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NEC / CEQ Climate Change Deputies Mtg, Wed, 3/19/97, 1:30pm, Rm. 472 w/ JAF

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Week 3/19/97, 1:30pm
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U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF POLICY, PLANNING AND EVALUATION

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To: Assistant Secretaries Group **Date:** March 14, 1997
Fax #: See attached list **Pages:** 10, including this cover sheet.
From: William N. White
Special Assistant to David Gardiner
Subject: Papers on Trading and Regulation

COMMENTS:

Please find attached two papers for discussion at the ~~Assistant Secretaries Climate Change Group~~ meeting on ~~Tuesday~~ ^{Wednesday}. The first is *Domestic Greenhouse Gas Emissions Trading*, the second is *Using Standards and Regulations to Reduce Greenhouse Gas Emissions*. Please contact me at 260-1345 if you have questions or do not receive a complete transmission.

~~second paper transmitted separately~~
who will be here when I'll be here
9/24 10:00 AM
off to be here

Domestic Greenhouse Gas Emissions Trading

Introduction

This paper describes options for a domestic emissions trading program to meet an international agreement on an emissions target for greenhouse gases. Emissions trading involves allocating or auctioning emissions allowances, and allowing the trading of allowances in a market with sufficient mechanisms to ensure compliance with targeted levels. Emission trading creates new, marketable assets that can have substantial value, so distributional issues will be an important component of program design. Allocation designs or auction revenues can be used to address these distributional issues.

Emissions trading offers two advantages over a system of emission taxes. First, by setting overall quantity targets, emissions trading programs offer greater certainty that national emission targets will be achieved. Under a tax system, the quantity of total emissions is the result of individual polluters' decisions in response to the incentive provided by the tax. In principle, if the entire cost structure is known, any quantity target attained by a tradable permit system could also be attained by an appropriately calculated tax. In so far as forecasting in practice is difficult, however, the resulting level of emissions can be greater or less than the level targeted when the tax rate is set. Second, under an allowance system, the government has greater flexibility in deciding whether to collect revenues. It can auction permits, allocate them based on historical emissions, or undertake some combination of the two. This flexibility can affect the public acceptance of the mitigation program. Emission tax systems always involve revenues accruing to the government (although they can be rebated).

Emission Trading of Greenhouse Gases

An emissions trading program, like any program designed to limit greenhouse gases, must contain certain elements. First, an agreed upon emissions budget, and any rules governing provision for the project-specific crediting of reductions made in activities not explicitly covered by the budget, must be established. A central authority must be given the domestic responsibility for verifying compliance and must be provided sufficient information to do so. Finally, noncompliance with allowance limitations or reporting requirements must generate real consequences, such as penalties or subtraction of allowances.

A program would have to establish permit lifetimes, monitoring and enforcement provisions, as well as rules for permit banking, borrowing, and trading. Consideration should also be given to transaction costs, which should be kept as low as possible. However, particularly difficult issues involve determining what types of activities require a permit and how permits should be allocated.

What types of Activities Should Require a Permit

Sources of greenhouse gases include not only those emitting carbon dioxide, but other gases such as methane, nitrous oxides, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). Gases differ both in their atmospheric lifetimes and in their ability to trap heat in the atmosphere. In addition, carbon is not only emitted through the combustion of fossil fuels, but is also absorbed by “sinks” such as trees and soils.

The decision for determining permit holders should consider the following:

- *Coverage:* While it may not be necessary to ensure that every ton of greenhouse gas is accounted for within an emission trading regime, the scope of coverage of the trading program should be sufficient to ensure compliance with targets set in accordance with an international agreement.
- *Administrative and compliance feasibility:* The number of sources involved in the trading program should be small enough to be administratively feasible and large enough to ensure market competition. In addition, monitoring and verification of permit compliance must be possible for those included in the program.
- *Potential to Diffuse Low Greenhouse Gas Technologies:* Alternative points of intervention should be evaluated for their ability to provide incentives for research, development, adoption and diffusion of low greenhouse gas technologies.
- *Market Impacts:* Any program that limits emissions will affect the bottom line of firms. The permit program will have economic impacts that vary depending on program design. For example, exempting certain sizes or categories of sources from permit requirements because of administrative or equity concerns (e.g., small boilers or home heating oil) has competitive implications within the energy market.
- *Public Acceptance:* The program must consider the ease or difficulty with which various allocation approaches would be accepted by the public.
- *Consistency with the international trading system:* The domestic program should be consistent with any international prescriptions concerning the coverage of sources and gases.

Carbon Sources

Carbon dioxide currently accounts for about 85% of U.S. greenhouse gas emissions and number in the hundreds of millions since they include sources such as automobiles and residential gas water heaters. However, since virtually all of the carbon contained in fossil fuel extracted from the ground (with the possible exception of certain feedstocks) is eventually released to the atmosphere, a trading program need not focus

uniquely on direct emitters, but can be implemented through other points in the energy market. These include fuel imports, fuel extraction, processing, refining, distribution, and secondary conversion (e.g., coal to electricity). In addition, these points could vary by sector. For example, an emission trading program could focus on the point of final combustion for coal, but on refining for oil, or distribution for natural gas. Given the wide variety of options available for including energy sources in a trading program, a few alternative programs are described below for illustration:

A Program Targeting Primary Fuel Producers

The primary fuel producing sector – extraction, processing, refining, and distribution – has many levels where a permit program could be implemented. One option would be to require permits at the point of first sale (a permit is surrendered with the first inter- or intra- company transaction). Such a system would include transactions between a coal company and an electric utility, between a natural gas producer and its marketing arm, between a natural gas producer and a broker, or between an oil extraction company and its refinery operations. Fuel importers would also require permits to import fuel. This would capture the carbon from fuel consumed in the refining process. The number of market actors under this program design would be under 5000 and virtually all carbon in the energy sector would be included in the program.

A Program of Emission Trading at the Sectoral Level

An emissions trading program could also be applied at the point of combustion, allowing trading among affected sources. This system would be most comparable to the current SO₂ emission allowance trading system.

Targeting the six largest industrial CO₂ emitting sectors (electric utilities, cement, primary metals, pulp and paper, petroleum refining and chemicals) in a sectoral trading program could encompass as many as 20,000 market participants and 90 percent of industrial CO₂ emissions. Mobile source emissions could either be indirectly included in the system by allocating transportation equipment manufacturers permits for emissions associated with their automobile fleets or by including refiners in the program. Residential and commercial emissions could be similarly addressed by focusing upstream in the energy system.

Other Greenhouse Gases and Sinks

Other gases account for the remaining 15% of greenhouse gas emissions (on a carbon-equivalent basis). Most important among these is methane, which accounts for 11% of national emissions. Since gases differ in their lifetimes and in their potential to trap heat in the atmosphere, an “exchange rate” or trading ratio must be established to convert all gases into common units for inclusion in a trading program. Such ratios have been developed by climate researchers and could be applied here. These should be consistent with the rules established in the international protocol.

Several, although not all, of the many sources of non-carbon greenhouse gases could likely be included in a trading system. For example, methane emitting coal mines, landfills, livestock manure management facilities and potentially natural gas distribution systems may meet the criteria described above for inclusion in a greenhouse gas trading program. These sources account for 7% of national greenhouse gas emissions. Similarly, emissions of some sources of other gases could potentially be included (e.g., magnesium production).

Forests in the United States currently remove an amount of carbon equal to 8% of national emissions from the atmosphere. Their inclusion in the trading program would theoretically enhance the system's flexibility. However, translating the potential of sinks into monitorable, verifiable, and cost effective emission reductions would require the development of a national accounting system for sinks. Such a system is needed to ensure that the planting of trees and preservation of forests in a given area would not result in offsetting losses elsewhere. The decision on whether to include sinks in the trading system will be influenced by the outcome of the international negotiations.

Allocating Permits

In an emission trading system, some mechanism must be provided for allocating permits to sources. This could be done on the basis of baseline/historical emissions (where permits are given to those currently emitting) or through an auction (where revenues accrue to the government). These two mechanisms might also be combined: a portion of permits could be allocated on the basis of historical emissions while the rest are auctioned. In any case, the value of these assets could be large depending on the permit price, which is determined by the emissions target and the costs of substitutes. Given that an auction could produce substantial revenues, some decision would have to be made with respect to what to do with the proceeds. These could be used to redress inequities in the distribution of control costs, fund R&D for less carbon intensive energy sources and end uses, or to reduce taxes or the deficit.

For example, a reserve of allowances or a portion of auction revenues could be set aside to encourage more rapid development and diffusion of low greenhouse gas emitting technologies. Manufacturers of energy consuming equipment could compete for the set aside based on the degree to which they produce equipment more efficient than the average in use or than required by current mandatory efficiency standards. Such a program could yield reductions in energy demand and help buffer the consumer from the impact of higher energy costs.

Alternatively, permit allocation formulae could take into account the market impacts of the mitigation program. "Set asides" could be made available to those industries, workers, or consumers who experience a grossly disproportional share of the costs of control. A set aside could also be auctioned, with the revenues used to redress gross inequities in the distribution of control costs.

Allocation Based On Baseline/Historical Emissions

Under this approach, sources are given a number of permits based on baseline fuel production or emissions and an allocation formula. Various allocation formulae can be devised, weighted to greater or lesser degrees in favor of sources with high historical emissions. Emissions allowances are endowed to facility operators for no cost and would be transferable. Those receiving permits thus obtain assets of potentially large value from the government at no cost.

Such an allocation mechanism could create entry barriers. In a capital intensive sector like primary fuel production, where entry barriers are already substantial, new entrants would be further disadvantaged if they had to purchase permits – especially if existing holders hoard permits. This problem could be mitigated by withholding a number of permits for purchase by new entrants or by auctioning a portion on the open market. Such an auction would also facilitate price discovery in a new market. Although new firms will still be disadvantaged (as they will pay for all of their permits), they would be able to enter the market. The pool of permits would need to be withheld from existing sources to ensure compliance with budgeted national emission levels – unless there are specific international provisions for early banking.

It may be desirable to design an allocation that would allow credit for early emissions reductions (those achieved prior to the start of the program, but after the baseline period) -- in particular for those that reduced greenhouse gas emissions as part of government sponsored voluntary programs. If credits for past actions are given, the total credits allowed would need to be deducted from the overall permit allocation in order not to exceed national greenhouse gas emissions target.

Auction

Alternatively, an auction could be used to allocate permits. In this case, permit holders would pay the market clearing price for every unit of greenhouse gas released. Auctions ensure that permits are available for trade, and would serve to inform potential traders about current price levels. All participants have equal access to permits, placing new entrants on the same footing as existing emitters. As discussed earlier, since an auction could produce substantial revenues, some decision would have to be made with respect to what to do with the proceeds.

Relationship to an International Trading System

Because control costs differ substantially among countries, international trading offers the potential of large, global efficiency gains. The current U.S. position calls for the international agreement on greenhouse gases to incorporate the trading of reduction obligations. While such obligations are the responsibility of governments, the creation of a domestic trading program reduces transaction costs and increases the likelihood that the theoretical gains of international trading will be realized.

Without a domestic trading system, some mechanism for effecting an international transaction between governments would need to be created. That is, once governments trade international obligations, some means to allocate the change in national "allowable" emission levels to sources within the country must be created. Without a domestic trading program, this is likely to require government intervention. With a program, sources of greenhouse gases could themselves become agents in the international market and undertake this function, thereby lowering transactions costs.

Consistency among the rules of domestic and international trading is therefore important. The International Agreement will specify the time dimension of national obligations, the coverage of gases, as well as the rules for banking and borrowing. If the domestic specifications for emissions trading are consistent with those for the trading of obligations among countries, the potential efficiency gains of international trading are more likely to be realized.

Attachment: US Experience with Emissions Trading

The US has had more experience with emissions trading than any other country in the world. Specific programs include:

- *Sulfur Dioxide (SO₂) Allowance Trading:* The Clean Air Act Amendments of 1990 required a 50% reduction in SO₂ emissions from electric utility boilers. To accomplish this goal, a fixed number of emission allowances were allocated to electric utilities based on a formula reflecting historical emissions. In addition, a small portion of allowances are auctioned every year to facilitate price discovery and new entrants. Allowances are specifically excluded from being defined as rights to pollute, may be traded to any party anywhere within the continental U.S., and may be "banked" for use in future years. Participants need to conduct regular monitoring of emissions and make an annual accounting of their emissions. Penalties are imposed if emissions exceed the number of allowances held by a source.

A functioning market in SO₂ allowances now exists, involving both bilateral exchanges between companies, and brokered exchanges through third parties. This market, along with other factors,¹ has helped to dramatically reduce the cost of the abatement program. Initially, forecasters claimed that a 50% reduction (10 million tons) in SO₂ would correspond to allowance prices in the range of \$400 to \$1000.² However, prices for allowances that would be needed in the next decade to achieve this level of emission reduction currently range between \$90 to \$100. In addition, 1995 emissions were actually 40% below the legally required levels for that year.

- *Water Effluent Trading:* The US generally has regulated surface water quality through a system of discharge limits for large sources of water pollution. In addition, states have standards for ambient water quality which are often not attained even after large dischargers apply "best technology." The reason is that small ("nonpoint") sources (such as runoff from farms) contribute significantly to water pollution. A number of state and local governments are employing trading systems for watersheds that either permit trading among large dischargers, or allow large dischargers to fulfill their requirements by controlling nonpoint sources. These include the Fox River in Wisconsin, the Dillon Reservoir in Colorado, and the Tar-Pamlico River in North Carolina. The latter two programs are designed to manage future economic growth. Thus, the quantity of effluent allowances allocated exceeds current discharge levels. Once growth consumes this excess, trading is expected to reduce compliance costs.

¹ These include the fact that the bill that was actually adopted was not as onerous as many in industry had feared, the low price and widespread availability of low sulfur coal, the awarding of "bonus allowances," the postponement of capital investments, and lower than expected transportation costs.

² Hahn, Robert W., and Carol May, "The Behavior of the Allowance Market: Theory and Evidence," The Electricity Journal, March, 1994.

- *Inter-refinery Lead Trading:* EPA operated a lead trading program from 1983 to 1987 as it phased out lead from gasoline. Lead trading allowed refiners and importers to trade lead reduction credits in order to meet limits for the lead content of gasoline. The quantity of allowances to which a firm was entitled was determined by the amount of leaded fuel produced by the firm and the contemporaneous EPA standard. Those who bettered the standard could sell their credits to others. Some 10 billion grams of lead were traded during the course of the program at prices ranging from 0.75 to 5 cents per gram. Allowing the trading of lead credits reduced the costs of the program by approximately 20 percent.
- *Criteria Air Pollutant Trading:* EPA first began incorporating aspects of emissions trading in its air program in 1974, when it allowed a modified source to use "credits" earned by another source within the same plant to avoid additional regulatory requirements. Since then, emission trading has substantially expanded. Trades have numbered in the thousands and have been estimated by Hahn and Hester (1986) to have achieved savings between \$525 million and \$12 billion.
- *Market Mechanisms for Chlorofluorocarbon (CFC) Phaseout:* Under the 1987 Montreal Protocol to limit stratospheric ozone depletion, the U.S. required the phase out of the production of CFCs by 1996. As part of its program, the U.S. adopted a tradeable permit regime covering CFC manufacturers and importers. These allowances were allocated based on each firm's 1986 market share. As the market for CFCs declined, the system allowed firms to allocate production among different facilities according to the least-cost pattern of supply. It also gave CFC users the flexibility to switch between different CFC compounds, within the overall limit on allowances. This program helped reduce the costs of the phaseout. In 1988, EPA estimated that the cost to *halve* CFC use would be \$3.55 per kilogram. By 1993, it became clear that all uses could be *eliminated* by 1996 at a cost of \$2.45 per kilogram.

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Assistant Secretaries' Meeting
19 March 97 1:30pm

REVIEW OF CLIMATE CHANGE PAPERS FROM THE EPA

1. Trading paper

Issue: sign off? Yes, this paper is in good shape.

2. Technology diffusion paper

Issue: sign off? No, A. Ask that the quote by the 2001 economists be removed. The quote is out of context and subject to wide interpretation.

B. Ask the authors to justify why they continue to blur market failure and non-market barriers (e.g., high discount rates, risk aversion, incomplete information). The reasons for slow diffusion differ, and policies should reflect this difference.

The EPA claims that this "text-book" distinction has no added value to actual policy analysis. This is untenable. For example, tradable pollution permits were "textbook" economics a few years ago but have gone on the save the economy billions of dollars. **Does the EPA have evidence to suggest that no additional benefits are gain when a policy accounts for the distinction between market failure and non-market barriers?**

C. Effectiveness rates of programs are debatable. I calculated that the implied rate of return to a \$200 m/yr CCAP program with their 1.25 E/GDP goal was about 2000 percent.

3. Regulation and Standards

Issue: sign off? No, this paper needs a good edit. I will send my comments over directly.

II. IAT UPDATE

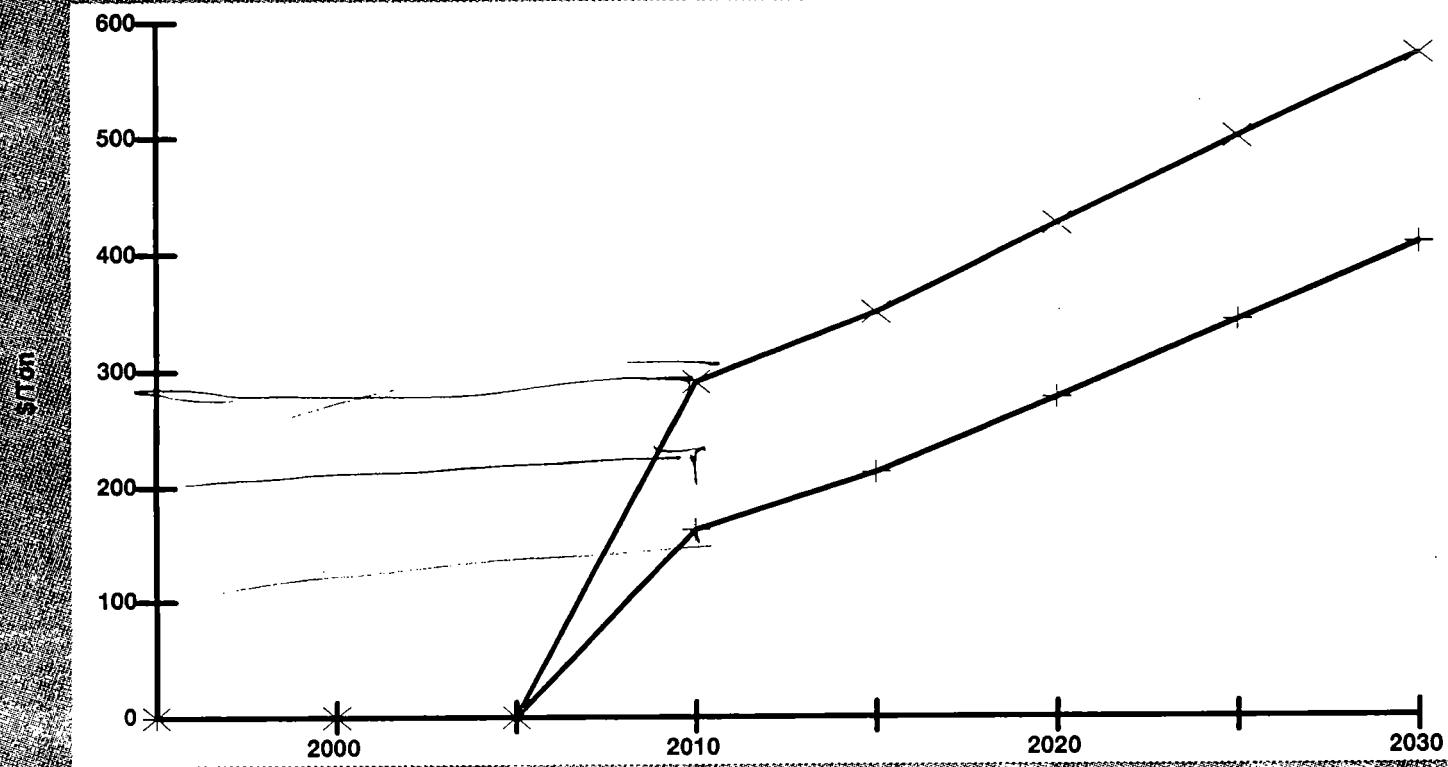
- 1. Rates of technological change remain an issue.** The implied 2000% rate of return for CCAP seems high to me. We need to ask for rates of return on tax payer dollars and ask whether these rates are reasonable.
- 2. Tax reform with and without carbon policy.** We asked for but have yet to receive the baselines with tax reform and no carbon policy?

year	gdp	%energy	%improve	gdp gain	disc factor	disc gdp	disc prog co
			0.25%		5%		2E+08
1	7E+12	0.04	0.0025	700000000	1.05	666666667	171428571
2			0.005	1.40E+09	1.1025	1.27E+09	163265306
3			0.0075	2.10E+09	1.157625	1.81E+09	155490768
4			0.01	2.80E+09	1.2155062	2.30E+09	148086445
5			0.0125	3.50E+09	1.2762816	2.74E+09	141034710
6			0.015	4.20E+09	1.3400956	3.13E+09	134318771
7			0.0175	4.90E+09	1.4071004	3.48E+09	127922639
8			0.02	5.60E+09	1.4774554	3.79E+09	121831085
9			0.0225	6.30E+09	1.5513282	4.06E+09	116029605
10			0.025	7.00E+09	1.6288946	4.30E+09	110504386
totals						2.76E+10	1.39E+09
rate of return							1982.98%

200 million -
 1.25 improvement
 in energy to
 GDP ratio

Why can we see growth
 from 1.00 to
 1.25
 history -

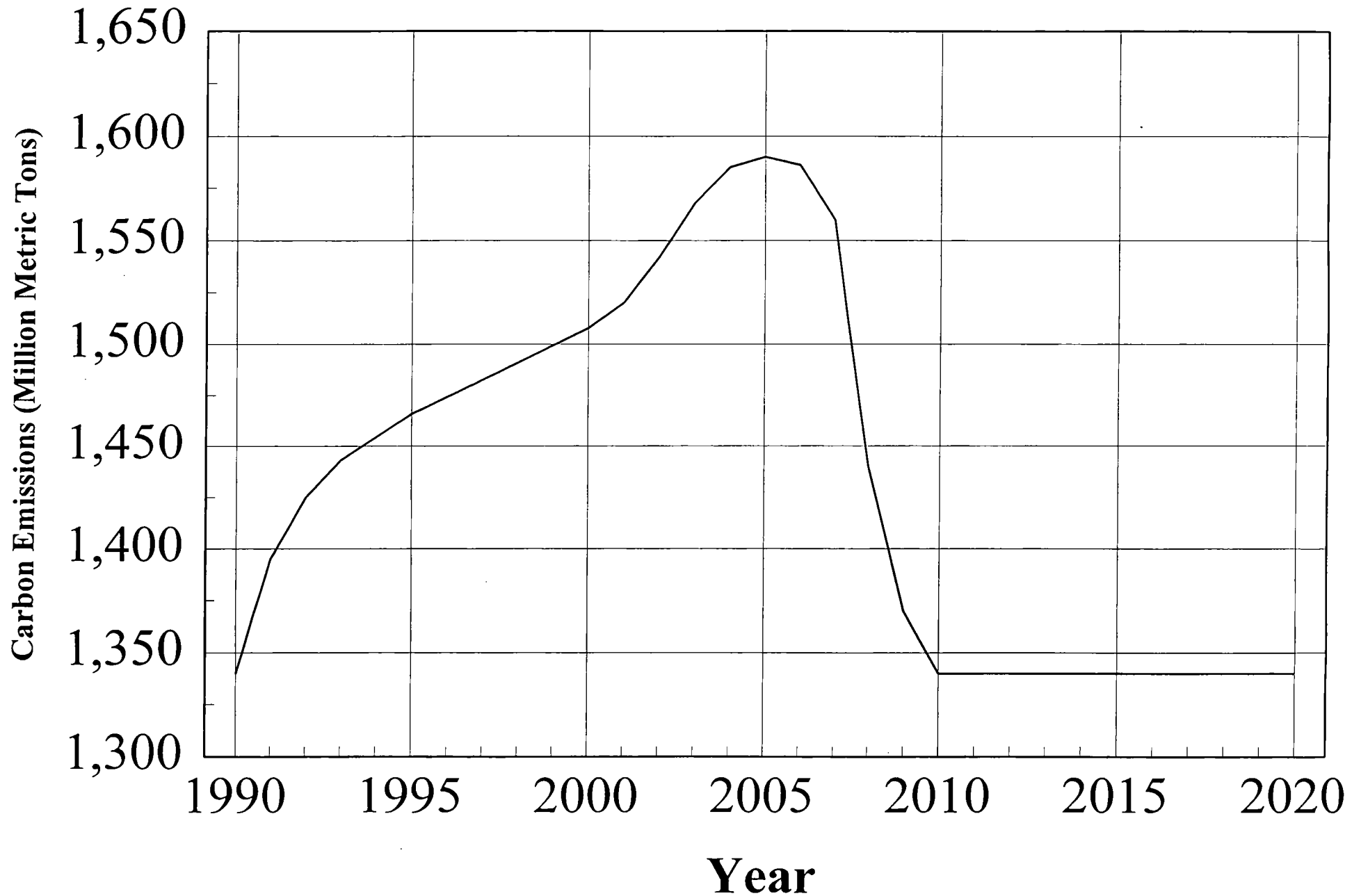
Carbon Tax



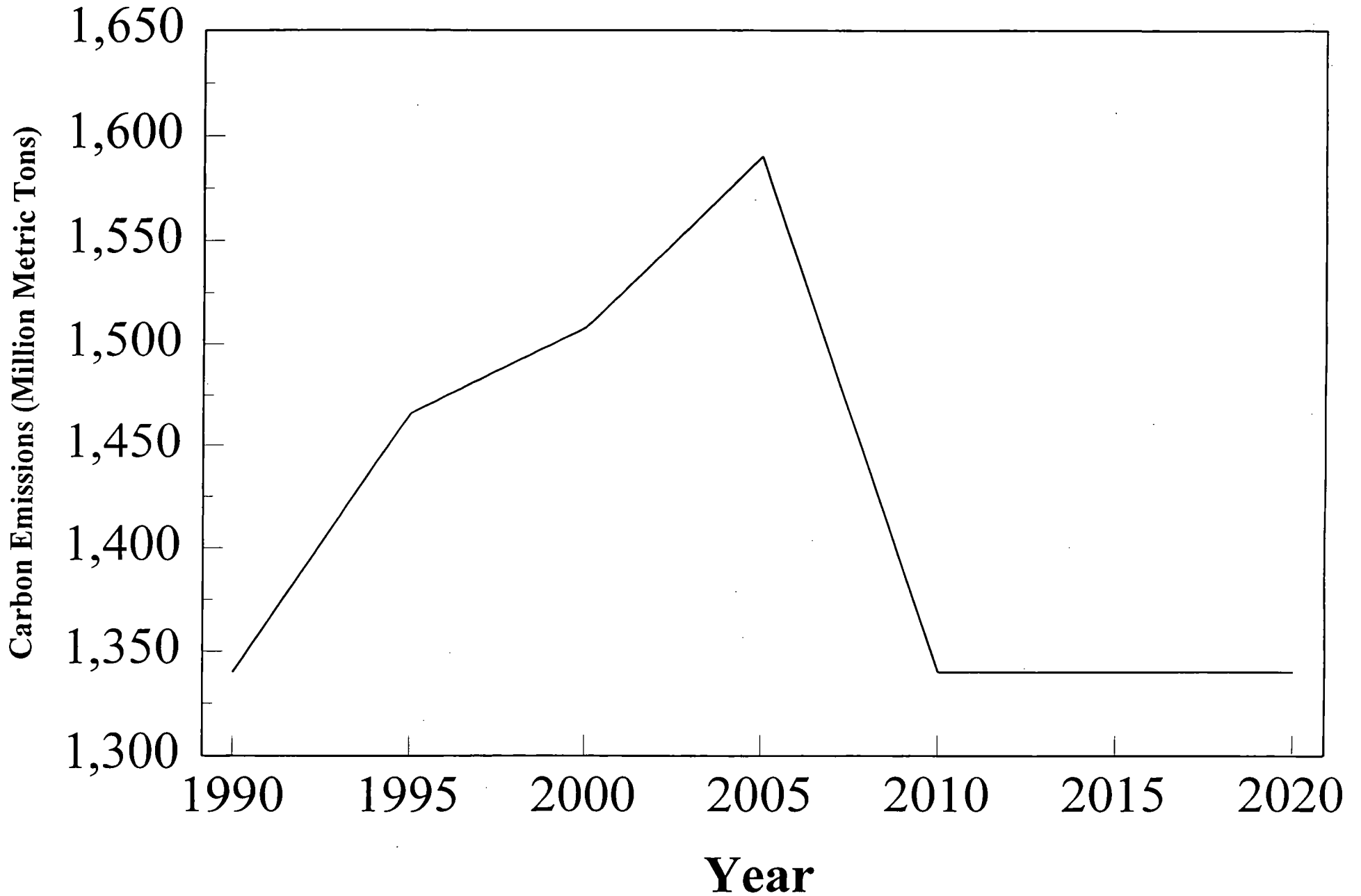
+
111
x
112

ID	Country	Policy	Oil Response	Import Subt	Backstop	Ref Scene
111	United States	US1	L	M	H	IS92A
112	United States	US2	L	M	H	IS92A

1.25 Extrapolated Stabilization Path



1.25 Stabilization Path



[All comes at a cost]

The Role of Technology Policies in Limiting Greenhouse Gas Emissions

"Economics studies have found that there are many potential policies to reduce greenhouse gas emissions for which the total benefits outweigh the total costs. For the United States in particular, sound economic analysis shows that there are policy options that would slow climate change without harming American living standards, and these measures may in fact improve U.S. productivity in the long run."

-- The Economists' Statement on Climate Change, Feb. 13, 1997 (signed by more than 2,000 economists, including six Nobel Laureates)

A strategy to accelerate the diffusion of existing technologies and the research, development and deployment of more advanced technologies is a critical component of any U.S. policy to stabilize greenhouse gas emissions. A cap and trade system alone — without such a technology strategy — would result in higher prices for carbon allowances than would otherwise be the case. Analysis suggests that an accelerated technology effort has a large potential for bringing down this price, and thus the cost to the economy. In addition to major studies in the early 1990s, forthcoming analysis by five leading National Laboratories finds that a large potential remains for reducing U.S. energy consumption and greenhouse gas emissions while meeting the full energy needs of U.S. businesses and families. In the long term, stabilizing concentrations at even twice pre-industrial levels, which will likely still have severe national and global environmental impact, poses an unprecedented challenge that can only be met with superior technology brought about by aggressive diffusion and significantly higher levels of R&D.

Two types of technology provide significant opportunities to reduce greenhouse gas emissions while providing our full energy needs. First, energy-efficient technologies are currently underutilized in all sectors of the economy. These technologies allow us to do more while consuming less energy and reducing pollution. Through increased energy efficiency, we can maintain GDP growth while cutting energy usage and associated greenhouse gas and other air pollution. Second, technologies using a variety of energy sources, such as solar, wind, and biomass, are becoming increasingly competitive. These technologies can supply energy with little or no carbon emissions, allowing us to sever the link between GDP and greenhouse gas emissions and other air pollution. Working together, energy efficiency and low-pollution technologies provide the means of sustaining economic growth while meeting medium- and long-term limits on greenhouse gas emissions.

In addition to reducing greenhouse gas emissions, these technologies provide other benefits to the nation that have long been the basis of national policy, including: achieving major reductions in criteria air pollutants, decreasing dependence on foreign oil, increasing productivity of domestic industries, and promoting U.S. leadership in the large and growing international market for advanced technologies.

By the year 2010, existing energy-efficient technologies comprise the bulk of the potential to substantially reduce greenhouse gas emissions in the U.S. The development of some additional key technologies, particularly in the transportation and energy supply sectors, can provide additional opportunities for economically beneficial reductions. Studies by the National Academy of Sciences, the Office of Technology Assessment, and the American Council for an Energy-Efficient Economy (jointly with the Union of Concerned Scientists and others) have all demonstrated that the technological potential exists to cut energy consumption and greenhouse gas emissions in the medium-term (by 20% or more at a net economic benefit. (Significant

*** PRE-DECISIONAL DRAFT -- Do Not Cite or Quote ***

March 10, 1997

Comments COB Friday

not of interest
- market has
- incentives to go
- be done anyway

why?

At what cost?

reductions before 2010 are more difficult to achieve cost-effectively because sufficient time must be allowed for the natural turnover of energy consuming equipment.)

A clear policy on limiting U.S. greenhouse gas emissions will help to focus attention on energy consumption and will provide important incentives for the diffusion of existing technologies and the development of even more advanced technologies. The technological response to past environmental policies, such as acid rain controls and the ban on CFCs, has been dramatic. In both cases, the actual cost of control has been dramatically less than early projections. Unfortunately, even with a clearer market signal, the technology response to a greenhouse gas policy will continue to be restrained. A host of market barriers contribute to today's large energy efficiency gap — the significant underutilization of existing, cost-effective energy-efficient technologies.

due to unavoidable reason

Federal policies that can unleash more of the technology potential are important because they allow a smoother and less costly transition to meeting a carbon constraint. Several federal programs, many of which were launched in the President's Climate Change Action Plan, are successfully overcoming market barriers to key energy-efficient technologies through partnerships with the private sector. These programs need to be fully supported, and additional initiatives need to be put in place to target the remaining barriers to energy efficiency.

1.25

To achieve a sustainable emissions pathway beyond the year 2010, there is an unavoidable need for advances in low-pollution energy supply technologies as well as continued improvements in the efficiency of energy using technologies. As global population and affluence continue to rise, technological advances provide the key to stabilizing global concentrations of greenhouse gases at safe levels without jeopardizing our quality of life. In order to stabilize greenhouse gas concentrations at safe levels, new technologies will have to reduce emissions by more than a factor of ten during the next few decades and be competitive enough to achieve deployment throughout the world. This need for major and continual advancements can only be met through a strong commitment to Federal RD&D.

mean what?

THE ROLE OF TECHNOLOGY THROUGH 2010

The key to cost-effective greenhouse gas reductions by 2010 is the large potential of today's underutilized energy-efficient technologies. Greater penetration of these technologies can enhance economic productivity through more efficient use of our energy resources. Paying energy bills is a relatively less productive use of consumer and business resources than the many other investments and spending choices that consumers and businesses have available to them. Shifting capital from energy expenditures to new investments elsewhere in the economy will help drive economic growth, employment and consumer income. Several major studies support the economic value of improved energy efficiency. For example, an Energy Information Administration report based on the *Annual Energy Outlook 1996* suggests that a reduction in U.S. energy consumption of 12 percent (by the year 2015) would increase GDP by 0.5 percent.

However, there is clear evidence that this potential is not being realized in the current market system because of a number of institutional, organizational, and other barriers that work against the diffusion of existing, energy-efficient technologies and the development of advanced technologies. The existence or availability of a financially attractive technology does not by itself

mean the technology will be purchased and used in sizable quantities. For high rates of market penetration, a number of other key factors must be in place:

- ▶ Potential buyers of products need to know of the technology;
- ▶ Potential buyers of products need clear, reliable information on the performance and economic benefits of the technology;
- ▶ Potential buyers must be the ones to see the benefits of lower energy bills;
- ▶ Service providers and users of the technologies must have expertise to appropriately design for, install, and operate the technology; and
- ▶ Sources of capital must understand the low-risk nature of these investments.

Mike can't do it

In many cases, these factors are not in place due to a wide variety of market barriers. For example, the attached table provides a list of market barriers in the buildings sector.

These barriers result in consumers and businesses ignoring otherwise cost-effective investments in energy-efficient technologies. Consequently, many of these energy-efficient technologies have relatively small market shares and low rates of technology diffusion. There is a sizable remaining potential, or "efficiency gap." For example, fluorescent lighting ballasts were found in almost every commercial building in 1989. Energy-efficient ballasts had been on the market for many years, were based on well-known, proven technology, delivered equivalent performance to its inefficient counterpart, and had a longer lifetime. Although purchases of efficient magnetic ballasts in 1989 represented investments with IRRs of 60% or greater, only about 12 percent of the market had found the technology and about 24 percent of the market was purchasing the technology due to state standards. The remaining 64 percent of the market was purchasing less efficient technologies and committing themselves to much higher operating expenses over the life of the ballast. This remaining 64% represented a large efficiency gap for building lighting.

A number of federal, voluntary programs are currently enhancing markets by overcoming the barriers to energy efficiency. The Administration's Climate Change Action Plan (CCAP) launched over 40 initiatives in 1993. Building on other DOE and EPA programs, the CCAP's goal was to return U.S. greenhouse gas emissions to 1990 levels by the year 2000. Despite large funding cuts, the CCAP programs are successfully overcoming market barriers and are currently expected to deliver approximately 3/4 of the emissions reductions originally projected. With continued support beyond the year 2000, these programs will significantly restrain growth in U.S. greenhouse gases through 2010 and beyond. Even at current funding levels, Administration projections indicate that these programs will eliminate 1/4 of total emissions growth through the year 2010, resulting in annual energy bill savings of approximately \$30 billion (in 1995 dollars). A sustained commitment to these programs beyond the year 2000 is needed to achieve these results, and restored full funding of CCAP programs will further cut the growth in greenhouse gas emissions. Total expenditures on CCAP programs in 1997 is \$183 million, \$120 million below the President's requested budget of \$305 million.

CCAP 1.25

A successful strategy to reduce greenhouse gas emissions by 2010 while improving the economy would include:

- (1) Restored full funding of CCAP programs, with a sustained commitment to these programs beyond the year 2000.

All about show people

- (2) New initiatives to overcome additional market barriers and aggressively develop and deploy key technologies.

Following is a discussion of the role of federal programs for accelerated technology diffusion and near-term RD&D in some key energy sectors. Because the CCAP's focus on the year 2000 limited the options that were implemented, a longer term goal provides significant new opportunities to overcome remaining market barriers and develop key technologies. Some of these areas of opportunity are also discussed below. An interagency effort is underway to assess potential initiatives to address these opportunities and to develop a national market transformation plan that effectively narrows the efficiency gap by 2010 and beyond. Example approaches mentioned below are illustrative of the types of initiatives that may be included in a final plan.

BUILDINGS

The largest untapped potential is our daily energy use in homes and commercial buildings, which consume one-third of the nation's energy and two-thirds of its electricity. Deploying existing, cost-effective technologies could return greenhouse gas emissions to below 1990 levels by 2010. These technologies include improved lighting, heating, cooling, windows, insulation, office equipment, energy management systems, and geothermal heat pumps. Many of these technologies improve the quality of service delivery (for example, improved comfort and lighting quality) and have been documented in a number of cases to improve productivity.

DOE's Rebuild America program and EPA's Green Lights and ENERGY STAR Buildings programs are demonstrating that many of the barriers to energy efficiency in the commercial buildings sector can be overcome. These programs have formed over 2500 partnerships to improve energy efficiency in buildings by up to 40% through technology investments with annual rates of return of 20-50%. Program partners saved over \$250 million on their energy bills in 1996. Because the rates of return on energy efficiency investments in commercial buildings are so high, they offer increased yields to businesses over typical investment opportunities, spurring new investment, economic growth, increased federal tax revenues, and new jobs.

EPA and DOE's ENERGY STAR Consumer Labeling program is removing barriers that consumers have faced in purchasing energy-efficient home products, such as heating and cooling equipment and appliances. The program has already transformed a number of markets, including cutting the energy used by computers, monitors, and printers by 50% at virtually no incremental cost. Manufacturers of home products are now partnering with the federal government and labeling their more efficient products as consumers are provided with information on these products' environmental and economic benefits. Through 1996, this program has seen thousands of products labeled and billions of dollars invested in ENERGY STAR products. Consumers saved approximately \$500 million on their energy bills in 1996.

Additional opportunities for new initiatives include:

Overcoming Split Incentives — In landlord-tenant arrangements, the building owner often makes long-range investment decisions but does not pay the energy bills for the property. In these situations, the owner will often not invest in energy efficiency opportunities in spite

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of excellent, low-risk financial returns because the returns go to someone else. The same problem occurs with building designers and builders, because they choose the technologies for new buildings but do not pay the energy bills. EPA and DOE could develop a means of providing reliable and impartial energy performance information for commercial buildings. This would allow building purchasers to make informed decisions and demand good energy performance. CCAP programs in this sector have built the reputations and developed the technical expertise that would be needed to address these barrier.

Energy Information — Empowering consumers and businesses to save money and preserve the environment requires that they be properly informed about energy choices. One available vehicle for better information is their monthly energy bills. Better information could include benchmarking comparisons showing how their bill measures up to model, cost-effective efficiency and to other customers. It could also include information on the overall efficiency and renewable components of the customer's power provider.

RD&D of Fuel Cells — An aggressive 5-year R&D effort aimed at fuel cells (running on hydrogen converted from natural gas), such as proton-exchange membrane (PEM) fuel cells, which could become the most cost-competitive energy provider for buildings (and light industry). If successful, a new or retrofit building in 2010 using efficient technologies with electricity and hot water provided by an 80% to 90% efficient fuel cell could have no first-cost penalty with well under half the energy bill of a typical 1990 building and one-quarter the greenhouse gas emissions.

Reflective Surfaces — Recent research has shown that a city can be cooled by five or six degrees Fahrenheit by planting shade trees and replacing roads, roofs and parking lots with lighter surfaces during the course of normal maintenance. This nominal additional cost could, by the year 2010, save the country up to \$5 billion a year in energy and environmental costs. In Los Angeles alone, this would lower annual air conditioning bills by \$170 million and reduce the creation of ozone smog by 10%. An aggressive diffusion and targeted reflective materials R&D effort could yield substantial greenhouse gas reductions.

INDUSTRY

The industrial sector consumes about one-third of the nation's energy. Since 1985, the energy intensity of the industrial sector has not improved significantly. Yet major energy-saving technological advances have continued steadily in cross-cutting areas (such as motors, which consume 70% of industrial electricity) and in industry-specific areas (such as impulse-drying in paper manufacturing, vacuum pressure swing adsorption in glass making, and electrochemical dezincing of steel scrap). Many industrial efficiency improvements also offer important productivity benefits. As an example, the average total annual savings from many energy efficiency projects undertaken at the Louisiana Division of Dow Chemicals were 3 to 13 times as large as the energy savings alone.

Several CCAP programs are achieving near-term efficiency improvements. DOE's Motor Challenge program, for example, is providing technical support to over 1,600 industry partners. Rather than focusing on a particular technology, DOE and EPA's Climate Wise program is working with over 250 companies to develop company-specific plans to reduce greenhouse gas emissions.

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The seven most energy-intensive industries—steel, aluminum, petroleum refining, chemicals, pulp and paper products, glass, and metal casting—account for about 80% of the energy consumed in U.S. manufacturing. They represent the largest opportunity for reducing industrial greenhouse gas emissions. DOE has formed long-term partnerships with each of these industries to develop "Visions" of energy-efficient, low-polluting, highly competitive "Industries of the Future," as well as roadmaps to identify an RD&D pathway to achieving the vision.

The announcement of a new climate policy would create a large opportunity to work more aggressively with major industries such as these to achieve significant reductions by 2010. The industry Visions developed with DOE typically foresee between a 1% to 1.5% per year improvement in efficiency for two decades. Achieving the high-end of that range, or even higher (by accelerating the rate of implementation) is possible, but would require a significantly greater government-industry effort. Because industry has already identified niches for each technology pursued, the diffusion of newly developed technologies can occur relatively quickly. For example, we have already seen in the metal casting area a leap from idea to actual prototype in 18 months.

Not only can we reduce the energy intensity of industry, an aggressive RD&D program could begin to reduce the carbon intensity of industrial energy consumption. Accelerating our current R&D effort in advanced gas turbine cogeneration (coupled with regulatory streamlining for accelerated diffusion) could allow significant market penetration by 2010 of distributed power plants with efficiencies in excess of 85%. Industries such as pulp and paper could power these turbines with low-cost biomass feedstocks.

TRANSPORTATION

Fuel economy has been flat for over a decade due in part to the absence of increased fuel-efficiency standards, but also because consumers haven't themselves demanded increased fuel economy. The attributes of cars most desirable to consumers change over time. During the 1970s, when oil prices were high, fuel economy was one of the top features consumers looked for when shopping for cars. Lately, fuel economy has fallen while speed, acceleration, four wheel drive and amenities are more in demand. Since 1982, the average horsepower ratings of the new light vehicle fleet has increased by 60 percent while the average fuel economy of the same fleet has remained unchanged. From an engineering point of view, manufacturers have increased the efficiency of new cars, but that efficiency has been devoted to delivering what consumers want today. Had the new cars sold in 1996 retained the same average acceleration performance and average weight as the new cars sold in 1982, the improved technologies actually incorporated into the fleet during this period could have increased new car fuel economy by about 6 miles per gallon, or about 20 percent. If fuel prices and/or consumer preferences were to change again, and there were increased demand for better fuel economy in new cars, manufacturers could redirect both past and future technology improvements to deliver better fuel economy.

With the focus on the year 2000, CCAP programs are focusing on reducing fuel consumption through increased telecommuting and reduced traffic congestion. The Partnership for a New Generation of Vehicles (PNGV), on the other hand, is a longer-term effort to develop more efficient technologies for new vehicles. PNGV is a joint automotive research and development effort between the federal government and the U.S.-based automakers. The goal is to develop new automotive technology that can more than double the fuel efficiency of a typical family sedan while

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meeting stringent emission and safety standards and maintaining affordability, performance, and utility. The timeline is for basic component research through 1997-1998, the design, buildup, and evaluation of concept vehicles through 2001, and the development of production prototypes by 2003-2004. Increasing the fuel economy of a midsize vehicle from 27 to 80 miles per gallon would reduce the carbon dioxide emissions of that vehicle by two-thirds. The full impact of the PNGV program and its effect on fuel efficiency won't be realized until beyond 2010. However, some of the technology elements that are developed will also provide an important near-term opportunity for improving fuel efficiency in vehicles prior to 2010.

One technology that offers the chance for dramatic gains in efficiency that could be realized by 2010 is the diesel engine. The diesel has a number of advantages from the perspective of stabilizing in 2010. Diesels are already more than 40% efficient, and a 55% efficient diesel is a plausible outcome of near-term research, an efficiency that no other engine can surpass or even match before 2010. Also, both the fuel and manufacturing infrastructures already exist for diesel, unlike several other proposed advanced engines, making rapid penetration more feasible. Advanced diesels not only afford potential savings in a hybrid for cars, but also for sport utility vehicles and light duty trucks (the segment of fastest growth in fuel use), and in heavy duty trucks, with their low fuel economy (7 to 8 mpg). The key problem is the unacceptably high level of particulate and NOx emissions. A "clean" diesel would be a major achievement, and is now viewed as plausible by many even in the near term through a combination of a cleaner fuel (such as dimethyl ether which can be made from natural gas or ethanol), an advanced engine, and after-treatment (including advanced catalysts). DOE is pursuing all of these areas, but successful penetration by 2010 will require additional funding.

Ethanol is another prime candidate for an intense RD&D effort. Federal R&D has brought the cost of ethanol from \$3.60 per gallon in 1980 to \$1.20 per gallon. With continued R&D in bio-engineered organisms and fast-growing crops, the biofuels program is expected to produce ethanol for under 70 cents a gallon by 2005, competitive with oil at its current price (ethanol has lower energy content). The ethanol would be derived not from the starchy (i.e., edible) part of corn, as it is now, but from cellulosic waste (such as waste paper or crop waste) and dedicated crops, either herbaceous (as from switchgrass) or woody (as from hybrid poplar trees). A 1996 Argonne analysis of total fuel cycle shows a greater than 90% reduction in greenhouse gases from woody-biomass-derived E85 (85% ethanol) compared to reformulated gasoline.

ADDITIONAL CROSS-CUTTING OPPORTUNITIES FOR NEW INITIATIVES

A number of additional opportunities exist across all sectors of the economy. For example:

Financing for Energy Efficiency Investments — Large companies often rely on their own capital for new investments and yet are reluctant, due to organizational barriers, to use that same capital for investments in efficiency (even though they offer impressive rates of return). Small to mid-size businesses and consumers have little access to capital to begin with, and they have a difficult time obtaining reasonable financing. Consequently, in all sectors of the economy, there are significant opportunities for efficiency improvements that could be made if financing designed specifically for energy efficiency investments were widely available. Previous opportunities to achieve a public good through organizing financial markets have been addressed by creating a secondary financing market through "government sponsored enterprises" (GSEs), like Fannie Mae, Freddie Mac or Sallie Mae.

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These GSEs purchase particular types of loans (e.g. home mortgages, student loans) from primary lenders, such as commercial banks and mortgage companies, and bundle these loans for sale in the secondary security market to investors. After more than three years of effort, much of it aimed at developing a broadly accepted North American Monitoring and Verification Protocol for efficiency retrofits, DOE has laid the foundation for jump-starting a billion dollar a year secondary market for energy efficiency loans.

Incentives Through a Domestic Greenhouse Gas Policy — A new U.S. climate change policy would provide unique opportunities to provide further incentives to improve the penetration and innovation of energy efficiency and renewable technologies. This could work in a number of ways. For example, under a domestic trading system with a cap on greenhouse gas emissions, a reserve of allowances or a portion of auction revenues could be set aside to reward new R&D investment and production of efficient and renewable technologies.

Business Accounting Practices — Currently, companies ignore future energy liability and undervalue the benefits of investments in energy efficiency. When a firm invests in energy efficiency, the accounting shows only a liability, and there is no recognition of the reduction in future energy expenditures. With the longer term focus beyond 2000 and a clear policy signal on energy, it may be possible to work with businesses to develop new practices that more accurately reflect energy liabilities. Strategic improvements to tracking demand and use of energy resources would allow firms to identify and capitalize on profitable improvements that are currently hidden in the noise of corporate financial data.

Government Procurement — In addition to providing a strong energy signal to businesses, a new climate policy will create additional opportunities for coordinated government action in promoting efficient technologies. Programs like ENERGY STAR Computers have benefited significantly from federal procurement policy in the past, but innovative initiatives are often difficult because of decentralized and sometimes restrictive procurement policies. The federal, state, and local governments together purchase a sizable portion of energy-consuming technologies. Harnessing the combined purchasing power of all levels of government could be an important opportunity to provide large markets for efficient and renewable technologies. This would provide a strong incentive for increased R&D; reduce the cost of production of these technologies (due to the effects of "learning by doing"); demonstrate the successful performance of new technologies; and make all participating governments more energy efficient.

ELECTRICITY PRODUCTION

The efficiency improvements described above could slow electricity demand growth substantially, and much of the growth that did occur could be provided locally by distributed cogeneration, such as advanced turbines in industry (running mainly on natural gas, with some biomass) or fuel cells in buildings (running on natural gas). The very low central station power demand growth means that the replacement of dirtier plants with cleaner ones that is expected to occur would also be slowed. However, a clear and consistent price signal from a cap and trade system at even a low level could have a substantial effect, most likely causing some of the dirtiest and oldest coal plants to be repowered with natural gas.

Such a price signal for carbon would almost certainly lead to increased utilization of natural gas, through a combination of increased gas use at dual-fuel power plants and repowering of selected older, inefficient plants. An estimated 10% of existing coal capacity is nominally dual-fuel. While some of this capacity would require some investments to use gas, the infrastructure is already there and costs would be minimal — likely well under \$100/kW. Repowering of older coal plants with gas would cost an estimated \$400/kW. This increased use of gas could be expected to increase prices. That suggests the need for expanded R&D into lowering the cost of natural gas production and increasing the domestic resource base, though efforts such as improved drilling and advanced computational modeling. Such R&D could have a large impact on the cost of climate mitigation.

In addition, much technological progress has been made in co-firing biomass fuels with coal. This technology exists, but economic incentives for widespread use are currently lacking. Incremental capital investments would be required, but up to an estimated 40% co-firing biomass with coal would be possible at costs of \$150-250/kW — making biomass co-firing an attractive option under a cap and trade policy.

THE ROLE OF TECHNOLOGY BEYOND 2010

A strategy of continued diffusion of efficient energy using and energy supply technologies and accelerated development of key new low-carbon technologies during the next decade sets the stage for accelerated development and diffusion of a number of very-low and zero carbon technologies that may begin to see limited penetration by 2010, but will have substantial impacts after 2010. The need for major technology advances can be seen from the following equation:

$$\text{Emissions} = \text{Population} \times \text{Affluence (GDP/capita)} \times \text{Technology (Emissions/GDP)}$$

From 1990 to 2050, we may well see global population double and affluence increase by a factor of four. At the same time, just to stabilize concentrations at pre-industrial levels (which would still have severe national and global impact), the world may ultimately need to *lower* emissions from 1990 levels, requiring the average emissions-related technology to improve by more than a factor of ten during the next few decades and then be rapidly deployed throughout the world.

This section examines the most promising R&D for mitigating CO₂, focusing on four strategic thrusts: (1) clean power generation, (2) energy efficiency, (3) carbon sequestration accompanying a transition to a hydrogen-based economy, and (4) basic and very advanced research. Responding to the climate problem may require breakthroughs in all of these areas, and in any case the high-risk nature of R&D requires the pursuit of multiple pathways.

Increasing the probability of achieving these desirable outcomes will require expanding the government's current R&D spending in these areas, which is roughly \$1.3 billion per year. Also, the policies described in the previous section, including partnerships with industry, "market pull" deployment initiatives, and improved regulations, will be required to ensure technological success and accelerated market penetration. The benefits could be enormous, including the avoidance of the costs associated with the other approaches to CO₂ mitigation such as higher taxes and regulation. A 1997 study by Pacific Northwest Laboratory found that developing and deploying advanced technologies over the next 15 to 30 years could substantially lower the cost to the global economy of achieving major reductions in emissions of greenhouse gases.

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CLEAN POWER GENERATION

Natural gas technologies now set the benchmark for low cost, cleaner power generation. Moreover, advances in natural gas turbines will yield overall energy conversion efficiencies of 60% or more in the next decade, doubling the efficiency of traditional coal-fired plants. High temperature fuel-cells, such as molten carbonate and solid oxide, may have significant application in power generation with further R&D, promising high efficiency and low emissions. Molten carbonate fuel cells are expected to reach 50-60% efficiency by 2000, and perhaps 70% by 2005. As a result, fuel cells can cut greenhouse gas emissions by as much as 50%.

High efficiency coal-fueled power plants, such as integrated gasification combined cycle (IGCC) are now being demonstrated at efficiencies (40 to 43%) that are competitive with more traditional coal-fired power plants but with much lower emissions, including 35-45% lower CO₂ emissions. The efficiency of the next generation IGCC plant could exceed 55%, and, in combination with a fuel cell, achieve 60% by 2015. While lowering CO₂ emissions, these technologies also dramatically reduce traditional pollutants, such as particulate matter, nitrogen dioxide, and sulfur dioxide, while allowing the continued use of low-cost fossil fuels. Hence, advances in technology from federal R&D in this area will ensure the supply of low cost, clean electricity, while helping the U.S. realize domestic and global market opportunities for these superior technologies.

While electricity from fossil fuels continue to become cleaner and cheaper, expanded R&D and deployment could make a number of renewable technologies competitive on purely economic grounds in the next two decades: wind power, PV, biomass power, solar thermal, and geothermal. In a greenhouse-gas constrained world, these zero-carbon emitting sources of power would be even more competitive. Royal/Dutch Shell projects these technologies to be the dominant global source of energy by the middle of the next century.

Renewable technologies are becoming more economically competitive over time. Both wind and PV are experiencing a 20% cost reduction for every doubling of cumulative production. Photovoltaic (PV) cells, which convert sunlight into electricity, have dropped from 90 cents per kilowatt-hour in 1980 to under 20 cents today while wind power has dropped from 25 cents per kWh to 5 cents. These cost reductions will continue to occur not just because of R&D, such as advances in thin film PV, but also through economies of scale and improvements in manufacturing that come with increased production. A number of different PV technologies are being pursued, providing multiple opportunities for breakthroughs. Accelerated RD&D for wind could potentially have an impact on CO₂ emissions in 2010.

Nuclear power provides 22% of our electricity emits no CO₂ and its contribution to reducing CO₂ emissions is expected to increase as plants become increasingly efficient over the next decade. However, these plants are due to begin retiring by 2010, with virtually all capacity due to be retired by 2030. To keep nuclear power a viable option for future electricity production, DOE has developed advanced nuclear reactor designs soon to be certified by the Nuclear Regulatory Commission. A plant similar to these advanced designs was recently completed in Japan at under half the time and about half the cost to complete the most recently finished U.S. nuclear plants. In addition, the Department is conducting R&D on life extension of existing nuclear power plants so continued operation of these zero carbon technologies is an option in the future.

Opportunities for new initiatives include:

Increasing market penetration of technologies such as PV and fuel cells — Government investments in R&D cannot be limited by the old notion of the linear model of R&D where basic research is fed into a technology pipeline and out pops a commercialized product. Today's complex technologies do not begin with basic research and then proceed in a simple fashion through the different stages until marketing begins. Successful innovation relies heavily on communication and feedback between engineers and scientists throughout the innovation process, including the later stages of development. Rapid penetration of clean technologies requires a concerted effort of activities across the technology innovation spectrum. The CCAP contains a number of measures to reduce costs through accelerated domestic deployment for wind, PVs, geothermal, and fuel cells, but these efforts are severely under-funded.

Increasing international diffusion of advanced supply technologies — A U.S. strategy to accelerate market penetration of these technologies requires an international component. Many renewables are most cost-effective today in developing countries without an electricity grid. Advanced coal technologies will be critical in developing nations with large coal reserves, such as China. Besides lowering costs, many of these efforts give vendors and utilities experience using these new technologies in niche markets, helping to remove barriers to more expanded use in the future as the technology improves.

A new government partnership with utilities — The power industry is reducing R&D and deployment of renewables, fuel cells and other technologies in the face of increased competitive pressures — which in turn drives short-term cost-cutting efforts. Congressional legislation to restructure the utility industry may well be enacted in the next two years — providing a crucial opportunity to find alternative means to support R&D and deployment of low-carbon power generation technologies.

Given the uncertain nature of R&D, the level of funding necessary to achieve such a world cannot be known, but is likely to be considerably higher than today's investment levels, especially if the Nation seeks to maintain world leadership in these technologies. In PVs, deep R&D cuts in the 1980's have left us with only 40% of the world market. The Japanese outspend our \$60 million R&D effort in PVs by more than two to one. The relatively high price for electricity in other developed nations, and the far greater financial incentives they offer industry, means alternative energy will be cost-effective in foreign countries before it is here. Our primary competitive advantage can come only from technological leadership. Innovative partnerships aimed at domestic deployment are essential because there aren't many instances of a nation achieving global market leadership in a technology for which there was not a robust domestic market.

END-USE ENERGY EFFICIENCY

Technology R&D in transportation is essential because the sector uses very little electricity, so advances in clean power generation offer little hope of lowering its CO₂ emissions in the near term. Also, two other major national problems — urban air pollution and dependence on foreign oil — stem largely from the transportation sector. The current federal strategy is to develop cars and trucks that are highly fuel-efficient as well as ones that run on fuels other than petroleum, including natural gas, electricity, and biofuels (ethanol). We could see significant penetration of biofuels in the next two decades with the RD&D strategy discussed in the first section.

As mentioned previously, the Partnership for a New Generation of Vehicle (PNGV) is pursuing multiple pathways for both advanced engines (hybrid electric, Stirling engine, gas turbine and clean diesel) and energy storage (such as a batteries, flywheel or ultra capacitor). Supporting R&D includes lightweight, super-strong materials such as composites; high-temperature ceramics; regenerative braking; and advanced power electronics. PNGV vehicles, available just prior to 2010, will be 2.5 times more efficient than today's conventional vehicles, providing large potential to reduce greenhouse gas emissions.

Proton Exchange Membrane (PEM) fuel cells have perhaps the greatest long-term potential for reducing transportation CO₂. Recently PNGV developed an on-board reformer for converting gasoline into hydrogen to run a PEM fuel cell, which would have a 50% increase in fuel efficiency over an internal combustion engine, half the CO₂, and a 90% reduction in conventional pollutants. below ultra-low emission vehicle standards. A PEM fuel cell running on ethanol would have virtually no net CO₂ emission. A decade of R&D may be needed to bring costs down and integrate fuel cells into a commercial vehicle, which Chrysler has committed to do in partnership with the government. Maximum efficiency and emissions reductions would come from running the car on hydrogen directly, which will require even more research with automakers.

The ultimate low-CO₂ vehicles and the fuels they would use cannot be known today. To ensure that the R&D leads to commercially viable vehicles, a number of programs are needed to guarantee that the infrastructure is available to support vehicles that run on non-traditional fuels.

The Industries of the Future visions and technology roadmaps identify the best R&D opportunities for increasing energy efficiency and reducing emissions in the industrial sector while increasing productivity. These include advanced materials development, such as ceramic composites; separation technology, such as advanced membranes; catalysis; bioprocessing, biocatalysis, and renewable feedstocks; sensors and controls; and industrial cogeneration. All of these industries would like to dramatically improve their environmental performance. The pulp and paper industry, for example, sees the possibility of becoming a no-net-CO₂ industry, through a combination of efficient use of energy and biomass cogeneration.

These industries (except chemicals) significantly under-invest in R&D compared to the industry average. What R&D they have devoted to the environment has traditionally been focused on compliance — end-of-pipe treatment and control, as opposed to prevention — since that is how our regulatory system is designed. While increased R&D is needed, the Administration's regulatory reinvention revolution must succeed.

Federal RD&D into buildings technologies has been remarkably successful. Consider just five technologies developed or advanced by the national laboratories in the past two decades at a cost of roughly \$40 million — building design software and advanced lighting, windows, oil burners, and refrigerator compressors. These have provided cumulative net savings of more than \$25 billion to consumers and businesses, exceeding the \$8 billion spent on all energy efficiency R&D since 1978. They now provide 18 million metric tons of annual CO₂ savings.

Continued RD&D in the buildings sector is likely to prove just as cost-effective. Key near-term technologies include improvements in lighting, superwindows, advanced design software, high-efficiency clothes washing, heat-pump water heaters, gas heat pumps, improved insulation and duct systems, more efficient cooling including gas cooling, solar heating and cooling, and day

lighting, and urban heat island mitigation R&D (such as more reflective roofing and road materials). Longer term R&D needs include electrochromic glazings for windows, building-integrated PV systems, and PEM fuel cells, all of which could begin to see market share before 2010 and make a very large impact in the following decade.

Opportunities for new initiatives include:

Increasing federal investments in technology RD&D with industry — Most of the technology pathways that will result in sizable reductions in CO₂ emissions in the 2010-2020 time frame are being pursued today, but at funding levels substantially below what is required to maintain greenhouse gas stabilization beyond 2010 at relatively low economic costs to our nation. Examination of these pathways and increased funding in some key areas is of critical importance.

CARBON CAPTURE AND SEQUESTRATION

In addition to the portfolio of R&D options related to less CO₂ intensive technologies for energy supply and use, capture and disposal of CO₂ offers an additional alternative for reducing atmospheric concentrations of CO₂. If major reductions in CO₂ emissions are necessary, and global reliance on fossil fuels continues beyond the middle of the next century, then some form of CO₂ sequestration will almost certainly be needed.

Moreover, a successful program to develop safe, low cost greenhouse gas sequestration options should garner bipartisan support for progress on climate change issues by allowing for continued use of fossil fuels while minimizing the direct costs of mitigation programs. If these disposal techniques are sufficiently low in cost, they could also be a means to induce developing country participation in a climate change mitigation program, thereby overcoming another institutional barrier to implementing an effective mitigation program.

A long-term R&D strategy would include demonstration of a number of sequestration options and research into their possible environmental impacts; converting CO₂ into an industrial chemical feedstocks; other novel sequestration options, such as CO₂ fixation by micro-algae; selectively permeable membranes for CO₂ capture; processes for converting fossil fuels and biomass into CO₂ and hydrogen; development of hydrogen infrastructure technology, including transportation and storage; and PEM fuel cells.

Technology R&D into clean power generation and energy efficiency support many long-standing national goals and have been pursued for years. Carbon dioxide capture and sequestration, however, makes sense on a massive scale only in a greenhouse-gas constrained world. So, at least in this country, this area has been relatively under funded; since 1990 Japan has spent more than 30 times what we have on CO₂ capture and sequestration.

BASIC AND ADVANCED RESEARCH

A number of areas of basic research could prove crucial to responding to climate change, including biotechnology, fermentation microbiology, combustion research, polymer and ceramic science, process engineering, supercritical CO₂, new materials synthesis, and nanotechnology. We need to better understand the underlying biochemistry of the bioconversion of carbon dioxide to

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methane or to other potential fuels and feedstocks. This new research includes the ability to sequence the genetic material of microorganisms and plants, to develop new molecular genetic engineering techniques, and to understand biophysical and biochemical pathways of photosynthesis.

One essential area for expanded R&D is superconductivity. Superconductors offer the possibility of storing and transmitting electricity with virtually zero loss, with potential savings of 5% to 10% of all electricity presently generated by utilities. Highly efficient superconducting motors could have an even larger impact since motors currently consume 60% of all electricity. While U.S. and German funding is roughly \$40 million annually, Japan spends nearly \$70 million, not including their superconducting MagLev train program, with some \$3.5 billion being spent over five years. Significant increases in both basic and applied research in superconductivity should be an essential part of a low-CO₂ R&D strategy.

reshed Tech barriers
Historical Forces ~~Leading to Market Barriers~~ to Energy Efficiency in the Buildings Market

Type of Barrier	Nature of Barrier	Examples of Barrier
Imperfect Competition Natural Monopoly Market Power (Monopoly and Oligopoly) Anti-Competitive Conduct	Economies of scale Bargaining power; Interdependent conduct Collusion; predation	Electric utilities Uniqueness of building location; few development firms in one area Manipulation of permit process to the detriment of competitors
Information Availability Information Costs Asymmetric Information Misinformation Lack of Information	Transaction costs Unequal bargaining Misinformed exchange Uninformed exchange	High cost of customized audit (cheaper if done en masse); collecting product info; finding credible information sources Developer's superior knowledge of building Belief: "no efficiency increase is possible" No knowledge of efficient technologies
Economic Non-Rationality Bounded Rationality, Satisficing Other Non-Rationality	Using rules of thumb to reduce transaction costs; not maximizing profits Cultural reasons for taking actions that affect business practice	Ignore costs that are < 5% of rent; use a two year payback; seek acceptable profits Preferring energy production to cost-cutting because it is more congruent with management culture
Risk Aversion	Resistance to change	Avoid changes in suppliers and technologies; avoid new technologies
Side Effects	Negative externalities from power production	Pollution from power generation; dependence on imported oil; risks of nuclear energy
Split Incentives	Utility costs not paid by purchaser and user of equipment	Landlord-tenant problem; builder-buyer problem
Public Goods R&D Expertise and Training	Non-excludability, zero marginal costs Non-excludability, zero marginal costs	Too little R&D performed Too little training on efficient design, installation and maintenance; too little information dissemination
Cash Flow Constraints	Lack of access to capital	Small business tenants on the edge; developer's reluctance to take on more debt
Regulatory Distortions Regulatory Bias Average Cost Pricing Building Codes	More profits for energy production than for efficient use Price signals do not reflect cost, leading to inefficient usage Obsolete codes and poor code enforcement inhibit innovation and efficiency; # of inconsistent codes inhibits achieving economies of scale	Utility reluctance to install conservation even when cheaper than new supply Utility regulation in the US Local US building codes contain requirements that interfere with efficient construction; thousands of building codes in the US

productivity \Rightarrow \leftarrow

cc: AW
JAF
SS

FAX TRANSMISSION

U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF POLICY, PLANNING AND
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401 M STREET SW
WASHINGTON, DC 20460
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FAX: 202-260-0275

To: Assistant Secretaries Group **Date:** March 17, 1997
Fax #: See attached list. **Pages:** 10, including this cover sheet.
From: William N. White
Special Assistant to David
Gardiner
Subject: Regulation paper

COMMENTS:

Please find attached the paper *Using Standards and Regulations to Reduce Greenhouse Gas Emissions*, to be discussed at tomorrow's Assistant Secretaries Climate Change Group meeting. Please contact me at 260-1345 if you have questions or do not receive a complete transmission.

3/19/97

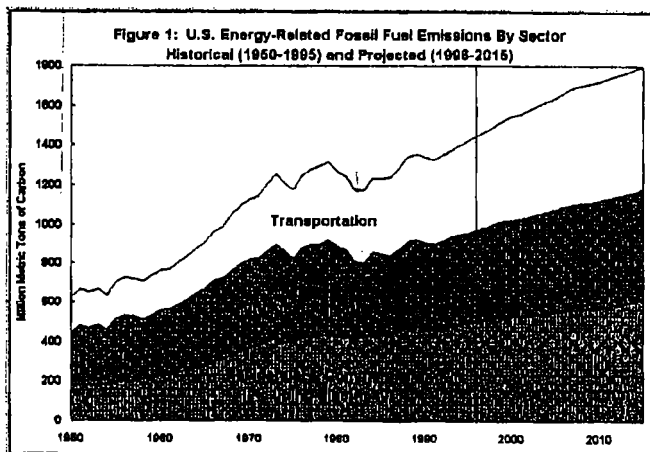
Using Standards and Regulations to Reduce Greenhouse Gas Emissions

Introduction

Limitations on greenhouse gas emissions could take the form of standards and regulations. This paper lays out the broad policy options available for limiting emissions using standards and other measures, but does not analyze the costs and benefits of particular options. Standards to limit greenhouse gas emissions could take the form of:

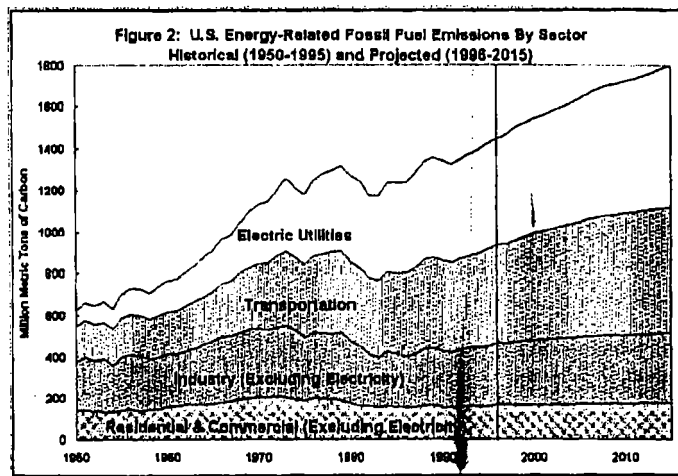
- *Minimum energy efficiency standards for energy consuming equipment:* Historically, these have targeted appliances and other residential and commercial equipment, as well as personal transportation (i.e., the Corporate Average Fuel Economy (CAFE) program).
- *Other measures:* These can take many forms and could include minimum purchase requirements for renewable sources of electricity, demand side management programs (which mandate electric utilities to undertake information and energy efficiency subsidy programs), federal spending rules for transportation infrastructure, and federal procurement policies.
- *Direct limits on greenhouse gases:* Standards could specify allowable greenhouse gas emission levels per unit of output (or some other factor). For example, a powerplant could face a limit on the amount of carbon dioxide emitted per kilowatt of electricity generated. Another example is methane from some landfills, which is already controlled due to limits on emissions of volatile organic compounds.

Within any program of standards, flexibility could be introduced by allowing those who perform better than the levels prescribed by the standards to trade their resulting "credits" with others, thereby reducing costs. Such a program could share many of the characteristics of an emissions trading program.



Figures 1 and 2 summarize sectoral CO₂ emissions (with and without emissions associated with electricity). As indicated, with respect to direct emissions, electric utilities account for about one-third of total CO₂ emissions, transportation for about one third, roughly one fifth for industry, seven percent for the residential sector, and about 4% for the

commercial sector. If electric utility emissions are attributed to final energy consumers, then industry's share rises to about one third and the residential and commercial sectors each account for 15-20% of the total.



Energy Efficiency Standards

1. Appliance Standards

Standards for energy consuming equipment can expand markets for such technologies, help to reduce information barriers and can lower consumer's decision costs. Standards can also provide incentives to private research and development by reducing uncertainty in the market. U.S. homeowners spend \$110 billion each year to power home appliances. These uses account for about 70% of all the primary energy consumed in homes.

During its typical 10-15 year lifetime, an appliance's operating costs may exceed its initial purchase price several times over. Nevertheless, many consumers do not consider energy efficiency when making purchases. Manufacturers are often reluctant to invest in more efficient technology that may not be accepted in the highly competitive marketplace.

Recognizing the great potential for energy savings, many states began prescribing minimum energy efficiencies for appliances. Anticipating the burden of complying with differing state standards, manufacturers supported the development of federal standards that would preempt state standards. Federal standards provide a high degree of certainty for energy savings and achieve higher penetration rates for efficiency gains than voluntary, educational or incentive programs.

In 1975, the U.S. Congress established a program of test procedures, energy conservation standards, and labeling for certain major household appliances including refrigerators, freezers, air conditioners, water heaters, furnaces, dishwashers, clothes washers, clothes dryers and kitchen ranges and ovens. A 1987 amendment, the National Appliance Energy Conservation Act, set the first national efficiency standards for these appliances and established a schedule for regular updates by DOE to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified.

The Energy Policy Act (EPACT) of 1992 expanded coverage to certain commercial and industrial equipment, including commercial heating and air-conditioning equipment, water heaters, certain incandescent and fluorescent lamps, distribution transformers, and electric motors. EPACT also established maximum water flow-rate requirements for certain plumbing products and provided for voluntary testing and consumer information programs for office equipment, luminaires, and windows.

Under DOE's first rulemaking in November 1989, updated standards were set for refrigerators and freezers that went into effect January 1993. The Final Rule for energy conservation standards for clothes washers, clothes dryers, and dishwashers issued in May 1991 became effective May 14, 1994.

The initial standards included in EPCA, and those already amended by DOE, are expected to save about 23 quadrillion Btus (24.3 exajoules) of source energy from 1993 to 2015. Current appliance standards have already saved consumers \$1.9 billion and will ultimately save \$58 billion in energy costs over the lifetimes of units installed between 1990 and 2015.

In addition, more efficient products are more competitive internationally and have environmental benefits from reduced atmospheric emissions. The total emission reductions of federal appliance standards implemented to date are estimated to be 14.2 MMTCE in the year 2000. Further development of standards could result in additional reductions.

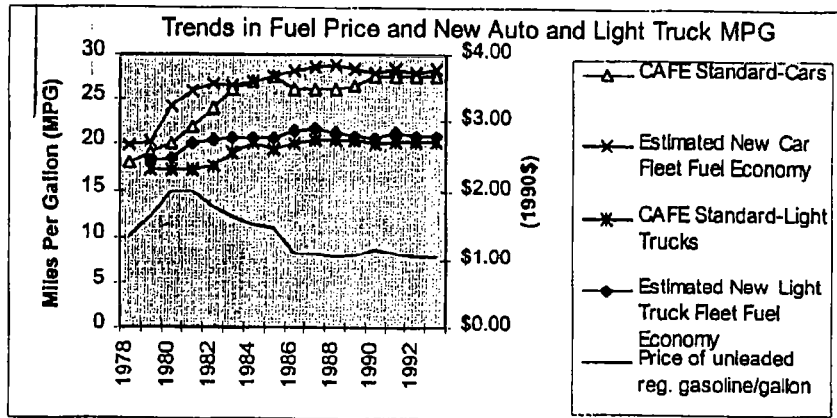
2. Personal Transportation

Consumers make choices about which type of vehicle to purchase and how much they drive their vehicles. There are many attributes that consumers may consider when purchasing a vehicle, such as: price, fuel economy, quality, safety, styling, performance, reliability, handling, comfort, options, size, etc. Fuel economy can conflict with a number of these attributes, and recent surveys confirm that fuel economy is very low on the list of attributes that consumers seek today. If the cost to society of greenhouse emissions is not reflected in the cost of owning and operating a vehicle, consumers will make inefficient choices, a classic case of market failure. One way to incorporate the external costs into the prices that consumers face is through regulation.

Such regulations already exist in the United States. The Energy Policy and Conservation Act of 1975 established mandatory average fuel economy standards for new cars and light trucks starting with the 1978 model year. The standard (currently, 27.5 mpg for cars and 20.7 mpg for light trucks) is calculated by each manufacturer's fleet (domestic or import) and model year. Each manufacturer's fleet average is equal to the sales-weighted fuel economy of all its new cars or light trucks of that vintage that are sold in the United States. Manufacturers that exceed the standard can carry forward credits for up to three years; manufacturers that fall short can carry backward projected future credits for up to three years. Failure to comply with CAFE requirements can result in a civil penalty. No major U.S manufacturer has ever paid a fine; only European manufacturers of luxury cars have opted to pay a fine rather than comply with the standards in a given year or take advantage of the credit system.

Emissions of greenhouse gases from the transportation sector account for about one-third of total U.S. GHG emissions. Transportation greenhouse gas emissions are expected to grow from about 430 million metric tons of carbon "equivalent" (MMTce) in 1990 to 550 or more MMTce in 2010. Passenger cars and light duty trucks (light vehicles) contribute the majority of transportation emissions. Emissions from light vehicles alone accounted for 20% of total U.S. greenhouse gas emissions in 1990, and in the absence of new policy measures are expected to rise from about 250 million metric tons of carbon equivalent (MMTce) in 1990 to 350-400 MMTce in 2010. All of this growth will likely be from light trucks, which are projected to account for a greater share of emissions than cars by the year 2000.

The major factors underlying the rapid growth in emissions from light vehicles are: growth in vehicle miles traveled; stagnant new fleet fuel economy levels; and growth in the relative proportion of light trucks sold, which have lower CAFE standards than cars.



Actual growth in vehicle miles traveled (VMT) since 1990 has averaged 2.4% per year. Growth in VMT is a function of a number of factors, including

demographic changes (more women in the workforce; immigration), land use patterns (where people live in relation to where they work, shop, etc); the cost of driving each mile (now at an all-time low on an inflation-adjusted basis); and others.

Corporate average fuel economy of new car fleets increased steadily along with increasing CAFE standards throughout the late 1970s until the mid 1980s. Since then, new car and light truck fuel economy has been stagnant as new more efficient technologies have been applied to performance (which has increased by 60% for all light vehicles in the last 15 years) and utility rather than to fuel economy. Absent a driving force such as policy changes or fuel price increases, no significant increase in new fleet fuel economy is expected to occur. Further, because new vehicle fuel economy has been stagnant for several years, the in-use fleet of cars and light-trucks has also nearly reached a fuel economy equilibrium.

In fact, the overall in-use fuel economy of the combined new light vehicle fleet (i.e., cars and light trucks such as minivans, sport utility vehicles, and pickup trucks) has already begun to *decline*. Each year, about 15 million light vehicles are sold in the United States. In the past 15 years, sales of light trucks have skyrocketed. They have gone from under 25% of the market in 1982 to almost 45% today. A key reason that this shift is important in terms of GHG emissions is that light trucks face lower CAFE standards than cars (almost 7 mpg lower). Moreover, since light trucks tend to last longer than cars, they are likely to be driven more miles over their lifetime than cars.

In 1994, President Clinton convened a Federal Advisory Committee Policy Dialogue to assist in the development of measures to significantly reduce greenhouse gas emissions from personal motor vehicles ("CarTalk"). Although CarTalk ended without consensus among all members of the Committee, the process did result in a number of analyses and proposed policy options.

Other Mandates

Standards could also be used to limit greenhouse gas emissions in other sectors of the economy. Most prominent among these are:

Electricity Restructuring: There is currently a trend among states to adopt retail competition for the electricity industry. This trend could be accelerated with federal legislation. Retail competition is expected to lower the price of electricity by as much as 20-25% in certain regions and change the fuel mix of generation. Preliminary EPA and DOE analysis indicates that utility greenhouse gas emissions could rise by as much as 2-6% as a result. To mitigate the environmental impacts of competition and maintain the environmental benefits of current state level renewable and demand side management programs, a number of options have been adopted at the state level (for states that have already adopted competition) or are under consideration for the rest of the nation. These include:

- A "portfolio standard" for renewable energy or greenhouse gas emissions: This involves requiring that all generators meet a specified level of renewable generation

or greenhouse gas emission reduction either by undertaking such projects themselves or purchasing "credits" from others who have.

- **A social benefit fund:** Revenue is collected by placing a charge on transmission service. The funds are then used to subsidize energy efficiency projects or low income consumers. California has already adopted this approach.
- **Information disclosure requirements:** Generators could be required to disclose the emission profiles of their generation, facilitating the marketing of "green" electricity.
- **Additional air pollutant requirements:** Many states are hesitant to adopt retail competition because they perceive that differing regional environmental requirements both put their electric industry at a competitive disadvantage and will result in more pollution being transported into their states. Thus, additional environmental requirements to "level the playing field" – which could include greenhouse gas emission reductions – are currently being debated.

The Intermodal Surface Transportation Efficiency Act (ISTEA): This Act establishes the rules for federal transportation funding to the states. In 1991, ISTEA authorized \$140 billion in transportation projects over a six year period. The Act expires in 1997 and Congress is now considering options for its reauthorization. These could include provisions that would indirectly reduce greenhouse gas emissions. Examples include the following:

- *Congestion Mitigation and Air Quality Improvement Program:* Additional funds could be targeted to transportation projects that reduce air emissions and energy consumption on a long-term sustainable basis.
- *Brownfields Restoration:* Successful redevelopment of brownfields can help revive inner city areas and reduce sprawl, thereby reducing vehicle miles traveled. By focusing job growth in inner city areas it encourages greater reliance on more energy efficient and environmentally sound transportation modes, including transit, walking, and bicycling. More funds could be made available for these projects.
- *Incentive Funds:* Climate actions through ISTEA can produce economic efficiency and reduce emissions, while increasing mobility choice and community livability. One option would be to create a \$500 million Fuel Efficiency Incentive Fund that rewards the ten states that are able to reduce fuel consumption, on a per capita basis, the greatest over the next five years.

A Program of Standards on Direct Emissions

This system would establish a set of greenhouse gas performance standards for sources of emissions. Flexibility could be introduced by allowing the trading of emission

reduction "credits" when sources perform superior to specified levels. A source could thus comply with the performance standard either through its own control efforts, or by purchasing credits from other sources.

For such a system to work, a performance standard would be established for each sector covered under the program. For example, for coal fired electric boilers, a limit could be placed on the amount of carbon per Btu of energy combusted. Sources surpassing that limit would earn "credits" that would be tradable. The amount of tradable credit would be based on the source's past production rate.

The performance standards themselves would be "rate based." That is, they would establish allowable emissions per unit of production, but not set total output limits. The total amount of tradable credit available to a source would be the product of the amount by which the source is surpassing the rate-based standard and its historical production levels.

Likely candidates to include in such a program include:

- Manufacturers of energy-using equipment for which an efficiency standard can be set. For example, residential, commercial, and industrial equipment (refrigerators, furnaces, ranges, HVAC equipment, motors, and lighting) could be included.
- Transportation equipment manufacturers, including passenger vehicles, light and heavy duty trucks, commercial transport equipment (planes, trains), and off-road equipment (e.g., tractors, farm equipment) and small engines (e.g., mowers).
- The many sources of non-CO₂ emissions (such as coal mine methane, agricultural sources of emissions, and halogenated substances). A credit program is also well suited to "opt-in" smaller sources which are not included under the regulator requirements due to administrative and monitoring considerations, but have the potential to reduce emissions at low costs.
- Electric utilities and heavy industry
- Petroleum refiners

Under a program of this type, the set of performance standards for all sectors must be consistent with the national target. Since total CO₂ emissions are not directly limited, such compliance would have to be projected based on an analysis of the performance standards.

Trading Credits and Determining Compliance

Credits could be traded bilaterally between the source who creates the credit and the source whose performance (i.e., emissions) exceed the regulatory standard. Alternatively, brokers and central exchanges could also be a mechanism for trades.

The regulating authority at some point must approve the authenticity of the credit generating reductions. For some sectors, credits could be certified for one year only. For example, a utility emitting under its limit in a year would generate credits equal to the reductions in that year only. These may be sold in that year or banked for the utilities or use or future sale.

For other sectors, annual certification would not be feasible. For equipment manufacturers, credits would be granted for each piece of equipment sold with performance better than the standard. Credits would equal the emissions associated with this improvement for the life of the equipment. It would not be feasible to track each piece of equipment that is produced to ensure its continued operation and performance. Therefore, lifetimes, usage, and degradation assumptions would need to be stipulated.

Conclusion

There is a long history of government using standards and regulations to address market failures relating to environmental externalities, the provision of information, and energy security. In addition, the role of government in the provision of transportation infrastructure and the regulation of natural monopolies is large. Consequently, the number of actions could be taken to mitigate emissions of greenhouse gases is large. These range from direct limits on emissions, to changes in government policies that indirectly affect the demand for energy. Given this wide array, choices must be made that consider both the costs that such interventions may impose and the resulting reductions in greenhouse gas emissions.

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