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investigation of the implications of international trading suggest that the conclusion that effective international trading can significantly reduce costs is robust (Weyant 1997).

Table 3. Countries/Regions in Second Generation Model

Annex I	**Non-Annex I**
United States	China
Western Europe	India
Former Soviet Union	Korea
Eastern Europe	Mexico
Japan	Rest of the World
Canada	
Australia	

Source: Second Generation Model

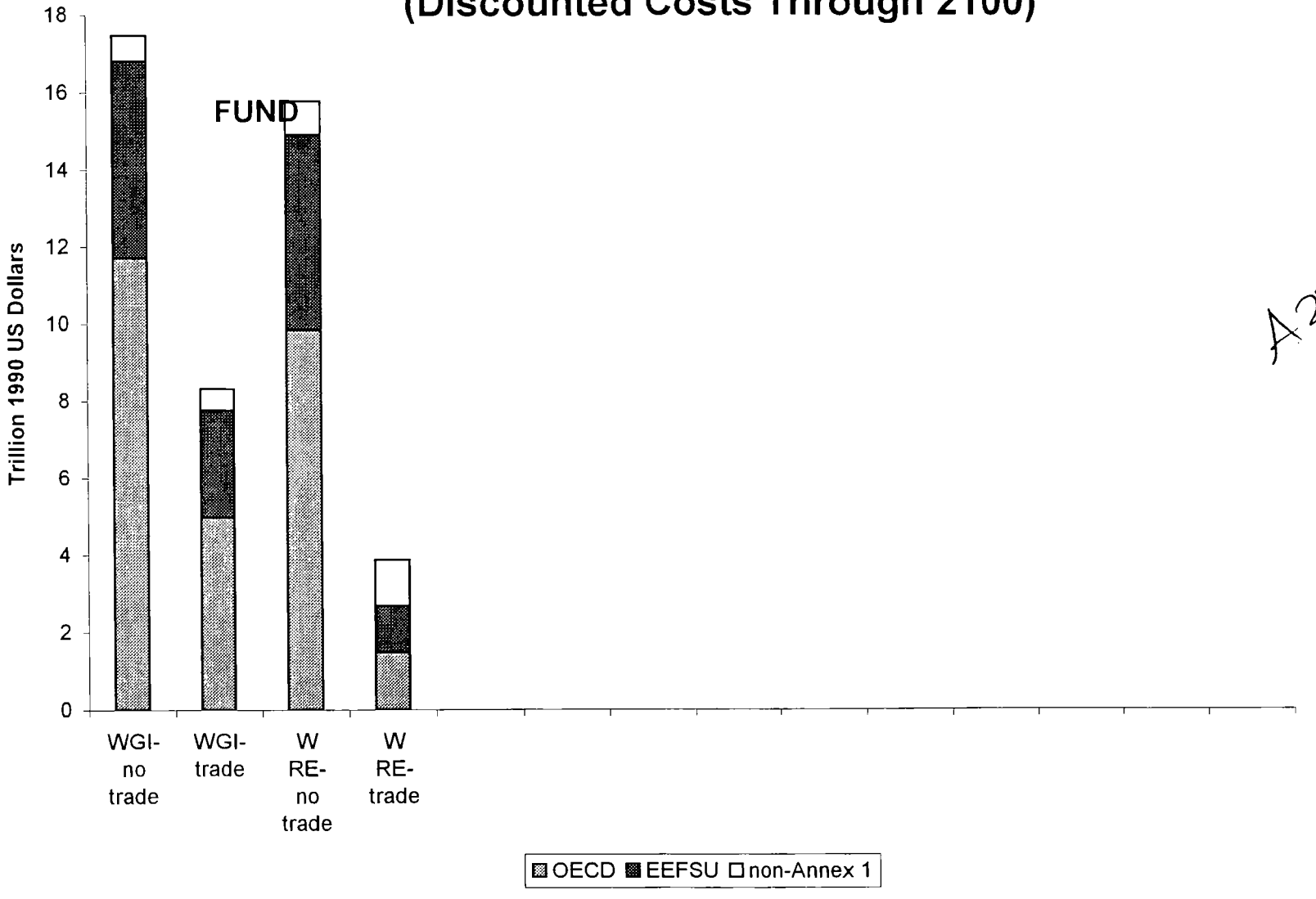
Abatement Cost Functions in Industrialized Countries

Drawing on results of more than 60 model runs from the SGM, the Administration developed country- and region-specific cost functions for carbon dioxide abatement by matching prices and emissions reductions in different model runs. For a given country or region, at a given emissions allowance price, the country/region reduces carbon emissions by a specified amount. Over a wide range of prices, the relationship between the allowance price and emissions reductions can be traced out. This relationship depicts the approximate marginal abatement cost for the country or region. For the United States, we aggregated the cost functions for the non-carbon dioxide greenhouse gas emissions developed by the Interagency Analytical Team (1997) with the U.S. carbon dioxide cost function to generate cost function for the entire basket of greenhouse gases. For all other countries and regions, we assumed the carbon dioxide cost function to hold for all six categories of greenhouse gases. Based on the pattern of U.S. abatement costs, this assumption for other countries would likely over-estimate the costs of abatement.

Abatement Cost Functions in Developing Countries

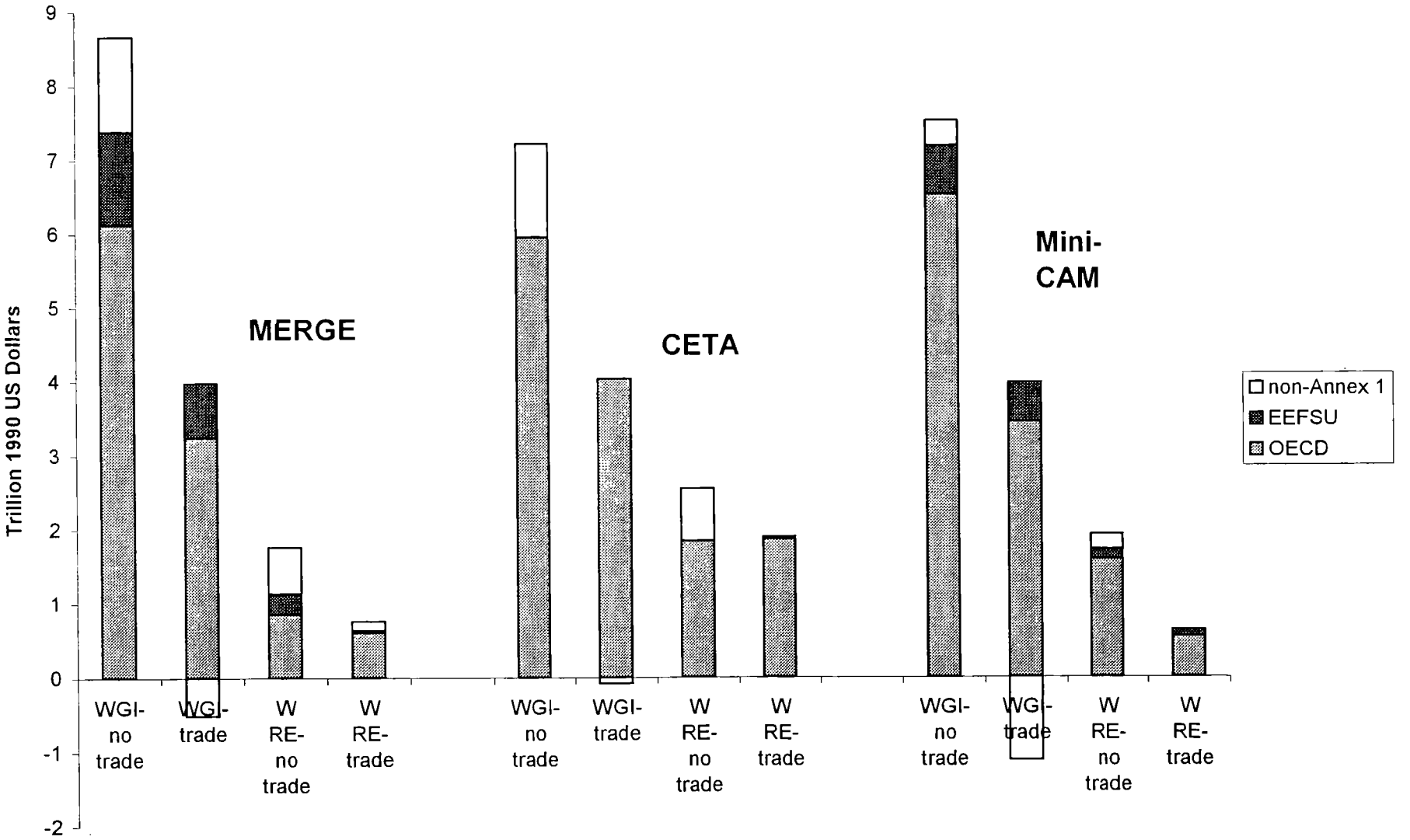
The marginal abatement cost functions for developing countries only include opportunities to reduce carbon dioxide released through energy consumption. Given that numerous options for abatement of other greenhouse gases and sequestration projects in these countries exist, these functions in fact over-estimate the costs of developing country participation.

Costs of Stabilizing Concentrations at 550 ppmv (Discounted Costs Through 2100)



A27a

Costs of Stabilizing Concentrations at 550 ppmv



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Energy Efficiency Improvement

The parameter that figures most prominently in analysis of energy efficiency is the rate of autonomous energy efficiency improvement (AEEI). The AEEI is defined as the rate at which the total use of energy falls relative to GDP, excluding the effect of energy prices on consumption. A plausible assumption on the AEEI is an improvement of about 1.0 percent per year. The developers of the Second Generation Model employ an AEEI of 0.96 percent per year as their default energy efficiency assumption. In this analysis, we used this default energy efficiency assumption.

Reflecting a conservative interpretation of the 15-year impact of various climate change initiatives, this 0.96 percent AEEI is only a small increase above the 0.9 percent number used in Energy Information Administration analyses (see Energy Information Administration 1997a). Some authorities in the field of energy policy forecast more rapid technological progress. Experts at five national laboratories managed by the Department of Energy, using an engineering approach rather than an economic paradigm, found that a third of the emissions reductions necessary to return to 1990 levels by 2010 could be achieved through the adoption of existing energy-efficient technologies at no net resource cost. The assumed improvement in energy efficiency in this case was 1.3 percent per year (Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies 1997). The National Academy of Sciences reached qualitatively similar conclusions in a 1992 report. As reflected in the Department of Energy study, if a higher rate of energy efficiency improvement were achieved, the United States could meet a correspondingly larger fraction of its commitment through domestic reductions potentially at lower permit prices.

Trading Scenarios

Intergas Trading

We assumed that trading occurs across all gases based on 100-year global warming potential values.

Trading Blocs

The Administration assessed three different industrialized country trading blocs.

- Annex I implies trading among all Annex I countries.

Energy Efficiency Improvement

Energy efficiency improvements over time -- defined as the rate at which the total use of energy falls relative to GDP -- are attributable to three factors: ~~price-inducements to~~ conservation ~~of energy use~~; non-price policy measures to improve energy efficiency (such as government support of R&D); and *autonomous* increases in energy efficiency. The first factor reflects the incentive provided by higher energy prices for firms and households to reduce energy consumption through efficiency measures and thereby make the economy as a whole more energy efficient. The second factor reflects the potential influence of a wide range of non-price public policies to improve the efficiency with which energy is used in the economy. For example, measures could be undertaken to speed the rate of diffusion and adoption of technologies which can simultaneously lower energy use and household and business energy bills. Finally, energy efficiency improvements occur over time which are independent of both prices and energy policies. For example, in the United States, the gradual transition from a manufacturing economy to a less energy-intensive service economy has improved the energy efficiency of the economy. The *autonomous energy efficiency improvement factor (AEEI)*[16] reflects only the pace of efficiency improvements that are purely autonomous and thus independent of both energy prices and energy policies.

In modeling energy efficiency improvement, these three components are addressed in different ways. For the *autonomous* energy efficiency factor (AEEI), a plausible assumption is an improvement of about 1.0 percent per year. The developers of the Second Generation Model employ an AEEI of 0.96 percent per year as their default energy efficiency assumption. Similarly, the Energy Information Administration analysis (see Energy Information Administration 1997a) assumes a pace of energy efficiency improvement of 0.9 percent. In this analysis, we used the SGM default assumption concerning the autonomous energy efficiency parameter. For price-induced changes in energy efficiency, the model generates its own forecasts of changes in energy consumption that reflect the effects of greenhouse gas permit prices on energy prices.

Economists have traditionally experienced significant difficulty in modeling non-price policy-induced shifts in energy efficiency. For example, it is hard to assess the likely future pay-off from investments in energy R&D, although historical estimates of the social rate of return from such investments are substantial. We are similarly unable to quantify adequately the potential payoffs from the Administration's Climate Change Technology Initiative, its voluntary sectoral initiatives, the federal sector's own energy efficiency program or measures that could be adopted to spur the diffusion and adoption of existing technologies in key sectors or nationwide. However, many authorities in the field of energy policy believe that policy initiatives could spur substantially more

[16] The Autonomous Energy Efficiency Improvement should be distinguished from the annual energy efficiency improvement used by some in the literature. The annual rate includes the autonomous component as well as price-induced and non-price policy-induced components.

Pacific Northwest Laboratories
901 D St. SW. Suite 900
Washington, DC 20024

FACSIMILE TRANSMITTAL

DATE: May 26, 1998

To:	Joe Aldy
Company:	CEA
City/State:	Washington, DC
Facsimile #:	202-395-6870
Telephone #:	202-395-1455

From:	Chris MacCracken
	Battelle - Washington Office
Facsimile #:	(202) 646-5233
Telephone #:	(202) 646-5274

Transmittal Consists of [2] Page(s) including cover page.

COMMENTS:

Joe –

Attached is the summary sheet with the SGM's US c/gdp and e/gdp values for the different IAT baselines. Hope this helps clear up some of the confusion. I also sent a copy to Peter Nagelhout as his question was the one that contributed to my own confusion.

Chris

SGM Carbon-to-GDP and Energy-to-GDP Ratios for 1997 IAT Analysis

May 26, 1998

The following values represent annual rates of improvement from 2000 to 2015 for the United States.
The "1.0" Baseline case is the standard SGM reference (used for the IAT process).
The "1.25" and "1.75" cases represent an ***additional*** improvement rate of Carbon-to-GDP of 0.25% and 0.75%, respectively.
For reference, the EIA's AEO 1997 values are also given.

Annual Energy Outlook 1997

Carbon-to-GDP	-0.77%
Energy-to-GDP	-0.96%

SGM

"1.0" Baseline Case

Carbon-to-GDP	-0.77%
Energy-to-GDP	-0.96%

A28

"1.25" Baseline Case

Carbon-to-GDP	-1.02%
Energy-to-GDP	-1.21%

"1.75" Baseline Case

Carbon-to-GDP	-1.53%
Energy-to-GDP	-1.67%

DOE/EIA-0383(98)
Distribution Category UC-950

Annual Energy Outlook 1998

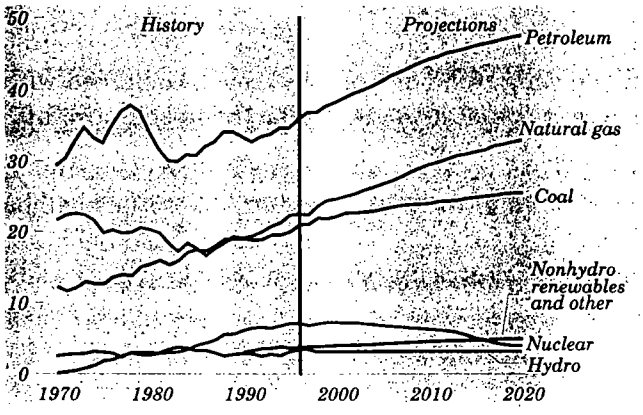
With Projections to 2020

December 1997

Energy Information Administration
Office of Integrated Analysis and Forecasting
U.S. Department of Energy
Washington, DC 20585

Natural gas consumption increases by an average of 1.6 percent a year (Figure 3), with increased demand in all sectors. The most rapid growth is in consumption by electricity generators (excluding cogenerators), which is projected to increase from 3.0 to 10.1 quadrillion Btu between 1996 and 2020. Total gas consumption in 2015 is 0.5 quadrillion Btu (2 percent) higher than in *AEO97*, due to higher projected consumption in the residential, commercial, and industrial sectors.

Figure 3. Energy consumption by fuel, 1970–2020 (quadrillion Btu)



Although coal-fired generation loses market share over the projection period, it accounts for more than one-half of electricity generation (excluding cogeneration). Total coal consumption increases from 20.9 to 25.6 quadrillion Btu between 1996 and 2020, an average annual rate of 0.9 percent. About 90 percent of U.S. coal consumption is used for electricity generation. Coal consumption is 5 percent (1.2 quadrillion Btu) higher than in *AEO97* in 2015, due to an increase in projected consumption for generation.

Demand for petroleum products is projected to grow by an average of 1.2 percent a year through 2020. In 2020, 72 percent of petroleum use is in the transportation sector, up from 66 percent in 1996. Increases in light-duty vehicle miles traveled more than offset the increases in vehicle efficiency throughout the projection period. Continued economic growth also increases petroleum use for air and freight travel and shipping over the forecast horizon. In 2015, total petroleum demand is 7 percent higher than in *AEO97*, due primarily to higher travel and slower efficiency inceases in the transportation sector.

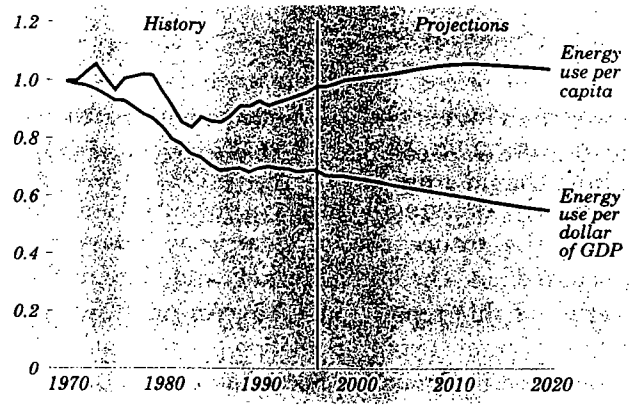
Renewable fuel use increases by an average of 0.5 percent a year. In 2020, 59 percent of the total is for electricity generation and the rest for dispersed heating and cooling, industrial uses, and blending in vehicle fuels. In 2015, renewables consumption is lower than in *AEO97* by 0.2 quadrillion Btu (3 percent) due to lower demand for renewables for electricity generation and for industrial sector cogeneration, as indicated by recent data.

Electricity consumption is projected to grow by 1.4 percent a year through 2020. Efficiency gains in electricity use partially offset the continued trend of electrification and the penetration of new electricity-using equipment. Compared to *AEO97*, electricity demand is 0.2 quadrillion Btu (2 percent) higher in 2015, due to slower efficiency improvements in the residential and commercial sectors and a more disaggregated treatment of residential end uses.

Energy Efficiency

Energy intensity, measured as energy use per dollar of GDP, has generally declined since 1970, particularly during periods of rapid increases in energy prices (Figure 4). From 1970 to 1986, it declined on average by 2.3 percent a year, as the economy shifted to less energy-intensive industries and more efficient technologies. Energy intensity was relatively stable from 1986 to 1996 due to moderate price increases and the growth of more energy-intensive industries. From 1996 to 2020, intensity is projected to decline at an average annual rate of 0.9 percent.

Figure 4. Energy use per capita and per dollar of gross domestic product, 1970–2020 (index, 1970 = 1)



Energy use per capita, which also declined from 1970 through the early 1980s, rose in the mid-1980s as energy prices declined. Per capita energy use is expected to remain relatively stable through 202 and below the high in the early 1970s, as efficiency gains offset higher demand for energy services.

SCENARIOS OF U.S. CARBON REDUCTIONS

Potential Impacts of Energy Technologies by 2010 and Beyond

Prepared by the
Interlaboratory Working Group on
Energy-Efficient and Low-Carbon Technologies

Oak Ridge National Laboratory*
Lawrence Berkeley National Laboratory*
Pacific Northwest National Laboratory
National Renewable Energy Laboratory
Argonne National Laboratory

Prepared for
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

*Coordinating laboratories for this study

or emissions levels of 850 to 1000 MtC/year of carbon in 2015. Our efficiency and HE/LC cases ranging from 1.3 to 1.6 billion tonnes of carbon emissions in 2010 are comparable to OTA's "moderate" case and show considerably higher emissions than OTA's "tough" case.

Table 1.3 Average Annual Energy and Carbon Growth Rates, 1997 to 2010, for Four Cases

	Business-As-Usual (BAU)	Efficiency Case	High Efficiency/ Low Carbon Case ($25/tonne)	High Efficiency/ Low Carbon Case ($50/tonne)
Gross Domestic Product (GDP)[a]	1.88%	1.88%	1.88%	1.88%
Energy Demand	1.09%	0.56%	0.34%	0.13%
Carbon Emissions	1.24%	0.65%	0.11%	-0.75%
Energy Consumption Per GDP (E/GDP)	-0.77%	-1.30%	-1.51%	-1.71%
Carbon Emissions Per GDP (C/GDP)[b]	-0.63%	-1.20%	-1.73%	-2.58%

[a] The Gross Domestic Product (GDP) in 1995 was $7251 billion in 1995 dollars. The 1.88% annual growth was assumed to apply to the entire period, 1995-2010 to derive the results above.

[b] The carbon decrease per unit GDP growth for 1990 to 2010 is 0.7%, 1.1%, 1.4% and 1.9% per year for the reference, efficiency, $25/tonne HE/LC, and $50/tonne HE/LC cases, respectively.

Another benchmark is provided by the 1992 National Academy of Sciences (NAS) report on *Policy Implications of Greenhouse Warming* (National Academy of Sciences, 1992). This study identified a set of energy conservation technologies that had either a positive economic return or that had a cost of less than $2.50 per tonne of carbon. Altogether, NAS concluded that these technologies offer the potential to reduce carbon emissions by 463 million tonnes, with more than half of these reductions arising from cost-effective investments in building energy efficiency. Our efficiency and HE/LC cases suggest the potential for reducing carbon emissions by between 120 and 380 million tonnes by the year 2010. One reason that the NAS estimate is higher is because it is not limited to the 2010 time frame, but rather characterizes the full potential for carbon reductions. Thus, it did not take into account the replacement rates for equipment and processes, and other factors that prevent the instantaneous, full market penetration of cost-effective energy-efficient and low-carbon technologies.

1.4.2 R&D's Potential for Further Benefits by 2020

If carbon reductions in 2010 and beyond are to be sustained at reasonable cost, vigorous R&D efforts are needed to fill the pipeline of next-generation energy technologies. It is difficult to estimate the carbon savings that will accrue from these technologies; however, our effort to characterize their features suggests that an aggressive pace of carbon reductions over the next quarter century can be sustained, with a sufficient investment in R&D. Our analysis of R&D potential for the year 2020 focuses on opportunities for improved energy-efficiency and renewable energy technologies. The potential long-term contributions of carbon sequestration, advanced coal technologies, and nuclear power may also be significant. However, the treatment of vigorous R&D initiatives to improve these supply options after 2010 is beyond the scope of this report.

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

influence decisions by individuals and organizations and include taxes and subsidies on production factors (carbon tax, fuel tax) and on products and other outputs (emission taxes, product taxes), financial inducements (tax credits, subsidies), and transferable emission rights (tradable emission reductions, tradable credits).

Interventions at all levels could effectively reduce greenhouse warming. For example, individuals could reduce energy consumption, recycle goods, and reduce consumption of deleterious materials. Local governments could control emissions from buildings, transport fleets, waste processing plants, and landfill dumps. State governments could restructure electric utility pricing structures and stimulate a variety of efficiency incentives. National governments could pursue action in most of the policy areas of relevance. International organizations could coordinate programs in various parts of the world, manage transfers of resources and technologies, and facilitate exchange of monitoring and other relevant data.

The choice of policy instrument depends on the objective to be served. Although this analysis of mitigation options does not include all possibilities, the panel is hopeful that it does identify the most promising options. This analysis provides the beginnings of a structure and a process for identifying those strategies that could appropriately mitigate the prospect of greenhouse warming.

CONCLUSIONS

There is a potential to inexpensively reduce or offset greenhouse gas emissions in the United States. In particular, the maximum feasible potential reduction for the options labeled "net benefit" and "low cost" in Table 6.2 totals about 3.6 billion tons (3.6 Gt) of CO_2-equivalent emissions per year. (Here, as elsewhere in the report, tons are metric.) This is a little more than one-third of the total 1990 greenhouse gas emissions in the United States and represents an optimistic upper bound on what could be achieved using these options.

A lower bound can be estimated from Figure 6.4. Arbitrarily using a cutoff of between $10 and $20 per ton of CO_2-equivalent emission reduction would produce a level of about 1 Gt of CO_2-equivalent emissions per year, or a little more than 10 percent of current greenhouse gas emissions in the United States.

This analysis suggests that the United States could reduce its greenhouse gas emissions by between 10 and 40 percent of the 1990 level at very low cost. Some reductions may even be at a net savings if the proper policies are implemented.

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- Umbrella without Eastern Europe refers to trading among a subset of Annex I countries, excluding participation by the European Union and Eastern European countries.[16]

- Umbrella with Eastern Europe refers to trading among a subset of Annex I countries, excluding participation by the European Union.

In addition, we assessed two forms of developing country participation in conjunction with the industrial country trading blocs.

- Developing countries generate emissions credits through the Clean Development Mechanism and sell them internationally. The CDM is assumed to provide 20% of emissions reductions that a country would otherwise undertake if it agreed to a target at business as usual and participated in international trading.

- Key developing countries are assumed to adopt emissions growth targets equal to their 2010 business as usual emissions level and participate in international emissions trading.

Trading across Time

This analysis assessed the permit price in 2010, the midpoint of the first commitment period. Since SGM is a computable general equilibrium model, all outputs are predicated on the full use of the economy's resources, so the analysis implicitly assumes an averaging out of business cycles, weather induced energy use fluctuations, and other short-term phenomena. This smoothing out is consistent with the effect of the five year averaging period between 2008 and 2012. The permit price estimates for 2010 therefore provide a reasonable representation of the average permit price over 2008-2012.

Banking

This analysis did not incorporate the banking provision in the Kyoto Protocol. To model banking behavior, it is necessary to know the emissions targets for subsequent commitment periods. Since these targets have not been established yet, any assumption about future emissions targets would be speculative.

---

[16] Eastern Europe as defined in the Second Generation Model includes the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Federal Republic of Yugoslavia, Hungary, Macedonia, Malta, Poland, Romania, Slovakia, and Slovenia.

A32

rapid improvements in energy efficiency. Experts at five national laboratories managed by the Department of Energy, using an engineering approach rather than an economic paradigm, found that a third of the emissions reductions necessary to return to 1990 levels by 2010 could be achieved through the adoption of existing energy-efficiency technologies at no net resource cost. This translates into a non-price policy related efficiency contribution of 0.3% per year (Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies 1997). The National Academy of Sciences reached qualitatively similar conclusions in a 1992 report. As reflected in the Department of Energy study, if a higher rate of energy efficiency improvement were achieved, the United States could meet a correspondingly larger fraction of its commitment through domestic reductions potentially at lower permit prices.

Trading Scenarios

Intergas Trading

We assumed that trading occurs across all gases based on 100-year global warming potential values.

Trading Blocs

The Administration assessed three different industrialized country trading blocs.

- Annex I implies trading among all Annex I countries.
- Umbrella without Eastern Europe refers to trading among a subset of Annex I countries, excluding participation by the European Union and Eastern European countries.[17]
- Umbrella with Eastern Europe refers to trading among a subset of Annex I countries, excluding participation by the European Union.

In addition, we assessed two forms of developing country participation in conjunction with the industrial country trading blocs.

---

[17] Eastern Europe as defined in the Second Generation Model includes the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Federal Republic of Yugoslavia, Hungary, Macedonia, Malta, Poland, Romania, Slovakia, and Slovenia.

FIGURE 1-1. Geopolitical divisions used in the study.

TABLE 1-1. Regional Distribution of Countries in the ORAU/IEA Assessment Framework

Region 1 (US): United States
United States

Region 2 (OECD West): Western Europe and Canada
Austria, Belgium, Canada, Denmark, Finland, France, Fed. Rep. of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom

Region 3 (JANZ): OECD Asia
Japan, Australia, New Zealand

Region 4 (EUSSR): Centrally Planned Europe
Albania, Bulgaria, Cuba, Czechoslovakia, East Germany, Hungary, Poland, Rumania, Soviet Union, Yugoslavia

Region 5 (ACENP): Centrally Planned Asia
China, Kampuchea, Laos, Mongolia, North Korea, Vietnam

Region 6 (MIDEST): Middle East
Bahrain, Cyprus, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudia Arabia, Syria, United Arab Emirates, North Yemen, South Yemen

Region 7 (AFR): Africa
Algeria, Angola, Benin, Botswana, Burundi, Cameroon, Central African Empire, Chad, Congo, Egypt, Equitorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Lesotho, Liberia, Libya, Malagasy Rep., Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierre Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Upper Volta, Zaire, Zambia, Zimbabwe-Rhodesia

Region 8 (LA): Latin America—Mexico, Central America, Caribbean, and South America
Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Surinam, Trinidad and Tobago, U.S. Virgin Islands, Uruguay, Venezuela

Region 9 (SEASIA): Non-Communist South, East and Southeast Asia
Afghanistan, Bangladesh, Brunei, Burma, Fiji, Hong Kong, India, Indonesia, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand

recognize varying rates of population, economic growth, and energy resource endowments without getting lost in excessive detail.

Four benchmark years were chosen for this analysis: 1975, 2000, 2025, 2050. The analytical tools for long-term energy assessments differ greatly from those used in short-term analyses.

As with geography, it often proves useful to aggregate energy by mode of delivery. There are four final use or secondary en-

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Identifying market clearing prices for trading blocs

After developing the baselines and cost functions, we calculated the market clearing prices for the trading blocs. Market clearing prices were estimated by constructing functions for the marginal cost of abatement of greenhouse gas emissions in each trading bloc. Given the greenhouse gas emissions reductions required by the Kyoto agreement for the countries within the trading bloc, these functions allow for the identification of marginal cost of abatement, and the unique price for permits traded among the countries comprising the bloc.

Calculating the Effects on Energy Prices

Reducing greenhouse gas emissions, in particular carbon dioxide emissions, would, in effect, modestly raise energy prices. At the same time, these higher prices would also have the effect of reducing energy consumption by a modest amount, as firms and households cut back on some low-value uses of energy. Tradable greenhouse gas permits would also cause some shift in the fuel mix, away from carbon-intensive fuels like coal, and toward carbon-lean and carbon-free fuels, like natural gas, nuclear, and hydropower. Households would hardly notice this fuel mix shift, however, as most of it would occur at power plants.

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Summary of Assumptions of Illustrative Analysis

The following list summarizes the assumptions in the illustrative modeling analysis described in the preceding section on methodology.

- Efficient and effective domestic trading of emissions allowances.
- International trading of emissions allowances (within each of three possible blocs).
  - Efficient and effective Annex I trading.
  - Efficient and effective Umbrella trading.
  - Efficient and effective trading with developing countries that adopt emissions targets.
- Trading across all six categories of greenhouse gases.
- Autonomous energy efficiency improvement (AEEI) value of 0.96% per year.
- No emissions mitigation through carbon sinks for any country.
- No banking of emissions allowances to second or later commitment periods.
- Emissions targets are expressed in terms of all six categories of greenhouse gases.
- Marginal abatement costs for carbon dioxide from SGM outputs.
- Marginal abatement costs for non-carbon dioxide greenhouse gases for U.S.
- Marginal abatement costs for non-carbon dioxide greenhouse gases for other countries assumed to be the same as the costs for carbon dioxide.
- No emission reductions from the Administration's electricity restructuring proposal included in the analysis (see p. 50).
- No emissions reductions from the Climate Change Technology Initiative included in the analysis (see p. 51).
- No emissions reductions from industries' voluntary plans through the Administration's industry-by-industry consultations included in the analysis (see p. 52).
- No estimate of the benefits of addressing risks associated with climate change (see p. 32).

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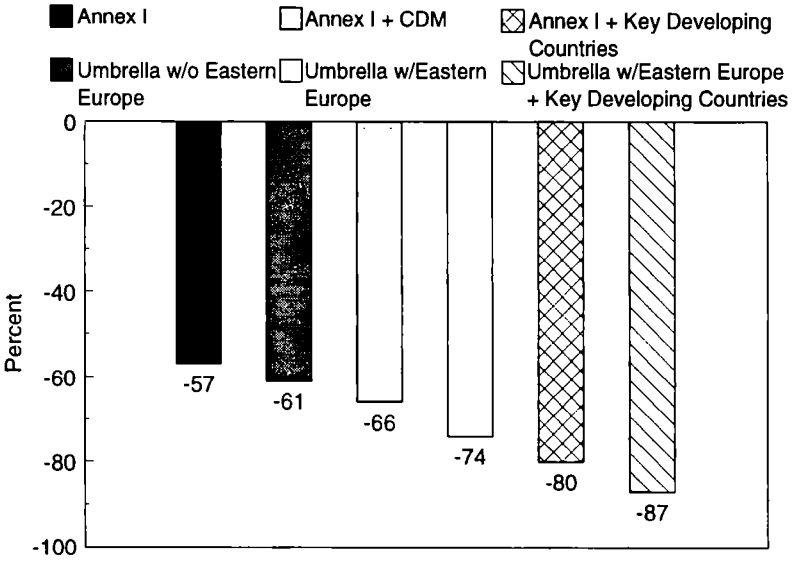
Economic Cost of the Administration's Policies to Reduce Greenhouse Gas Emissions in the Illustrative Analysis

The flexibility measures embodied in the Kyoto Protocol and the Administration's climate change approach could dramatically reduce the costs of complying with the Protocol (see Figure 19 and Table 4.) An effective international market for trading emissions permits among developed countries -- even without taking into account the added benefit of including key developing countries -- would potentially lower the resource cost to the United States of climate change policy by more than half relative to a scenario in which all abatement is performed domestically and would lower the price for emission permits (expressed as carbon equivalent) by nearly three fourths.[17] If the international trading took place only among "umbrella countries" (Annex I except for, in one scenario, the European Union, and, in another scenario, the European Union and Eastern Europe) resource costs could drop by 60-75% as compared to the domestic only cost, while permit prices could drop by 75-85% compared to a "domestic only" approach. Trading among industrialized countries alone could bring costs down into a relatively modest range.

An effective Clean Development Mechanism could lower resource costs by 25% above and beyond the cost-savings associated with various Annex I trading scenarios and could lower permit prices by an additional x%. Finally, if some developing countries adopt growth emissions targets and participate in an effective trading system, the total resource cost to the United States could well fall by 80-86% compared to a domestic only approach, while permit prices could sink by 91-93% compared to a domestic only effort.

Figure 19. Percentage Reductions in Resource Costs Relative to "Domestic Only" Abatement Under Various Trading Scenarios



[17] "Resource cost" refers to the direct cost to the U.S. economy of meeting its Kyoto target measured as the cost of emissions abated domestically plus the cost of purchases of international emissions allowances and emissions credits by U.S. firms. "Permit price" refers to the price paid for a permit to emit one metric ton of carbon equivalent. The permit price can be translated readily into an added increment for U.S. energy prices. See, for example, Table 6.

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Table 4. Permit Prices and Resource Costs Relative to "Domestic Only" Abatement of Various Trading Scenarios

Trading Scenario	Percent Reduction in Permit Price (relative to domestic only)	Percent Reduction in Resource Cost (relative to domestic only)
Annex I	72%	57%
Umbrella (with Eastern Europe)	85%	74%
Umbrella (without Eastern Europe)	75%	61%
Annex I + Key Developing Countries	88%	80%
Umbrella (with Eastern Europe) + Key Developing Countries	93%	87%
Umbrella (without Eastern Europe) + Key Developing Countries	91%	83%
Annex I + CDM	79%	66%
Umbrella (with Eastern Europe) + CDM	88%	80%
Umbrella (without Eastern Europe) + CDM	82%	71%

The Administration supports effective international trading and meaningful participation by key developing countries. An assessment using the SGM model accounts for effective trading and developing country participation yields permit price estimates ranging between $14/ton and $23/ton, and resource costs between $7 billion and $12 billion/year (see Table 5). The range reflects uncertainty about the extent of Annex I participation in international trading.

Table 5. U.S. Permit Prices and Resource Costs Under the Administration's Policies

Trading Scenario	**Permit Price**	**Total Resource Cost**	**Share of 2010 GDP**
Umbrella with Eastern Europe + key developing country participation	$14/ton	$7 billion/year	0.07%
Annex I + key developing country participation	$23/ton	$12 billion/year	0.11%

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The illustrative modeling analysis does not account for several key components of the Kyoto Protocol and the Administration's policies to reduce greenhouse gas emissions. These key issues include the benefits of reducing net emissions through carbon sinks, the Administration's electricity restructuring proposal, the Administration's Climate Change Technology Initiative, and the Administration's sectoral consultations to encourage and support voluntary efforts by U.S. industry to undertake emissions reductions including the provision of credit for early action. Each of these factors has the potential to significantly increase the amount of reductions made domestically, while lowering the level of permit prices. The illustrative model also does not account for ancillary benefits of reducing greenhouse gas emissions, such as improved local air quality. For a discussion of these cost mitigating factors, see page 50

U.S. Energy Prices

Under the assumptions of the Administration's analysis, permit prices in the range of $14/ton to $23/ton translate into energy price increases at the household level between 3 and 5%. As Table 6 illustrates, the price increases for electricity and an array of fuels would be modest, and in several cases, the prices faced by consumers, even under the $23/ton permit price, would be lower in real terms than prices experienced today (see Appendix D for long-term energy price trends). By 2010, the increase in energy cost for the average household expected with permit prices between $14/ton and $23/ton would range between $70 and $110 annually, but this would be roughly offset by cost-savings associated with the Administration's electricity restructuring proposal.

Table 6. U.S. Energy Prices Under Permit Prices of $14/ton to $23/ton

Energy Source	1996 Price	2010 BAU Price	2010, $14/ton	2010, $23/ton
Electricity	6.9¢/Kwh	5.9¢/Kwh	6.1¢/Kwh	6.2¢/Kwh
Gasoline	$1.225/gallon	$1.259/gallon	$1.293/gallon	$1.314/gallon
Fuel Oil	$1.087/gallon	$1.092/gallon	$1.140/gallon	$1.170/gallon
Natural Gas	$4.25/mcf	$3.80/mcf	$4.00/mcf	$4.13/mcf

All data are in 1996 dollars. 1996 and 2010 business as usual (BAU) prices are from Energy Information Administration 1997a.

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U.S. Energy Prices

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All data are in 1996 dollars. 1996 and 2010 business as usual (BAU) prices are from Energy Information Administration 1997a.

	1995	2010: BA	2010: $14	2010: $23	1995 E/G	2010 BAU	2010 $14	2010 $23	E/GDP annual rate	
Energy	95.6	112.9	110.46	108.72	0.014186	0.012292	0.012027	0.011843		
GDP	6739	9185	9184	9180						
									BAU	0.009601
									$14	0.011065
									$23	0.012107

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The average price of electricity is projected to fall between now and 2010 as a result of competition at the wholesale level, expected declines in coal prices, anticipated efficiency improvements, and falling capital expenditures (Energy Information Administration 1997a). Under business as usual, the average price of electricity in 2010 is projected to be 5.9¢ -- 1¢ below the average price in 1995. Permit prices of $14/ton to $23/ton would yield average electricity prices about 3 to 5% above this projected price of 5.9¢ (see Figure 20). In addition, the Administration's electricity restructuring proposal, by spurring competition at the retail level, is expected to cause electricity prices to fall an additional 10% on average. The electricity restructuring proposal with permit prices of $14/ton to $23/ton would yield electricity prices well below the business as usual projection for 2010 (see Figure 21). Refer to Appendix C for a discussion of the potential cost-savings associated with the Administration's electricity restructuring proposal.

Figure 20. Average U.S. Electricity Prices Under $14/ton to $23/ton Permit Prices, Excluding the Cost-Savings Associated with Electricity Restructuring

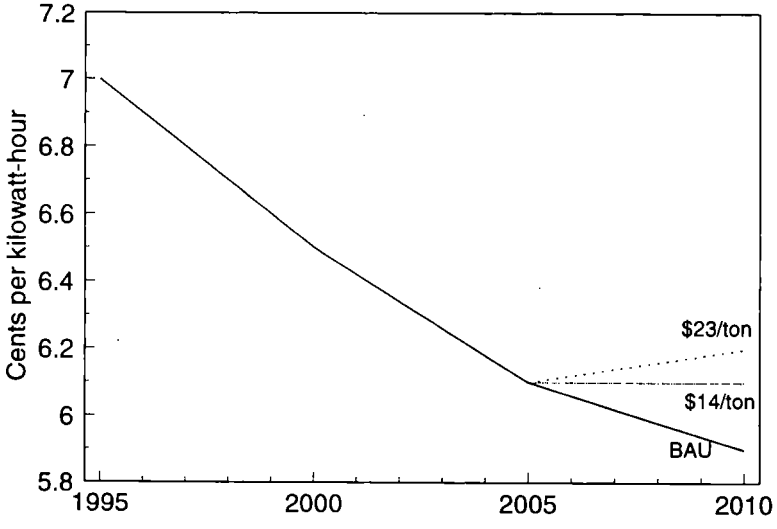
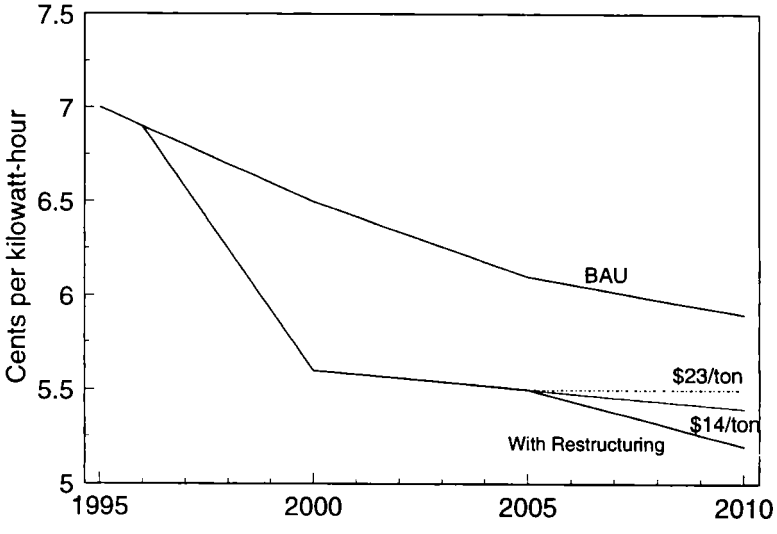


Figure 21. Average U.S. Electricity Prices Under $14/ton to $23/ton Permit Prices, Including the Cost-Savings Associated with Electricity Restructuring



DOE/EIA-0383(98)
Distribution Category UC-950

Annual Energy Outlook 1998

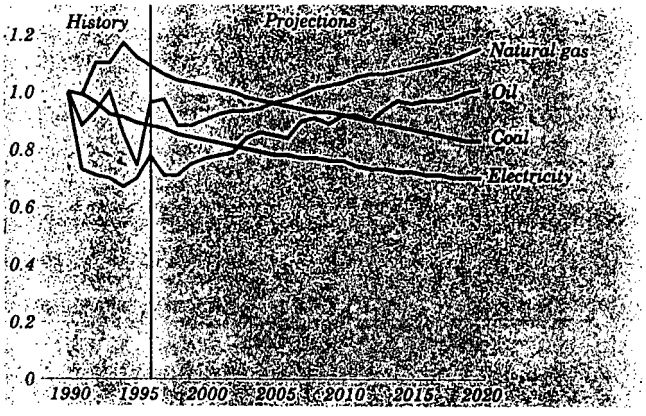
With Projections to 2020

December 1997

Energy Information Administration
Office of Integrated Analysis and Forecasting
U.S. Department of Energy
Washington, DC 20585

Competition, Lower Coal Prices Are Expected To Reduce Electricity Prices

Figure 58. Fuel prices to electricity suppliers and electricity price, 1990-2020 (index, 1990 = 1)



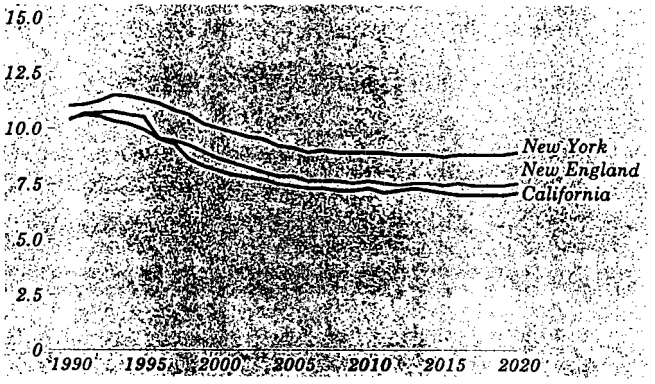
Between 1996 and 2020, the average price of electricity in real 1996 dollars is projected to decline by 1.0 percent a year as a result of competition among electricity suppliers (Figure 58). By sector, projected prices in 2020 are 19, 21, and 24 percent lower than 1996 prices for residential, commercial, and industrial customers.

The cost of producing electricity is a function of fuel costs, operating and maintenance costs, and the cost of capital. For existing plants, fuel costs typically represent $24 million annually or 79 percent of the total operational costs (fuel and operating and maintenance) for a 300-megawatt coal-fired plant and $31 million annually or 93 percent of the total operational costs for a gas-fired combined-cycle plant of the same size in 1996.

Natural gas prices to electricity suppliers rise by 0.7 percent a year in the forecast, from $2.70 per thousand cubic feet in 1996 to $3.22 in 2020. Gas-fired electricity generation increases by 376 percent, from 462 to 1,583 billion kilowatthours. Offsetting these increases are declining coal prices, declining capital expenditures, and improved efficiencies for new plants. Oil prices to utilities are expected to increase by 29 percent. As a result, oil-fired generation is expected to decline by more than 56 percent between 1996 and 2020. However, oil currently accounts for only 2.5 percent of total generation, and that share is expected to decline to 0.8 percent by 2020 as oil-fired steam generators are replaced by gas turbine technologies.

Three Regions Illustrate Projected Effects of Market Competition

Figure 59. Electricity prices in the New England, New York, and California regions, 1990-2020 (1996 cents per kilowatthour)



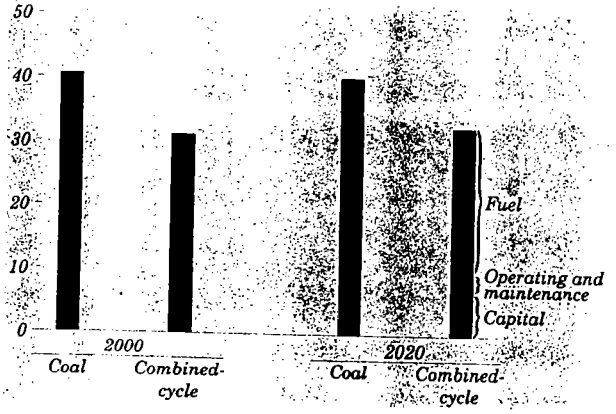
The reference case assumes a transition to competitive pricing in California, New York, and the New England States. It is assumed that electricity prices in California will remain constant at nominal 1996 levels between 1998 and 2001 for commercial and industrial customers, whereas residential customers will see a 10-percent reduction from 1996 prices in 1998; that there will be a transition from regulated to competitive prices between 2002 and 2007; and that the market will be fully competitive by 2008. Similarly, in New York and New England, the transition period is assumed to be from 1998 through 2007, with fully competitive pricing of electricity beginning in 2008.

The transition period reflects the time needed for the establishment of competitive market institutions and recovery of stranded costs as permitted by regulators. The reference case assumes that competitive prices in these regions will be the marginal cost of generation, and the distribution of prices across economic sectors is the same as that for regulated prices.

As a result of the moves toward competition in California, New York, and New England electricity prices in those regions are expected to fall rapidly from 1996 to 2005—by 2 to 3 percent a year (Figure 59). Over the longer term, prices in the three regions are projected to decline at approximately the same rate as the national average—1 percent a year—as electricity prices in all regions approach the cost of building and operating new power plants.

Lower Projected Capital Costs Give Gas Technologies a Competitive Edge

Figure 60. Electricity generation costs, 2005 and 2020 (1996 mills per kilowatthour)



Technology choices for new generating capacity are made to minimize cost while meeting local and Federal emissions constraints. The choice of technology for capacity additions is based on levelized costs (Figure 60). The reference case assumes a capital recovery period of 20 years. In addition, the cost of capital is increased by 1 percentage point, to account for the competitive risk of siting new units.

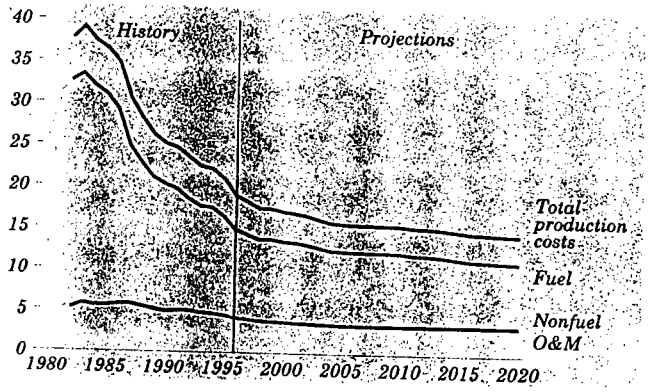
AEO98 forecasts, capital costs of conventional technologies are assumed to decline by 2.5 percent for each doubling of new capacity. For advanced technologies, after an initial upward adjustment to account for technological optimism, capital costs decline by 10 percent for each doubling of capacity for the first 5 units, 5 percent for the 6th through 40th units, and 2.5 percent after 40 units. Heat rates for both advanced and conventional fossil-fired technologies decline annually from 1995 until 2010. In 2020, levelized costs for gas-fired combined-cycle capacity are 19.2 percent lower than those for coal (Table 7).

Table 7. Costs of producing electricity from new plants, 2005 and 2020

Item	2005		2020	
	Conventional pulverized coal	Advanced combined cycle	Conventional pulverized coal	Advanced combined cycle
	1996 mills per kilowatthour			
Capital	26.6	7.5	27.1	7.2
O&M	6.9	2.8	6.9	2.8
Fuel	6.9	20.7	6.1	22.5
Total	40.3	31.0	40.1	32.4
	Btu per kilowatthour			
	9,386	6,812	9,087	6,350

Projected Electricity Production Costs Continue To Decline

Figure 61. Production costs for coal- and gas-fired generating plants, 1982-2020 (1996 mills per kilowatthour)

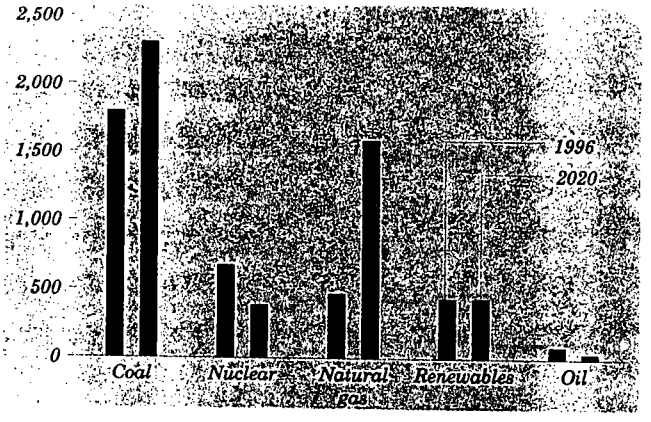


Since 1982, nonfuel operating and maintenance expenses for coal- and gas-fired steam generating plants have declined by 1.8 percent annually in real terms (Figure 61). These expenses include operation and maintenance of the boiler and electric plant, supervisory and engineering expenses, steam production expenses, and rents. The decline is the result of more energy-efficient plant components, more exacting engineering methods, demand growth, and reductions in staff. In addition, fuel expenses for these plants have declined by 5.5 percent a year, mirroring the falling prices of natural gas and coal during the period. As a result, total production expenses for coal- and gas-fired steam plants have declined by 5.1 percent annually since 1982.

The same trend is expected to continue but at a slower pace than the decline seen over the past decade. In 1982, coal-fired steam plants used 250 employees per gigawatt of installed capacity, and utilities were able to reduce that number to 200 by 1995. Gas-fired steam plants employed more than 138 staff per gigawatt in 1982 and fewer than 100 in 1995. Much of the incentive to cut staff and reduce operating costs came from the anticipation of competitive electricity markets. The amount by which utilities can continue to cut costs is uncertain, but many analysts agree that further reductions are possible, if not inevitable, in a competitive environment. Between 1996 and 2020, operating and maintenance costs for coal- and gas-fired steam generating plants are expected to decline by 0.8 percent a year and fuel costs by 1.2 percent a year.

Coal Continues as the Leading Electricity Fuel in the Projections

Figure 62. Electricity generation by fuel, 1996-2020 (billion kilowatthours)



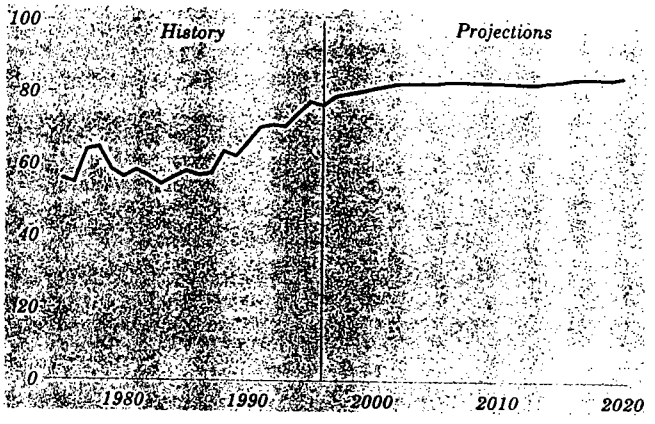
As they have since early in this century, coal-fired power plants are expected to remain the dominant source of electricity through 2020 (Figure 62). In 1996, coal accounted for 1,797 billion kilowatthours or 52 percent of total generation. Although coal-fired generation is projected to increase to 2,304 billion kilowatthours, increases in natural gas generation will lower coal's share to 49 percent in 2020. Concerns about the environmental impacts of coal plants, combined with their relatively long construction leadtimes and the availability of economical natural gas, make it unlikely that many new coal plants will be built before 2000. Nevertheless, slow demand growth and the huge investment in existing plants will keep coal in its dominant position.

The large investment in existing plants will also make nuclear power a growing source of electricity at least through 2000. In recent years, the performance of nuclear power plants has improved substantially. As a result, nuclear generation is projected to increase until 2000, then decline as older units are retired.

In percentage terms, generation from gas-fired power plants shows the largest increase in the forecast, growing from 14 percent of generation in 1996 to 33 percent in 2020. As a result, by 2003, gas-fired generation overtakes nuclear power as the Nation's second-largest source of electricity. Generation from oil-fired plants remains fairly small throughout the forecast.

Nuclear Power Plant Capacity Factor of 85 Percent Is Projected by 2020

Figure 63. Nuclear power plant capacity factors, 1975-2020 (percent)



The *AEO98* reference case forecast assumes that 24 nuclear units will be retired before their license expiration dates, based on utility announcements and an analysis of the operating costs and aging degradation of the oldest vintage of plants. The remaining nuclear units are assumed to operate to the end of their current 40-year license terms, with 65 units (51 percent of current nuclear capacity) retiring between 1996 and 2020. Sixty percent of the projected retirements occur in the last 10 years of the forecast. (One new unit, Watts Bar 1, became operable in 1996.) Given these assumptions, 45 nuclear units are projected to provide 8 percent of total electricity generation in 2020, down from 19 percent in 1996. No new nuclear units are expected to become operable by 2020, because natural gas and coal-fired plants are projected to be more economical.

Nuclear generation forecasts depend on both operating capacity and assumed capacity factors. The national average capacity factor, which was below 65 percent in the 1970s and 1980s, has surpassed 70 percent since 1991 (Figure 63), achieving 76 percent in 1996. *AEO98* assumes that individual reactor performance improves for the first 20 or 25 years of operation, maintains this level for several years, then declines slightly just before retirement. As a result, the national average capacity factor increases fairly steadily throughout the forecast, reaching 85 percent in 2020.

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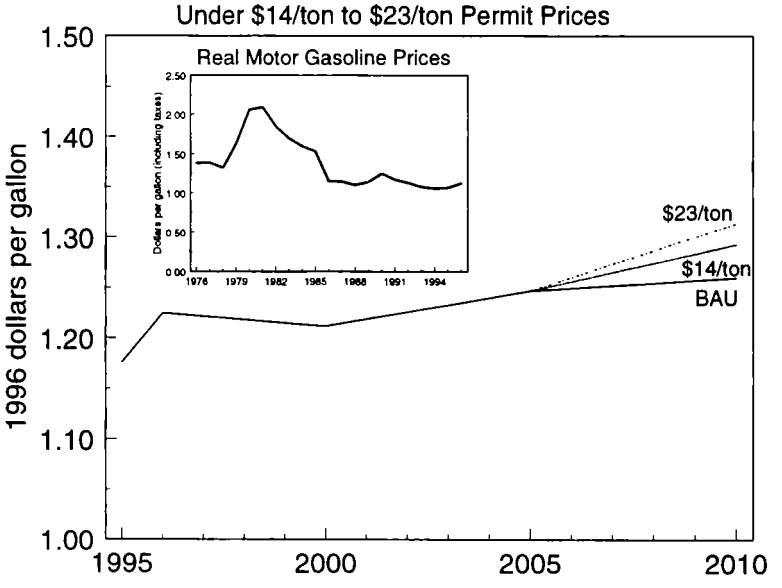
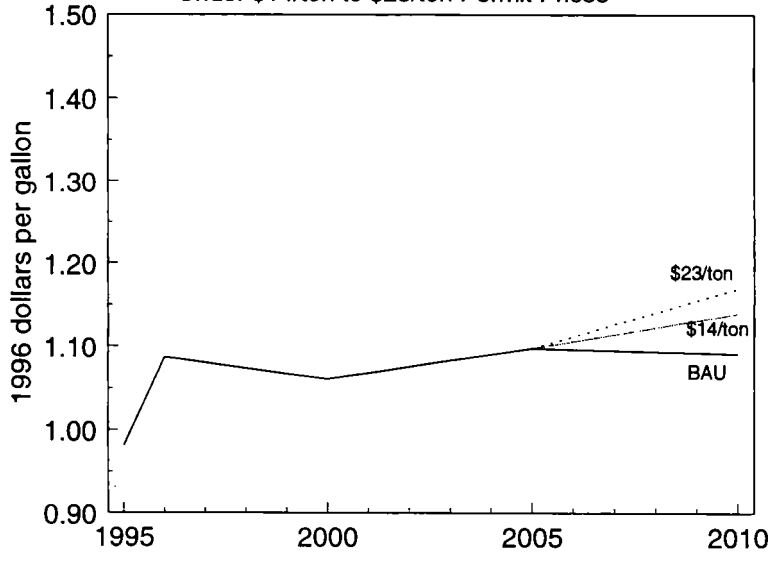
Permit prices of $14/ton to $23/ton also would be expected to increase gasoline prices by 3 to 4%, or 4 to 6¢ per gallon, relative to BAU projections for 2010 (See Figure 22). This increase, which would occur over the next decade, is smaller than the increase in gasoline prices over 1995-1996. Further, this change in gasoline price is small compared to historical changes in gas prices (see inserted figure). Over the past two decades, the average annual absolute change in the price of gasoline was 7.5%, about double the projected increase in gasoline prices under the assumptions set out here.

Figure 22. Average U.S. Gasoline Prices
Under $14/ton to $23/ton Permit Prices



Permit prices of $14/ton to $23/ton could increase fuel oil prices by 5 to 8¢/gallon above their projected price in 2010 (see Figure 23). However, as in the case of gasoline, this increase is smaller, for example, than the jump in fuel oil prices experienced over 1995-1996.

Figure 23. Average U.S. Fuel Oil Prices
Under $14/ton to $23/ton Permit Prices



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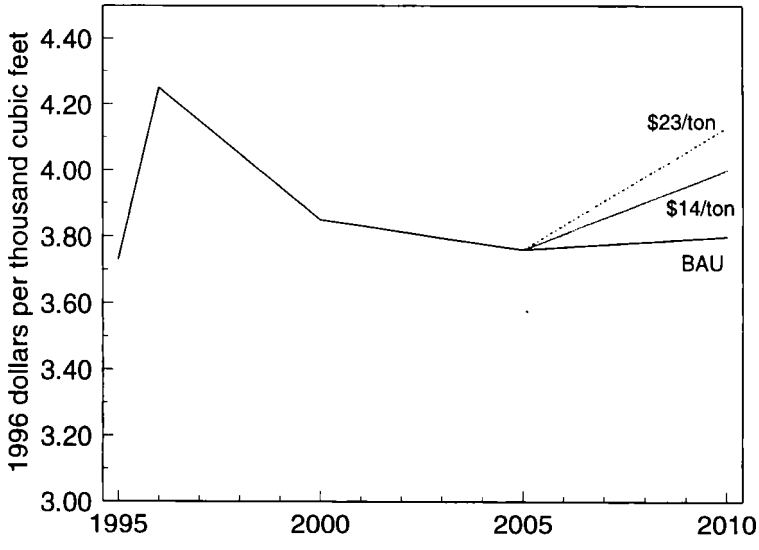
Between now and 2010, delivered natural gas prices are projected to fall because of anticipated efficiency improvements and an increasingly competitive market (Energy Information Administration 1997a). While greenhouse gas permit prices of $14/ton to $23/ton would likely result in modest increases in the price of natural gas relative to baseline projections, 2010 gas prices would still be below current prices (see Figure 24). Further, the price increases under these permit prices would be smaller than the price increase over 1995-1996.

Figure 24. Average U.S. Natural Gas Prices Under $14/ton to $23/ton Permit Prices



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U.S. GDP, Investment, and Consumption

The Second Generation Model projects economic growth for the United States in its business as usual scenario through 2010 shown by the difference between the first two bars in Figure 25. Implementing climate policy through effective international trading in conjunction with meaningful developing country participation would have a negligible effect on economic output. A $14/ton permit price would result in a $1 billion (0.01 %) decline in GDP relative to business as usual. Under a $23/ton permit price, GDP would be $5 billion less in 2010 than it is projected to be otherwise.[18]

Figure 25. U.S. GDP Under $14/ton to $23/ton Permit Prices

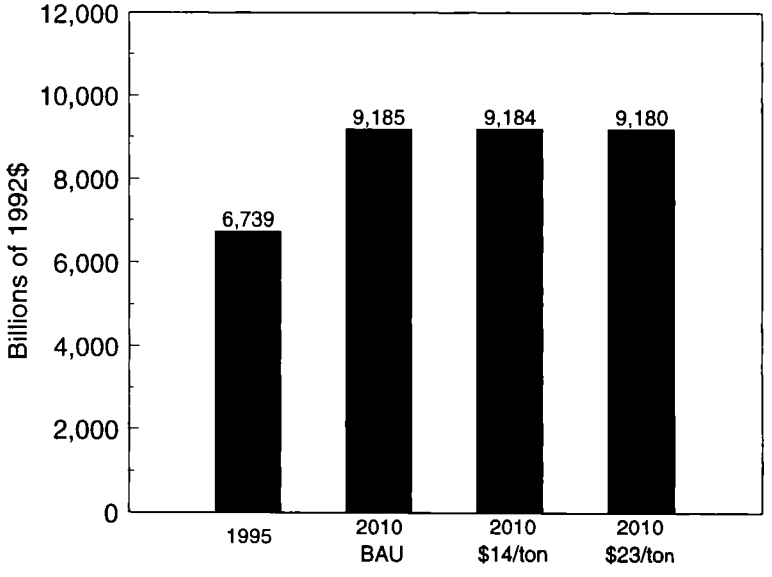
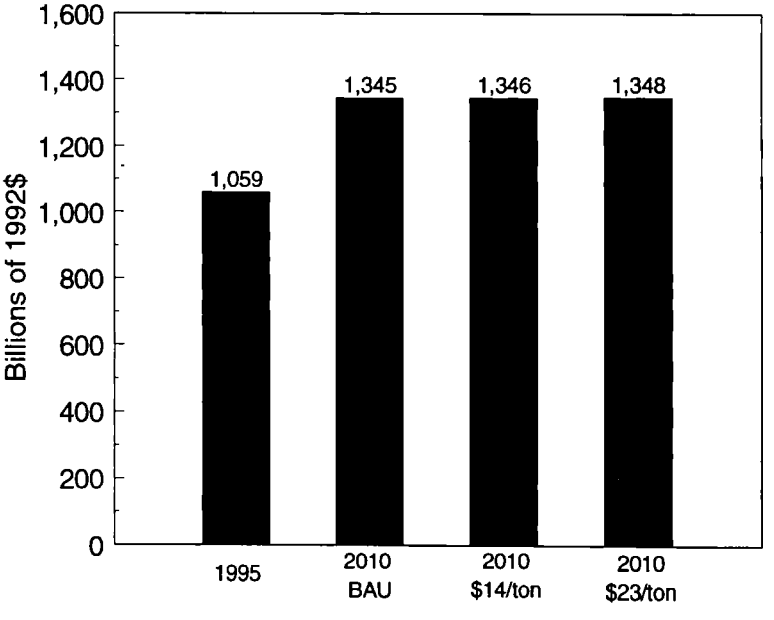


Figure 26. U.S. Investment Under $14/ton to $23/ton Permit Prices



Permit prices of $14/ton to $23/ton imply a small increase in investment relative to business as usual (see Figure 26). Under a $14/ton scenario, investment would increase by $1 billion while a $23/ton permit price scenario entails a $3 billion increase in investment in 2010 relative to business as usual. This increase in investment reflects the adoption of energy efficient and carbon-lean technologies stimulated by the price of greenhouse gas permits.

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[18] Note that the SGM GDP estimate does not reflect the effects of reducing non-carbon dioxide greenhouse gas emissions.

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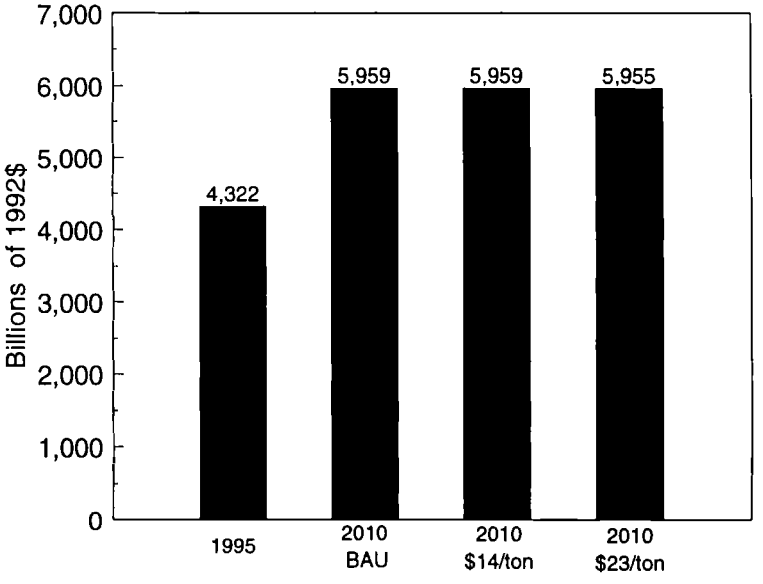
Permit prices of $14/ton to $23/ton would cause a slight shift from consumption to investment; however, this shift would be small. Under the $14/ton permit price scenario, the change in consumption would be insignificant relative to the business as usual baseline (see Figure 27). Under the $23/ton scenario, the shift would amount to a decline of about $4 billion in 2010.

Figure 27. U.S. Consumption Under $14/ton to $23/ton Permit Prices



Employment

The Second Generation Model is conditioned on the assumption that aggregate employment effects are negligible. Given the small projected energy price increases anticipated and the long lead time before any impact would occur, this assumption is appropriate. Although there may be job gains in some sectors and job losses in others, the analysis of the Kyoto Protocol with effective international trading and developing country participation suggests that there will not be any significant aggregate employment effect under permit prices of $14/ton to $23/ton. Some employment reduction could occur in energy-intensive sectors, although given the very small predicted change in energy prices, impacts in most such sectors are apt to be minimal. Furthermore, new jobs will be created in other sectors -- such as in environmental protection technologies, energy production, and energy efficient technologies. Many of these are high-tech jobs that pay high wages.

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Additional Cost Mitigating Factors

Potential Benefits of Carbon Sinks

Various forestry activities sequester carbon dioxide and thereby offset some emissions associated with industrial activity. Trees, other vegetation, and organic matter in soils take up carbon dioxide through photosynthesis and transform the carbon dioxide and store it in vegetative tissue. These carbon sinks can serve as opportunities to mitigate the emissions of carbon dioxide from fossil fuel combustion. For example, the Climate Action Report (1997) reported that gross anthropogenic greenhouse gas emissions in the United States in 1990 were 1,583 MMTCE. However, by including certain carbon sinks,[19] *net* greenhouse gas emissions totaled 1,458 MMTCE, or 8% lower.

The Kyoto Protocol includes opportunities to reduce net emissions through carbon sinks. Certain forestry activities -- afforestation and reforestation net of deforestation -- will be used by countries with emissions targets to meet their commitments (Kyoto Protocol, Article 3.3). The Kyoto agreement does not include carbon sinks in calculating the emissions target, but does allow for countries to achieve their targets by accounting for sequestration by these forestry activities that occur between 1990 and 2012. For countries such as the United States, where acres of tree-planting exceed acres of tree-cutting annually, this provision illustrates another opportunity where the United States can reduce net emissions at low cost. In addition, the Protocol provides the option to include additional categories of carbon sinks, like agricultural soils and other land-use change and forestry activities, based on additional technical work and negotiations (Kyoto Protocol, Article 3.4). With these carbon sinks, the United States could more easily meet its target even without additional policies to specifically encourage sink activity. However, given the ongoing negotiations to develop rules regarding carbon sinks, the Administration employed the very conservative assumption that business as usual sink activity generates no net sequestration.

Complementing the opportunities to reduce net emissions domestically through existing forestry activities, several economic analyses indicate that policies could stimulate the creation of additional carbon sinks at low costs. Stavins (1996) derived a marginal cost curve for carbon sequestration for the United States based on his analysis of land use decisions between 1935 and 1984 for a set of counties in Mississippi, Arkansas, and Louisiana. He found that more than 150 MMTCE could be sequestered at $25/ton. Adams et al. (1993) assessed several different scenarios of tree planting on agricultural land and found that about 250 MMTCE could be sequestered at

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[19] Note that carbon sinks, as defined in the Climate Action Report, are different from the set of forestry activities included in the sinks definition in Article 3.3 of the Kyoto Protocol. While the estimate of sequestration from the Climate Action Report indicates that the United States has been a net sink of carbon, it should not be construed to represent the U.S. carbon sink potential under the Kyoto Protocol.

Climate Change 1995

Impacts, Adaptations and Mitigation of Climate Change:

Scientific-Technical Analyses

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

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EXECUTIVE SUMMARY

Three categories of promising forestry practices that promote sustainable management of forests and at the same time conserve and sequester carbon (C) are considered in this chapter: (1) management for conservation of existing C pools in forests by slowing deforestation, changing harvesting regimes, and protecting forests from other anthropogenic disturbances; (2) management for expanding C storage by increasing the area and/or C density in native forests, plantations, and agroforestry and/or in wood products; and (3) management for substitution by increasing the transfer of forest biomass C into products such as biofuels and long-lived wood products that can be used instead of fossil-fuel based products. Since the 1992 assessment, significant new information has been developed that improves estimates of the quantities of C that can be conserved or sequestered—and the associated implementation costs of forest sector mitigation strategies—and better identifies limits to the amount of lands available for such mitigation strategies.

- The most effective long-term (>50 years) ways in which to use forests to mitigate the increase in atmospheric CO_2 are to substitute fuelwood for fossil fuels and for energy-expensive materials. However, over the next 50 years or so, substantial opportunities exist to conserve and increase the C store in living trees and wood products (High Confidence).
- Under baseline conditions (today's climate and no change in the estimated available lands over the period of interest), the cumulative amount of C that could potentially be conserved and sequestered over the period 1995–2050 by slowing deforestation (138 Mha) and promoting natural forest regeneration (217 Mha) in the tropics, combined with the implementation of a global forestation program (345 Mha of plantations and agroforestry), would be about 60 to 87 Gt—equivalent to 12–15% of the projected (IPCC 1992a scenario) cumulative fossil fuel C emissions over the same period (Medium Confidence).
- The annual C gain from the above program would reach about 2.2 Gt/yr by 2050, or about four times the value of 0.5 Gt C/yr estimated in the 1992 assessment. The gradual increase over time occurs because of the time it takes for programs to be implemented and the relatively slow rate at which C accumulates in forest systems (Medium Confidence).
- Uncertainty associated with the C conservation and sequestration estimates is caused mainly by high uncertainty in estimating land availability for forestation and regeneration programs and the rate at which tropical deforestation can actually be reduced; estimates of the net amount of C per unit area conserved or sequestered under a particular management scheme are more certain (High Confidence).
- The tropics have the potential to conserve and sequester the largest quantity of C—45–72 Gt—more than half of which would be due to promoting natural forest regeneration and slowing deforestation. Tropical America has the largest potential for C conservation and sequestration (46% of the tropical total), followed by tropical Asia (34%) and tropical Africa (20%). The temperate and boreal zones could sequester about 13 Gt and 2.4 Gt, respectively—mainly in the United States, temperate Asia, the former Soviet Union (FSU), China, and New Zealand (Medium Confidence).
- The cumulative cost—excluding land costs and other transaction costs—to conserve and sequester the above amounts of C range from US$247 billion to $302 billion at a unit cost of about $2–8/t C. These unit costs are considerably lower than those in the 1992 assessment, which ranged from $8/t C in tropical latitudes to $28 in non-U.S. Organisation for Economic Cooperation and Development (OECD) countries. Transaction costs may significantly increase these estimated costs (Low Confidence).
- Costs per unit of C sequestered or conserved generally increase from low- to high-latitude nations (High Confidence) and from slowing deforestation and promoting regeneration to establishing plantations (Low Confidence). The latter trend may not hold if transaction costs of slowing deforestation are excessive.
- These cost estimates, although benefitting from improved data and methodology since the first assessment, generally represent only the cost of direct forest practices. These costs could be several times higher if land and opportunity costs and/or the costs of establishing infrastructure, protective fencing, training programs, and tree nurseries were included; on the other hand, costs could be offset by revenues from timber and non-timber products. No complete cost estimates are available (Medium Confidence).
- Under conditions of climate and land-use change as projected by the IMAGE 2.0 model ("conventional wisdom" scenario, akin to the IPCC 1992a scenario), the carbon conservation and sequestration potential may be somewhat less than estimated under baseline conditions because less land may be available in the tropics, unless land was secured for mitigation measures or sustainable agriculture/agroforestry systems were widely adopted, and sequestration by new forests in temperate and boreal regions may be offset by transient decline and the loss of carbon from existing forests in response to climate change (Medium Confidence).

EXECUTIVE SUMMARY

Agriculture accounts for one-fifth of the annual increase in anthropogenic greenhouse warming. Most of this is due to methane (CH_4) and nitrous oxide (N_2O); agriculture produces about 50 and 70%, respectively, of their anthropogenic emissions. This chapter on mitigation options confirms earlier IPCC estimates and quantifies potential contributions by agriculture to reduce greenhouse gas emissions.

Between 400 and 800 Mt C/yr could be sequestered worldwide in agricultural soils by implementation of appropriate management practices to increase productivity—including increased input of crop residues, reduced tillage, and restoration of wasteland soils. However, soil carbon (C) sequestration has a finite capacity over a period of 50–100 years, as new equilibrium levels of soil organic matter are established.

Biofuel production on 10–15% of the land area currently in agricultural use or in agricultural set-asides could substitute for 300–1,300 Mt of fossil fuel C per year. Recovery and conversion of crop residues could substitute for an additional 200 Mt fossil fuel C per year. However, the possible offsets by increased N_2O emissions need to be considered.

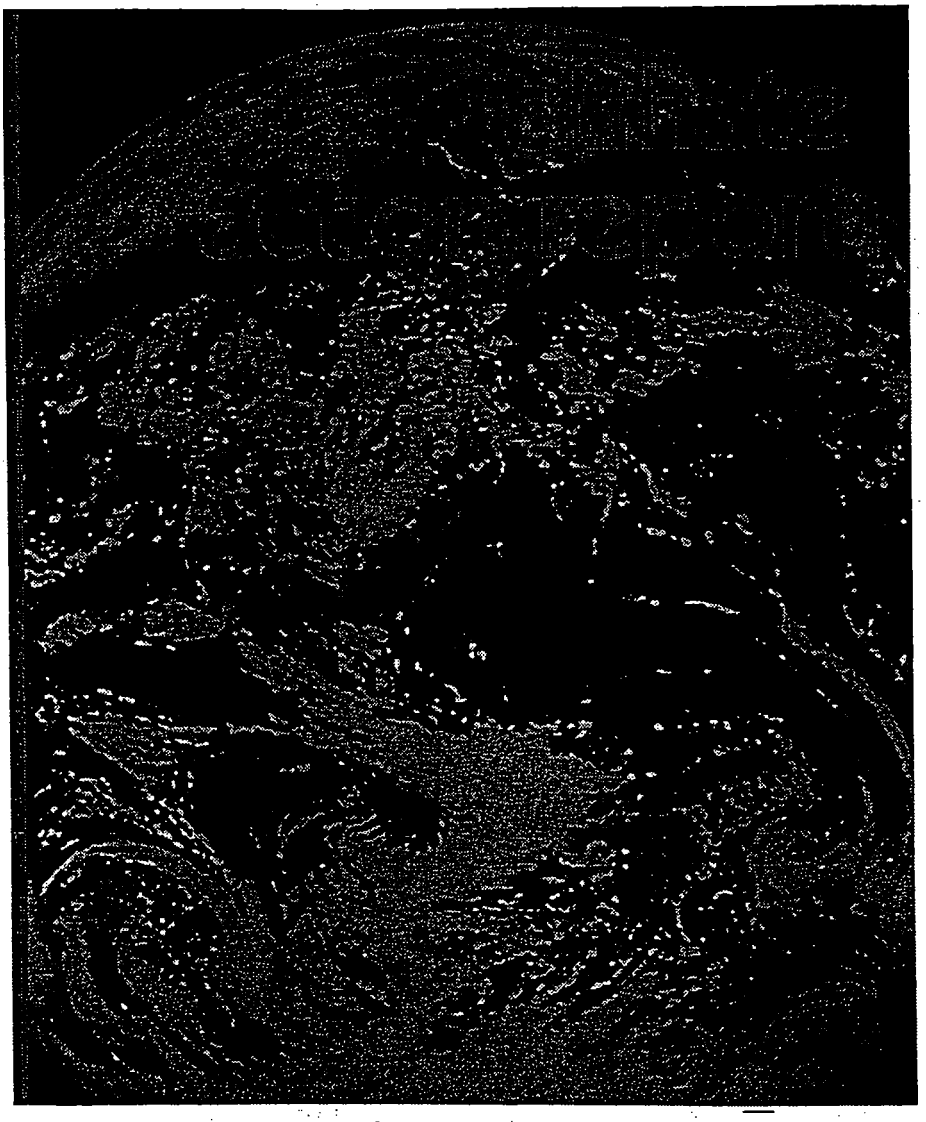
Energy use by agriculture relative to farm production has decreased greatly since the 1970s. Fossil fuel use by agriculture in industrialized countries, although constituting only 3–4% of overall consumption, can be further reduced by, for example, minimum tillage, irrigation scheduling, solar drying of crops, and improved fertilizer management.

Significant decreases in CH_4 emissions from agriculture can be achieved through improved nutrition of ruminant animals and better management of paddy rice fields. Additional CH_4 decreases are possible by altered treatment and management of animal wastes and by reduction of biomass burning. These combined practices could reduce CH_4 emissions from agriculture by 15–56%.

The primary sources of N_2O are mineral fertilizers, legume cropping, and animal waste. Some N_2O also is emitted from biomass burning. N_2O emissions from agriculture could be reduced by 9–26% by improving agricultural management with available techniques.

Ranges in estimates of potential mitigation reflect uncertainty in the effectiveness of recommended management options and in the degree of future implementation globally. Comprehensive model-based analyses and improved global databases on soils, land use, and trace gas fluxes are needed to reduce the uncertainty in these estimates.

Farmers will not voluntarily adopt greenhouse gas (GHG) mitigation techniques unless they improve profitability. Some techniques, such as no-till agriculture or strategic fertilizer placement and timing, already are being adopted for reasons other than concern for climate change. Proposed options for reducing GHG emissions are consistent with maintaining or increasing agricultural productivity.



1997 Submission of the United States of America Under the United Nations Framework Convention on Climate Change

Projected Greenhouse Gas Emissions: 1990–2020

Emissions of greenhouse gases are projected to rise at a decreasing rate between now and the year 2020 (Table 4–2 and Figure 4–3). Between 1990 and 2000, emissions increase by 12 percent; between 2000 and 2010, they increase by an additional 11 percent; and between 2010 and 2020, they increase by another 9 percent. The growth of overall greenhouse gas emissions is due to the continued but slowing growth in projected baseline emissions.

Among all gases, net carbon emissions increase the most in absolute terms, while emissions from halogenated gases increase the most in percentage terms. Net carbon emissions are projected to increase by 195 MMTCE between 1990 and 2000, by 137 MMTCE between 2000 and 2010, and 117 MMTCE between 2010 and 2020. The largest percentage increase in net carbon emissions, 16 percent, occurs between 1990 and 2000. (Net carbon emission is equal to gross domestic energy-related carbon emissions, minus international bunker fuel, plus Adjustments to U.S. Energy, plus emissions from Other Sources, minus sequestered carbon.)

Although the projected absolute increase in carbon-equivalent emissions for halogenated gases is relatively small compared to net carbon emissions, halogenated gases increase by 73 percent between 1990 and 2000, by 115 percent between 2000 and 2010, and by 46 percent between 2010 and 2020. The largest absolute increase for these gases was 49 MMTCE, which is projected to occur between 2000 and 2010.

Table 4-2

Historical and Projected 1997 CAR Greenhouse Gas Emissions (MMTCE)

Greenhouse Gas	Historical Emissions		Projected Emissions		
	1990	1995	2000	2010	2020
Net CO_2	**1,228**	**1,305**	**1,423**	**1,560**	**1,677**
Energy	1,327	1,391	1,504	1,634	1,737
Adjustments and Other Sources	26	31	31	35	34
Carbon Sequestration	-125	-117	-112	-109	-95
Methane	**170**	**177**	**150**	**152**	**154**
N_2O	**36**	**40**	**31**	**34**	**34**
HFCs, PFCs and SF_6	**24**	**37**	**42**	**91**	**133**
Total	**1,458**	**1,559**	**1,646**	**1,837**	**1,998**
Difference from 1990		**101**	**188**	**378**	**540**

Note: Projections assume timely receipt of legislative authority for parking cash-out. Program funding is based on funding proportional to current funding with respect to 1993 CCAP funding levels. Columns may not sum due to independent rounding.

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CONFERENCE OF THE PARTIES

Third session

Kyoto, 1-10 December 1997

Agenda item 5

KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Protocol,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

In pursuit of the ultimate objective of the Convention as stated in its Article 2,

Recalling the provisions of the Convention,

Being guided by Article 3 of the Convention,

Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the

Conference of the Parties to the Convention at its first session,

technologies;

(v) Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and apply market instruments;

(vi) Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol;

(vii) Measures to limit and/or reduce emissions of greenhouse gases not controlled by the Montreal Protocol in the transport sector;

(viii) Limitation and/or reduction of methane through recovery and use in waste management, as well as in the production, transport and distribution of energy;

(b) Cooperate with other such Parties to enhance the individual and combined effectiveness of their policies and measures adopted under this Article, pursuant to Article 4, paragraph 2(e)(i), of the Convention. To this end, these Parties shall take steps to share their experience and exchange information on such policies and measures, including developing ways of improving their comparability, transparency and effectiveness. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, consider ways to facilitate such cooperation, taking into account all relevant information.

2. The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively.

3. The Parties included in Annex I shall strive to implement policies and measures under this Article in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties and in particular those identified in Article 4, paragraphs 8 and 9 of the Convention, taking into account Article 3 of the Convention. The Conference of the Parties serving as the meeting of the Parties to this Protocol may take further action, as appropriate, to promote the implementation of the provisions of this paragraph.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol, if it decides that it would be beneficial to coordinate any of the policies and measures in

paragraph 1(a) above, taking into account different national circumstances and potential effects, shall consider ways and means to elaborate the coordination of such policies and measures.

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

2. Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.

3. The net changes in greenhouse gas emissions from sources and removals by sinks resulting from direct human-induced land use change and forestry activities, limited to afforestation, reforestation, and deforestation since 1990, measured as verifiable changes in stocks in each commitment period shall be used to meet the commitments in this Article of each Party included in Annex I. The greenhouse gas emissions from sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.

4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide for consideration by the Subsidiary Body for Scientific and Technological Advice data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how and which additional human-induced activities related to changes in greenhouse gas emissions and removals in the agricultural soil and land use change and forestry categories, shall be added to, or subtracted from, the assigned amount for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

5. The Parties included in Annex I undergoing the process of transition to a market economy whose base year or period was established pursuant to decision 9/CP.2 of the Conference of the Parties at its second session, shall use that base year or period for the implementation of their commitments under this Article. Any other Party included in

Annex I undergoing the process of transition to a market economy which has not yet submitted its first national communication under Article 12 of the Convention may also notify the Conference of the Parties serving as the meeting of the Parties to this Protocol that it intends to use a historical base year or period other than 1990 for the implementation of its commitments under this Article. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall decide on the acceptance of such notification.

6. Taking into account Article 4, paragraph 6, of the Convention, in the implementation of their commitments under this Protocol other than those in this Article, a certain degree of

flexibility shall be allowed by the Conference of the Parties serving as the meeting of the Parties to this Protocol to the Parties included in Annex I undergoing the process of transition to a market economy.

7. In the first quantified emission limitation and reduction commitment period, from

2008 to 2012, the assigned amount for each Party included in Annex I shall be equal to the percentage inscribed for it in Annex B of its aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A in 1990, or the base year or period determined in accordance with paragraph 5 above, multiplied by five. Those Parties included in Annex I for whom land use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include in their 1990

emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions minus removals in 1990 from land use change for the purposes of calculating their assigned amount.

8. Any Party included in Annex I may use 1995 as its base year for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, for the purposes of the calculation referred to in paragraph 7 above.

9. Commitments for subsequent periods for Parties included in Annex I shall be established in amendments to Annex B to this Protocol, which shall be adopted in accordance with the provisions of Article 20, paragraph 7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall initiate the consideration of such commitments at least seven years before the end of the first commitment period mentioned in paragraph 7 above.

10. Any emission reduction units, or any part of an assigned amount, which a Party acquires from another Party in accordance with the provisions of Article 6 and of Article 16 bis shall be added to the assigned amount for that Party.

11. Any emission reduction units, or any part of an assigned amount, which a Party transfers to another Party in accordance with the provisions of Article 6 and of Article 16 bis shall be subtracted from the assigned amount for that Party.

12. Any certified emission reductions which a Party acquires from another Party in accordance with the provisions of Article 12 shall be added to the assigned amount for that Party.

13. If the emissions of a Party included in Annex I during a commitment period are less than its assigned amount under this Article, this difference shall, on request of that Party, be added to the assigned amount for that Party for subsequent commitment periods.

14. Each Party included in Annex I shall strive to implement the commitments mentioned in paragraph 1 above in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention. In line with relevant decisions of the Conference of the Parties on the implementation of those paragraphs, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, consider what actions are necessary to minimize the adverse effects of climate change and/or the impacts of response measures on Parties referred to in those paragraphs. Among the issues to be considered shall be the establishment of funding, insurance and transfer of technology.

Article 4

1. Any Parties included in Annex I that have agreed to jointly fulfil their commitments under Article 3 shall be deemed to have met those commitments provided that their total combined aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of Article 3. The respective emission level allocated to each of the Parties to the agreement shall be set out in that agreement.

2. The Parties to any such agreement shall notify the secretariat of the terms of the

agreement on the date of deposit of their instruments of ratification, acceptance, approval or accession. The secretariat shall in turn inform the Parties and signatories to the Convention of the terms of the

THE COSTS OF CARBON SEQUESTRATION: A REVEALED-PREFERENCE APPROACH

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and
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April 2, 1996

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FIGURE 4:
ALTERNATIVE ESTIMATES OF MARGINAL COST OF U.S. CARBON SEQUESTRATION

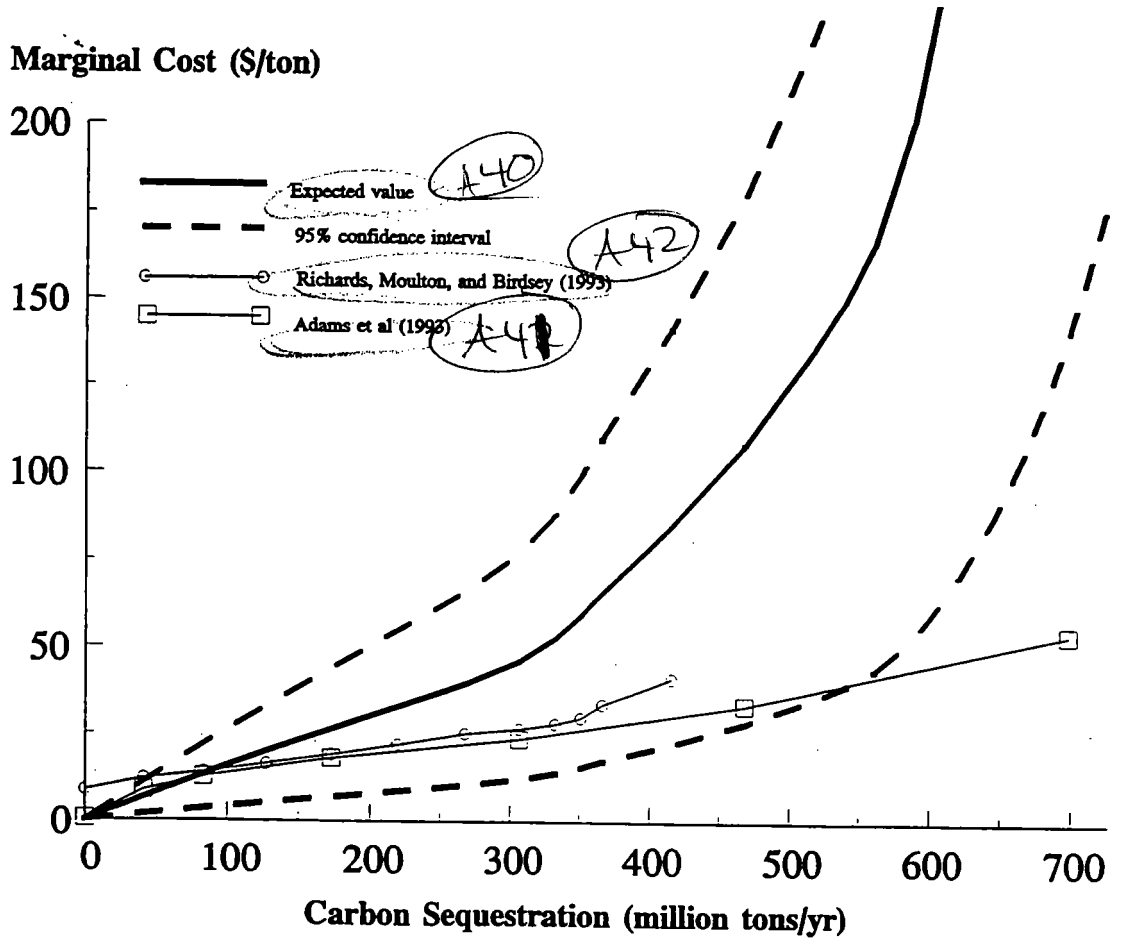
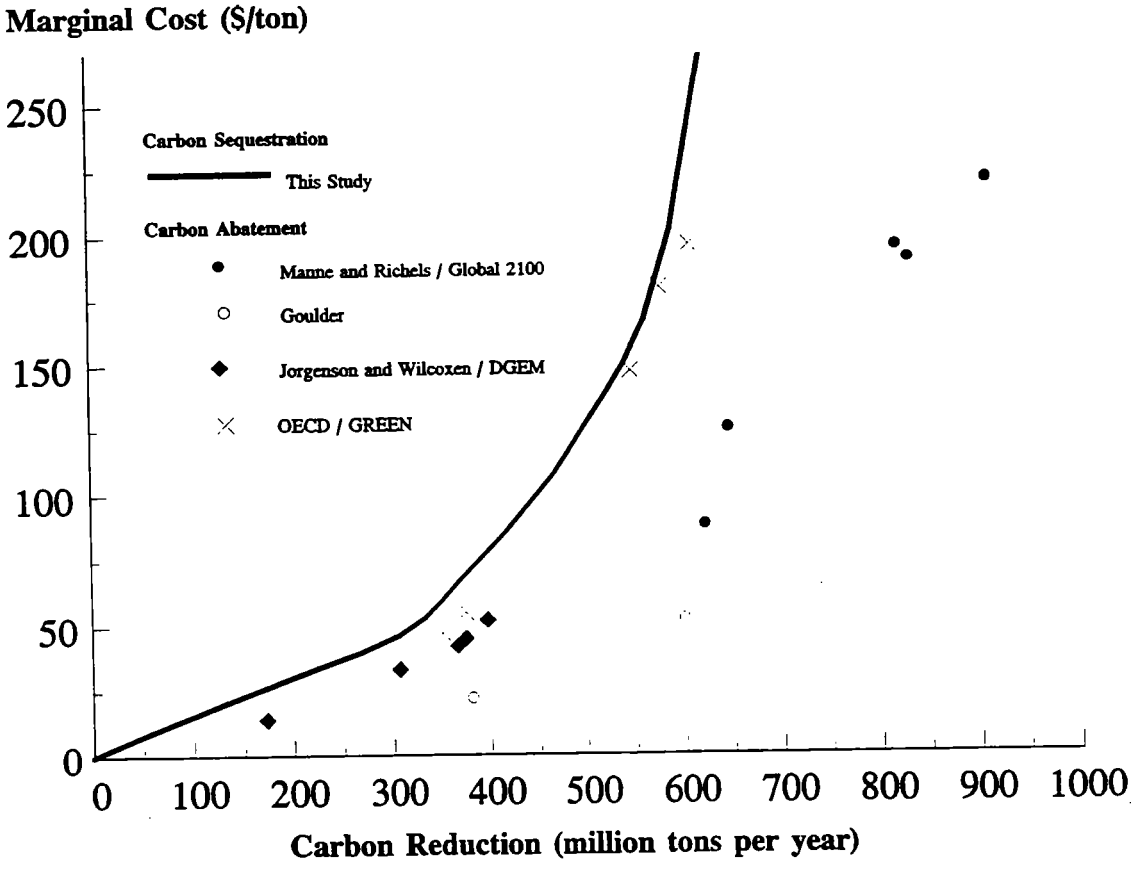


FIGURE 5:
ESTIMATES OF MARGINAL COSTS
OF U.S. CARBON ABATEMENT AND SEQUESTRATION



Source: Carbon abatement marginal cost estimates are annuities calculated from time-paths of 100-year predicted baseline carbon emissions and predicted carbon emissions under alternative policy scenarios presented in: Energy Modeling Forum (1995). See text of present study for detailed explanation.

SEQUESTERING CARBON ON AGRICULTURAL LAND: SOCIAL COST AND IMPACTS ON TIMBER MARKETS

RICHARD M. ADAMS, DARIUS M. ADAMS, JOHN M. CALLAWAY, CHING-CHENG CHANG, and BRUCE A. McCARL*

Planting trees to sequester carbon has broad political appeal. However, effects of a major tree planting program on the agricultural sector and on timber markets are unclear. This paper examines social costs of sequestering carbon in tree plantations on U.S. agricultural land and investigates harvesting's effects on timber prices and on private timber producers' welfare. The analysis links a model of the U.S. agricultural sector that includes the land base in major production areas with a model of the U.S. softwood economy. Using current data on planting, maintenance, and harvesting costs for tree plantations and carbon sequestration rates, the models estimate the price and welfare effects of alternative carbon sequestration goals. Results indicate a range of outcomes. Consumers pay higher prices for food as farmers divert land from crops to trees. However, wood products consumers gain from falling timber prices if the trees enter commercial markets. Agricultural producers and landowners gain from higher commodity prices, but private forest owners lose. Large tree planting programs imply that policymakers must compensate private commercial tree planting to prevent farmers from displacing present tree plantations.

I. INTRODUCTION

Planting trees to sequester carbon is a prominent strategy for mitigating effects of greenhouse gas emissions on global climate and the environment (National Academy of Sciences, 1991; U.S. Office of Technology Assessment; Center for Strategic and International Studies, 1991). In fact, the Administration's National Energy Strategy calls for planting one billion new trees each year (DOE, 1991).

*Richard M. Adams is Professor, Department of Agricultural and Resource Economics, Oregon State University; Darius Adams is Professor, School of Forestry, University of Montana; John M. Callaway is Senior Economist, RCG/Hagler, Bailly, Boulder, Colorado; Ching-Cheng Chang and Bruce McCarl are Visiting Assistant Professor and Professor, respectively, Department of Agricultural Economics, Texas A&M University. This is a revised version of a paper presented at the Western Economic Association International 66th Annual Conference, Seattle, Wash., June 29-July 3, 1991. This paper is also technical paper No. 9925, the Oregon Agricultural Experiment Station. Seniority of authorship is shared.

Planting trees is an important policy topic for several reasons. First, enough land exists worldwide to offset a considerable amount of carbon until scientists develop other mitigation options (Marland, 1988; Lashof and Tirpak, 1989; Moulton and Richards, 1990; Sedjo and Solomon, 1989; Dudek and Leblanc, 1990; Trexler, 1991). Thus, carbon sequestration passes preliminary tests of technical feasibility. Second, many other alternatives, such as carbon taxes, are politically and fiscally unattractive. Third, some studies report that planting trees to sequester carbon is relatively inexpensive (Moulton and Richards, 1990; Sedjo and Solomon, 1989; Dudek and Leblanc, 1990). Finally, potential benefits are broad-based. Planting trees creates a low-cost source of biomass and of alternative fuels and a supply source for carbon-based materials.

This paper evaluates social costs of sequestering carbon in tree plantations on

TABLE 1
Marginal Cost ($/per ton) and Agricultural Acreage to Sequester Carbon Via Tree Plantations

Evaluation	Total Carbon Sequestered (10^6 short tons Carbon)							
	140		280		420		700	
	$/ton	Acres (10^6)	$/ton	Acres (10^6)	$/ton	Acres (10^6)	$/ton	Acres (10^6)
Case 1[a]	18.31	49.62	25.19	103.79	34.17	162.35	55.01	274.44
Case 2[b]	18.50	49.36	25.11	103.18	37.21	157.92	95.06	270.83
Case 3[c]	18.50	49.36	25.11	103.18	38.18	157.78	200.45	267.63
Moulton and Richards[d]	16.57	70.90	20.69	138.40	23.24	197.60	34.73	303.40

[a]Case 1: Restricts tree planting activities to regions where rainfall exceeds 18 inches per year.
[b]Case 2: Same as case 1 but also restricts pastureland to not more than 50 percent of total acreage in tree plantations.
[c]Case 3: Same as case 1 but removes Southern Plains from solution.
[d]These numbers are from Moulton and Richards (1990, appendix, table 1A).

are arid portions of the Southern Plains, the Southwest, and the Northern Plains, where rainfall is less than 18 inches per year. The analysis also allows unrestricted use of pastureland. This case comes closest to matching Moulton and Richards' (1990) assumptions. The last row of table 1 shows points from their supply curve.

The marginal costs (averaged across all regions) per ton increase as the carbon-fixing goals increase, from a low of about $18 per ton for 140 million tons to approximately $55 per ton for a goal of 700 million tons (about half of total U.S. carbon emissions). The rising costs per ton reflect rising opportunity costs of agricultural land as farmers divert more land and higher quality land from crop growing to tree planting.

At low levels of carbon sequestration, case 1 marginal costs and Moulton and Richards' estimates (1990) closely agree. For example, at 140 million tons, case 1 marginal cost is about 10 percent higher than Moulton and Richards' estimates. However, above 280 million tons of carbon the marginal cost increases more rapidly in case 1 than in Moulton and Richards' estimates. At the 700 million ton level, the marginal cost in case 1 is 60 percent greater than in Moulton and Richards's estimates. The two marginal cost estimates diverge because agricultural prices increase more rapidly at higher carbon sequestration levels, forcing up land rents. ASM captures this process but Moulton and Richards do not. Their analysis considers land rents as fixed. Finally, differences between the two studies in acreages required to sequester carbon reflect the different data bases used in the two studies to construct the land base.

Case 2 resembles case 1 but limits pastureland use to 50 percent of total tree production. In case 1, pastureland makes up between 40 and 60 percent. This analysis tests the effect of the land inventory and productivity assumptions on such estimates. That is, inventory "pastureland" contains some of low productivity. Using

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REMARKS BY THE PRESIDENT
ON GLOBAL CLIMATE CHANGE

National Geographic Society
Washington, D.C.

2:57 P.M. EDT

THE PRESIDENT: Thank you very much. Mr. Murphy, Mr. Vice President, to all of you who are here. I thank especially the members of Congress who are here, the leaders of labor and business who are here, all the members of the administration, and especially the White House staff members that the Vice President mentioned and the Secretary of Energy, the Administrator of the EPA, and the others who have helped us to come to this moment.

On the way in here we were met by the leaders of the National Geographic, and I complimented them on their recent two-part series on the Roman Empire. It's a fascinating story of how the Empire rose, how it sustained itself for hundreds of years, why it fell, and speculations on what, if any, relevance it might have to the United States and, indeed, the West.

And one of the gentlemen said, well, you know, we got a lot of interesting comments on that, including a letter referencing a statue we had of the bust of Emperor Vespasian. And one of our readers said, why in the world did you put a statue of Gene Hackman in a piece on the Roman Empire? (Laughter.) And I say that basically to say, in some senses, the more things change, the more they remain the same. (Laughter.)

For what sustains any civilization, and now what will sustain all of our civilizations, is the constant effort at renewal, the ability to avoid denial and to proceed into the future in a way that is realistic and humane, but resolute. Six years ago tomorrow, not long after I started running for President, I went back to my alma mater at Georgetown and began a series of three speeches outlining my vision for America in the 21st century -- how we could keep the American Dream alive for all of our people, how we could maintain America's leadership for peace and freedom and prosperity, and how we could come together across the lines that divide us as one America.

And together, we've made a lot of progress in the last nearly five years now that the Vice President and I have been privileged to work at this task. At the threshold of a new century, our economy is thriving, our social fabric is mending, we've helped to lead the world toward greater peace and cooperation.

aspirations.

What Argentina, with dramatic projected economic growth, recognizes is true for other countries as well: We can and we must work together on this problem in a way that benefits us all. Here at home, we must move forward by unleashing the full power of free markets and technological innovations to meet the challenge of climate change. I propose a sweeping plan to provide incentives and lift road blocks to help our companies and our citizens find new and creative ways of reducing greenhouse gas emissions.

First, we must enact tax cuts and make research and development investments worth up to $5 billion over the next five years -- targeted incentives to encourage energy efficiency and the use of cleaner energy sources.

Second, we must urge companies to take early actions to reduce emissions by ensuring that they receive appropriate credit for showing the way.

Third, we must create a market system for reducing emissions wherever they can be achieved most inexpensively, here or abroad; a system that will draw on our successful experience with acid rain permit trading.

Fourth, we must reinvent how the federal government, the nation's largest energy consumer, buys and uses energy. Through new technology, renewable energy resources, innovative partnerships with private firms and assessments of greenhouse gas emissions from major federal projects, the federal government will play an important role in helping our nation to meet its goal. Today, as a down payment on our million solar roof initiative, I commit the federal government to have 20,000 systems on federal buildings by 2010.

Fifth, we must unleash competition in the electricity industry, to remove outdated regulations and save Americans billions of dollars. We must do it in a way that leads to even greater progress in cleaning our air and delivers a significant down payment in reducing greenhouse gas emissions. Today, two-thirds of the energy used to provide electricity is squandered in waste heat. We can do much, much better.

Sixth, we must continue to encourage key industry sectors to prepare their own greenhouse gas reduction plans. And we must, along with state and local government, remove the barriers to the most energy efficient usage possible. There are ways the federal government can help industry to achieve meaningful reductions voluntarily, and we will redouble our efforts to do so.

This plan is sensible and sound. Since it's a long-term problem requiring a long-term solution, it will be phased in over time. But we want to get moving now. We will start with our package of strong market incentives, tax cuts, and cooperative efforts with industry. We want to stimulate early action and encourage leadership. And as we reduce our emissions over the next decade with these efforts, we will perform regular reviews to see what works best for the environment, the economy, and our national security.

After we have accumulated a decade of experience, a decade of data, a decade of technological innovation, we will launch a broad emissions trading initiative to ensure that we hit our binding targets. At that time, if there are dislocations caused by the changing patterns of energy use in America, we have a moral obligation to respond to those to help the workers and the enterprises affected -- no less than we do today by any change in our economy which affects people through no fault of their own.

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approximately $25/ton.[20] Studies based on engineering/costing models indicate that even more carbon could be sequestered at low costs (Moulton and Richards 1990). While the Administration's illustrative modeling analysis did not incorporate carbon sinks, these studies clearly illustrate the potential for carbon sequestration efforts to play a significant role in meeting our emissions target. These studies provide some evidence that carbon sinks in the United States and other countries could significantly reduce the international emissions trading price and consequently, the costs of achieving the environmental objective.

A42

Potential Emissions Reductions through the Administration's Electricity Restructuring Proposal

The Administration's Comprehensive Electricity Competition Plan (CECP) is estimated to reduce greenhouse gas emissions by about 25 to 40 million metric tons of carbon equivalent per year by 2010. Although competition will lower prices, which will tend to increase consumption, it will also provide a direct profit incentive for generators to produce more electricity with less fuel and improve energy efficiency as competitive sellers seek to maximize the value of their product offerings to buyers by bundling electricity with energy efficiency and management services. In the 2010 timeframe, the net result of retail competition in the absence of additional specific provisions to encourage renewables or subsidize investments in energy efficiency is expected to be nil or a small reduction in emissions.

A43

Specific CECP provisions that will yield additional emission reductions include a renewable portfolio standard, a public benefits fund that will support renewable energy and energy efficiency investments, "green" labeling to help consumers who value clean energy choose it, and a net metering provision encouraging the installation of small renewable systems.

A44

Potential Emissions Reductions through the Administration's Climate Change Technology Initiative

The President's Fiscal Year 1999 budget includes the Climate Change Technology Initiative, a $6.3 billion package of tax cuts and R&D investments intended to spur the discovery and adoption of new technologies. The goal is both to stimulate the development of new energy-saving and carbon-saving technologies and to encourage the deployment of those that exist already. The proposed package contains $3.6 billion over the next 5 years in tax cuts for energy efficient purchases and renewable energy, including tax credits of $3,000 to $4,000 for consumers who purchase highly fuel efficient vehicles, a 15 percent credit (up to $2,000) for purchases of rooftop

A45

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[20] Adams et al. (1993) provide their estimate in short tons, and for purposes of comparison, we have converted this estimate to metric tons.

of tree planting on agricultural land and found that about 250 MMTCE could be sequestered at approximately $25/ton.[21] Studies based on engineering/costing models indicate that even more carbon could be sequestered at low costs (Moulton and Richards 1990). While the Administration's illustrative modeling analysis did not incorporate carbon sinks, these studies clearly illustrate the potential for carbon sequestration efforts to play a significant role in meeting our emissions target. These studies provide some evidence that carbon sinks in the United States and other countries could significantly reduce the international emissions trading price and consequently, the costs of achieving the environmental objective.

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Specific CECP provisions that will yield additional emission reductions include a renewable portfolio standard, a public benefits fund that will support renewable energy and energy efficiency investments, "green" labeling to help consumers who value clean energy choose it, and a net metering provision encouraging the installation of small renewable systems.

Potential Emissions Reductions through the Administration's Climate Change Technology Initiative

The President's Fiscal Year 1999 budget includes the Climate Change Technology Initiative (CCTI), a $6.3 billion package of tax cuts and R&D investments intended to spur the discovery and adoption of new technologies. The goal is both to stimulate the development of new energy-saving and carbon-saving technologies and to encourage the deployment of those that exist already. Many of the components of the CCTI reflect recommendations made in a recent report by the President's

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[21] Adams et al. (1993) provide their estimate in short tons, and for purposes of comparison, we have converted this estimate to metric tons.

THE COSTS OF CARBON SEQUESTRATION: A REVEALED-PREFERENCE APPROACH

Robert N. Stavins

John F. Kennedy School of Government, Harvard University
and
Resources for the Future

April 2, 1996

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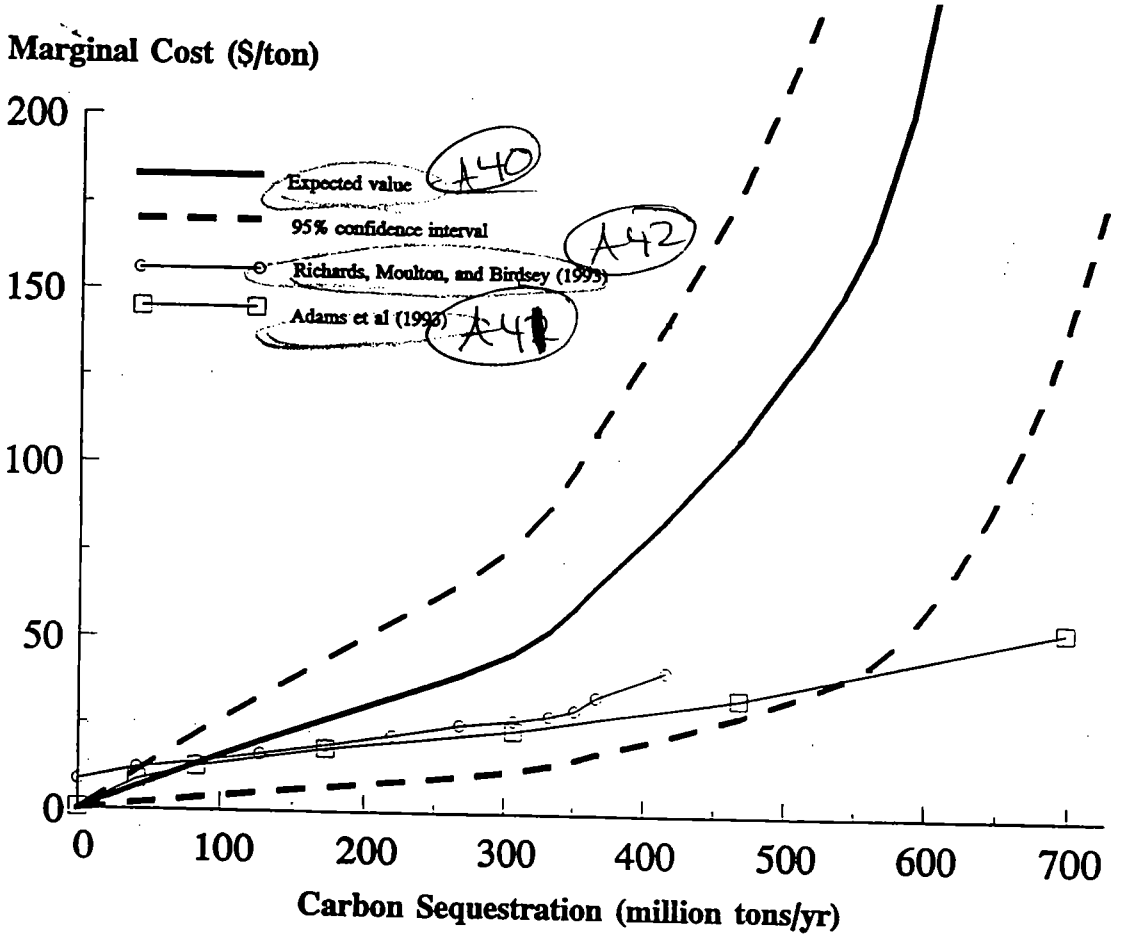
FIGURE 4:
ALTERNATIVE ESTIMATES OF MARGINAL COST OF U.S. CARBON SEQUESTRATION



U.S. DEPARTMENT OF ENERGY

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COMPREHENSIVE ELECTRICITY COMPETITION PLAN:

SUPPORTING ANALYSIS

Office of Economic, Electricity and Natural Gas Analysis
Office of Policy and International Affairs

June 1998

billion lower than under the cost-of-service scenario.

- The average national price of electricity would be 12 percent lower under competition in 2010. The largest reductions are realized in areas of the country with the highest cost-of-service rates. However, all regions of the country benefit from competition if, as under the Administration Plan, existing mechanisms for pricing and allocating power produced at federal facilities (preference power) are maintained.

- Projected emissions of carbon dioxide from the electricity sector are reduced by between 25 and 40 million metric tons of carbon. This reduction reflects the net impact of the emissions-increasing and emissions-reducing effects of the Administration Plan.

The POEMS analysis was informed by an effort to identify potential cost savings from restructuring, a summary of which is provided as Appendix C. Using information from reports filed by investor-owned and public utilities, quantifiable potential cost reductions resulting from competition in operations and maintenance costs, administrative and general costs, more efficient use of the transmission and distribution system, and capital cost savings at existing facilities are estimated to exceed $20 billion annually. This estimate does not include: the savings that would result from a reduction in the need for new capacity due to more efficient pricing, the benefit to consumers of avoiding the costs of any future mistakes with respect to capacity planning, technology choice, or project management that have in the past raised the cost of power to consumers; or the greater economic value to consumers of new products and services that will be created in a competitive environment.

The remainder of this document summarizes the POEMS analysis. Section 2 presents the results. Section 3 presents key assumptions used in the analysis and the rationale for the scenario formulation. Section 4 discusses future direction of the modeling and analytic efforts. Appendix A provides supplementary figures and graphs. Appendix B provides a summary table of results. Appendix C summarizes an analysis of costs at existing plants that was used to derive projected efficiency improvements for the Competitive scenario. Appendix D provides documentation for the POEMS.

Section 2. Results of the POEMS Analysis

Electricity Prices and Stranded Costs

The introduction of retail competition is projected to lead to lower electricity rates for customers in all regions of the country. Figure 1 illustrates the projected average electricity prices in 2010. These prices are the average across all customer classes and include generation, transmission, and distribution costs, and stranded cost recovery.

or retain customers by offering energy-efficiency and management services or "green power" from renewable sources in order to add value and distinguish their products from those of other suppliers. The initial experience in nascent competitive markets suggests that efficiency and management services are already a key strategy used to attract commercial and industrial customers, while the prospects for green power appear to be strongest in residential markets.

The Plan does not rely solely on the market to produce a positive environmental result. Specific provisions of the Administration's plan also provide direct environmental benefits. These include a renewable portfolio standard to ensure a minimum level of generation from non-hydroelectric renewable energy sources; consumer information provisions to help consumers identify and choose environmentally friendly generators; a public benefits fund to match State commitments for financing energy efficiency, renewable energy, and other public benefits programs; and a net metering provision encouraging the installation of small renewable energy systems.

Quantifying the Economic and Environmental Benefits of Competition

This paper presents modeling results that compare scenarios for electricity markets in the continental United States under cost-of-service regulation and competition. The scenarios were developed using the Policy Office Electricity Modeling System (POEMS). POEMS is a system that integrates two existing models, the Energy Information Administration's (EIA) National Energy Modeling System (NEMS) and TRADELEC™ an electricity model developed to evaluate competitive electricity markets in more detail than the standard NEMS electricity module (see Appendix D for an overview of the POEMS model).

The POEMS analysis examines the economic and environmental impacts of a transition to retail competition. However, the analysis does not attempt to explicitly account for state actions that are already beginning the transition to competition or reflect the timing of future actions that states might take to implement competition consistent with the Administration Plan's "flexible mandate" for retail competition. From an analytical perspective, it is difficult to isolate the economic and environmental effects of the Administration Plan from the effects of state actions alone. The Plan will benefit consumers even in states where the transition to competitive markets is already underway by providing additional authority to help assure that potential gains from competition are actually realized.

- On the economic side, the Plan strengthens FERC's ability to require utilities' participation in regional independent system operators, enhances FERC's authority to remedy market power, requires strong consumer information disclosure, allows states to condition market access on reciprocal treatment, and clarifies state-federal jurisdictional boundaries to promote competition and maintain reliability.

- Similarly, Plan provisions that provide important environmental benefits, such as the renewable portfolio standard and the public benefit fund, apply to all states, including those where the transition to competitive markets is already underway.

The focus of the POEMS analysis is the impact of full competition nationally compared to a continuation of cost of service regulation. The main results of the analysis are as follows:

- The delivered cost of electricity to consumers in 2010 in the Competitive scenario is $30.7

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

See page 10

JUNE 4, 1998

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

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

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

I. Basic Economic Rationale of the Kyoto Treaty

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

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

VI. Assessing the Potential Costs of Emissions Reductions

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

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

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

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A45 cont

The Administration has not included quantitative estimates of emissions reductions associated with the Climate Change Technology Initiative in the modeling analysis. This reflects the uncertainty in calculating the pay-offs from funding research and development. A fully funded CCTI would provide for additional U.S. emissions reductions and result in lower permit prices than there otherwise would be.

Potential Emissions Reductions through the Administration's Industry Consultations

Under the Administration's 1993 Climate Change Action Plan, many businesses and institutions are taking voluntary steps to improve their energy efficiency and reduce greenhouse gas emissions. According to the Climate Action Report (1997) the wide array of actions in that Plan -- most of which are voluntary -- are expected to reduce emissions by 76 MMTCE in the year 2000 and 169 MMTCE in 2010. Annual energy savings are projected to grow to $50 billion (1995 dollars) in the year 2010.

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A47

In October 1997, President Clinton called for sectoral consultations which will build on the voluntary efforts undertaken pursuant to the Climate Change Action Plan. One partnership already announced, the Partnership for Advanced Technology in Housing ("PATH"), sets goals for voluntary improvements in home energy use that would result in an estimated 24 MMTCE in 2010 while saving consumers $11 billion in home energy bills. The Administration will be looking for voluntary agreements with major energy-intensive industries and energy providers to yield further emissions reductions.

A48

As the sectoral consultations are still at an early stage, it would be premature and difficult to incorporate emissions reductions from consultations into the illustrative modeling analysis. Based

Committee of Advisors on Science and Technology (PCAST 1997).[22] PCAST found that "the inadequacy of current energy R&D is especially acute in relation to the challenge of responding prudently and cost-effectively to the risk of global climatic change from society's greenhouse gas emissions.... Much of the new R&D needed to respond to this challenge would also be responsive to the other challenges" (PCAST 1997, p. i). The report concluded that investments in energy R&D would generate economic and environmental benefits, especially in the long run.

Building on PCAST's recommendations, the proposed CCTI package contains $3.6 billion over the next 5 years in tax cuts for energy efficient purchases and renewable energy, including tax credits of $3,000 to $4,000 for consumers who purchase highly fuel efficient vehicles, a 15 percent credit (up to $2,000) for purchases of rooftop solar equipment, a 20 percent credit (subject to a cap) for purchasing energy-efficient building equipment, a credit up to $2,000 for purchasing energy-efficient new homes, an extension of the wind and biomass tax credit, and a 10 percent investment credit for the purchase of combined heat and power systems. The package also contains $2.7 billion over the next 5 years in additional research and development investments -- covering the four major carbon-emitting sectors of the economy (buildings, industry, transportation, and electricity), plus carbon removal and sequestration, Federal facilities, and cross-cutting analyses and research. One example of the R&D effort is the Partnership for a New Generation of Vehicles (PNGV). PNGV is a government-industry effort to develop attractive, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. In FY99, the combined proposal for PNGV is $277 million, up from $227 million appropriated in FY98. Similar government-industry efforts are proposed to develop more efficient diesel engines for both light trucks and heavy trucks. If supported by the Congress, this effort could further improve energy efficiency and lower the cost of meeting our Kyoto target.

The Administration has not included quantitative estimates of emissions reductions associated with the Climate Change Technology Initiative in the modeling analysis. This reflects the uncertainty in calculating the pay-offs from funding research and development. A fully funded CCTI would provide for additional U.S. emissions reductions and result in lower permit prices than there otherwise would be.

Potential Emissions Reductions through the Administration's Industry Consultations

Under the Administration's 1993 Climate Change Action Plan, many businesses and institutions are taking voluntary steps to improve their energy efficiency and reduce greenhouse gas

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[22] The President's Committee of Advisors on Science and Technology was established in 1993 to advise the President on matters involving science and technology. PCAST consists of distinguished representatives from industry, academia, research institutions, and other non-governmental organizations.

THE WHITE HOUSE

Executive Office of the President

President's Committee of Advisors on Science and Technology

For Immediate Release **September 30, 1997**

Contact:
Dr. John Holdren (617/495-1464)
Dr. Sam Baldwin (202/456-6073)
Jeffrey M. Smith (202/456-6047)

Energy R&D for the Twenty-First Century

The President's Committee of Advisors on Science and Technology (PCAST) today released a 30-page Executive Summary of a report entitled "Federal Energy Research and Development for the Challenges of the Twenty-First Century."

This report was prepared in response to a January, 1997 request from President Clinton to "review the current national energy R&D portfolio, and make recommendations by October 1, 1997 on how the ensure that the United States has a program that addresses its energy and environmental needs for the next century." The full report will be released later in October.

This country's economic prosperity, environmental quality, national security, and world leadership in science and technology all require improving our energy technologies, the report says, and an enhanced national R&D effort is needed to provide these improvements.

The report recommends focusing the government's energy R&D on projects where high potential payoffs for society as a whole justify bigger R&D investments than industry would be likely to make on the basis of expected private returns and where modest government investments can effectively complement, leverage, or catalyze work in the private sector.

It proposes a substantial increase in Federal spending for applied energy-technology R&D. The largest shares of such an increase would go to R&D in energy efficiency and renewable energy technologies, but nuclear fusion and fission would also receive increases.

The composition of Federal R&D on advanced fossil-fuel technologies would change in favor of longer-term opportunities, including fuel cells and carbon-sequestration technologies, but the overall spending level would stay roughly constant in real terms.

Federal Energy Research and Development for the Challenges of the Twenty-First Century

Panel on Federal Energy R&D,
President's Committee of Advisors on Science and Technology
Executive Office of the President of the United States

30 September 1997

EXECUTIVE SUMMARY

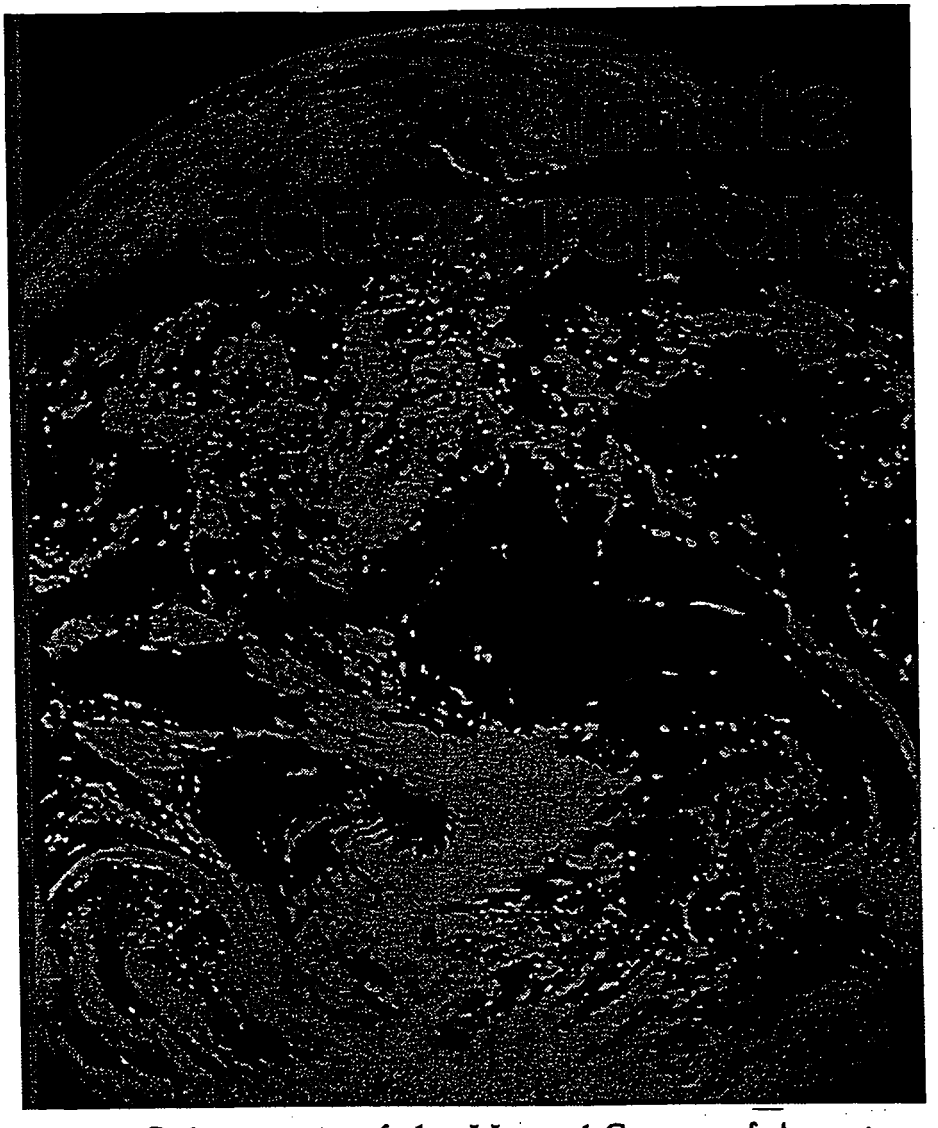
The United States faces major energy-related challenges as it enters the twenty-first century. Our economic well-being depends on reliable, affordable supplies of energy. Our environmental well-being — from improving urban air quality to abating the risk of global warming — requires a mix of energy sources that emits less carbon dioxide and other pollutants than today's mix does. Our national security requires secure supplies of oil or alternatives to it, as well as prevention of nuclear proliferation. And for reasons of economy, environment, security, and stature as a world power alike, the United States must maintain its leadership in the science and technology of energy supply and use.

All of these energy-related challenges to the well-being of this country are made more acute by what is happening elsewhere in the world. The combination of population growth and economic development in Asia, Africa, and Latin America is driving a rapid expansion of world energy use, which is beginning to augment significantly the worldwide emissions of carbon dioxide from fossil-fuel combustion, increasing pressures on world oil supplies, and exacerbating nuclear proliferation concerns. Means must be found to meet the economic aspirations and associated energy needs of all the world's people while protecting the environment and preserving peace, stability, and opportunity.

Improvements in energy technologies, attainable through energy research and development, are the key to the capacity of the United States to address — and to help the rest of the world address — these challenges.

Many of the energy R&D programs of the Federal government, which are primarily conducted by the Department of Energy (DOE), have been well focused and effective within the limits of available funding. But these programs, taken as a whole, are not commensurate in scope and scale with the energy challenges and opportunities the twenty-first century will present. (This judgment takes into account the contributions to energy R&D that can reasonably be expected to be made by the private sector under market conditions similar to today's.) The inadequacy of current energy R&D is especially acute in relation to the challenge of responding prudently and cost-effectively to the risk of global climatic change from society's greenhouse-gas emissions, of which the most important is carbon dioxide from combustion of fossil fuels. Much of the new R&D needed to respond to this challenge would also be responsive to the other challenges.

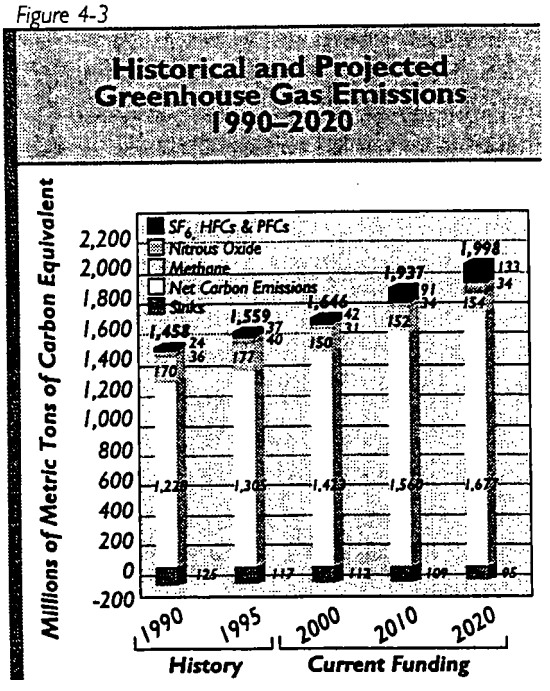
PCAST



1997 Submission of the United States of America Under the United Nations Framework Convention on Climate Change

4

Figure 4-3



The results of this integrated analysis combined with a review of actual emission trends to date suggest that CCAP programs can be effective in reducing U.S. greenhouse gas emissions. CCAP actions reduce 4 percent of baseline emissions in 2000, 8 percent in 2010, and 10 percent in 2020. However, despite these substantial contributions, emissions will significantly exceed their 1990 levels in the year 2000.

- U.S. net greenhouse gas emissions in 1990 were 1,458 MMTCE.
- Estimated U.S. greenhouse gas emissions in 1995 were 1,559 MMTCE—6.9 percent above the 1990 level, and somewhat above the short-term increase projected in the first U.S. national communication, the 1994 *Climate Action Report*.
- The updated "point estimate" for greenhouse gas emissions in the year 2000, assuming continued funding support for CCAP actions described in this report, comparable to the 1997 levels approved by Congress is 1,646 MMTCE—188 MMTCE above the 1990 level.
- Under current funding levels, planned actions are estimated to reduce greenhouse gas emissions by 76 MMTCE in the year 2000, compared to what they would have been otherwise (the baseline).
- Due to estimated energy savings initiated by CCAP actions to reduce greenhouse gas emissions, approximately $10.3 billion and $51.1 billion are saved in energy fuel use in 2000 and 2010, respectively.
- If funding were higher, as originally envisioned in the 1993 CCAP, estimated emission reductions would be about 30–40 MMTCE greater.
- While reductions from CCAP programs increase over time, projected greenhouse gas emissions still continue to grow over time, reaching 1,837 MMTCE by 2010 and 1,998 MMTCE by 2020.

The emission projections presented here include the full effect of the "foundation" actions contained in the earlier 1993 CCAP. The three foundation actions scored are: Climate Challenge, Climate Wise Companies, and State and Local Outreach. Emission reduction estimates are sensitive to the order in which foundation actions and other CCAP programs are counted. If reductions resulting from the activities of program participants that can be reflected in other actions or in the baseline are excluded, the estimated "incremental" emission reductions associated with the foundations are estimated to provide

Table 4-11

Projected Emission Reductions From Climate Change Actions

Sector or Gas	1993 CCAP 2000	1997 CAR 2000	1997 CAR 2010	1997 CAR 2020
Total Energy Related	**66.0**	**31.6**	**94.9**	**144.7**
Commercial	10.6	5.1	24.8	40.7
Residential	16.3	5.2	28.1	37.3
Industrial	19.0	4.8	11.5	16.7
Transportation*	8.1	5.3	15.5	22.1
Supply	10.8	1.3	7.1	19.3
Foundation Actions**	0.0	10.9	9.1	11.9
Methane	**16.3**	**16.0**	**23.4**	**24.2**
HFCs, PFCs, and SF_6	**11.8**	**20.1**	**40.5**	**49.2**
Nitrous Oxides	**4.5**	**5.3**	**5.3**	**5.3**
Forest Sinks	**10.0**	**2.8**	**4.6**	**5.5**
Total Reduction	**108.6**	**76.0**	**169.3**	**229.5**

Note: Totals may not sum due to independent rounding or interactive effects.

* *Assumes receipt of legislative authority for parking cash-out by the end of 1997.*

** *Foundation action partners provide additional reductions in almost all sectors and gases. These values only represent incremental savings not accounted for in other actions or baseline activities. They exclude 0.4 MMTCE for forest sequestration activities accounted for in forest sinks below.*

from the 1993 CCAP analysis for each major greenhouse gas and source category.

Energy-Related Actions

The projected decrease in natural gas prices and increased electricity sales compared to the 1993 CCAP have increased the projected market share for new natural gas-fired electric-generating capacity. Although the reduction in projected natural gas prices is beneficial from a climate change perspective because natural gas is a less carbon-intensive fuel per unit of energy than other fossil fuels and because natural gas technologies tend to be more efficient, it reduces the efficacy of climate change policies designed to reduce electricity use.

Many of the 1993 CCAP actions reduce carbon emissions through their impact on electricity demand. Changes in the marginal fuel used for generation has important implications for translating electricity savings into carbon reductions. Marginal fuel is the fuel consumed to produce the last "unit" of electricity generated. In this instance, the unit is defined as the kilowatt-hour savings from electricity-related actions.

In the original 1993 CCAP, the marginal fuel mix for electricity production was 80 percent coal and 20 percent oil and natural gas in the year 2000. This resulted in carbon emissions decreasing by 0.28 MMTCE for every decrease in 1 billion kilowatt-hours of electricity (0.28 MMTCE/bkWh). In the cur-

PRESIDENT CLINTON ANNOUNCES THE UNITED STATES CLIMATE CHANGE POLICY

NATIONAL GEOGRAPHIC SOCIETY
GILBERT H. GROSVENOR AUDITORIUM
Washington, D.C.

October 22, 1997

PRESIDENT CLINTON'S CLIMATE CHANGE PROPOSAL

October 22, 1997

Global climate change is the premier environmental challenge and opportunity of the 21st century, and the risks it poses justify sensible preventive steps. Addressing this issue is one of the United States' greatest imperatives, for this and future generations. Recognizing the solid foundation of climate science, President Clinton is committed to strong and sensible action to reduce greenhouse gas emissions -- including realistic and binding emissions targets.

Key elements of President Clinton's climate change proposal include:

- **Binding Targets to Reach 1990 Emissions Levels by 2008-2012 and Reductions Below 1990 Levels in the 5-Year Period That Follows.** A critical component of the President's comprehensive framework is a realistic, achievable, and binding target of reducing greenhouse emissions to 1990 levels by 2008-2012 and reductions below 1990 levels in the 5-year period that follows.

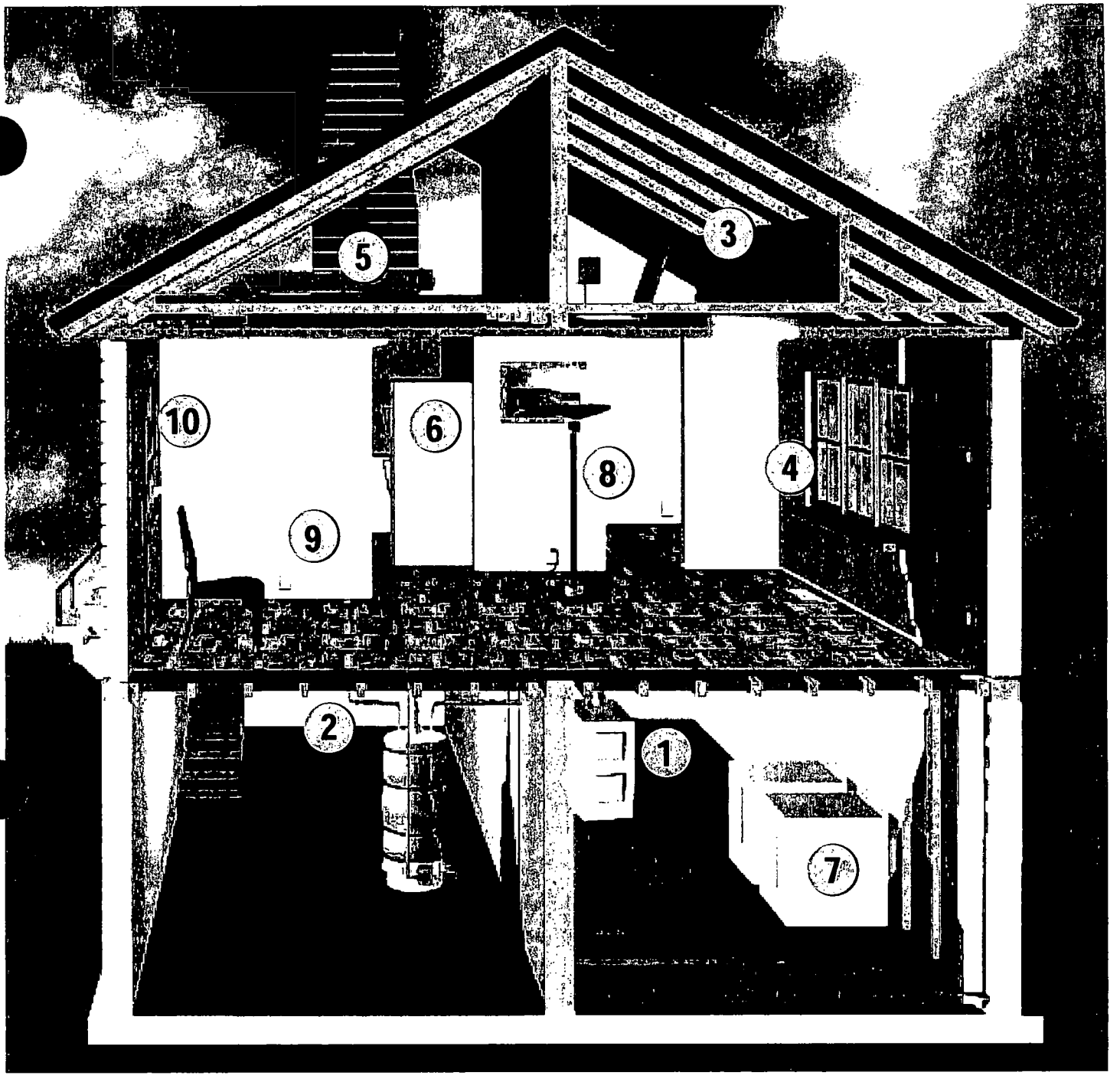
- **$5 Billion Program of Tax Cuts and R&D for New Technologies.** To spur energy efficiency and the development of new technologies, the President proposes a major new package of tax cuts and R&D spending amounting to $5 billion over five years.

- **Industry-by-Industry Consultations and Early Credit.** The Administration challenges key industries to prepare plans over the next 9 months on how they can best reduce emissions. To provide an incentive for near-term actions to cut emissions, the President is committed to ensuring appropriate rewards for firms that act early.

- **Developing Countries Must Participate.** Climate change is a global problem, and requires a global solution. That's why the United States has spear-headed joint implementation projects, and the President has committed that the United States will not adopt binding obligations without developing country participation.

- **Broad-Based Domestic and International Emissions Trading System Begins After A Decade of Experience Has Accumulated.** The President is committed to a market-based emissions trading system, both domestically and internationally, that will harness the power of the market to reduce emissions to 1990 levels by 2008-2012. The trading system would begin after a decade's worth of experience with tax incentives, R&D, early credit, electricity restructuring, Federal efforts, and other measures.

BINDING TARGETS: The U.S. binding target is realistic: It seeks to return U.S. emissions to 1990 levels in the period 2008-2012 and reduce them further thereafter. We reject the European proposal for more stringent early reductions, as well as the "do-nothing" approach of some interests. The target is achievable: By providing incentives for early action to reduce emissions, attacking domestic energy inefficiencies, and putting in place a market-based emissions trading system, we can reach 1990 levels in the proposed time frame with minimal economic costs. And it is meaningful: Achieving 1990 levels in the period 2008-2012 would amount to almost a 30 percent reduction off a business-as-usual path, an important first step on the road toward stabilizing greenhouse gas concentrations in the atmosphere.



Ten steps you can take at home to save money, save energy and fight global warming

1 Heating and cooling systems
2 Hot water systems
3 Insulation
4 Windows
5 Air leaks
6 Refrigerators
7 Clothes washers
8 Lighting
9 Consumer electronics
10 Putting it all together

U.S. Department of Energy
Office of Building Technology, State and Community Programs
Office of Energy Efficiency and Renewable Energy

Ten steps you can take at home to save money, save energy and fight global warming

Energy costs in the typical American home are $1300 a year. Home energy use is also responsible for putting more than three metric tons of carbon into the atmosphere per household. This is equal to the emissions from $2^1/_2$ cars. More than 30% of your home energy use and associated carbon emissions could be eliminated by taking action in these ten areas.

1. Heating and cooling systems — These two items account for 44% of a household's energy bill. Buy ENERGY STAR® heating and cooling equipment, use a programmable thermostat and have your system maintained with regular tune-ups.

2. Hot water systems — Heating water accounts for 14% of typical energy usage in the home. Look for high-efficiency water heaters, heat pump water heaters and solar water heaters. Proper maintenance, insulation and water-saving features like aerators in faucets and low-flow showerheads will help save here.

3. Insulation — Insulating attics, walls, ducts and basements are among the most cost-effective energy-saving actions you can take.

4. Windows — Inefficient windows can account for 10% – 25% of heating bills and increase your air conditioning. ENERGY STAR windows will help to decrease your heating and cooling bills.

5. Air leaks — Poorly sealed ducts and air leaks in the home waste dollars and can cause health and safety problems. You can save 10% or more by providing mechanical ventilation and by sealing cracks, penetrations, and heating and cooling ducts.

6. Refrigerators — New refrigerators can save you $35 – $70 a year over the models available 15 years ago. This can mean $500 – $1000 in savings over the life of the refrigerator.

7. Clothes washers — New high-efficiency front-loading washing machines can save more than 50% of the energy used for washing. They use 30% less water and save on the energy needed for drying your clothes, as well.

8. Lighting — Lighting accounts for 5% – 10% of home energy use. Increased use of fluorescent lighting in the home and installed timers and motion sensors can reduce your lighting costs. If you buy compact fluorescent floor lamps (torchieres) instead of a halogen lamp, it will not only save energy but also eliminate a dangerous fire hazard.

9. Consumer electronics — Consumer electronics are the fastest energy growth area in the home. Look for the ENERGY STAR label when buying computers, VCR's and TV's.

10. Putting it all together — Treating the whole house as a system saves even more energy and money. For example, you can reduce the size and cost of a heating and cooling system through better insulation, windows and air sealing.

ENERGY STAR is a government industry partnership program. This labeling program is jointly managed by the U.S. Department of Energy and the U.S. Environmental Protection Agency.

The Partnership for Advancing Technologies in Housing (PATH) is a public/private effort to improve the quality, durability, environmental performance, energy efficiency and affordability of our Nation's housing.

For more information, contact the Department of Energy: 1-800-DOE-3732 or http://www.eren.doe.gov

THE PRESIDENT'S NEW PARTNERSHIP FOR HOUSING: HELPING HOMEOWNERS CUT ENERGY COSTS AND FIGHT GLOBAL WARMING

Today, President Clinton launches a new partnership with America's building industry to dramatically improve the energy efficiency of our homes -- cutting consumers' energy bills by 30-50 percent, while reducing the greenhouse gases that cause global warming. At a Los Angeles construction site, where building will soon commence on 186 energy-efficient homes, the President will tour a model home with advanced energy-saving features that will cut homeowners' utility bills by $230 a year. By promoting the use of these and other advances in new and existing homes, ***the new Partnership for Advancing Technology in Housing (PATH) could save consumers $11 billion a year in energy costs by 2010 and reduce annual carbon emissions in 2010 by nearly 24 million tons -- the amount produced by some 20 million cars.***

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Advanced Housing for the 21st Century. PATH brings together federal agencies, state and local governments, and the building, finance and insurance industries to spur design and construction innovations for the next generation of American housing. The goal is homes that are stronger, more affordable, more comfortable and far more energy-efficient.

> ***Over the next decade, PATH aims to cut energy use by 50 percent in new homes, and by 30 percent in 15 million existing homes, while reducing the monthly cost of new housing by 20%.***

Meeting the Challenge of Climate Change. Rising emissions of greenhouse gases, primarily from the burning of fossil fuels, threaten to warm the planet 2-6 degrees over the next century. Likely results include rising sea levels, the spread of infectious disease, increased flooding and drought, and extreme weather like that caused by this winter's El Nino. ***Energy use at home accounts for about 20 percent of U.S. emissions of greenhouse gases.*** PATH is part of a comprehensive Administration strategy to fight climate change through cost-effective steps that cut emissions while creating opportunities for economic growth.

A Commitment to Work Together. PATH joins government and industry in a coordinated strategy to identify promising housing technologies and swiftly move them to market.

> ***Federal partners,*** led by the Department of Housing and Urban Development and the Department of Energy, commit to support research, facilitate removal of barriers to new technology, and provide technical assistance.
>
> ***Industry partners*** commit to fund research, bring advanced products to market, share information and work with government to demonstrate new technologies.
>
> ***State and Local Government*** partners commit to streamline approval processes so new technologies are rapidly deployed and devote resources to local pilot projects.

PATH Projects Around the Country. The 186-home Village Green development in Los Angeles is one of several PATH pilot projects under way. Others include a Tucson project that is the largest "sustainable" master-planned development in the United States and a "new traditional" neighborhood being built on a decontaminated "brownfields" site in Pittsburgh.

Tax Incentives for Energy Efficiency. To further promote energy efficiency and clean energy technologies, the President's Fiscal Year 1999 budget proposes a five-year $6.3 billion package of tax incentives and research investments. Included are $200 million in tax credits for the purchase of ultra-energy-efficient homes and $1.4 billion in tax credits for the purchase of energy-saving systems and appliances for buildings and homes. The budget also proposes $200 million next year to accelerate R&D for appliances and construction. ***The President calls on Congress to approve this common-sense package of tax and research incentives to build a stronger economy and a stronger environment.***

PATH: ADVANCED HOUSING FOR THE 21ST CENTURY

PATH's primary goal is to dramatically improve the energy efficiency, quality, durability and affordability of new and existing homes.

The Partnership for Advancing Technology in Housing (PATH) brings together federal agencies, state and local governments, and the building, finance and insurance industries to spur technological innovations for the next generation of American housing. Federal agencies, with policy leadership provided by the Department of Housing and Urban Development and the Department of Energy, will serve as a catalyst, working with the private sector to identify promising technologies and swiftly bring them to market. Some examples: ultra efficient heating and cooling systems, a new generation of windows that provide as much insulation as most walls today, and roof shingles that generate solar power.

PATH partners will work together on:

Collaborative Research on Next-Generation Technologies. PATH partners will collaborate to develop and evaluate technologies that can achieve both performance and cost goals. A national ***Conference on the Future of the American House*** in early 1999 will help set the research agenda. Federal research related to residential housing will focus on PATH goals and the evolving research agenda.

Moving Technology from the Laboratory to the Marketplace. Because the housing industry is large and dispersed, it can take 10 to 25 years for a new technique or product to gain wide acceptance. PATH aims to cut that time in half by removing market barriers, developing national testing and evaluation standards and streamlining approval processes. A ***blue-ribbon panel*** made up of experts from among PATH members will investigate regulatory and other barriers. Federal, state and local organizations are committed to helping remove unnecessary barriers and encourage adoption of cost-effective new technologies.

Stimulating Wider Use of Existing Products. One way to move technology to markets more efficiently is to ensure that accurate information about innovative products and experience with their use is readily available. PATH will help get the work out to builders, suppliers and consumers through a ***new website*** available in early June (**http://www.pathnet.org**). Information for consumers about making their homes more energy efficient is available now at (**http://eetd.lbl.gov/path**).

PATH GOALS

Using voluntary approaches, the partnership aims to develop innovative housing components, designs and production methods and reduce by half the time needed to move quality technologies to market. Our goal is that within a decade, technologies widely accepted in the market will make it possible to produce housing that is affordable and at the same time to:

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on the effectiveness of these approaches in the past, these consultations could produce a significant amount of cost-effective action in the coming decade.

Ancillary Benefits of Greenhouse Gas Emissions Reductions in the United States

Ancillary Emissions Reductions

Reductions in fossil fuel combustion typically lead to reductions in conventional air pollutants. These include sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter and volatile organic compounds. These reductions in emissions can have important implications for environmental quality and public health.

To estimate the ancillary benefits for the U.S. of the Kyoto Protocol, we applied the same methods as were used for the Regulatory Impact Analysis that EPA published in July 1997 for the revised national ambient air quality standards (NAAQS) for particulate matter and ozone. First, a Data Resources Institute model was used to simulate the changes in fossil fuel combustion by region and economic sector that the Kyoto Protocol would bring about.[21] These changes in fuel consumption were then used by Pechan Associates, an EPA contractor, to estimate changes in emissions of local air pollutants.[22]

Identification of the baseline from which to estimate emission reductions attributable to a carbon control strategy is complicated by the gradual transition to full attainment of the new NAAQS. In particular States and emission sources could respond to a carbon control strategy by either replacing or maintaining NAAQS related emission controls. Because of this uncertainty, ancillary benefits are treated as a range.

If ancillary benefits of carbon mitigation make the NAAQS related emissions controls unnecessary, an estimate of avoided pollution control expenditure is required. Reasonable estimates of the cost savings per ton are approximately $1,620 for NO_x and $700 for SO_2, based on current information about the specific technologies likely to be avoided at utilities and large industrial sources. (These estimates are derived from the estimates of the incremental costs of tighter regional caps on NO_x and SO_2 emissions that were developed for the NAAQS Regulatory Impact Analysis [RIA].) Given these unit values, the value of these cost savings for sulfur dioxide is $520 to $970 million per year, and for NO_x is $1.2 to $2.2 billion per year. Adding these together gives cost savings of about $1.7 to $3.2 billion per year.

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[21] DRI/McGraw-Hill U.S. Energy Model. Model simulations were based on DRI/McGraw-Hill's World Energy Service U.S. Outlook, Fall/Winter 1996.

[22] See E.H. Pechan and Associates 1997a, b.

Ancillary Benefits From Carbon Emissions Reductions

In the scenario in which the ancillary benefits of carbon mitigation completely crowd-out the NAAQS related emissions controls, an estimate of avoided pollution control expenditure is required. Although there is uncertainty about which controls required to meet local standards would not be necessary under a carbon mitigation strategy, and over the costs of such controls, reasonable estimates of the cost savings per ton for NO_x are approximately $1620 and $700 for SO_2, based on current information about the specific technologies likely to be avoided at utilities and large industrial sources. **[The $1620 and $700 data are from a May 7 1998 memo from Ronn Dexter of EPA OPPE (57dexter.wpd). They were converted from the estimates in the memo (Costs of $581/ton for utility SO2, and $1,350/ton for utility and industrial Nox), to 1997 dollars using the GDP deflator in Table B.4 of the 1998 ERP.]** (These estimates are derived from the estimates of the incremental costs of tighter regional caps on NO_x and SO_2 emissions that were developed for the NAAQS Regulatory Impact Analysis [RIA].) Given these unit values, the value of these cost savings for sulfur dioxide is $360 to $600 million per year, for the $14 per ton and the $23 ton cases respectively. For nitrogen oxides, the cost savings are $370 to $610 million per year for the $14 and $23 cases respectively. Adding these together gives cost savings of about $.74 to $1.2 billion per year. **[For cost savings estimates, see w77..z79 of the spreadsheet ancil3.wk4.]**

In the scenario in which the ancillary benefits of carbon mitigation partially supplement, rather than displace, NAAQS related controls, valuing the ancillary health and welfare benefits requires (1) an estimate of the changes in air quality, and (2) an estimate of the value in dollars of such changes. For this analysis we employed the same methodologies and tools as were used for the NAAQS RIA of July 1997. Since the measure of air quality that most influences benefits is fine particulate matter, we do not quantify changes related to ozone, and concentrate instead on $PM_{2.5}$. Reducing $PM_{2.5}$ concentrations yields a wide variety of categories of benefits. Our analysis indicates that the reductions in $PM_{2.5}$ attributable to carbon mitigation that corresponds to the $14 per ton case would lead to between $1.1 billion and $5.7 billion in benefits annually, while the reductions in $PM_{2.5}$ attributable to carbon mitigation in the $23 per ton case would lead to between $1.8 and $9.4 billion in benefits. **[See the spreadsheet Ancil07.xls, cells m30-o33, and the bold parts of the 7/21 e-mail named 721peter from EPA discussing that some results are for a case consistent with $56/ton carbon case.]** Although these plausible ranges appear large, they are consistent with prior estimates, e.g., in the NAAQS RIA, and reflect a variety of uncertainties in the nature of the health effects discussed in that document.

In this scenario, there are additional ancillary benefits in the form of avoided NAAQS-related air pollutant control costs. Specifically, for the two pollutants governed by cap and trade programs, SO_2 and NO_x, avoided control costs total $450 million in the $14/ton case and $740 million per year for the $23/ton case. **[See 721Peter stating that the control costs avoided are $.8B/year at $25/ton. Scaling proportionally gives 14/25*800=450, and 23/25*800=740.]**

Thus total annual ancillary benefits for this valuation approach range from $1.6 billion to $6.2 billion for the $14/ton case and from $2.5 billion to $10 billion for the $23/ton case. **[Addition given the preceeding numbers.]** Thus as a conservative estimate, a quarter of the

costs of the Kyoto agreement are offset by these ancillary benefits, although there is substantial uncertainty about these estimates. Note that the estimated resource costs of $7 to $12 billion per year for these permit prices do not reflect the offsetting economic benefits of the ancillary environmental quality improvement.

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Collection/FOIA: 2017-1095-F

Diskette Title: n/a

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If carbon mitigation partially supplements, rather than displaces, NAAQS related controls, valuing the ancillary health and welfare benefits requires (1) an estimate of the changes in air quality, and (2) an estimate of the value in dollars of such changes. For this analysis we employed the same methodologies and tools as were used for the NAAQS RIA of July 1997. Since the measure of air quality responsible for most of the quantifiable benefits is fine particulate matter, we do not quantify changes related to ozone, and concentrate instead on fine particulate ($PM_{2.5}$). Reducing $PM_{2.5}$ concentrations yields a wide variety of categories of benefits. Our analysis indicates that the reductions in $PM_{2.5}$ attributable to carbon mitigation that corresponds to the $14 per ton case would lead to between $1.1 billion and $5.7 billion in benefits annually. Similarly, the reductions in $PM_{2.5}$ attributable to carbon mitigation in the $23 per ton case would lead to between $1.8 and $9.4 billion in benefits. Although these plausible ranges appear large, they are consistent with prior estimates, e.g., in the NAAQS RIA, and reflect a variety of uncertainties in the nature of the health effects.

In this scenario, there are additional ancillary benefits in the form of avoided NAAQS-related air pollutant control costs. Specifically, for the two pollutants governed by cap and trade programs, SO_2 and NO_x , avoided control costs total $0.8 billion. Total annual ancillary benefits for this valuation approach range from $1.9 billion to $6.5 billion for the $14/ton case and from $2.6 billion to $10.2 billion for the $23/ton case.

Thus as a conservative estimate, a quarter of the costs of the Kyoto agreement are offset by these ancillary benefits, although there is substantial uncertainty about these estimates.

It should be noted that the level of ancillary benefits from carbon mitigation increases with the extent of domestic mitigation. These ancillary benefits have implications for the gains from trade in carbon permits that might result under the Kyoto agreement. For example, the gains to countries that might buy permits abroad are less than predicted by models that fail to take into account these ancillary benefits, since such benefits fall with greater purchases of permits abroad. In general the magnitude of these ancillary benefits depends on the type of regulation of air quality and emissions of local air pollutants, as well as baseline local air quality.

Greenhouse gas mitigation strategies will result in additional reductions of other air pollutant emissions, including several that have not been quantified. (See Table 7). In particular, greenhouse gas mitigation strategies will result in additional reductions in heavy metals, acetaldehyde, formaldehyde, organic aromatics, polycyclic aromatic hydrocarbons (PAH), and chlorinated dioxins and furans. These substances are capable of producing a wide array of health and environmental effects. Exposure to these substances can cause effects in addition to cancer; these may range from respiratory problems to reproductive and developmental effects. Further, although reductions in nitrogen and sulfur dioxide emissions were quantified in dollar terms, the estimated values exclude the mitigation of adverse impacts on agricultural and forestry yields, aquatic and terrestrial ecosystems and recreational fishing.