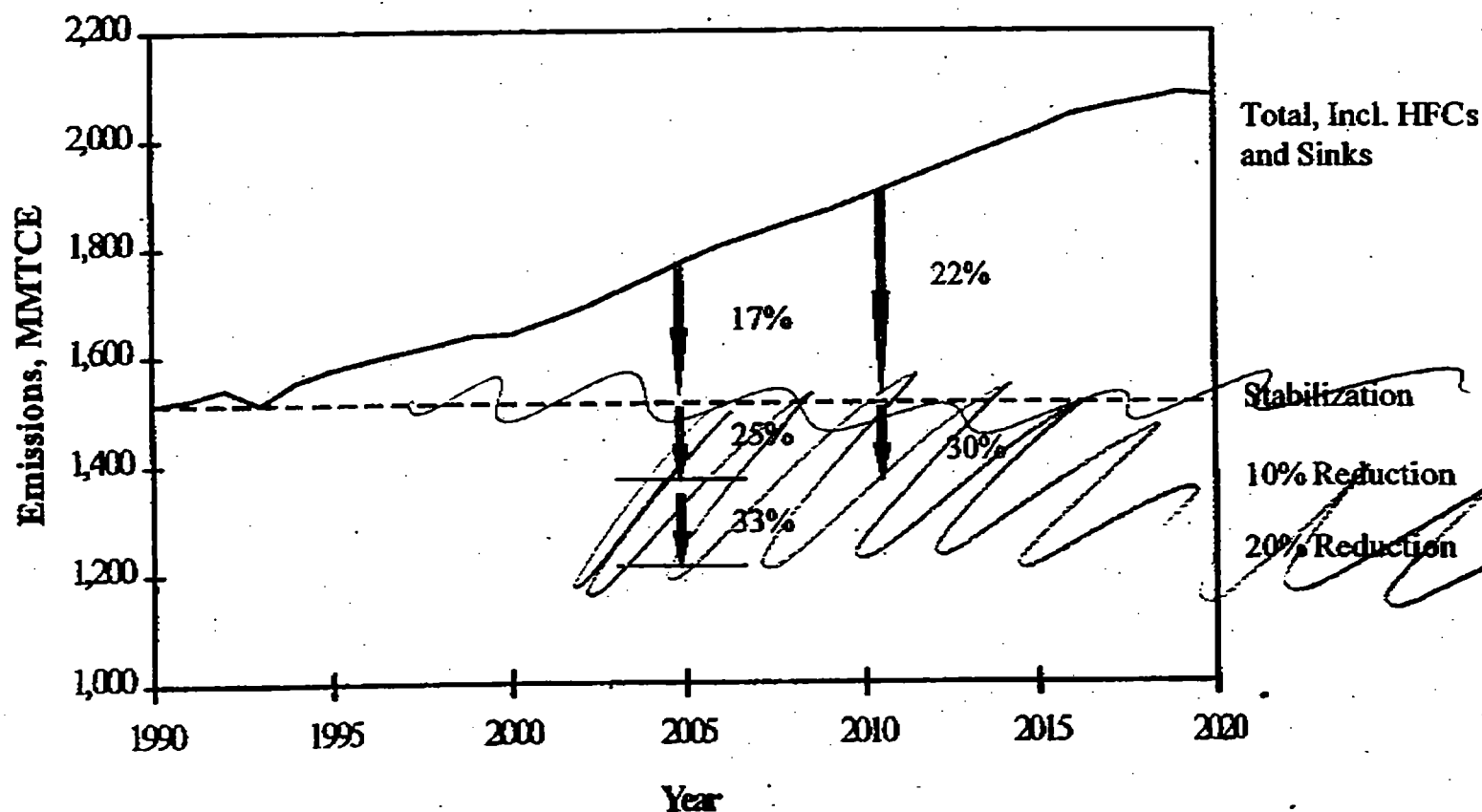
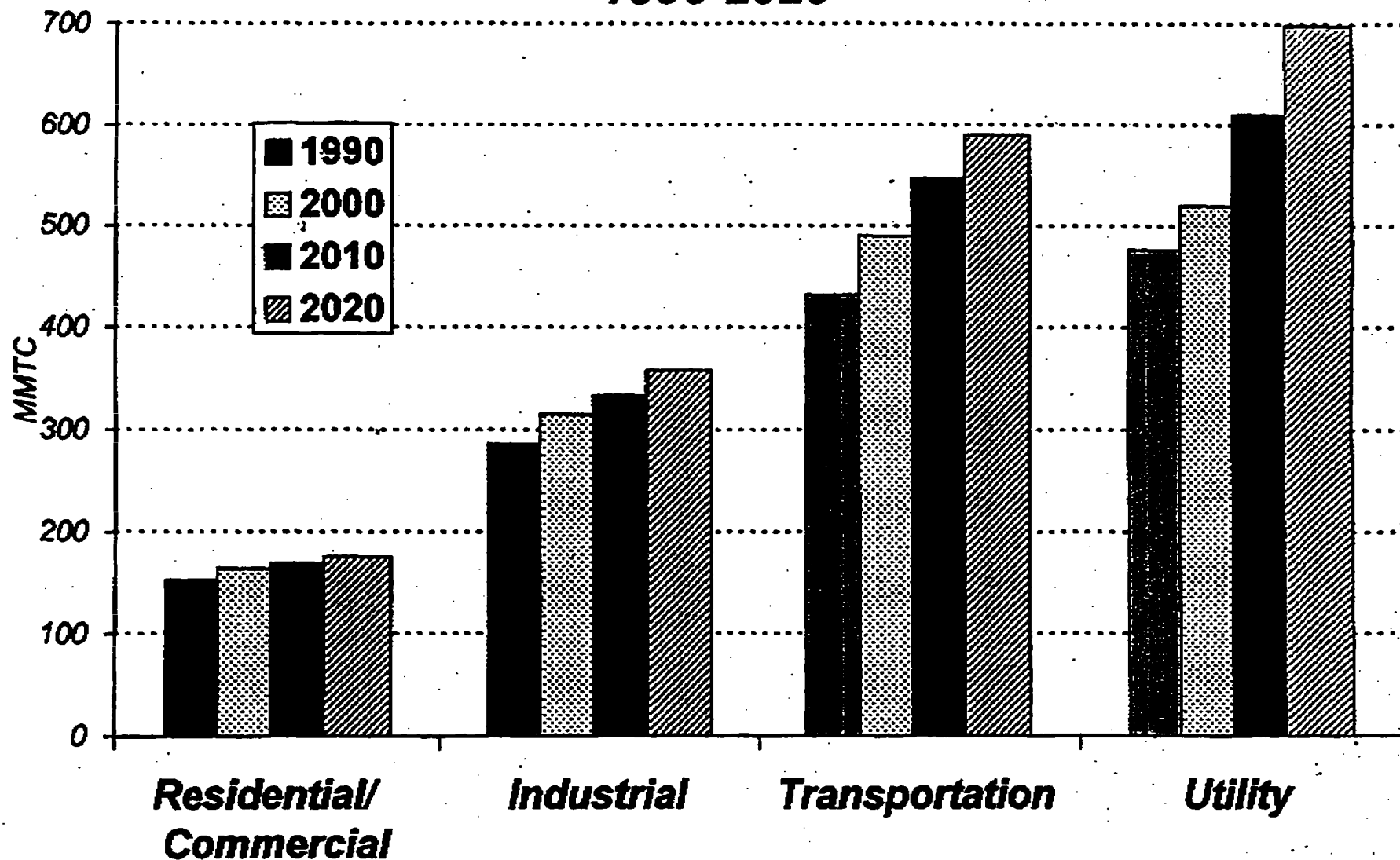


Figure b

Sectoral Energy-Related Carbon Emissions

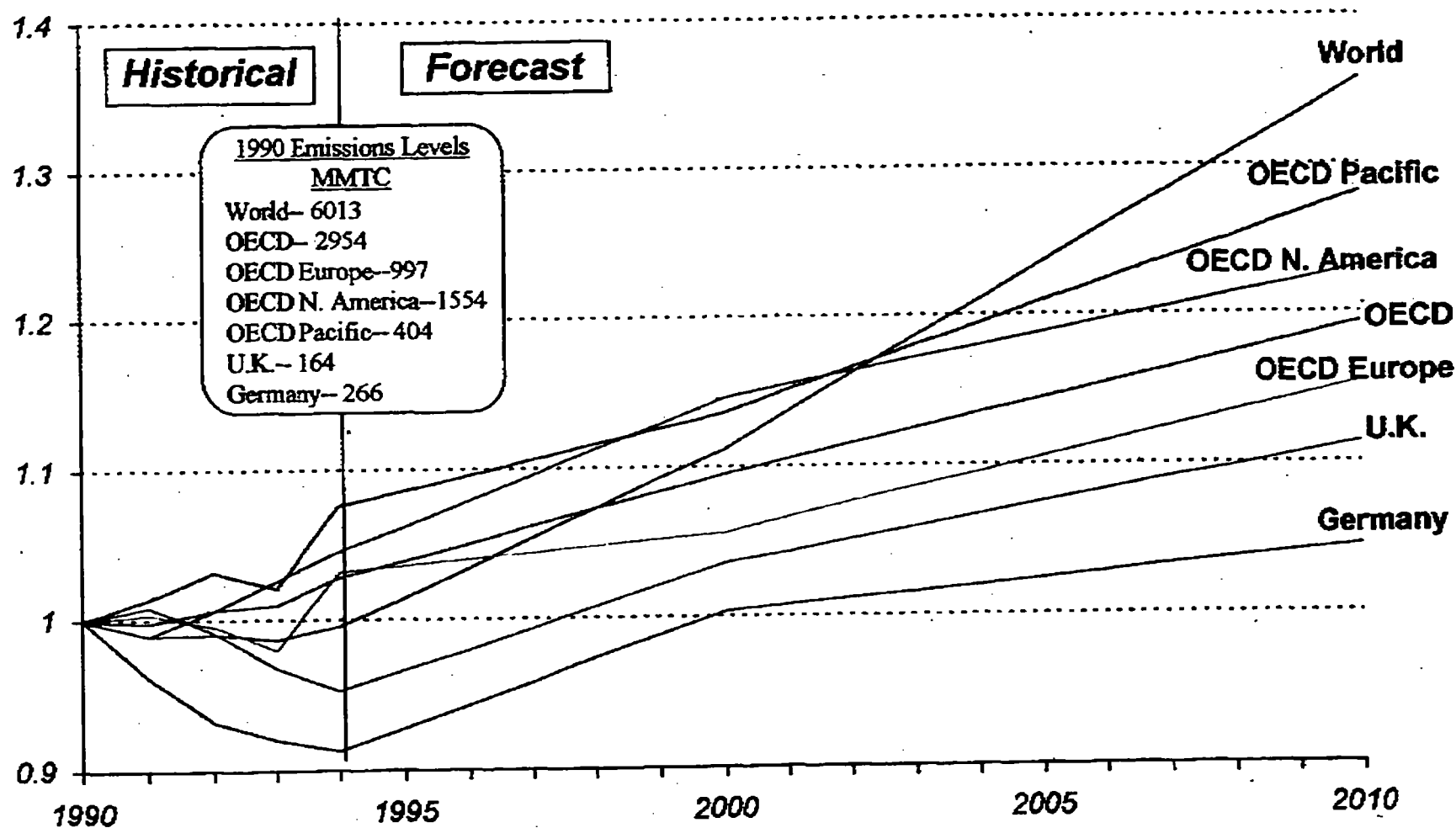
1990-2020



Note: The Residential/Commercial share of total electricity use increases from 65% in 1990 to 68% in 2020. The Industrial sector accounts for virtually all other electricity use.

Figure C

Energy-Related Carbon Emissions Forecasts: Indices for OECD Groupings



Note: Developing countries increase to about double their 1990 emissions by 2010. The former Soviet Union and other East Bloc countries, whose emissions have fallen sharply since 1990, reach only 90% of their 1990 level by 2010.

Source: The historical data is from BP Statistical Review of World Energy. The forecasts are an average of DRI, WEO, and IEO scenarios. Individual country forecasts are based on DRI estimates.

Figure d

EPA Engineering Cost Curves are consistent with the findings of NAS (1991) and OTA (1991).

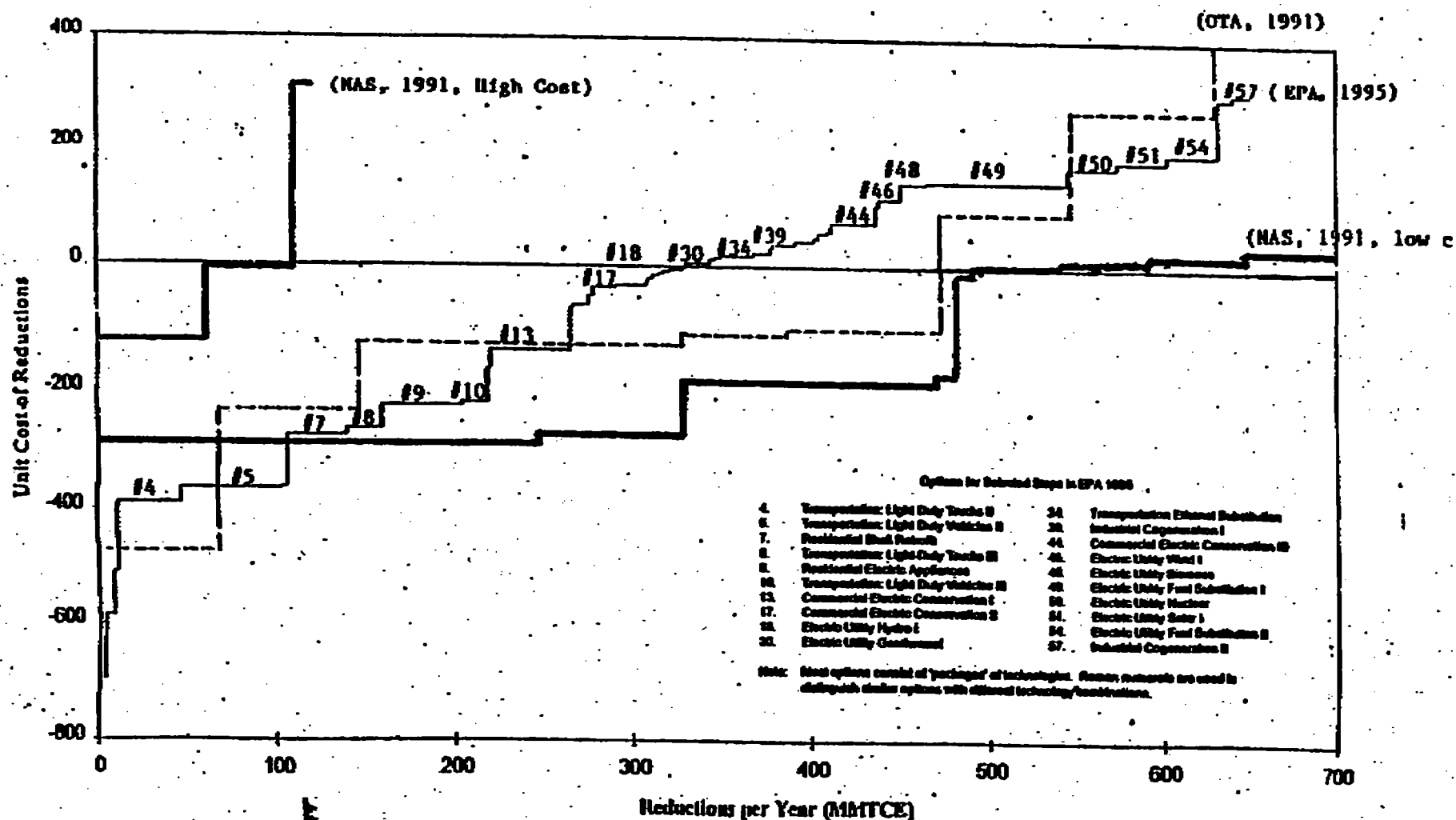


Figure e

Impact of Different Emission Proposals on U.S. GHG Emissions

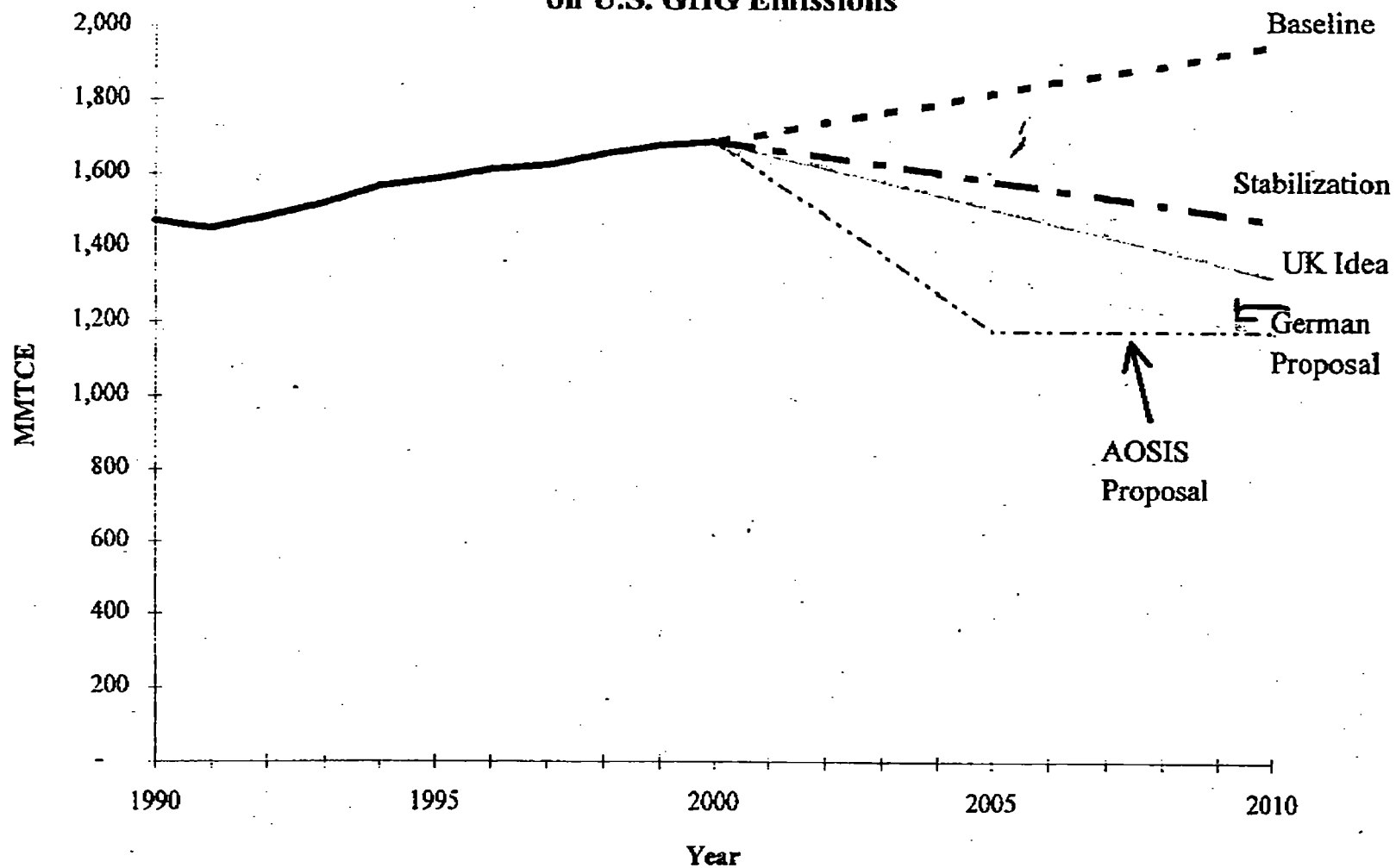


FIGURE 1

Comparison of GDP Impact Estimates: Alternative Implementation and Modeling Assumptions for Stabilization

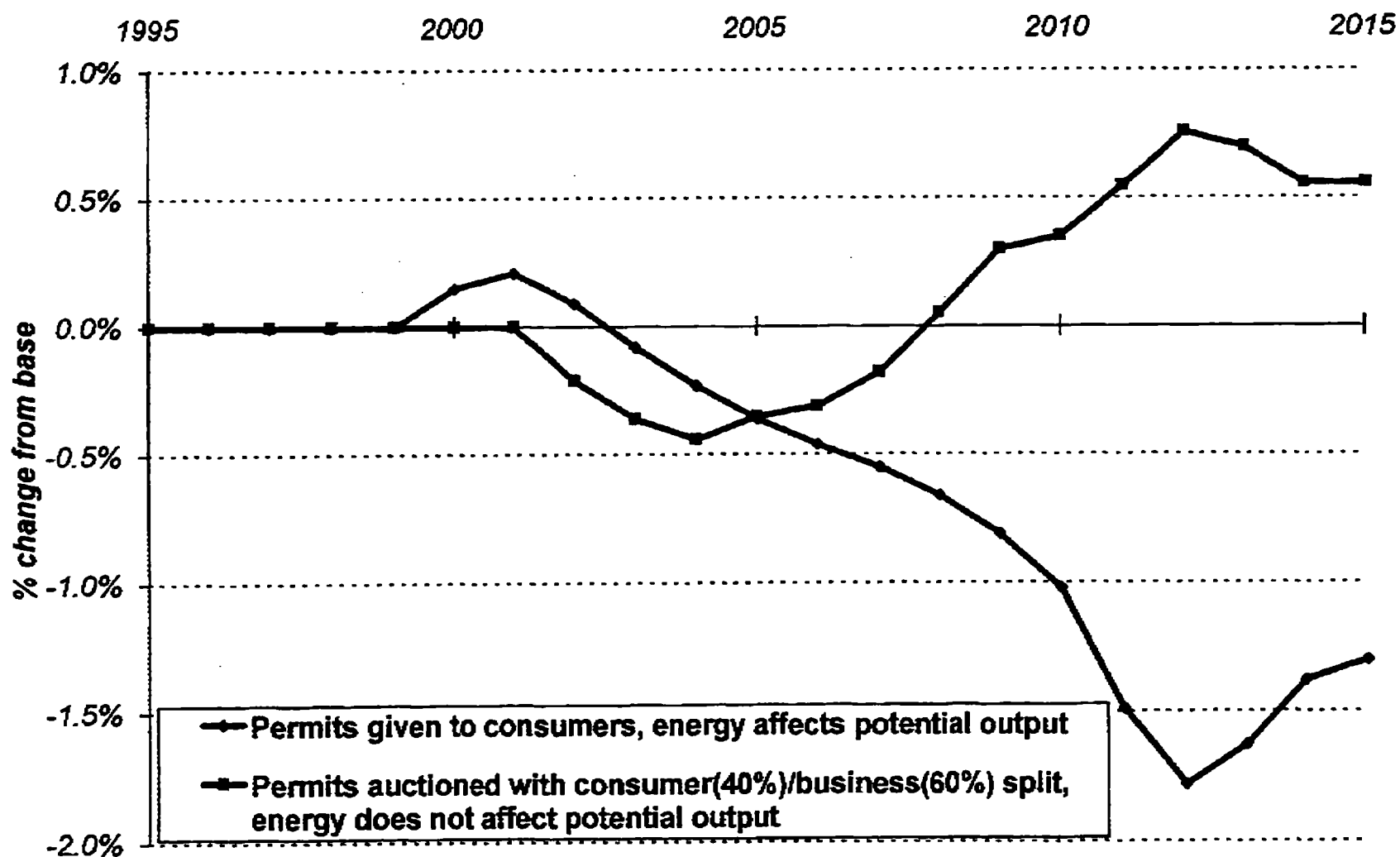


Figure 2

Percent Change in Real GDP from Base Permits to Consumers with Potential GDP Linkage

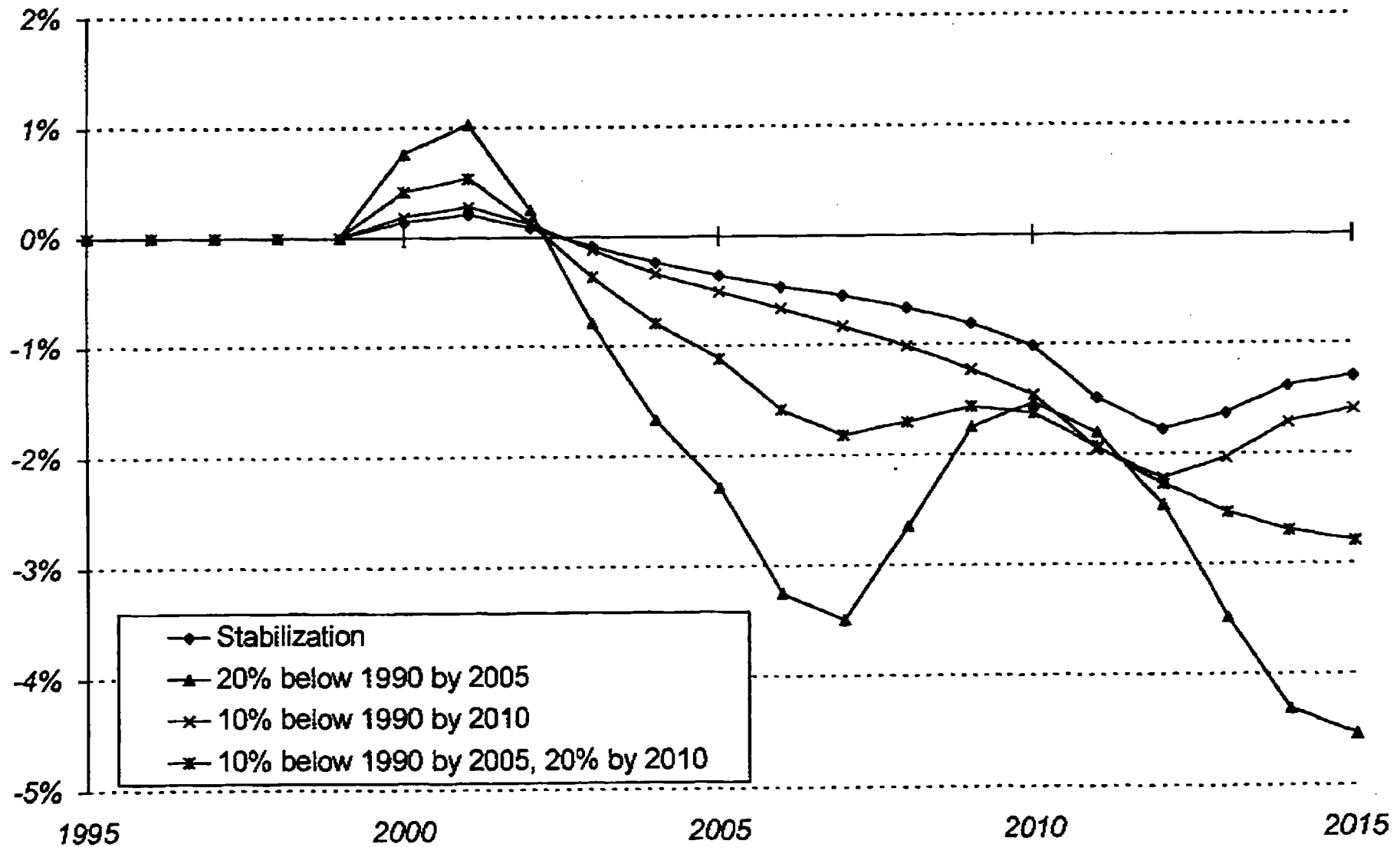


Figure 3

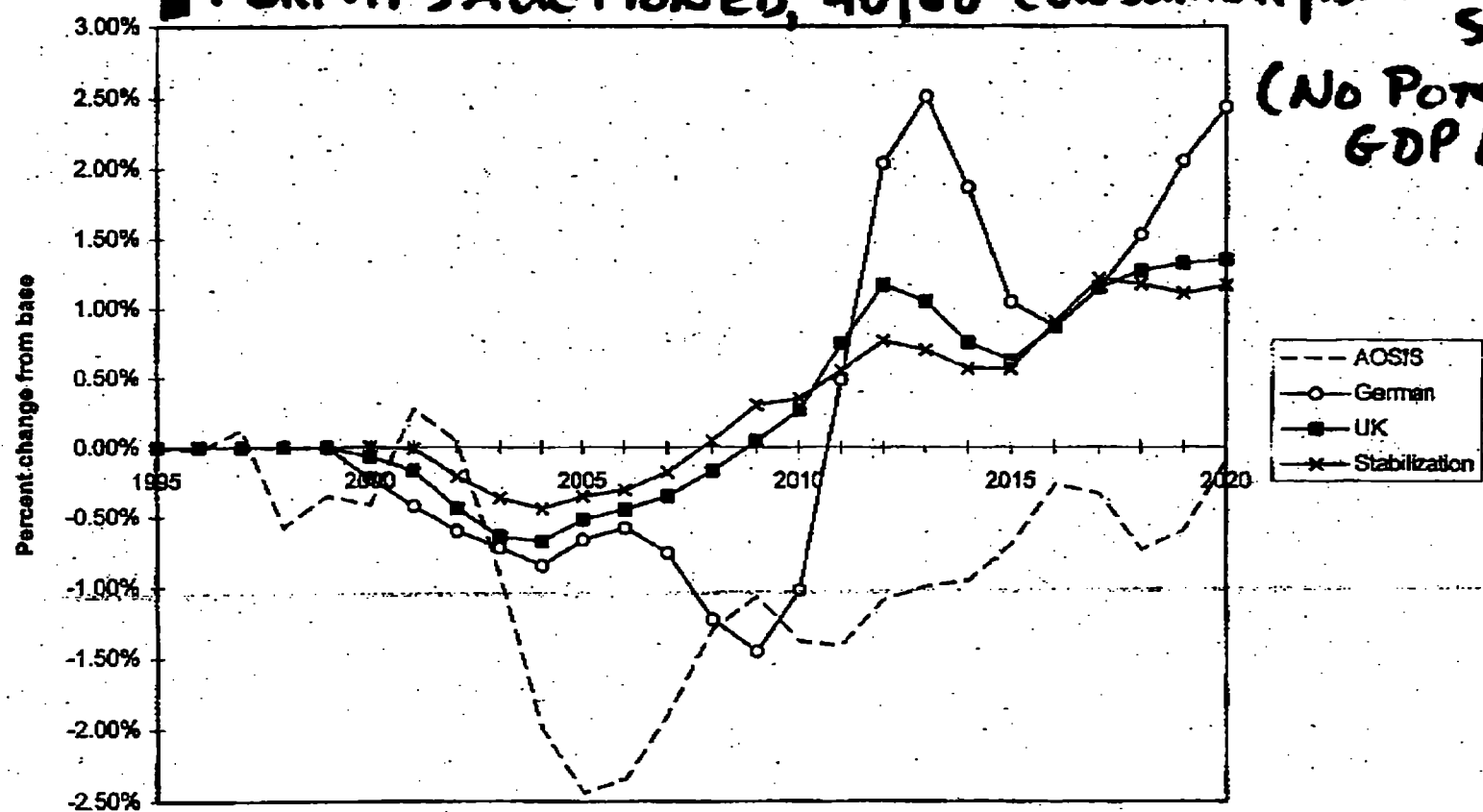
Chart3

PERCENT CHANGE IN REAL GDP from BASE:

Real GDP
Auction: 40/60 Split

PERMITS AUCTIONED, 40/60 CONSUMER/BUSINESS SPLIT

(No Potential GDP Linkage)



* AOSIS scenario based on slightly different assumptions; phase-in begins in 1996 instead of 2000.

Figure 4

GDP Change for the US and other OECD: Stabilization Case

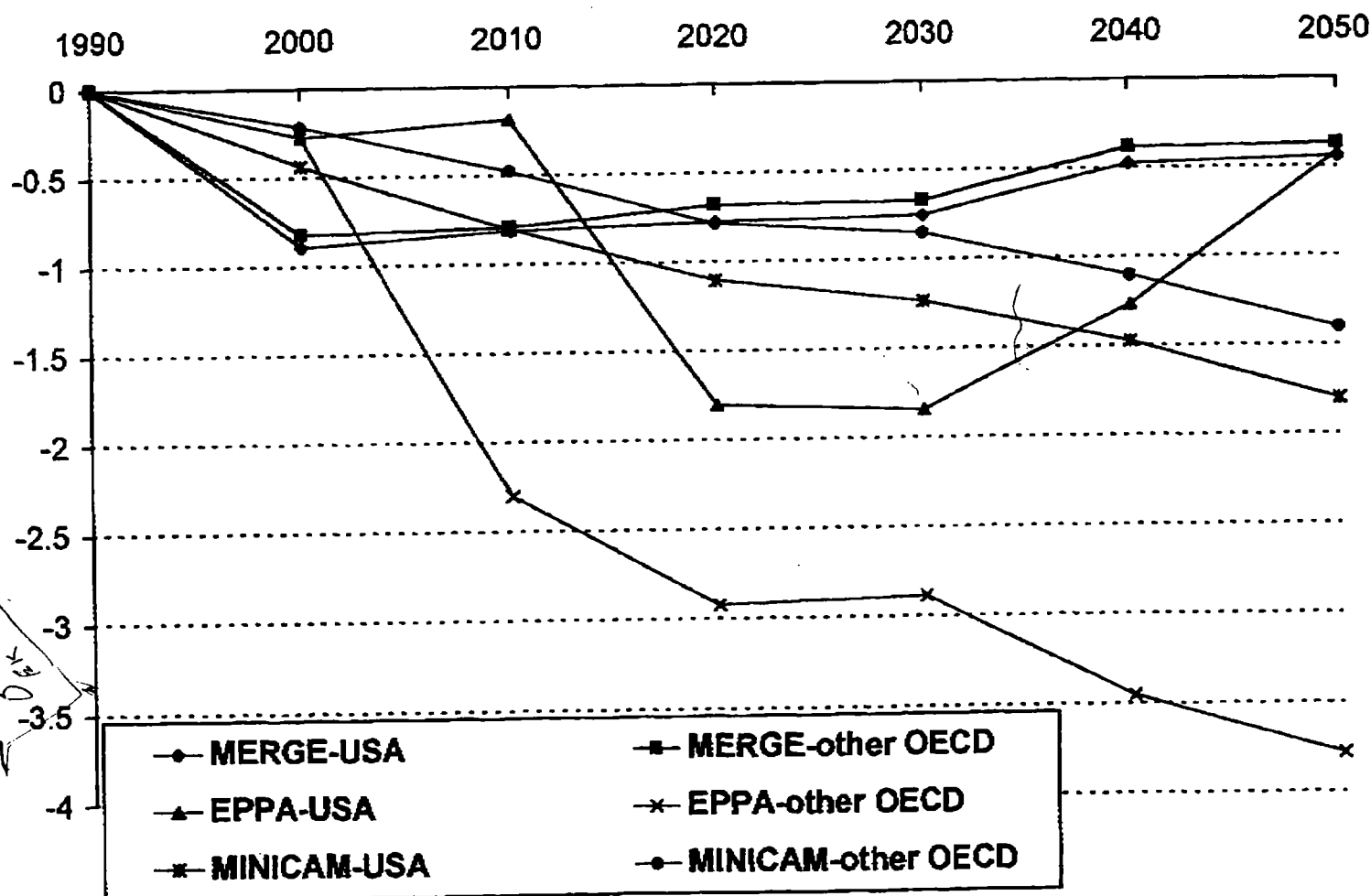


FIGURE 5

**Modeler's Reference Case
USA**

