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**EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
Washington, D.C. 20503-0001**

Tuesday, November 4, 1997

LEGISLATIVE REFERRAL MEMORANDUM

TO: Legislative Liaison Officer - See Distribution below

FROM: Ronald K. Peterson (for) Assistant Director for Legislative Reference

OMB CONTACT: Robert J. Tuccillo
PHONE: (202)395-5609 FAX: (202)395-5836

SUBJECT: Council on Environmental Quality Oversight Testimony on Global Climate Change

DEADLINE: 12:00 Noon Wednesday, November 5, 1997

In accordance with OMB Circular A-19, OMB requests the views of your agency on the above subject before advising on its relationship to the program of the President. Please advise us if this item will affect direct spending or receipts for purposes of the "Pay-As-You-Go" provisions of Title XIII of the Omnibus Budget Reconciliation Act of 1990.

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SUBJECT: Council on Environmental Quality Oversight Testimony on Global

☐ Concur
☐ No Objection
☐ No Comment
☐ See proposed edits on pages _____
☐ Other; _____
☐ FAX RETURN of _____ pages, attached to this response sheet

Revised Draft 11/04 - 4:35 p.m.

TESTIMONY BEFORE
HOUSE SCIENCE COMMITTEE
by
KATHLEEN A. McGINTY
CHAIR, COUNCIL ON ENVIRONMENTAL QUALITY
NOVEMBER 6, 1997

I am pleased to be here today to describe to this committee the Administration's plan to address the health and environmental risks associated with climate change. We are proposing a comprehensive strategy that creates new opportunities to redirect our use of energy in ways that will be good for both our economy and our environment. The plan creates incentives for the private sector, alone and in partnership with the government, to provide the energy-efficient technologies that will enhance our prosperity, both at home and in the global marketplace, as we move into the next century.

This Committee is a particularly appropriate venue for this discussion because, first and foremost, the issue of climate change starts with the evidence developed by the scientific community. The overwhelming majority of that community has concluded that unless actions are taken to reduce greenhouse gas emissions, at some time in the future we will likely experience unprecedented climatic disruptions.

Over the past several months, the President hosted two sessions where leading scientific and technology experts, economists and business leaders described the current state of knowledge. It was extremely clear from these meetings that, while uncertainties remain, based on what we know today, it would be foolhardy not to begin acting to limit emissions of greenhouse gases.

In responding to this call for action, the President rejected extreme views frequently heard on both sides. He declined the call by some for drastic short-term cuts in emissions that could undermine our continued economic prosperity. At the same time, he rejected those voices urging a "do nothing" approach based on the premise that adverse consequences are the next generation's issue, not ours.

Instead, the President's plan recognizes the challenge of climate change as a tremendous opportunity for heightened economic growth. It challenges our nation's creativity and innovation to reap the benefits from the many win-win opportunities that exist to reduce emissions of greenhouse gases. It is designed to enhance our role as the world's number one economic power by ensuring our continued competitive edge in developing and marketing technologies in an increasingly global marketplace in the 21st century. And in so doing, this policy will protect future generations from having to confront the risks either of severe climatic disruption or of economic dislocations if drastic actions to reduce emissions were to prove necessary at some future time because we failed to begin acting now.

The President's proposal contains both a domestic action plan and an international strategy for dealing with what is fundamentally a global issue. It provides clear instructions to our negotiators involved in talks to strengthen the Framework Convention on Climate Change which are scheduled to conclude in early December of this year in Kyoto, Japan.

The plan was developed following extensive consultations with all interested parties. What the experts - and the economic models - told us is that there are smart ways and dumb ways to address climate change. The President's plan harnesses all of the smart ways: It provides incentives through budget cuts and research and development; it allows for flexibility by proposing budget periods instead of rigid targets for emissions reductions; it taps the power of the marketplace through emissions trading both domestically and internationally; and it recognizes the global nature of the problem by insisting on the participation of all countries.

On the domestic side, the President's plan rejects costly approaches that rely on energy taxes and heavy-handed regulation. Instead, it promotes new business

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POTUS said
Key developing
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countries

opportunities through tax cuts, R&D incentives and public-private sector partnerships. Further, it allows a decade's worth of experience with these approaches before introducing the emissions trading system that will assure we meet the emissions reduction target.

The plan represents a strong, innovative, yet realistic approach. Not surprisingly it has been attacked by some on both sides of the issue who want either stronger action or no action at all. However, more importantly, it has won the support of a number of firms in the manufacturing and high-tech sectors, as well as energy companies and electric utilities who see this as the best path forward.

On the international side, the President's plan couples a binding, realistic target with proposals that allow countries the flexibility to meet it. The President announced that we would support returning emissions to 1990 levels by the period from 2008 through 2012. This initial step would be followed by further reductions over the next five years. Both here and abroad, during the recent negotiating session, this position has been supported by some, but attacked by many others as being either insufficiently stringent or overly so. It will require the U.S. to reduce emissions in the period 2008-2012 by nearly 30 percent from where they otherwise would be. This represents a substantial, but we believe, realistic challenge and that it is an important first step in safeguarding our nation and the planet against climate change.

The U.S. negotiating position contains several important provisions aimed at providing flexibility for reducing emissions at substantially lower costs. For example, by calling for a five- year budget period, we are seeking to avoid the potential problems inherent in the more traditional single-year target where short-term economic, weather related or energy price influences could make

meeting a target more difficult. We have also proposed both emissions trading and joint implementation with credit for reductions. Both provisions provide incentives for finding and capturing low cost reductions wherever they occur and have the potential for reducing compliance costs by as much as 90 percent. Finally, the U.S. has proposed emissions banking and limited borrowing to allow for cost saving transfers of reductions over time.

*check**we have*

The U.S. position also calls for developing countries to play a meaningful role in addressing concerns about global warming. Our position recognizes the need for developed countries to lead the way, but calls on developing countries to play an increasing role as their emissions grow and economic conditions improve over time. Specifically, the U.S. has called for the establishment of a new annex allowing developing countries to agree to take on binding obligations and for agreement by a date certain on a graduation mechanism under which developing countries would take on increasingly stringent provisions over time.

The President stated very clearly that the United States will not take on binding obligations unless key developing meaningfully participate in this effort.

The last major negotiating session concluded in Bonn last week. Based on reports from that meeting, many issues remain to be resolved for an agreement to emerge from Kyoto. While we remain committed to working as hard as we can to make Kyoto a success, we also believe that no agreement in Kyoto would be a better outcome than an agreement that would be bad for our country or one which sets us down a path that would not be sustainable.

Now I would like to return to issues related to domestic implementation and the question of what it will mean for our country to return emissions back to 1990 levels by the period 2008-2012. Let me start by saying categorically it will not mean, as some have suggested, skyrocketing energy prices and wholesale shifts of

jobs to developing countries. The President has carefully nurtured our economy back to its strongest point in decades and would not support any action that would undermine our continued prosperity.

As outlined above, our proposed domestic plan relies extensively on incentives, removing barriers to innovation, partnerships with industry, reinventing federal energy policies, and market-based incentives. During the ten year period prior to 2008, we have proposed the following 9 part plan:

1. Tax Cuts and Research Funding: \$5 billion in tax cuts and expanded federal research and development over five years to spur markets for existing energy efficiency and low-carbon technologies and the creation of even better next generation technologies.
2. Credit for Early Action: to provide immediate incentives for near-term actions by firms and localities able to achieve low cost reductions.
3. Industry by Industry Consultations: The Administration challenges firms to prepare plans over the next 9 months on the most effective ways to reduce greenhouse gas emissions in their sectors.
4. Encouraging the Use of Energy Efficient Products: we are committed to working to remove barriers that exist to expanded markets for existing energy efficient technologies. | what does this mean?
5. Federal Procurement and Energy Use: The Department of Energy will spearhead a comprehensive effort to reduce greenhouse gas emissions from federal sources.
6. Electricity Restructuring: To deliver a significant down payment on emissions reductions, while saving consumers billions, we will pursue a bold plan for electricity restructuring, that also ensures greenhouse gas reductions and other [irrelevant - delete
~~environmental protection goals.~~
7. Setting a Concentration Goal: Working with the National Academy of Sciences

and other bodies, we will examine issues related to developing a long-term goal for concentrations of greenhouse gases in the atmosphere.

8. **Bilateral Dialogues:** The President has already had substantive discussions with many world leaders include those from Argentina, China, the United Kingdom and Japan. Senior officials throughout our government will continue to press the case for the U.S. position at every appropriate opportunity over the coming weeks.

Beyond Kyoto, we plan to continue to advance our nation's interests in deploying climate-friendly technology abroad in ways that create environmental and economic benefits for both our national and our international partners.

9. **Economic and Science Reviews:** Recognizing that over time we will learn more about both scientific and economic issues, we will periodically review our policies in light of improved understanding.

Taken together, we believe these actions represent a comprehensive initial step toward reducing our greenhouse gas emissions. This initial stage would be followed by a domestic and international emissions trading regime to meet the binding target beginning in 2008.

We are now beginning the process of moving forward to implement this plan. We will continue to have extensive consultations with interested parties and build on the almost 40 voluntary partnerships between government and the private sector that have been developed over the last several years under the President's Climate Change Action Plan. We welcome your input into these efforts as we move forward in this process.

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EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL OF ECONOMIC ADVISERS
WASHINGTON, D.C. 20500

SENIOR ECONOMIST

MEMORANDUM

TO: Bob Tuccillo
FROM: Jay Shogren and Joe Aldy *[Signature]*
DATE: July 28, 1997
RE: Comments on 7/28/97 Discussion Paper: A Technology Approach to Addressing Global Climate Change

We provide comments on the discussion paper below. The first set of comments reflects several issues that we believe need to be emphasized. The second set reflects specific edits and necessary clarifications in the paper. Also, we have compiled a draft chart describing the emissions and costs across sectors.

Set 1:

p. 2: The two fundamental changes imply the need to influence firm and consumer behavior through price signals. The importance of pricing carbon should be stated explicitly.

p. 5: DOE's Labs Study: The discussion of this study should reflect the following assumptions that are noted in the report:

- The model runs for the 3 end-use sectors were not integrated and may overstate the effects of technology penetration (6/11/97 draft, p. 1.2).
- The analysis of costs is confined to technology costs, and does not assess policies or programs necessary to achieve market acceptance (p. xvi).
- The assessment of cost-effectiveness ignored implementation costs (p. xvi).
- The high efficiency/low carbon case invokes the announcement effect, but does not specify a numeric change in the rate of energy efficiency improvement (p. 1.6).
- The high efficiency/low carbon case requires technology breakthroughs, not just accelerated diffusion, to achieve emissions reductions in the transportation sector (p. 1.7).
- Emissions reductions under both scenarios require additional public sector programs and funding (p. x).

p. 6: The discussion of prices in the economy should note that the total costs to society of a cap and trade program should be lower than the costs of the subsidies listed in the second and third bullets.

Fax Cover Sheet

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Please Deliver to:

Tom Rhoads

Fax #: 395-6853
Company: CEA

From:

JEREMY SYMONS

Phone: 233-9301

Pages: 2

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Message:

OAR Climate Change Programs, mmtce reductions																	
			1991-1995	1996	1997	1998	1999	2000									
1&2	Green Lights and ESB	✓ 1.5	0.7	0.8	1.4	2.4	3.7	5.5									
6	Energy Star Labeling	✓ 1.9	0.7	1.2	2.2	3.5	4.9	6.8									
30	Transformers	✓ 0.0	0.0	0.0	0.1	0.2	0.3	0.5									
32	Natural Gas Star	✓ 1.6	0.8	0.8	1.0	2.5	3.8	4.9									
33	Landfill Rules	✓ 0.0	0.0	0.0	0.0	0.0	6.3	6.3									
34	Landfill Outreach	✓ 0.1	0.0	0.1	0.2	0.5	1.2	1.9									
35	Coalbed	✓ 1.9	0.7	1.2	1.3	1.5	1.9	2.6									
38	Agstar	✓ 0.0	0.0	0.0	0.0	0.1	0.2	0.3									
39	Ruminant Efficiency	✓ 0.0	0.0	0.0	0.1	0.4	0.6	1.0									
40	SNAP	✓ N/A	0.0	N/A	N/A	N/A	N/A	6.4									
New	Stewardship Initiative	✓ N/A	0.0	N/A	N/A	N/A	N/A	6.5									
41	HFC-23	✓ N/A	0.0	N/A	N/A	N/A	N/A	5.0									
42	Aluminum	✓ 2.9	1.4	1.5	1.7	1.9	2.1	2.2									
	Total		4	6	8	13	25	50									
N/A Not immediately available. HFC programs are currently verifying emission reduction achievements, which will affect interim goals.																	
Reductions in 1996 for Action 41 were likely a significant portion of the year 2000 goal.																	
Note: Does not include EPA's OPPE programs. Contact Bill Hohenstein at 260-7019.																	

July 3, 1997

To: Janet Yellen, Alicia Munnell

Cc: Jay Shogren, Mark Mazur,
Tom Rhoads, Cristian Santesteban, Quindi Franco

From: Jeff Frankel

Re: Climate Change, "Technology", and Prices

It appears that two engineering-based studies have just been, or are about to be, released — both fitting into our "wishful thinking" category. They are being widely touted. Janet: Jack Gibbons asked me to pass on to you the enclosed one-pager on the DOE/Labs study. The other study, co-sponsored by Alliance to Save Energy, Tellus and others, was touted by John Holdren at a recent State Department lunch (a summary from Quindi and Tom is enclosed). The Vice President mentioned one of these studies to me at my swearing-in.

Meanwhile, I have had Quindi and Cristian doing some econometrics on Energy Efficiency Improvement numbers (memo enclosed, though I am not sure whether it is in final form). It seems to support my prior expectations, that **we can claim to be technology optimists, in the sense of the EEI bang one gets per change in energy prices**. It's just that we don't think you get much without a change in price. (Let me remind you that this definition of technology is not remotely what economists would call technological change. In addition to true innovation, it includes dissemination of existing technology, substitution among well-known technologies, the switch from manufacturing to services, and energy conservation. In short, it is everything.)

- ? (
- * The point estimate of the truly autonomous component of EEI is only .54-.63 per cent per year, generally not statistically significant, but near the .6-.7 range that our outside reviewers cite.
 - * The price elasticity is highly significant.
 - * Adjustment is gradual, so that the long-run elasticity is 20 times the one-year elasticity.
 - * When one includes government spending on energy R&D, its effect on EEI is insignificant.
 - * The "simulation" that Quindi and Cristian carried out (see graph at the back) suggests that under our assumptions, we get a slightly more rapid path of energy saving for a somewhat lower carbon tax than in the IAT results. The main point is that we think that our relative emphasis on the price component vs. the truly autonomous component of EEI is based on better economics, and is more likely to lead to good policy, than some others'. But it is nice that the bottom line is one that our green friends should like!

I think we want to verify and refine these results a bit more before using them, but I hope you agree that they are very suggestive.

RE: DOE/Labs Study

Attachment 2.

U.S. CARBON REDUCTIONS BY 2010 AND BEYOND

The Potential Impact of Energy-Efficient and Low-Carbon Technologies

CONCLUSION: Technology can lower the cost of stabilizing carbon emissions at 1990 levels in the medium term (i.e. 2010) to \$10 billion a year or less (0.1% of GDP). The study did not consider international trading or more flexibility in meeting the stabilization target, which could reduce costs by another 50% or more. The study assumes penetration of technologies from expanded Administration initiatives, such as the Partnership for a New Generation of Vehicles.

BACKGROUND: Five DOE national laboratories led by Oak Ridge and Lawrence Berkeley labs have conducted a comprehensive, peer-reviewed, 9-month "bottom-up" analysis of the role technology can play in stabilizing U.S. carbon emissions. It is the most authoritative and documented study of this subject since the National Academy of Sciences report in 1992 and the Office of Technology Assessment Report in 1991. The study documents in detail how four key sectors of the economy—buildings, transportation, industry, and electric utilities—could respond to the same climate scenario being modeled by the interagency team: a climate treaty is launched in the year 2000 with a goal of stabilizing in 2010, and a cap and trade system is phased in with gradually rising permit prices. The lab study examined what an aggressive program of research, development, and deployment of clean technologies could have combined with a marginal permit price of \$50/ton of carbon (the average permit price is much lower).

RESULTS: The study concludes that energy efficiency and low-carbon technologies have a very large potential to cost-effectively reduce U.S. carbon emissions while meeting the full energy needs of U.S. businesses and families. Many consumers will save money. Current projections suggest that a carbon emissions reduction of 380 million metric tons (MMT) is required to stabilize U.S. emissions in 2010 at 1990 levels. Under moderate technology and market assumptions, energy efficiency technologies alone can reduce emissions in 2010 by 120-190 MMT. This level of carbon reductions estimated to be possible at little or no net cost—that is, the energy bill savings exceed the investments required to achieve the carbon savings. Under more aggressive assumptions, a combination of energy efficiency, low-carbon technologies and relatively inexpensive coal power plant conversions to natural gas can reduce 2010 emissions by 340-390 MMT. The net cost of reductions of this magnitude is estimated to be on the order of \$10 billion per year in 2010 (0.1% of GDP). These low costs are due to the net savings resulting from investments in many of the technologies considered.

METHODOLOGY: In contrast to the current top-down economic modeling of the interagency team, the five laboratory study uses a bottom-up technology-by-technology assessment as well as a top-down engineering-economic modeling approach. It draws upon a wide variety of technology cost and performance information to assess potential impacts. It has been peer-reviewed by industry experts. A utility sector analysis quantifies the impacts of end-use efficiency improvements on utility carbon emissions, potential emissions reductions through operations changes, and the costs of converting coal power plants to natural gas. Finally, a number of promising very low carbon technologies are examined to determine their potential for emissions reductions, including advanced gas turbines in industry, biomass/biofuels energy, and improved aluminum smelting.

TOTAL BENEFITS EXCEED TOTAL COSTS: In the long term, these climate change mitigation actions will provide additional benefits not fully considered in the study—reductions in criteria air pollutants (i.e. ozone and fine particles), decreased dependence on foreign oil, greater industrial productivity, and U.S. leadership in technologies likely to be a major source of international trade and jobs in the next century.

**ALLIANCE TO
SAVE ENERGY**

**AMERICAN
COUNCIL FOR AN
ENERGY-EFFICIENT
ECONOMY**

**NATURAL
RESOURCES
DEFENSE
COUNCIL**

**TELLUS
INSTITUTE**

**UNION OF
CONCERNED
SCIENTISTS**

CHOOSING OUR ENERGY FUTURE

The Present Path

National energy consumption rises from 85 Quads in 1990 to 105 Quads in 2010 and 119 Quads in 2030.

Economic growth averages 2.2% per year under *Present Path* assumptions.

In spite of economic growth, many job opportunities are lost due to energy waste and rising oil imports.

National energy bill rises to \$650 billion in 2010 from \$540 billion in 1990.

Fossil fuels, which account for 85% of U.S. energy use today, still account for 85% in 2010.

The United States remains fossil-fuel dependent for the foreseeable future, with renewable resources meeting only 11% of our energy needs in 2030.

Petroleum use rises from 17 Mbd (million barrels of oil per day) to 21 Mbd in 2010 and 25 Mbd by 2030.

U.S. oil import bill rises to \$104 billion annually by 2010, continuing to add to our trade deficit and drain the economy.

Energy intensity of the U.S. economy declines at 1.1% per year.

Air pollution from nitrogen oxide (NO_x) emissions persists with little change from present level of 20 million tons per year.

Sulfur dioxide (SO₂) emissions decline only slowly, from 19 million tons annually today to 13 million tons by 2010.

Global warming emissions of carbon dioxide (CO₂) rise steadily from 1338 MTc (million metric tons of carbon per year) in 1990 to 1621 MTc in 2010 and 1892 MTc in 2030.

The Innovation Path

National energy consumption held to 89 Quads in 2010 and is cut to 69 Quads in 2030.

Economic growth averages 2.2% per year under the *Innovation Path*.

Energy savings result in job creation, with a net employment boost of nearly 800,000 jobs nationwide by 2010.

National energy bill held to \$560 billion in 2010. Net savings amount to \$530 per household per year in 2010.

Fossil fuel dependence drops to 79% by 2010 and down to 68% by 2030.

The country starts a clear transition toward renewable resources, which meet 14% of U.S. energy use needs by 2010 and 32% by 2030.

U.S. petroleum use trimmed to 16 Mbd by 2010 and then drops to 12 Mbd by 2030.

Oil import bill cut to \$83 billion by 2010, saving \$21 billion per year that would be otherwise largely lost to the economy.

U.S. energy intensity declines at 1.9% per year, falling 32% by 2010.

NO_x air pollution is reduced 24% below the 1990 level by 2010, falling to 15 million tons per year.

SO₂ pollution is reduced 64% below the 1990 level by 2010, dropping to 7 million tons per year.

U.S. CO₂ emissions are cut to 1207 MTc, 10% below the 1990 level, by 2010 and reductions continue, pushing emissions down to 728 MTc, or 45% below the 1990 level, by 2030.

Memorandum

To: Jeff Frankel, Jason Shogren
From: Quindi Franco, Tom Rhoads
Date: July 2, 1997
Subject: **Review of *Energy Innovations, A Prosperous Path to a Clean Environment*¹**

Summary

This summary is based on the executive summary (full report is scheduled for release sometime mid-July). As such, specifics on the analysis are superficial at best. The study shows that CO2 emissions by 2010 can be reduced to 10 percent below 1990 levels at a net benefit to the economy, reducing annual energy costs by \$530 per household and creating nearly 800,000 net jobs. All of this by enhancing energy efficiency, using new technologies, and tapping into domestic renewable resources through a set of sector specific, revenue neutral policies.

The "Innovation Path" -- Policies & Technologies

The study analyzes a set of policies that can "put the U.S. on an innovative, prosperous path leading to an economically and environmentally sustainable future... The approach involves setting fair performance standards, creating incentives, providing better information, and reducing transaction costs in order to foster investments in clean and efficient technologies." The set of policies does not include an economy wide carbon or energy tax. Rather, the policies are sector specific (transportation, buildings, electricity, industry), and present no net increase in taxes or fees within any sector.

Examples of Sectoral Policies:

- Renewables Content Standards A credit-trading system requiring increasing percentages of electricity & motor fuels to come from renewable sources.
- Emissions Performance Allowances Caps on emissions of sulfur dioxide, nitrogen oxides, and carbon dioxide, with emissions allowances allocated to generators in proportion to their electrical output.
- Advanced Vehicles Initiative Stronger fuel economy and emissions standards, backed by rebates paid for by fees on gas guzzlers, market introduction programs and technology R&D.
- Investment Tax Credit 10 percent tax credit for investments in new manufacturing equipment, paid for by fees on purchased energy.

¹ "Energy Innovations, A Prosperous Path to a Clean Environment," by Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists, June 1997.

7/1/97

Memorandum

- Market Introduction Incentives Technology demonstrations, manufacturer incentives, consumer education, and "market innovations" to reduce transactions costs.

Technologies Developed: fuel cells, advanced gas turbines, integrated green building designs, membrane technology, fuels and electricity from biomass, advanced wind turbines, photovoltaic modules.

Analysis

The National Energy Modeling System (NEMS) and the Long-range Industrial Energy Forecasting (LIEF) model were used to represent the different energy sectors. Results were then fed into a macroeconomic model (IMPLAN) to project GDP, wage, and employment impacts. NEMS and IMPLAN are federal government models. *Details as to how energy diffusion and innovation (and the costs associated with them) were modeled are unclear from information released so far.*

Results:

Along the "innovation path" (full adoption of the policy approaches described above), primary energy consumption is 15 percent lower than the present path by 2010, and 42 percent lower by 2030. CO₂ emissions are 10 percent below 1990 levels by 2010. Oil and coal use decline, and an increasing share of energy is supplied from renewable sources (14% of energy need by 2010, almost doubling energy output from renewable sources). Wages, GDP, and employment all improve in the innovation path over the baseline.

Economic Benefits of "Innovation Path" (\$1993, versus business as usual)

	2000	2010
Incremental Investments (B\$)	28	73
Fuel Cost Savings (B\$)	38	131
Net Savings per Household (\$)	100	530
Avoided Petroleum Imports (B\$)	5	21
Cumulative Investments (B\$)	89	588
Cumulative Savings (B\$)	96	1005
Cumulative Benefit/Cost Ratio	1.1	1.7
Net Employment	n/a	773,000
GDP (B\$)	n/a	2.8
Income (B\$)	n/a	14

Memorandum

TO: Jeffrey Frankel, Jason Shogren
FROM: Quindi Franco, Cristian Santesteban
DATE: July 2, 1997
RE: Energy Efficiency, Energy Prices & AEEI Revisited

As you requested, we ran a series of regressions to look at the relationship between energy efficiency (E/GDP), energy prices, energy R&D, and time. We then constructed a small scenario to illustrate differences between our estimates and those of the IAT. After re-running the numbers in the scenario, our results have changed significantly from a previous memo (June 30). We are confident the numbers presented below are accurate. In brief, we find that while the total (price and time) impact of the our estimates is similar to the IAT results, the portion due to prices (and therefore the costs involved) is much greater.

Analysis of Historical Data

Geometric Lag Regression:

$$\ln(E/GDP_t) = \beta_0 + \beta_1 \ln(\text{Energy Price Index}) + \beta_2 \ln(E/GDP_{t-1}) + \beta_3(\text{Time})$$

Where the energy price index is a relative index of the CPI Energy Price Index over the general CPI. Data from 1959 through 1995.

Variable	Coefficient (std. error)
Price Elasticity (β_1) Short Run	-0.03855 (0.008)
Long Run	-0.76832
Lagged Energy Efficiency (β_2)	0.949 (0.042)
Time Trend (β_3) Short Run	-0.00031 (0.0006)
Long Run	-0.00627
$R^2 = .99$	

AEEI = 6.3 %/yr

Energy R&D:

$$\ln(E/GDP_t) = \beta_0 + \beta_1 \ln(\text{Energy Price Index}) + \beta_2 \ln(E/GDP_{t-1}) + \beta_3(\text{Energy R\&D Intensity}) + \beta_4(\text{Time})$$

Where Energy R&D intensity is government funded Energy R&D over total R&D. Various forms of Energy R&D data (real R&D expenditures, and various lag times) generate roughly the same non-statistically significant results. This could be because our aggregate energy R&D

figures include substantial funding for energy production technologies; we are not isolating the component of Energy R&D that is specifically efficiency related.

Variable	Coefficient (std. error)
Price Elasticity (β_1) Short Run	-0.03075 (0.014)
Long Run	-0.71051
Lagged Energy Efficiency (β_2)	0.9567 (0.043)
Energy R&D (β_3) Short Run	-0.00619 (0.00878)
Long Run	-0.14307
Time Trend (β_4) Short Run	-0.00024 (0.00062)
Long Run	-0.00544
$R^2 = .99$	

Scenario:

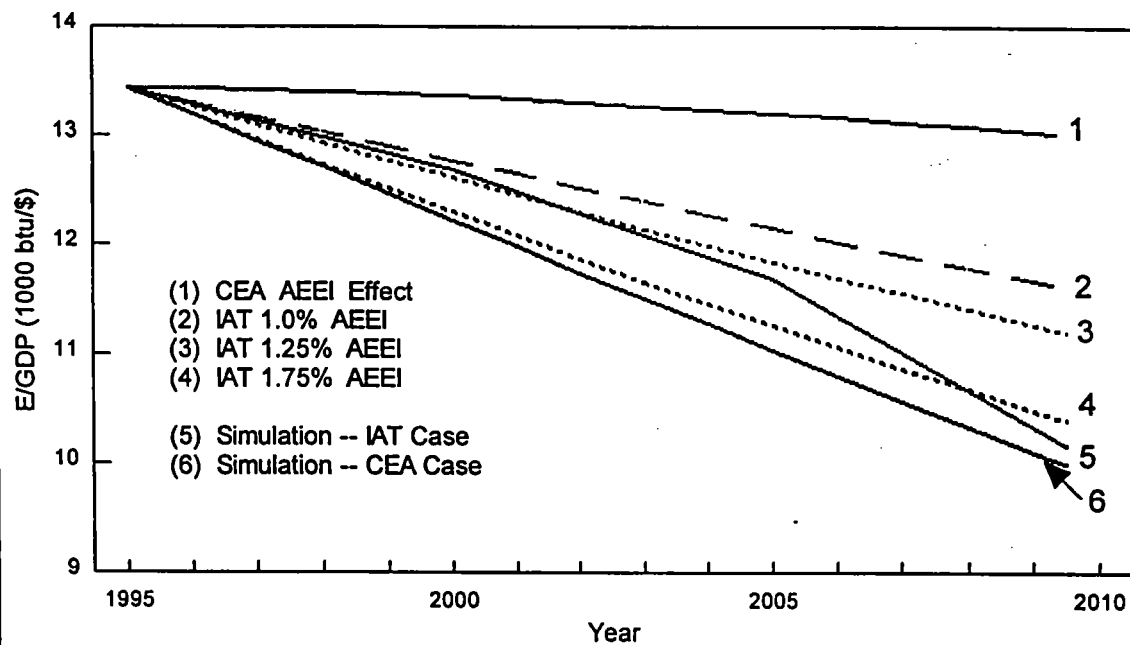
CEA CASE A \$100 per ton carbon tax is levied on all fuels in 1995; we assume this causes a 30% increase in energy prices (range in literature is 15% to 200%). Initial E/GDP of 13.45 (000btu/\$) in 1995, and a time horizon of 1995-2010. The long-run impact of the price increase is fully incorporated by 2010. The simulation uses the original regression estimates excluding energy R&D (lines 1 and 6 in the graph). Over this time period, the CEA estimated time effect is equivalent to an annual AEEI of 0.23 percent.

IAT CASE IAT results are from the most recent Markal-Macro simulations for stabilization at 1990 levels by 2010 under a 1.25% annual AEEI (5). This is a complex policy scenario and should only serve as a rough comparison to our simulation (the model estimates an implicit carbon tax of \$144 in 2010). The impact of the IAT AEEI assumptions (1.0% -- #2, 1.25% -- #3, and 1.75% -- #4) have been modeled continuously throughout the period (some IAT runs assume the rate starts at 1% in 2000, and increases to 1.25/1.75 by 2010).

Component	Drop in E/GDP (percent)	
	CEA	IAT
Time Effect (AEEI)	0.45 (23%) (1) in graph	2.31 (67%) (3) in graph
Price Effect (CEA)	3.1 (87%) from regression	-
Price + Other	-	1.14 (33%) implicit
Total	3.55 (6) in graph	3.45 (5) in graph

units?
ann (annual)
?

Energy Efficiency Improvements



MEMORANDUM

COUNCIL OF ECONOMIC ADVISERS

22 August 1997

TO: Jeffrey Frankel

FROM: Jeremy Rudd *JR*

SUBJECT: Energy Efficiency Regressions

Per your request, I examined some of the "energy efficiency" regressions that Quindi and Cristian submitted to you in a memorandum dated 2 July 1997. I also played around with some alternate specifications. The bottom line is as follows:

- I was in fact able to reproduce the "geometric lag regression" from the July 2nd memorandum. However, the simulation reported in the memo. appears to be incorrect. The memo. makes the assumption that the full effect of a relative price change has occurred by the end of the fifteen-year period over which the simulation takes place. In actuality, the coefficient on the lagged dependent variable is so large (0.95) that only about half of the adjustment has occurred after 15 years. Hence, by my calculations, a thirty percent increase in the relative price of energy causes the E/GDP term to be about 10 percent (log points) lower than the baseline in the fifteenth year of the simulation, while the long-run effect is a 20 log point decline.
- The data used in the regression are probably nonstationary. I therefore also considered a variant in which the first difference of the log E/GDP term is regressed on contemporaneous and lagged values of the first difference of the log relative energy price term. In this specification, a thirty percent increase in relative energy prices reduces the E/GDP term by about four percent, which is a much smaller decline than that which obtains from the geometric lag specification.

Note that the time trend in the log-levels regression (-0.6 log point per period) is not significant (its t -statistic is about 0.5), while the constant term in the first-differences regression (-0.9 log point per period) usually is.

Caveats:

- *I have no idea what the dependent variable is in these regressions.* Cristian is trying to find this out for me. Also, the relative price term is the log of the ratio of the energy component of the CPI to the total CPI. It is not clear that using the CPI is *a priori* sensible, although I would note that the PPI for finished and intermediate energy moves in a fashion that is broadly similar.
- Following the specification used in the July 2nd memo., I used the *log* of the E/GDP term as the dependent variable in these regressions. I do not know whether this is reasonable; it depends somewhat on whether this variable represents a share (e.g., the share of energy in GDP) or is instead some kind of index.
- The estimate of the long-run elasticity from the geometric lag specification is extremely sensitive to changes in the coefficient on the lagged dependent variable (since the coefficient is so close to one).

I also have several other reservations about this exercise, but they are probably immaterial given its purpose.

8/6

Phil Tseng, DOE

M-M 1.25

90%

1340 Stabilization

	2000	2005	2010	2015	2020	2025
price		~30-40	126.1	116.7	112.1	129.3
baseline			176.7	182.8	1940	2066
policy			1340	→		

.75

increases all the way through 2025

→ will get to me on Monday

Phil

8/11

M-M 0.75 90%

	2010	2015	2020	2025
price	\$126	\$135	\$122	\$146

beyond 2025, need to redo tech assumptions for 2050, 2075 cases

→ may be infeasible w/ frozen tech at 2020

need to redo tech innovation if far into future

may take a couple of weeks

Some analysts have proposed using revenues from the sale of emissions permits (designed to slow global warming) to plug the projected entitlements financing gap. This memo argues that earmarking is a bad idea, because there is no inherent connection between the magnitude of the two streams, and because the size of both streams (particularly the emission permit revenues) is extremely uncertain.

Comparison of Anticipated Magnitudes

The first three columns of the attached table show the Social Security Actuary's low, intermediate, and high estimates of the annual financing shortfall in the Social Security system as a fraction of GDP (excluding interest payments or receipts on trust fund balances).¹ In the intermediate projections, the shortfall is monotonically increasing over time, although about 80 percent of the ultimate deterioration has occurred by 2030, when the shortfall is projected to be about 1.7 percent of GDP.

The next three columns show projected emissions permit revenues as a fraction of GDP under the "Peak in 2015" plan (the least aggressive option considered), under three assumptions about the nature of the market for emissions permits: no international trading, trading among Annex I countries, and global trading.² Revenue estimates in 2030 vary by about a factor of ten depending on the assumption about trading. In the "no trading" regime, revenues in 2030 are roughly the same size as the Social Security shortfall, but under the other two options revenues fall far short. By 2050, revenues under "no trading" are more than twice the Social Security shortfall, but under the Annex I trading regime revenues are about 3/4 of the shortfall. The remaining columns of the table show projections of revenues under Annex I trading for the main alternatives to the "Peak in 2015" plan. Revenues for either the "-10% in 2010" or the "1995 in 2010" plans roughly match the intermediate projection of the Social Security financing gap by 2050, but in the early decades revenues substantially exceed the financing gap. Revenues from the "1990 in 2010" plan exceed the financing gap early on but are about 2/3 of the financing gap by 2050.

Of course, the emission-permit revenue scenarios that best match the intermediate projections of the Social Security shortfall do not even remotely match the low or high projections of the Social Security shortfall. Furthermore, the degree of uncertainty about the emission permit revenues is enormous. As an example, the current market price of sodium dioxide emissions permits in the US is about 1/10 of the price that economists had anticipated before the opening of the market.

Public Finance Considerations

Standard public finance theory indicates that earmarked taxes are generally a bad idea, because an optimizing social planner should be free to choose the overall tax schedule to minimize

¹This memo ignores Medicare because the cost estimates for Medicare are so extremely uncertain at this point.

²The permit price streams, emissions paths, and GDP for the climate policy simulations are outputs of SGM. Permit revenues assume an annual auction of all permits allocated to the U.S. government.

efficiency losses, and free to allocate incoming revenues to the places where the social marginal utility of expenditure is highest. From this perspective, the circumstances in which earmarking is least damaging are those in which the tax revenues bear some relationship to expenditure needs. The best example is the dedication of gasoline tax revenues to a trust fund for highway construction and maintenance. On this test, earmarking emissions permit revenues to financing Social Security is a terrible idea. Many of the kinds of shocks that would affect emission permit revenues (especially improvement of emissions technologies) are completely unrelated to shocks to the need for Social Security revenues, while shocks to Social Security needs are probably *negatively* correlated with emission permit revenues. For example, if fertility increases, Social Security financing needs will decline (at least over the projection period), but the extra population will produce more pollution and therefore *more* emission permit revenues.

The most persuasive arguments for earmarked taxes are generally public choice or political economy arguments, which begin either from the premise that the policymaker's objective function differs from that of society, or that the politics of the specific earmarked tax and expenditure have some important interaction that justifies the inefficiencies of earmarking. The best argument that can be made along such lines in this context is that the emission permit is "good" in a sense not likely to be appreciated by the political system at large (presumably because of global externalities), and that therefore it is important to tie the selfish interests of some powerful constituency to the fate of the emissions permits revenues. Specifically, the argument is that if emission permits are perceived as funding Social Security, they may survive political battles because the AARP would defend them (I use the AARP here as a stand-in for all self-proclaimed guardians of Social Security). This argument is not persuasive. The enormous uncertainty about the magnitude of emission permit revenues makes it seem very unlikely that the AARP would be keen to tie the fate of Social Security to an emissions-permit horse in the first place. Even if the Social Security and emissions permits could be linked initially, it seems likely that any shocks to emissions permit revenues would only make the AARP more eager to switch to a more reliable source of revenues. By contrast, the payroll tax is very well-suited as a source of Social Security revenues, because benefits are a function of wages and wage growth, so long-term productivity shocks affect both revenues and expenditures in similar ways.

Conclusion

A less explicit link between entitlements needs and emission permit revenues is more palatable than earmarking. In essentially any foreseeable future, the retirement of the baby boom generation will expand the Federal spending beyond any automatic increase in revenues, putting pressure on the Federal deficit. Extra general revenues from emissions permits would likely be used to some extent to plug that deficit hole, although it also seems likely that part of the revenues would be absorbed by extra spending. One could then use standard public finance arguments to say that, if emission permits are desirable from a social welfare perspective, they should be phased in gradually over time, with a time path chosen to deliver revenues just when the budget deficit is under the greatest pressure.

Year	Social Security Financing Gap (Annual, Percent of GDP)		
	Low	Intermediate	High
2000	0.6	0.4	0.2
2005	0.7	0.3	-0.2
2010	0.7	0.1	-0.5
2015	0.3	-0.3	-1.0
2020	-0.2	-0.9	-1.6
2025	-0.5	-1.4	-2.3
2030	-0.7	-1.7	-2.7
2035	-0.7	-1.8	-3.0
2040	-0.5	-1.7	-3.2
2045	-0.4	-1.7	-3.4
2050	-0.3	-1.7	-3.6

Emissions Trading Revenues (Annual, Percent of GDP)						
Peak in 2015			1990 in 2010	-10% in 2010	1995 in 2010	
US Only	Annex I	Global	Annex I	Annex I	Annex I	
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	0.0	0.6	1.2	1.2	
0.0	0.0	0.0	0.8	1.4	1.4	
0.1	0.4	0.1	0.9	1.5	1.5	
1.2	0.7	0.2	1.0	1.5	1.6	
1.7	0.9	0.2	1.0	1.5	1.6	
2.3	1.1	0.2	1.1	1.6	1.6	
3.0	1.2	0.3	1.2	1.6	1.7	
3.7	1.3	0.3	1.2	1.7	1.8	
4.7	1.3	0.3	1.3	1.8	1.9	

Linda Doman, EIA
9/29/97

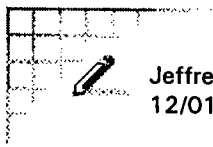
<u>MMTCE</u>	<u>1990</u>	<u>1995</u>
UK	173	170
Fr	113	110
Ger	279	241
Italy	118	124
Netherlands	61	67
Other Europe	272	303

Art Ruppel
586-8425

EIA
90
1344

96 energy related CO₂ - US
1463

Enail Bob WEFA paper



Jeffrey A. Frankel
12/01/97 06:33:15 PM

Record Type: Record

To: Joseph E. Aldy/CEA/EOP
cc: Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP
Subject: Some more questions on GCC

- The 12/1 Eco newsletter distributed by State with other materials from Kyoto claims that "Annex I emissions are now 4.6% below 1990 levels". They have said that before. Given that U.S. emissions are up 10 Percent (right?), that would have to be a whopping decrease in the FSU (and UK and Germany) to be a correct figure? Do you think it is right?
 - Any update of figures in your EurMemo2 (9/30) that W.Eur will be 18% above 1990 in 2010 (and U.S. 28%; that one's up to 30%, no?)? - 34 %.
 - In what year are LDCs expected to pass OECD countries in emissions? JF
- JF

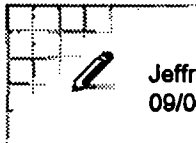
EIA- IEO 97

1990 Annex I (Industrialized + EE/FSU - Mexico)

4237

1995

3947



Jeffrey A. Frankel
09/06/97 04:46:33 PM

Record Type: Record

To: Randall W. Lutter/CEA/EOP, Joseph E. Aldy/CEA/EOP, Adele C. Morris/OMB/EOP
cc: Janet L. Yellen/CEA/EOP
Subject: a graph showing emission paths

I think it would be very useful to have a clear simple graph showing exactly what some commonly discussed emission paths look like.

- It should include BAU
- all other paths should follow BAU up to 2000 (or perhaps 1997), reflecting that it is already too late for the 90s to be in decline.
- it should include some past history, perhaps back to 1960, in addition to the main forward part, which perhaps should go as far forward as 2100 (of perhaps just to 2050, if doing the whole century would mean that one could not tell the difference among the paths for the early years it should definitely include:
 - "1990 by 2010," with some natural peak date like 2002
 - 1990 by 2040, with the "peak in 2015"
- perhaps some others

Randy, could you see that someone does this. Then try out some samples on Janet. It might be useful for making presentations (at the highest levels). End of the week is fine for this one.

JF

Case 6S.X15 Peak in 2015 + BAU

total emissions 1985-2050: 109135

2000-2050: 92971

1990 in 2010 + BAU

total emissions 1985-2050: 105973

2000-2050: 89809

Peak in 2015 = 1.0298

1990 in 2010 1.0352

3-3½% more emiss.

only over

2005-2040

Feb. - rms for Rosina

2100 WRE 2100 BAU

541 ~1.8°C 9/10

~2.4°C

9/30/97

Arthur Rypinski, EIA, S86-8425

1990: 1372 MMTCE: total CO₂ - cement manufacturing 9-10
territories (e.g. VI) 9-10
misc. (e.g. flares) 9-10

1344 MMTCE: energy related CO₂

estimates are accurate to 0.2-0.5% → bias error in energy
information collected - probably off by same amt. each yr.

keep revising GHG estimation methodology → then revise historical data

- removed several doublecounting cases

to be published in October, latest estimates

	Total CO ₂	Energy-Related CO ₂
1990	1373.8	1345.8
1996	1495.9	1463.0

ORNL CO₂ estimates - Greg Marland

derived from US energy consumption data

may vary from other estimates given conversions

- coal C factors can vary ~10% per unit energy
~50% per unit energy per ton

- oil densities range ~20%, C factor can vary 5-10%
per unit energy (w/o LPG, ~5%)

- nat. gas varies ~2% per unit energy w/ a couple
of exceptions

non-fuel use excluded - misses ~5%

10/1/97

Linda Doman, EIA, 586-1041

Japan

	<u>1990</u>		<u>1995</u>	
	Energy	Emissions	Energy	Emissions
	(Quads)	(MMTCE)	(Quads)	(MMTCE)
Total	18	308	21.4	361
oil	10.1	210	11.6	232
gas	2.6	30	2.4	35
coal	2.7	68	3.6	93
nuclear	1.9		2.8	
renewables				

$$\Delta \text{Energy} = -0.1$$

11% ↑ oil

30% ↑ coal

50% ↑ nuclear

7% ↓ renewables

baseline 1990 $\rightarrow$ 2010 US

22% or 29% $\rightarrow$ call EIA

talk to Jeff about higher growth rates

$\rightarrow$ might want to touch base w/ EPA - sensitivity

9/15 Susan Holt (EIA)

1722 in 2010

1345 in 1990

$\rightarrow$ 28%

Emissions of GHG report $\rightarrow$ 1345

MMTC from CO₂ emissions from energy use
measured in MMTC

Emissions of GHG in the U.S.

$\rightarrow$ 1344. Commissions

★

From: Mark Bernstein on 10/02/97 05:21:15 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP, Joseph E. Aldy/CEA/EOP

cc: Rosina M. Bierbaum/OSTP/EOP, Henry C. Kelly/OSTP/EOP

Subject: Sources of Greenhouse Gases

TO: Jeff Frankel and Joe Aldy

From: Mark Bernstein, Rosina Bierbaum and Henry Kelly

Date: 10/2/97

RE: Comments on *Sources of Greenhouse Gases*

Thanks for your comments on *the Sources of Greenhouse Gases* document. We find from your comments that we made a couple of errors, and also needed to clarify some items so that they would not be misinterpreted. Here are some responses to your comments:

On your first bullet - we have been working with an interagency team and OMB to develop new initiatives and expansions of programs to meet climate change objectives. There is considerable backup documentation on the potential programs and emissions savings which we would be happy to share. We think that keeping the options on the charts are important because it gives decision makers a visual perception of the types of programs that could address particular areas.

On your second bullet - the first part was a good catch - thanks. On the remaining greenhouse gases which are about 15%, we project that they remain about that into the future and when we reduce emissions of CO₂, we scale back the portion of methane emissions from natural gas proportionally.

There seems to be some misunderstanding on the use of some numbers, and the wording of bullets. We generally use carbon coefficients as follows: coal = 25; oil = 20 and gas = 14.5. To that end, the relative carbon impact of coal to gas is 25/14.5 or 72% as stated. The rest of that bullet was written improperly and should have said "and 22% more than oil"

On energy prices - we did take the numbers from AEO97 and in some cases we were looking at different numbers than you were - in particular we were looking at delivered coal which declines by 11% (which we had wrong and have corrected), and delivered natural gas which declines at 5% even though wellhead prices increase, and finally the last part should have been gasoline prices which are pretty flat (growing at less than .1% per year according to EIA).

Again, thanks for your review of the document. Let us know if we can answer any other questions.



U.S. Department of Justice

Environment and Natural Resources Division

Assistant Attorney General
950 Pennsylvania Avenue, N.W.
Washington, DC 20530-0001

Telephone (202) 514-7701
Facsimile (202) 514-0557

October 10, 1997

cc: BB
SR
AM
MJ

MEMORANDUM

To: Assistant Secretaries Group

From: Lois J. Schiffer, Assistant Attorney General
Environment & Natural Resources Section

Re: Right-to-Know Proposal for GHG Emissions

Background

On numerous occasions, the President has expressed his personal commitment to right-to-know provisions and has recognized their effectiveness. For example, in an August 28, 1996 speech in Kalamazoo, Michigan, the President stated,

We're also going to expand our community right-to-know law to make more information, practical information available to families easier and faster. Right-to-know will protect you here in communities like Kalamazoo because you can find out what's dangerous to your families. Once there is a right-to-know law, companies think twice about what they do.

Similarly, in an August 8, 1995 speech in Baltimore, the President stated,

Community right to know is here to stay. . . . Democracies always have depended upon the free flow of information to ordinary citizens.

Finally, the President wrote regarding an existing right-to-know program that information disclosure "encourage[s] informed community based environmental decision making and provide[s] a strong incentive for businesses to find their own ways of preventing pollution." 60 Fed. Reg. 41,791 (1995)

Proposal

The principle of right-to-know is directly applicable to emissions of greenhouse gases (GHG). The public has a right to know who are emitters of gases that threaten community, national and global health and the environment. Were information on emission levels made public, domestic companies would be encouraged to maximize their energy efficiency and minimize GHG. Moreover, the public would have sufficient information to make choices about providers of various services which result in GHG emissions.

Hence, we recommend that a right-to-know proposal be included in any options memorandum to the President which generally identifies federal programs that can help reduce national GHG emissions. The proposal should apply to emitters of GHG at an appropriate level

(i.e. over a particular threshold amount). Information on emissions would be reported to EPA or other appropriate agency and made publicly available on a database. Such a proposal would mesh well with a domestic allowance trading program, since emissions information would already be provided to EPA (or relevant agency) by companies within that program. But the right-to-know proposal would also be important in sectors not covered by a trading program or if reductions were secured through other means (e.g. performance standards).

SOC

1997 OCT 10 PM 6:04

DISTRIBUTION:

(8/12) From: Lois Schaffer, DOJ

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Treasury	Robert Gillingham	622-2633	622-2220
	Jon Gruber		622-0563
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	~~Jim Simon~~		
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	Josh Gottbaum	395-3174	395-9188
USTR	Jennifer Haverkamp	395-4579	395-7320
USDA	Charlie Rawls	720-5437	720-6158
DOE	Dan Reicher	586-0148	586-9500
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	David Hales	703-875-4639	703-875-4205
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DOD	Sherri Goodman	703-693-7011	703-695-6639
	Roy Salomon	703-607-3124	
NEC	Peter Orszag	456-2223	456-5358
* CEQ/NSC	David Sandalow	456-2710	456-6224

THE WHITE HOUSE
WASHINGTON

August 15, 1997

CC: JS
JA
Lutter

NOTE FOR CLIMATE CHANGE POLICY OVERSIGHT GROUP

FROM: PETER ORSZAG
DAVID SANDALOW

Subject: Summer Reading

Attached is a summary of workgroup activity underway.

Also attached are papers on:

1. Joint Implementation "Additionality"
2. International Emissions Trading, and
3. Developing country commitments.

Additionality in the Context of Joint Implementation

Issue:

The U.S. is calling for joint implementation (JI) with credit to be included in the new agreement adopted in Kyoto under the Framework Convention on Climate Change (FCCC). JI is a mechanism by which a private entity in a country with an emissions budget (developed countries) invests in greenhouse gas mitigation projects in a country without a budget (developing countries). In exchange, the investor (and its country) receives credit towards its emission budget.¹

There is a broad consensus among countries and private parties that for JI to make sense, the emission reductions that give rise to JI credit must be "additional" to -- above and beyond -- reductions that would have happened anyway in the baseline case. Consider the case where a developer wants credit for building a low-GHG-emitting plant rather than a high-GHG-emitting plant. If the high-emitting plant truly represents what would have happened in the baseline case, then it would be appropriate to give the developer credit for the difference in emissions between the high and low-emitting plant. But if the low-emitting plant would have been built anyway (because its technology represents the business-as-usual case), then credit would not be appropriate. The project would have no environmental benefit.

The principal problem identified to date is that the question "what would have happened anyway" is extraordinarily difficult to answer. Experience in the U.S. pilot program on JI indicates that analysts can differ over whether a proposal will go forward without the reward of JI credit, or conversely that it will be implemented only if credit is available.

The consequences of "getting it wrong" are large in both directions. If credit is given systematically for projects that would happen anyway, then the use of these credits to meet developed country obligations will result in higher global emissions. Consider only one area in which JI projects may be undertaken: energy efficiency improvements. The energy efficiency of electric power projects and other industrial projects in developing countries is expected to improve significantly over the next 10-20 years, reflecting the normal penetration of better technologies. Indeed, a key part of the U.S. negotiating position is to require countries to undertake "no regrets" reductions in emissions that are economically justified on their own. Preliminary analysis by EPA suggests that currently anticipated improvements in the efficiency of energy production and use in developing countries will reduce their expected emissions growth in 2010 by as much as 865 million tons of carbon, as compared with growth on the basis of existing technologies.² If credit were given for projects in developing countries without accounting for these expected improvements, a large amount of excess carbon emission credits could be awarded. Developed countries, as a whole, only

¹Note that several modelers have interpreted JI to mean international trading between Annex I and non-Annex I countries. This interpretation is not correct and is not adopted here.

²Recent SGM model runs.

need 750 million tons of carbon reductions to reach 1990 levels by 2010.³

On the other hand, if the standard of "additionality" is set too high (i.e., if unrealistic improvements are taken into the baseline case), or if projects are choked off by transaction costs associated with resolving baseline and additionality questions, then the large potential savings associated with JI will be lost.

The issue discussed in this paper is how "additionality" for JI can be assured on a practical basis in the Kyoto agreement. Since there are a large number GHG mitigation opportunities available in the developing world which are inexpensive compared to domestic opportunities, it would greatly benefit the U.S. if practical methods could be developed to assure additionality. To that end, this paper presents and develops six options for addressing additionality. All of the options are briefly evaluated in terms of their development costs, ongoing costs (transaction costs for project developers and verification costs for verifiers), comprehensiveness of applicability, accuracy,⁴ and robustness over time. A final section presents stakeholder positions on JI and additionality in particular, to the extent that agencies are familiar with such positions.

The extent to which the issues surrounding additionality need to be addressed prior to Kyoto is uncertain. Some would argue that the agreement need only reference a method for addressing additionality or simply reference the need to address additionality. The details of a method for addressing additionality could be worked out by Parties post-Kyoto. Others see the resolution of issues related to additionality, to the degree possible, as essential prior to Kyoto. As discussed above, the consequences of getting additionality "wrong" are large.

Option 1. Forward-Looking Benchmarking:

A set of benchmarks could be developed and internationally agreed upon for specific technologies and practices associated with JI. JI projects would be considered additional if the technology they employed were lower-emitting (more efficient) than the benchmark emission level. Credits would be calculated as the difference between the performance of the JI technology or practice and the benchmark performance level.

From a practical standpoint, these benchmarks would have to be developed and negotiated following Kyoto. JI provisions in the Kyoto agreement would have to include a description of the option and a call for the subsequent adoption of guidelines by the Parties to the agreement. The first set of benchmarks would be applicable to JI projects undertaken in the first budget period. They would

³This number is based on the Interagency Analytic Team's (IAT) results. IAT's baseline projections of energy use and fuel mix were based on DOE's Annual Energy Outlook (1997), and the International Energy Administration's 1997 World Energy Outlook.

⁴None of the options can truly be "accurate" at determining additionality since it is impossible to answer the question "what would have happened anyway." The paper presumes, however, that some methods are better at answering this question than others.

need to be updated and renegotiated for subsequent budget periods, reflecting improvements in the baseline ("would have happened anyway") case over time.

Several simple examples may serve to illustrate the benchmark concept.

Some JI proposals involve upgrades of existing energy production facilities. Consider a proposal to reduce the emissions of an electric power plant, by increasing the efficiency (improving the heat-rate) of the generator or by switching fuels. A benchmark would be developed for the expected future of such facilities. For illustration, that might take two forms:

- Based on economic forecasts, estimated technology penetration rates, and other factors, it may be agreed that in the business-as-usual case, these facilities would continue to be operated indefinitely without upgrade. In that case, the benchmark would reflect the emissions rate of the current facilities and credit would be given for improvements made.
- Alternatively, forecasts may show that the proposed technologies are already penetrating these markets and that these upgrades are expected to take place in the business-as-usual case. In that case, the benchmark would reflect these improvements, and no credit would be given for making them.

Other JI proposals involve projects to meet new power demand with lower emissions. Proposals include building lower-emitting power projects (e.g., renewable, gas-fired, or very efficient coal-fired plants) in place of building relatively inefficient coal-fired plants. A benchmark would be developed for the emissions-intensity of base case power production facilities, with credit given for lower-emitting projects. For illustration:

- Based on economic forecasts, estimated technology penetration rates, and other factors, it may be agreed that the baseline case is the construction of high-emitting plants, with credit given for alternative technologies with lower emissions per kilowatt-hour output. On the other hand, it may be agreed that a certain penetration of gas, wind, or other technologies is already expected, and thus JI credit should not be given to low-emitting projects which are part of that expected technology penetration.

Similar benchmarks could be developed for other technologies, such as new automobiles (carbon per mile per vehicle), or steel mills (tonnes carbon per tonne of steel). Similar issues are presented by projects to enhance the sequestration of carbon in forests or soils. A range of projects have been proposed, from preservation of existing forests, to changing logging practices (e.g., selective logging rather than clear-cutting), to the creation of tree plantations. Benchmarks for logging projects might be in tonnes of carbon emissions per board feet of lumber.

Forecasting and negotiating benchmarks for these expected emissions futures will be complex. Consideration should be given to ways to reduce such complexity. Can a single set of global benchmarks can be used, or do they will need to be regionally- or nationally-specific? Moreover, should the energy sector benchmarks be fuel neutral (tonnes of carbon equivalent emissions per unit MWh) so that it is less difficult to determine the appropriate benchmark from which to determine additionality.

The characteristics of this option are:

- *High accuracy* -- This option is likely to be highly accurate since it attempts to account for many of

the factors which affect "what would have happened anyway" such as changing economic conditions and rates of technology penetration.

- *Low verification costs* -- Once benchmarks are developed, it would be easy for verifiers to evaluate additionality. A project's emissions are either less than a benchmark or they are not.
- *Low transaction costs for project developers* -- Additionality could be determined quite easily. A project's emissions are either less than a benchmark or they are not.
- *Uncertain comprehensiveness* -- The comprehensiveness of this option depends on the extent to which benchmarks can be developed and negotiated. To the extent benchmarks are developed for a broad set of technologies and practices, the option would be fairly comprehensive. Comprehensiveness is important because the larger the set of JI mitigation opportunities, the lower the cost of reducing greenhouse gas emissions.
- *High development costs* -- Such costs would be high because countries would have to conduct a great deal of data collection and analysis to determine appropriate benchmarks and would have to negotiate benchmarks internationally.
- *Low robustness over time* -- The benchmarks not only have to be developed and negotiated initially, but they also have to be updated over time.

Option 2. Historical Benchmarking

Historical benchmarking works on the same basic principle as forward-looking benchmarking. Benchmarks are developed for technologies and practices associated with JI projects. JI projects are considered additional if the technology they employ is lower-emitting than the benchmark.

The difference between this option and the first option is that in this option the benchmarks are not negotiated at the beginning of each budget period for the entire budget period based on economic forecasts, estimated technology penetration rates, and other factors. They are instead determined on a project by project basis based on historical emissions in the sector of the project. Consider a proposal to build a lower-emitting power project (e.g., renewable, gas-fired, or even very efficient coal-fired plants) in place of a relatively inefficient coal-fired plant. The benchmark might be the average emissions intensity of coal-fired power plants in that country in the past year. Credit would be given for the difference between the emissions intensity of the benchmark and the emissions intensity performance of the project if it is lower than the benchmark.

The benchmark would not take into account factors which affect the emissions intensity of JI technology or practices as a particular JI project progresses. In this example, for instance, energy efficiency improvements in baseline coal technology in the country of the project would not be accounted for in calculating the credit for the project. Such changes would not be ignored, however. As a each new JI project is implemented, a new benchmark is utilized. Since more and more efficient processes would be implemented over time, the emissions intensity of the benchmarks would fall over time. Thus the extent to which JI credits could be created in a sectors where emission intensity is decreasing over time would diminish over time.

Presumably the methods for determining such benchmarks, rather than the benchmarks themselves, would be negotiated internationally.

The evaluation of this option is very similar to evaluation of Option 1 except that this option has lower development costs, is more robust over time, may be more comprehensive, and is less accurate. The option has lower development costs because only methods, not benchmarks, have to be developed and negotiated. The option is more robust over time because neither benchmarks nor methods would have to be renegotiated every budget period. The option may be more comprehensive to the extent that it is easier to develop methods to determine additionality rather than actual benchmarks. The option is less accurate because individual projects would be getting credit from a benchmark that does not take into account forward-looking factors which will affect what would have happened anyway such as business as usual technology penetration. Moreover, the use of average emission intensities in formulating historical benchmarks can be problematic. Averages can change slowly or be weighted down if, even as new less greenhouse gas intensive technologies are introduced, old inefficient technologies continue to be used.

Option 3. Measuring Additionality From Sector-Specific Emission Baselines

This option would involve the development of sector-specific (rather than project or technology specific) emission baselines in countries which wish to host JI for the sectors in which each country wishes to host JI. These baselines would constitute a quantitative determination of projected future GHG emissions for relevant sectors. The emissions baseline for each sector would be based on such factors as forecasted economic growth, expected penetration rates of technologies or practices, and adopted and projected policies and measures affecting the sector. Before a JI project could be deemed additional, a determination would first have to be made that emissions from an entire sector in a developing country are below the emissions baseline. The same methodologies used to report and verify emissions by Annex I countries could be used for this assessment of actual emissions. Then, the host country in conjunction with project developers, could attribute the "surplus" emission reductions to specific projects deemed worthy.

The characteristics of this option are:

- *High accuracy* -- This option is likely to be highly accurate since it attempts to account for many of the factors which affect "what would have happened anyway" such as changing economic conditions and rates of technology penetration.
- *Uncertain robustness over time* -- This option would be robust to the extent that developing countries do not change their emissions baselines or methods for allocating surplus emission reductions over time.
- *Uncertain transaction costs for project developers* -- The process used to allocate surplus emissions reductions to projects would vary by country and possibly by sector within a country. To the extent that such allocation systems are straightforward and transparent, transaction costs would be low.
- *Uncertain verification costs* -- Such costs would depend on how this option is implemented by countries.
- *Uncertain comprehensiveness* -- To the extent that all host countries develop baselines for all sectors available for investment from JI, this option would allow a broad set of projects to be eligible for JI and as a result potentially many countries. To the extent that some countries may do not develop baselines such comprehensiveness would be limited.
- *High development costs* -- Such costs would be high because countries would have to conduct a great deal of analysis to determine the appropriate emission baselines. The availability of

international guidelines, developed for Annex I countries, for determining actual emissions would reduce the costs of determining sector-wide surplus emissions.

- *Low political feasibility* -- Political feasibility is not a criteria on which the other options have been evaluated since many of these ideas are new and it is very unclear how countries would react to them. It is possible to predict that this option would be very unpopular with developing countries, however. They are likely to view this option as a step toward their acceptance of national, quantitative, GHG emission reduction commitments.

Option 4. Defining Additionality As Overcoming Project-Specific Barriers

An option, which is being advanced internationally by the International Energy Agency, would involve assessing whether a project breaks ground by overcoming barriers (institutional, financial, technological, informational, policy, financing, or market) specific to that project in the country where it is proposed. A project would be deemed additional if it is demonstrated that the existence of such barriers is inhibiting the project from going forward, that the project would represent an innovation in overcoming those barriers, and that JI credit would supply the necessary incentive to go forward. The IEA has developed a typology of barriers which provides developers and evaluators with a framework for identifying and evaluating barriers.⁵ The typology defines and categorizes generic barrier types for specific sectors (power generation, transport, etc.).

The characteristics of this option are:

- *High comprehensiveness* -- The barrier typology can easily be expanded to include multiple project types.
- *Low development costs* -- To the extent that many of the development costs of this option have already been borne by the IEA (or are currently being borne as they further develop it), this option would have minimal development costs.
- *High robustness over time* -- The barrier typology can be adjusted as needed fairly easily.
- *Moderate transaction costs and investor uncertainty for project developers* -- Transaction costs and investor uncertainty will be lowered by the standardization presented by the barrier typology, but it will be unclear to project developers which additionality arguments will be accepted by reviewers. Consistency of decisions by reviewers is not guaranteed since decisions will be made on a case by case basis.
- *High verification costs for organizations determining compliance* -- Review on a project by project basis of unique additionality arguments is resource-intensive.
- *Low accuracy* -- Low probability of accuracy results from the difficulty of digesting subjective arguments about additionality and then making a determination of additionality. Also, both parties selling and buying credits would have incentives to promote the existence of barriers that might not exist.

Option 5. Assess additionality using a general set of guidelines

⁵Not yet published International Energy Agency paper titled "Activities Implemented Jointly Under the FCCC."

This option would provide for project by project judgments of additionality based on information provided by project developers. Project developers and evaluators would use a general set of guidelines to develop and evaluate additionality arguments. This is similar to the approach currently used by the U.S. Initiative on Joint Implementation (USIJI). For example, in the original guidelines for development of a project proposal USIJI asks, regarding additionality, that project developers include a discussion of the following subjects in their project proposal:

- (1) How the existence of the USIJI program helped or could help overcome any barriers to develop or implement the project;
- (2) A discussion of whether the specific measures taken by the project to reduce or sequester greenhouse gas emissions are required by existing laws or regulations applicable in the U.S. or host country; and
- (3) A description of the prevailing technologies and management practices now used in the host country and how the specific measures proposed in the project differ from them.⁶

The characteristics of this option are:

- *Low development costs* -- Guidelines used for existing JI programs could be compiled.
- *High robustness over time* -- General guidelines can be adjusted as needed fairly easily.
- *High comprehensiveness* -- General guidelines are not project specific and can be comprehensively applied.
- *High transaction costs and investor uncertainty for project developers* -- High transaction costs and investor uncertainty result from the lack of standardization of the process. Which arguments will work? Which will not? Consistency of reviewer decisions is not guaranteed since they will be developed on a case by case basis.
- *High verification costs* -- Review on a project by project basis of unique additionality arguments is resource-intensive.
- *Low accuracy* -- Low accuracy results from the difficulty of digesting subjective additionality arguments and then making a determination of additionality.

Option 6. Employing safeguards such as discounting

Given that any method to determine additionality is likely to be imperfect, this option would employ safeguards, such as discounting, in addition to whatever method is adopted for addressing additionality. In this way the overall quantity of credits created through JI, some of which may have happened anyway, could be reduced. Other options for safeguards include phasing out JI in some future year, or limiting the scope of JI (e.g. developed countries might be limited to meeting 10% of their emission reduction targets through JI).

This option cannot be evaluated like other options since the results are dependent on which safeguard is selected and which method to address additionality is used in combination with the safeguard.

Stakeholder Positions On JI And Additionality

⁶Description of the U.S. Initiative on Joint Implementation, 1994.

Most business NGOs involved in the climate change debate are supportive of including JI in the Kyoto agreement, while most environmental NGOs are opposed to such inclusion. Two organizations actively involved in the climate change debate support the inclusion of JI in the Kyoto agreement only on the condition that the emission reductions associated with JI are both credible and verifiable (Environmental Defense Fund, Business Council for Sustainable Energy).^{7 8}

Several stakeholders not only have positions on JI but have also developed positions on the topic of additionality. The Edison Electric Institute has suggested that a form of historical benchmarking be used for the electric power sector.⁹ If JI is included in the Kyoto agreement, the U.S. Climate Action Network suggests that credits be based on clear criteria and benchmarks, rather than "an inherently subjective and unverifiable project-by-project determination of what would otherwise have happened"¹⁰ The Environmental Defense Fund takes the opposite tack and suggests that additionality be determined on a project by project basis. They specifically reject the benchmarking approach stating that past U.S. use of centrally-defined best available technology (BAT) standards failed; a one-size-fits-all approach to BAT overlooks the differences among nations and among regions within nations; and efforts to develop definitions of BAT will likely deteriorate into difficult and divisive trade negotiations.¹¹ Finally, the Center for Clean Air Policy has recommended that the U.S. drop the additionality test altogether for 1) projects that reduce net emissions (fuel switching, efficiency improvement and other projects that reduce emissions at existing facilities) and 2) all renewable energy projects. They argue that dropping the additionality test would make credits produced by these projects more fungible, increase transparency and reduce the transaction costs associated with the current JI process both here and abroad. They also recommend the discounting of JI project credits to account for uncertainty and to improve the credibility of JI generally.¹²

⁷Facsimile from Annie Petsonk of the Environmental Defense Fund to Lisa Carter of the U. S. Environmental Protection Agency dated February 7, 1997

⁸BCSE "Position Statement -- Global Climate Change" 1997

⁹Letter to Eileen B. Claussen, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, March 24, 1997 from Edison Electric Institute.

¹⁰Letter to Eileen B. Claussen, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, May 2, 1997 from the U.S. Climate Action Network.

¹¹Facsimile from Annie Petsonk of the Environmental Defense Fund to Lisa Carter of the U.S. Environmental Protection Agency dated February 7, 1997.

¹²Letter to Bob Dixon from Edward A. Helme, Director, Center for Clean Air Policy, dated June 26, 1997 which accompanies a paper titled "Integration of Joint Implementation into an Annex I Greenhouse Gas Trading System."

[illegible]

Annex A allowable emissions based on 3 metric tons per capita (millions metric tons)

Reg/Co	1990	1995	2000	2005	2010	2025
OECD-NA						
US	750	789	828	861	897	993
Canada	84	87	96	99	105	114
Mexico						
OECD-EUR	1287	1317	1344	1368	1383	1395
Austria	24	24	24	24	24	24
Belgium	30	30	30	30	30	30
Denmark	15	15	15	15	15	15
France	171	174	180	183	186	183
Germany	237	246	237	240	237	228
Greece	30	30	33	33	33	30
Ireland	12	12	12	12	12	12
Italy	171	171	174	171	168	156
Netherlands	45	48	48	48	48	48
Norway	12	12	12	12	12	15
Portugal	30	30	30	30	30	30
Spain	117	120	120	120	120	114
Sweden	27	27	27	27	27	30
Switzerland	21	21	21	24	24	24
Turkey	171	183	201	219	234	273
UK	174	174	180	180	183	183
other						
OECD-PAC						
Australia	51	54	57	60	63	75
Japan	372	375	381	387	390	366
New Zealand	12	12	12	12	12	12
EE/FSU						
FSU	864	879	882	891	900	951
Belarus,Rep	30	30	30	30	30	30
Estonia,Rep	6	6	6	6	6	3
Latvia, Rep	9	9	9	9	9	6
Lithuania,Rep	12	12	12	12	12	12
Moldova, Rep	12	12	12	12	12	15
Russian Fed	444	441	438	432	429	417
Ukraine	156	153	153	153	153	147
Armenia	9	12	12	12	12	15
Azerbaijan	21	24	24	24	24	30
Georgia, Rep	15	15	15	15	15	18
Kazakhstan, Rep	51	51	51	54	54	66
Kyrgyz Rep	12	15	15	15	18	21
Tajikistan, Rep	15	18	18	21	24	36
Turkmenistan,Rep	12	12	12	15	15	21
Uzbekistan,Rep	60	69	75	81	87	114

Annex A allowable emissions based on 3 metric tons per capita (millions metric tons)

Reg/Co	1990	1995	2000	2005	2010	2025
East. Eur	324	324	324	327	327	342
Albania	9	9	9	9	12	15
Bulgaria	27	27	27	27	24	24
Czech Rep	30	30	30	30	30	33
Hungary	30	30	30	30	30	27
Poland Rep	114	114	114	117	117	126
Romania	69	69	69	69	69	66
Slovak Rep	15	15	15	15	15	18
Yugoslavia, FR	30	30	30	30	30	33
E.Asia						
So. Korea						
Total	3744	3837	3924	4005	4077	4248

Annex A Populations 1990-2025 (millions)

Reg/Co	Historical 1990	1995	Projected 2000	2005	2010	2025
OECD-NA						
US	250	263	276	287	299	331
Canada	28	29	32	33	35	38
Mexico						
OECD-EUR	429	439	448	456	461	465
Austria	8	8	8	8	8	8
Belgium	10	10	10	10	10	10
Denmark	5	5	5	5	5	5
France	57	58	60	61	62	61
Germany	79	82	79	80	79	76
Greece	10	10	11	11	11	10
Ireland	4	4	4	4	4	4
Italy	57	57	58	57	56	52
Netherlands	15	16	16	16	16	16
Norway	4	4	4	4	4	5
Portugal	10	10	10	10	10	10
Spain	39	40	40	40	40	38
Sweden	9	9	9	9	9	10
Switzerland	7	7	7	8	8	8
Turkey	57	61	67	73	78	91
UK	58	58	60	60	61	61
other						
OECD-PAC						
Australia	17	18	19	20	21	25
Japan	124	125	127	129	130	122
New Zealand	4	4	4	4	4	4
EE/FSU						
FSU	288	293	294	297	300	317
Belarus,Rep	10	10	10	10	10	10
Estonia,Rep	2	2	2	2	2	1
Latvia, Rep	3	3	3	3	3	2
Lithuania,Rep	4	4	4	4	4	4
Moldova, Rep	4	4	4	4	4	5
Russian Fed	148	147	146	144	143	139
Ukraine	52	51	51	51	51	49
Armenia	3	4	4	4	4	5
Azerbaijan	7	8	8	8	8	10
Georgia, Rep	5	5	5	5	5	6
Kazakhstan, Rep	17	17	17	18	18	22
Kyrgyz Rep	4	5	5	5	6	7
Tajikistan, Rep	5	6	6	7	8	12
Turkmenistan,Rep	4	4	4	5	5	7
Uzbekistan,Rep	20	23	25	27	29	38

Annex A Populations 1990-2025 (millions)

Reg/Co	Historical 1990	1995	Projected 2000	2005	2010	2025
East. Eur	108	108	108	109	109	114
Albania	3	3	3	3	4	5
Bulgaria	9	9	9	9	8	8
Czech Rep	10	10	10	10	10	11
Hungary	10	10	10	10	10	9
Poland Rep	38	38	38	39	39	42
Romania	23	23	23	23	23	22
Slovak Rep	5	5	5	5	5	6
Yugoslavia, FR	10	10	10	10	10	11
E.Asia						
So. Korea						
Total	1248	1279	1308	1335	1359	1416

Sources

IEA- Energy Policies of IEA Countries - 1996 Review
World Resources 96-97 pp. 190-1 WRI

Notes

- 1 - Other OECD-EUR are Finland, Iceland, Luxembourg
- 2 - E. Eur includes Albania, Bulgaria, Czech Rep., Slovakia
Hungary, Poland, Romania, Former Yugoslavia
- 3 - FSU includes Russian Federation, Eur Rpbcls(Belarus,
Moldova, Ukraine); Cen. Asian Rpbcls(Kazakhstan,
Kyrgyz Rep., Tajikistan, Turmenistan, Uzbekistan);
Transcaucasus (Armenia,
Azerbaijan, Georgia); and Baltic Sts(Estonia, Latvia, Lithuania)
- 4 - No data included for Greenland, Guam and Virgin Islands
- 5 - FSU and EE interpolated for 2000, 2005, 2010

GDP, Carbon Emissions, and Population Projections through 2050

GDP in billions of 1990 US\$ (ppp)

	1	2	3	4	5	6	7	8
	Canada	FSU	Japan	USA	W. Europe	Australia	China	India
1985	475	1,614	2,040	4,635	5,345	232	1,207	821
1990	520	1,810	2,221	5,501	6,046	278	1,824	983
1995	588	946	2,461	6,038	6,760	320	2,758	1,232
2000	673	1,238	2,736	6,759	7,560	367	4,066	1,536
2005	770	1,567	3,025	7,517	8,549	422	5,954	1,888
2010	861	1,946	3,248	8,230	9,671	482	8,391	2,255
2015	927	2,390	3,391	8,852	10,921	551	11,369	2,664
2020	971	2,941	3,551	9,490	12,317	627	14,769	3,144
2025	999	3,504	3,750	10,173	13,883	709	18,964	3,668
2030	1,018	4,152	3,954	10,905	15,644	799	23,789	4,217
2035	1,051	4,817	4,141	11,690	17,629	905	29,153	4,777
2040	1,096	5,480	4,269	12,532	19,877	1,009	35,500	5,294
2045	1,150	6,198	4,451	13,434	22,409	1,132	43,827	5,828
2050	1,207	6,944	4,697	14,401	25,267	1,269	54,266	6,514

Carbon Emissions (bold numbers indicate emissions base: 90 or 95 for An I, but for non An I year at which begin to limit emissions = 5yr after income factor >0)

	1	2	3	4	5	6	7	8
	Canada	FSU	Japan	USA	W. Europe	Australia	China	India
1985	106	945	242	1227	820	55	509	132
1990	117	1050	272	1350	835	62	648	198
1995	135	664	311	1480	887	69	808	252
2000	146	710	337	1550	937	75	979	300
2005	158	760	356	1637	1008	82	1173	345
2010	169	836	368	1729	1074	88	1379	373
2015	176	886	370	1808	1112	92	1610	432
2020	180	933	373	1871	1146	96	1829	503
2025	181	960	380	1922	1172	98	2068	573
2030	180	963	386	1972	1179	99	2316	632
2035	180	982	390	2029	1172	99	2607	657
2040	181	1023	389	2093	1174	99	2887	676
2045	185	1050	394	2166	1170	99	3153	732
2050	189	1050	406	2245	1160	100	3443	816

Population (millions)

	Canada	FSU	Japan	USA	W. Europe	Australia	China	India
	Region 2	Region 4	Region 6	Region 1	Region 1	Region 1	Region 3	Region 5
1985	24.721	279.208	120.751	239.28	420.54	15.944	1051.672	744.884
1990	26.524	289.514	123.532	250.3	432.681	17.064	1133.687	810.709
1995	28.423	295.497	125.213	263.301	444.44	18.241	1199.332	883.401
2000	29.842	302.106	126.84	275.603	452.87	19.291	1255.054	967.133
2005	31.052	309.267	127.749	287.102	457.323	20.19	1301.519	1058.659
2010	32.168	317.056	127.947	298.897	461.356	20.972	1347.517	1147.597
2015	33.158	324.709	127.295	311.2	464.781	21.616	1392.235	1229.515

Source: SGM

Population (millions) (cont.)

	Canada	FSU	Japan	USA	W. Europe	Australia	China	India
	Region 2	Region 4	Region 6	Region 1	Region 1	Region 1	Region 3	Region 5
2020	34.022	331.335	126.027	322.742	467.469	22.115	1434.385	1306.26
2025	34.659	337.583	124.292	335.046	469.292	22.525	1471.284	1381.008
2030	34.999	342.812	122.152	346.9	469.616	22.824	1500.61	1456.898
2035	35.14	347.215	120.118	358.459	468.465	23.023	1521.626	1533.732
2040	35.085	350.787	118.297	369.981	465.065	23.118	1535.192	1607.294
2045	34.991	353.898	116.507	381.709	461.665	23.137	1542.178	1673.931
2050	34.89	359.034	114.677	393.934	458.265	23.178	1555.809	1732.87

GDP in billions of 1990 US\$ (ppp)

	9	10	11	12	13
	Korea	Mexico	ROW	E. Europe	Mideast
1985	265	507	1,258	246	510
1990	336	597	1,497	279	607
1995	420	721	1,782	144	712
2000	548	883	2,129	178	841
2005	727	1,086	2,530	219	967
2010	973	1,309	2,981	269	1,111
2015	1,242	1,548	3,475	333	1,274
2020	1,497	1,796	4,005	411	1,499
2025	1,713	2,043	4,563	507	1,767
2030	1,912	2,283	5,141	625	2,080
2035	2,101	2,513	5,740	771	2,441
2040	2,316	2,726	6,351	953	2,830
2045	2,550	2,939	6,956	1,098	3,226
2050	2,801	3,149	7,580	1,264	3,608

Carbon Emissions (bold numbers indicate emissions base: 90 or 95 for An I, but for non An I year at which begin to limit emissions = 5yr after income factor >0)

	9	10	11	12	13
	Korea	Mexico	ROW	E. Europe	Mideast
1985	36	69	412	379	130
1990	50	86	499	417	172
1995	57	111	601	276	214
2000	65	131	673	299	246
2005	74	152	746	317	274
2010	90	175	836	339	304
2015	107	199	936	361	336
2020	120	221	1039	382	382
2025	130	242	1141	401	420
2030	139	259	1242	422	468
2035	143	272	1342	444	533
2040	148	281	1440	468	600
2045	157	289	1532	482	661
2050	162	296	1622	499	695

Population (millions)

	Korea	Mexico	ROW	E. Europe	Mideast
	Region 7	Region 8	Region 1	Region 13	Region 9
1985	40.42	73.171	1564.955	122.455	127.933
1990	42.872	81.723	1763.484	124.182	141.48
1995	44.825	90.464	1970.463	124.561	157.466
2000	46.721	98.784	2186.477	125.704	175.678
2005	48.396	106.718	2411.628	127.172	196.377
2010	49.874	114.021	2644.263	128.772	218.926
2015	51.076	121.173	2875.197	130.119	241.617

Source: SGM

Population (millions) (cont.)

	Korea Region 7	Mexico Region 8	ROW Region 1	E. Europe Region 13	Mideast Region 9
2020	52.071	128.455	3104.766	131.149	263.685
2025	52.947	135.611	3330.54	131.981	285.132
2030	53.681	142.334	3548.174	132.701	306.591
2035	54.143	148.314	3752.314	133.202	328.69
2040	54.129	153.562	3939.744	133.463	350.986
2045	54.114	158.028	4107.266	133.488	372.848
2050	54.1	162.356	4285.822	134.234	393.323

Burden Sharing

Emissions in 2050 - SCM output

No LDC Part.	World	US	US/World (%)
Peak 15 ~~2080~~	10448	1350	12.93
1990-2010	10439	1350	12.93
-10%	10031	1215	12.11
1995-2010	10161	1480	14.56

no ramp in

2030 Levels:

1990-2010	8688	1350	15.54
Peak 15	8687	1350	15.54

ramp in

2030-2050 Per Capita

1990-2010	10872	1350	~~10872~~ 13.4
Peak 15	10071	1350	13.4

ramp in

BAU

11988	2245	18.73
-------	------	-------

1990	5583	1350	24.18
------	------	------	-------

Population

	US ¹	World ²	US/world (%)
1990	249,913,000	5,281,551,305	4.73
2050	393,931,000	9,355,700,376	4.21

1: 1996 Stat Abstract

2: <http://www.census.gov>

<http://www.worldpop.net>

August 19, 1997

Comments on International Emissions Trading Paper
Office of Economic Policy, Treasury Department

- 1) Points 1 and 2 under commonly asked questions should be struck. This is an overly optimistic picture of the benefits of trading, and we address this set of issues in more detail in the domestic emissions trading paper. These points do not need to be made here.
- 2) There should be some discussion of an "international escape clause", to parallel the domestic escape clause discussion in another paper. International trading provides a natural escape clause for the U.S.; if growth in demand in the U.S. is particularly rapid, we can buy permits from abroad. But what happens if the worldwide demand for permits rises so quickly that they become prohibitively expensive internationally? In this case, we should have some mechanism for allowing a loosening of the worldwide restrictions embedded in this trading scheme.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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AIR AND RADIATION

FAX MEMORANDUM: 10 Total Pages

TO: Jeff Frankel, CEA, (202) 395-5046
FROM: Skip Laitner, EPA/OAP *Skip Laitner*
SUBJECT: An EPA Working Paper on Technology and Climate Change
DATE: September 15, 1997

Attached is a copy of the draft paper I gave last week to the North American Conference of the International Association of Energy Economics. Since I referenced Janet Yellen's recent testimony, I thought CEA should have a copy of it for internal review. Please let me know if you have any questions or comments.

WYMIWYG (What You Measure is What You Get): The Benefits of Technology Investment as a Climate Change Policy¹

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INTRODUCTION

In a June 26, 1997 speech to a United Nations environmental conference, President Clinton acknowledged that "concentrations of greenhouse gases in the atmosphere are at their highest levels in more than 200,000 years and climbing sharply." If that trend does not change, the President noted that the resulting climate changes would "disrupt agriculture, cause severe droughts and floods and the spread of infectious diseases." In underscoring the fact that no nation can escape the danger of climate change, the President stated that: "We must create new technologies and develop new strategies like emissions trading that will both curtail pollution and support continued economic growth. We owe that in the developed world to ourselves, and equally to those in the developing nations. Many of the technologies that will help us to meet the new air quality standards in America can also help address climate change. This is a challenge we must undertake immediately."

Drawing on the guidance of the President's statement to the United Nations, it is clear that any future climate change policies adopted by the United States should be anchored by a technology-based investment strategy. Recent modeling efforts by an Interagency Analytical Team (IAT) found that the accelerated use and development of energy efficient and low-carbon technologies can substantially reduce the costs of U.S. greenhouse gas reductions. Indeed, a number of the modeling results suggest that with the right mix of technologies, the economy can actually be strengthened by a technology-based strategy. This is

because the right mix of technologies can convert wasted resources into productive assets. As Janet Yellen, Chair of the Council of Economic Advisers, recently commented, "if we do it dumb, [climate change policy] could cost a lot, but if we do it smart, it will cost much less and indeed could produce net benefits in the long run." (Yellen 1997). This opportunity is also underscored by a June 1997 NGO study entitled, *Energy Innovations*. A detailed analysis of the technology opportunities within the United States indicated that an innovative path could reduce U.S. carbon emissions 10 percent below 1990 by the year 2010. At the same time, consumers would save \$530 per household, and the economy would support 800,000 more jobs by 2010 compared to present path projections (Energy Innovations 1997).

Despite the opportunity inherent to an investment-led climate strategy, a number of studies continue to find that the economy will be the real loser should the United States make any attempt to cap carbon emissions at or below anything close to 1990 levels. A study for the American Petroleum Institute, for example, found that carbon abatement strategies could lead to GDP losses by 3.0 percent or more. (Bernstein 1997). Yet, a close review of such studies suggests that a WYMIWYG phenomenon may be at work — "What You Measure is What You Get." In a different context this point was dramatically made by a WRI review of 16 of the more widely accepted economic models which have been used to evaluate different climate change policies. (Repetto and Austin, 1997). In their landmark review, the WRI researchers found that the macroeconomic impacts of stabilizing greenhouse gas emissions are likely to be

1. A draft paper given to the 18th Annual North American Conference of the USAEE/IAEE, September 7-10, 1997, San Francisco, CA, USA.

modest, and if improved technology assumptions and environmental benefits are factored into the modeling runs, the results are likely to be positive. Focusing more on the technology perspective, Greening (1997) suggests that if a policy or set of policies reduces per unit factor prices of capital and energy, the marginal product of those factor inputs will increase. "Provided that this policy has sufficiently low transaction costs associated with it," she notes, "then an energy efficiency policy should increase rates of economic output."

BACKGROUND AND CONTEXT

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

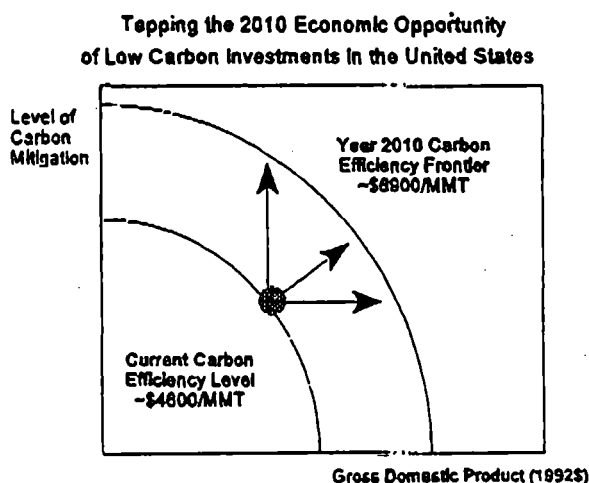
Since that June 1996 workshop, the IAT has more fully explored the "technology option" as a climate change strategy. As part of the review, the IAT developed a better set of assumptions about the opportunity for technology improvements, and then developed a new set of modeling runs that lead to a better understanding of the economic dimensions of the climate change policy problem. Preliminary results of the IAT effort were released in mid-July by Yellen (1997) in remarks before the House Commerce Subcommittee on Energy and Power. Unfortunately, the complete sets of modeling runs were not yet integrated within the IAT reports. As a result, the public received only the "best" of the bad news, with the good news yet to come.

This paper describes those missing technology assessments. It first discusses the opportunity for technology to both reduce greenhouse gas emissions and strengthen overall economic activity within the United States. Second, it reviews the IAT model selection and, in particular, the use of Markal-Macro which is an integrated energy supply and demand modeling system (Markal) and a macroeconomic model (Macro). Markal-Macro is especially useful for translating technology assumptions into economic impacts.

The development of the technology assumptions was done primarily by staff members from DOE and EPA — the agencies that have the primary responsibility for the Administration's energy and environmental policies. The IAT also included members from the Departments of Commerce, Treasury, Labor, and State, as well as members of the White House staff. The author was one of several co-chairs of the various IAT task forces.

What is the technology opportunity?

The common perception among policy makers and industry leaders is that the twin objectives of protecting the environment and encouraging continued economic



growth are inherently contradictory. Because of the "unavoidable tradeoff" between the environment and the economy, a battle is constantly being waged between industry, government and interest groups regarding how much of the environment should be sacrificed for the benefit of the economy — or vice versa. From a technology perspective, however, it becomes increasingly clear that these two goals are not necessarily contradictory. The reason is that the U.S. economy is not operating at its optimal level of energy efficiency. In economic jargon, this means that the country is operating well "within" rather than "on" its production possibilities frontier (PPF). This is illustrated in the figure above.

Based upon a set of IAT runs from the Markal-Macro model, the data suggest that the U.S. economy now obtains about \$4,600 dollars of value-added (measured as GDP in constant 1992 dollars) for every

million metric tons (MMT) of carbon emitted to the atmosphere. Using a reasonable set of technology assumptions (described later in this paper), it appears that by the year 2010, the economy could be obtaining at least \$6,900 of GDP for every million metric tons of carbon emitted. As it turns out, the base case forecast suggests that the normal rate of efficiency improvement will obtain about 30 percent of this "carbon gap." Perhaps more important, implementing a set of policies which encourage the development and deployment of energy efficient and low-carbon technologies can close this gap to the benefit of both the climate and the economy (DOE 1997, Energy Innovations 1997, Krause 1996, Laitner, et al., 1995, OTA 1991).

How have other studies approached the problem?

Typical of many analytical perspectives is a recent policy brief published by the Brookings Institution (McKribbin and Wilcoxon 1997). In explaining the value of tradable permits, the authors ask us to suppose that a particular firm has an abatement cost of \$100 per ton of carbon while a second firm has a higher cost of \$200 per ton. If greenhouse gas emissions are to be reduced by a total of 20 tons, with each firm sharing the responsibility to reduce emissions equally, the total abatement cost is estimated to be \$3,000. Yet, in continuing their discussion, the authors offer no information about the possible production savings made possible by the \$3,000 investment. In effect, this and many other such analyses examine only the cost side of the ledger. By definition, then, any analysis that evaluates only the abatement cost of a given climate policy would tend to show a loss in the overall level of economic activity.

How does Markal-Macro Improve the Analysis?

As described in other documentation, the IAT process relied on three primary models and a number of other analytical tools and models to feed information into the modeling runs. The three major economic models were the DRI Macroeconomic Model, the Second Generation Model, and the Markal-Macro Model already referenced.

The DRI Macroeconomic Model is a macroeconomic and energy-end use model maintained by

DRI/McGraw-Hill. It has a strong representation of U.S. energy supply and consumption, and it contains a reasonable level of detail for approximately a dozen industrial sectors. The Second Generation Model (SGM) is a computable general equilibrium (CGE) model maintained by Battelle's Pacific Northwest Laboratory. Its strength lies in its ability to model the long-term path of climate change policies including key aspects of international trade. It also has a strong representation of energy supply technologies but has very little industry detail. The model contains 8 energy-related sectors, two economic sectors, and the household and government sectors.

Finally, the Markal-Macro model is a dynamic linear optimization model that contains a technology rich, "bottom-up" perspective. Markal-Macro is a domestic model which is maintained by DOE's Office of Policy and International Affairs and EPA's Office of Planning and Program Evaluation. It was this model that was used to examine the question of whether an investment-led technology policy might lower the cost associated with climate change mitigation.

The Markal-Macro model was used to establish a Base Case, and then to simulate the effects of a carbon constraint on energy service demand, choice of fuels, substitution of capital/labor for energy, and the penetration of energy-efficient and low-carbon technologies. The model has two parts to its modeling system. The first part is Markal (short for Market Allocation) which is an energy model that contains the dynamic linear programming routine that is run over time in five-year intervals, from the period 1990 through 2025. The second is Macro which is a macroeconomic model with an aggregated view of long-term economic growth. While maintaining the technological richness and flexibility of Markal, Markal-Macro adds price elasticity on demands for energy services and links changes in the energy system to the level of economic activity. The Markal-Macro solution maximizes consumer welfare over the solution period, optimizes aggregate investment, and provides a least-cost energy system that will meet the endogenously determined demand for energy services (Markal-Macro, 1997).

The advantage, then, of Markal-Macro is that it: (a) allows both a "bottom-up" and a "top-down" perspective within an economic and accounting framework, and (b) allows the user to explore and

compare different assumptions about the cost and energy bill savings of technology and technology choices. As an example, in a set of runs referenced as a "Technology Investment Case," Markal-Macro shows the level of investment increasing by an average of 0.8 percent over the period of analysis compared to a reference case. It also shows that — despite a carbon constraint and, therefore, higher energy prices — the cost of energy services (including both the incremental cost of investment and the annual energy bill) actually declining by an average of 1.7 percent compared to a reference case. At the same time, Markal-Macro shows GDP (measured in constant 1992 dollars) increasing by an average 0.32 percent over the study period.

THE MODEL SCENARIOS

The Reference Case

The domestic energy and emissions baseline forecasts for all three IAT models were benchmarked to the Energy Information Administration's *Annual Energy Outlook 1997* (AEO97). Adapting the AEO97 base case assumptions, Markal-Macro forecasts an average U.S. economic growth rate of 2.1 percent annually in the years 1995 through 2010, tapering off to 1.4 percent in the period 2010 through 2020. A slower population growth, coupled with only very modest productivity improvements, is the reason for the decline in the economic growth rate.

At the same time, the nation's energy intensity is expected to decline 0.9 percent and 0.7 percent annually in those same two periods. This is because of technology assumptions that parallel those in AEO97 and the expected rates of efficiency improvement given normal capital stock turnover in the absence of either a carbon constraint or other energy price signals. The net result is a projected growth in the nation's total energy use that rises from 90.9 quads in 1995 to 107.9 quads in 2010 and 115.2 quads in 2020.

Carbon emissions are expected to rise to 1,767 million metric tons (MMT) in 2010 and 1,940 MMT in 2020. By 2020, baseline emissions will be an estimated 600 MMT above the 1990 levels — a level of reduction that is commonly discussed as an interim target to help achieve overall climate stabilization. These results are

summarized in Table 1 that follows at the end of this paper.

The Behavioral and Technology Cases

While there were many different model runs within the IAT process, in Markal-Macro the alternative scenarios generally focused on two separate cases. The first was a largely behavioral response to a carbon constraint capped at the 1990 levels of carbon emissions (1,340 MMT). The second was a technology investment case that assumed both the existence of presently cost-effective but underutilized technologies, and the development and deployment of cost-effective but advanced technologies. This scenario was also capped at the 1990 level of carbon emissions.

With some differences, the behavioral case assumes the same set of technology assumptions as found in AEO97. Before the emissions cap is imposed, it is assumed that energy intensity will decline 1.0 percent in the year 2000, and decrease linearly to 1.25 percent between 2000 and 2010, and remain at 1.25 percent per year between 2000 and 2020. This modest improvement is based upon the assumed policy announcement effect: the actions that take place because of an international agreement on climate change will generate an increased willingness to invest in energy efficient technologies. In Markal-Macro, this response is generated by lowering hurdle rates to 80 percent of the base case assumptions.

The technology investment case adopts the same hurdle rate assumptions as in the behavioral case, but in this scenario, both consumers and businesses have a richer and deeper mix of technologies from which to choose. The technology choices parallel those generally found in the DOE Interlaboratory Study and the *Energy Innovations* Study previously cited.

RESULTS OF TECHNOLOGY ASSUMPTIONS

The behavioral case and the technology investment case offer an important comparison of economic impacts resulting from climate policies that stabilize at 1990 levels of greenhouse gas emissions. Again, Table 1 provides this comparison.

Perhaps the most immediate result is the cost of carbon between the two alternative scenarios. In the behavior case the carbon price in 2010 rises to \$145 per metric ton (in 1995 dollars), falling to only \$129 in 2020. As might be expected, the impact on GDP is small but negative. In 2010 GDP is 0.05% lower in the behavioral case compared to the base case, or \$9,150 billion compared to \$9,205 billion (measured in constant 1992 dollars). On the other hand, carbon prices in the technology case start in 2010 at \$87 per metric ton, falling to as little as \$24 per ton by 2020. At the same time, the net gains in GDP are positive throughout the period of analysis. In 2010, the level of GDP is 0.23% above the base case, increasing from \$9,205 billion to \$9,226 billion.

The reason for the not positive impact on GDP needs to be seen from several perspectives. First, the carbon constraint, in the absence of better technology choices, increases the cost of carbon. This, in turn, increases overall energy prices. Second, the higher energy prices coupled with a limited set of cost-effective technologies decrease the demand for energy services which tends to weaken economic activity. In the year 2010, for example, energy service demand is down by about 8 percent in the behavior case compared to the reference case. As a result, both investment and the cost of energy services are down, 2.80 percent and 3.61 percent, respectively. Hence, GDP declines in the behavioral case compared to the base case.

On the other hand, the improved assumptions about technology choices in the technology investment case allow businesses and consumers to respond to the price signal by investing in more cost-effective technology. This pattern decreases the cost of carbon since more tons of carbon are removed as a result of both energy-efficient and low-carbon technologies. This can be seen in two ways. First, energy service demand for the year 2010 is down only 0.8 percent in the technology case compared to the base case. Second, while total investment is down slightly in the year 2010 (-0.15 percent), total capital is up as a result of higher investment levels in earlier years (0.58 and 1.75 percent for the years 2000 and 2005, respectively). These conditions nudge economic activity to 0.23 percent above the base case forecast for 2010.

POLICY IMPLICATIONS

Under the United Nations Framework Convention on Climate Change (UNFCCC), 153 countries are working in a combined effort to draft an international treaty aimed at reducing atmospheric greenhouse gases to help prevent global climate change. Initial efforts to reduce emissions to 1990 levels by 2000 have not been successful. For this reason the United States and other negotiators have agreed that a new legally binding target should be set which is both "real and achievable." In so doing the United States has also made it clear that while the *targets* must be binding in order to achieve results, *individual measures* should not be binding to give each country maximum flexibility in the implementation of the treaty. Through a differentiated approach, policy makers will have the freedom to develop national strategies which meet treaty obligations without jeopardizing economic growth and prosperity.

For the United States, a national climate change mitigation policy should be anchored by a productivity-led investment strategy — one that is focused on the promotion and diffusion of cost-effective energy-efficient and emerging renewable energy technologies that are now widely available but underutilized. This type of policy will provide the market with a clear and unambiguous signal about the importance of a climate change mitigation policy. At the same time, a productivity-led strategy will allow innovators from all economic sectors to take advantage of emerging investment opportunities resulting from increased demand for energy efficient technologies.

An effective climate policy needs to ask: (1) how much "underutilized technology" is now available; (2) how much near-term technology can be reasonably made available; and (3) how much long-term technology needs to be developed through research and development programs? Models such as Markal-Macro cannot answer that question since they can only choose from among the technologies that are previously entered into their respective databases. Indeed, there is evidence that the base case assumptions of Markal-Macro itself do not adequately capture the full set of currently available technologies now on the market (Laitner 1997). Moreover, there is no ability for Markal-Macro and other models to incorporate endogenous technological change in response to either price or policy signals.

Estimates of Existing Potential

Several major studies have already established the existence of an efficiency gap which can contribute to an investment-led climate policy major. The *Energy Innovations* study shows, for example, that through 2010 the technology generally exists to reduce the nation's energy intensity (measured as the number of Btus of primary energy per dollar of GDP) at a rate consistent with the technology investment case evaluated by the Markal-Macro model (see, Table 1). In addition, there is strong evidence that the potential may be understated, especially in the industrial sector, since efficiency technology investments also lead to other production cost savings not captured by such models (Elliott, et al, 1997).

Estimates of the R&D Potential

Numerous studies show a very high private and social rate of return to investment in research and development (R&D) programs. Mansfield (1991) notes, for example, that "[d]ozens of economists working independently with quite different sorts of models and entirely different kinds of data have found that the social rate of return from industrial innovations and R&D has been very high, frequently 40 percent or more. This is a remarkable fact, and one that policy-makers should recognize." DeCanio (1997) provides a table of almost two dozen studies showing an average social rate of return to R&D of 60 percent. The Council on Economic Advisors (1994) reports estimated social rates of return on R&D range as high as 50 to 100 percent. CEA suggests that the high rates of return are a strong indication that both firms and society as a whole are underinvesting in R&D.

Such evidence indicates a significant potential to improve both the economic and environmental welfare by increasing aggregate R&D, including R&D in energy efficient technologies. We know that it is possible to increase aggregate R&D substantially; this is a policy decision having mainly to do with the funding of graduate education for scientists and engineers, and with the availability of jobs and equipment for those researchers upon completion of their degrees. DeCanio notes that we have the historical experience of the post-Sputnik push that demonstrates the feasibility (and benefits) of an increase in society-wide R&D. The time

lag for beginning to see the effects of such an effort would be three years at the most. Breger (1997) found that after 20 years, 1.3 Quads of energy could be saved for each \$100 million of R&D devoted to energy efficiency technologies.

Some analyses have suggested that if the current pattern of R&D programs are changed to emphasize the development of technologies which can help mitigate the problems of global climate change, the opportunity costs may be substantial. However, there is no evidence that the present allocation of R&D monies is optimal. Even if it were known that the social rate of return to energy-efficiency R&D were lower than the return to some other kinds of R&D, it would still be justified to increase energy-efficiency R&D if: (1) the environmental benefits augment the other economic benefits sufficiently; or (2) it is not possible (perhaps for political reasons) to increase R&D in the other sectors. A social rate of return of 40 percent is still quite attractive, even if some other (unobtainable) opportunity offers 50 percent.

Estimates of the Economic Costs of Promoting Technology

There are two categories of costs which must be accounted for within any modeling exercise. The first is the actual level of technology investment. The second is the R&D and program costs associated with delivering the technologies to the market and in making both consumers and businesses aware of those investment opportunities. Similarly, there are at least three categories of benefits that should be included within an economic analysis. These include: (1) the direct energy bill savings driven by the investments made necessary with a proposed climate policy; (2) the environmental benefits created by the investments and not captured within the usual modeling framework; and (3) the spillovers created by either the investment or the R&D and program costs. The latter benefit generally stems from the nonenergy productivity gains made possible by the energy-efficient technologies (Elliott, et al., 1997) and the social rates of return referenced by DeCanio (1997) and others. The results from the Markal-Macro technology investment case captures only the direct investment costs and the energy bill savings. Hence, this tends to make the results highly conservative since: (a) the nonenergy benefits are not captured in the analysis; and (b) the R&D and program costs are quite small in

comparison to the actual level of direct investment. Still, it is helpful to provide at least a working estimate of the costs and benefits associated with stabilizing greenhouse gas emissions to 1990 levels. For this we turn to the DOE Interlaboratory Study and the *Energy Innovation Study*.

The DOE analysis suggests a cumulative investment on the order of \$400 billion would be necessary to stabilize carbon emissions with a \$50 per ton cost of carbon in the years 1997-2010. This will generate a cumulative savings of about \$700 billion within the same period (in 1995 dollars). The *Energy Innovation Study* suggests a \$333 billion investment that would yield a \$550 billion savings (in 1993 dollars). Both studies, then, suggest a net positive gain for the economy.

The DOE analysis then suggests that the noninvestment costs would be about 7.0 percent of the cumulative investment, or about \$28 billion. In a separate estimate, Laitner (1997b) estimates the combined R&D and program costs to be on the order of \$21 billion (in 1995 dollars) over the period 1997 through 2010. This is about 5.0 percent of the total technology investment estimated by the DOE study.

CONCLUSION

The emerging evidence suggests that the United States is in a strong position to reduce carbon and other greenhouse gas emissions through a technology-led investment strategy. While the total investment appears to hover around \$400 billion, it is worth noting that in the period 1998 through 2010, the AEO97 forecast indicates the United States will generate a total investment of \$17.2 trillion (in 1992 dollars). If the Lab Study numbers are right, the roughly \$400 billion investment (in 1995 dollars, or ~\$375 billion in 1992 dollars) is about 2.2 percent of the total investment otherwise anticipated by AEO97 (Laitner 1997b). In other words, we are talking about diverting only 2 to 3 percent of the typical investment pattern away from less-efficient and more carbon-intensive technologies into a more productive mix of technologies. Moreover, the associated transaction costs appear to be quite low, on the order of 5-7 percent of the total investment required to stabilize emissions by 1990. In keeping with Greening's comments about the marginal product of

capital and energy (Greening 1997), then an energy efficiency and low-carbon policy "should increase rates of economic output." This is now supported by the analysis generated within the IAT process using the Markal-Macro model.

ACKNOWLEDGMENTS

I wish to thank the Environmental Protection Agency's Office of Atmospheric Programs and the staff within the Atmospheric Pollution Prevention Division for supporting my work in this area. However, the views expressed in this paper do not necessarily reflect those of either the EPA or the Clinton Administration.

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Table 1. Summary of Markal-Macro Simulation Results

	1995	2000	2005	2010	2015	2020
GDP (Billion 1992 Dollars)						
Base Case	6,739	7,554	8,387	9,205	9,884	10,569
Behavioral Case	6,739	7,540	8,380	9,150	9,813	10,481
Technology Case	6,739	7,559	8,428	9,226	9,907	10,614
Total Primary Energy Consumption (Quads)						
Base Case	90.9	97.6	103.5	107.9	110.4	115.2
Behavioral Case	90.9	95.4	98.4	91.9	94.9	97.5
Technology Case	90.9	91.9	92.8	91.2	93.7	96.6
E/GDP (Thousand Btu's Per 1992\$ of GDP)						
Base Case	13.49	12.92	12.34	11.72	11.17	10.90
Behavioral Case	13.49	12.65	11.74	10.04	9.67	9.30
Technology Case	13.49	12.16	11.01	9.89	9.46	9.10
Carbon (Million Metric Tons)						
Base Case	1,424	1,583	1,691	1,767	1,824	1,940
Behavioral Case	1,424	1,526	1,579	1,340	1,340	1,340
Technology Case	1,424	1,448	1,457	1,340	1,340	1,340
Cost of Energy Services (Percent Change from Base Case)						
Behavioral Case	0.00%	-0.55%	-1.03%	-3.61%	-4.10%	-2.72%
Technology Case	0.00%	-2.11%	-1.34%	-2.63%	-1.49%	-0.97%
Level of Technology Investment (Percent Change from Base Case)						
Behavioral Case	0.00%	0.00%	-0.79%	-2.80%	-2.09%	-3.91%
Technology Case	0.00%	0.58%	1.75%	-0.15%	0.49%	1.50%
Marginal Cost of Carbon (\$1995 Per Ton)						
Behavioral Case	NA	NA	NA	145	134	129
Technology Case	NA	NA	NA	87	52	24



EXECUTIVE OFFICE OF THE PRESIDENT
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WASHINGTON, D.C. 20500

SENIOR ECONOMIST

MEMORANDUM

TO: Bob Tuccillo

FROM: Jay Shogren and Joe Aldy *[signature]*

DATE: August 5, 1997

RE: Comments on 7/30/97 Discussion Paper: The Role of Technological Change to Address Global Climate Change

We continue to be concerned about two issues in this paper: 1) the need for a common method to measure emission reductions and costs; and 2) the provision of cost estimates.

Common Method: In the current version of the role of technology paper, the set of sector papers use more than one method to present emissions and costs: Markal 1.25, Markal 1.75, DRI 1.25, and the DOE Labs Study. These methods use different sets of assumptions, and generate different results for both emissions reductions and costs by sector. Also, the methods all impute a different permit price to achieve 1990 levels stabilization. Given these differences, comparing one sector's potential for emissions reduction to another sector's potential is like comparing apples and oranges. Comparing sectors to determine the biggest bang for the buck would be more useful if the numbers for each sector were comparable.

In addition, the same method should be used to estimate the costs to achieve the projected emission reductions. The costs reflect the emissions reductions by sector -- the models should generate emissions reductions based on the marginal costs of new technologies and fuel switching. The final ton of emission reduction within each sector should cost the same across sectors given that a domestic trading system is implied throughout the analysis. Applying cost estimates from other sources generates inappropriate estimates.

Cost Estimates: The papers should provide reliable estimates of annual costs over a specific period of time. Several papers provide annual costs, but do not specify the period of time: through 2010, 2020, or perpetuity. Further, some of the costs estimates are inadequate: an annual cost estimate is necessary for light duty vehicles; and the range of costs in the buildings paper reflect two different scenarios (efficiency and high efficiency in the DOE Labs Study), while the carbon emissions reductions provided in the first chart reflect only one scenario. The costs of achieving these reductions is one of the range's endpoints, not a value somewhere within the range.

ADVANTAGES / DISADVANTAGES OF VARIOUS POSSIBLE ECONOMIC TRIGGERS

Desirable characteristics of a trigger:

- related to cost of limiting emissions
- built-in stabilizer for macro-economy
- simplicity/conducive to public salesmanship

Yet to be discussed:

- (i) Would this go in the treaty?
- (ii) What is it that would be "triggered on"? If the response is to be the sale of additional emission permits, what would be the quantity and price?

First-best trigger:

- **Price of Carbon Permit**

Advantages:

- (1) Specifically addresses the possibility that emissions reductions would result in high costs, and thus insures against uncertainty in an economically desirable way;
- (2) Once the price level of the trigger is set, then the answer to item (ii) above is clear.

Disadvantage:

The price of carbon emission permits may not be a widely understood concept.

(The possibilities that follow are economic triggers *other* than the price of carbon. Ranking is preliminary; principals may not agree.)

Second-best trigger:

- **Permit price*Quantity-of-permits/GDP**

Advantage: The formula contains the carbon price, and thereby responds to the onerousness of emission limitations per se.

Disadvantage: it is more complicated than some of the other possibilities, and does not allow the President to say "I promise that if X [an easily-understood bad thing] happens, the constraint will be loosened."

Third-best trigger

- **growth below 2%**

Advantages: (1) Acts as an automatic stabilizer (as do the others).

(2) Encompasses both the possibility of slowdown in long-term growth and the possibility of cyclical downturns. Both are relevant: (i) slow growth of either sort could be the result of onerous emissions restrictions, (ii) slow growth of either sort, even if the result of standard macroeconomic factors, might still lead one to choose less aggressive emissions reductions (assuming environmental benefits are a “normal” good).

Disadvantages: (1) a measure of GDP will not fully reflect the economic costs of the policy because declines in consumption will be masked by some increases in investment, (2) the trigger does not address situations where climate policy negatively impacts high economic growth years (e.g., imagine that under climate policy, GDP grows at 2.2%, but under the counterfactual, GDP would have grown at 3%), (3) the shadow price of the quantitative emissions constraint is lower if growth falls, not higher.

Fourth-best triggers:

- **recession**

Advantage: Very easily explained and understood.

Disadvantages: (1) Doesn't get at slow long-term growth. (2) Unlikely to be triggered often. (3) In the year following a recession, output gap is usually still high.

- **output gap above 1%**

Advantage: May address short-term cyclical conditions better than a recession trigger.

Disadvantages: (1) Doesn't get at long-term growth. (2) Not explainable to public. (3) Partly subjective even within economists' paradigm.

- **unemployment above 7%**

Advantage: easily explained and understood

Disadvantages: (1) Unrelated to long-term growth. (2) An imperfect measure even of short-term cyclical conditions: the natural rate of unemployment moves around. (3) Probably bears the least connection to emissions of any of the measures.

- **a committee (Sec. Treas, Chair Fed. Res., etc.) judges "economic distress"**

Disadvantage: very subjective/political/ad hoc.

- **some attempt to judge whether economic slowdown is attributable to climate change policy**

Disadvantage: even more subjective/political/ad hoc.



EXECUTIVE OFFICE OF THE PRESIDENT
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WASHINGTON, D.C. 20500

SENIOR ECONOMIST

MEMORANDUM

TO: Bob Tuccillo

FROM: Jay Shogren and Joe Aldy *JS*

DATE: July 28, 1997

RE: Comments on 7/28/97 Discussion Paper: A Technology Approach to Addressing Global Climate Change

We provide comments on the discussion paper below. The first set of comments reflects several issues that we believe need to be emphasized. The second set reflects specific edits and necessary clarifications in the paper. Also, we have compiled a draft chart describing the emissions and costs across sectors.

Set 1:

p. 2: The two fundamental changes imply the need to influence firm and consumer behavior through price signals. The importance of pricing carbon should be stated explicitly.

p. 5: DOE's Labs Study: The discussion of this study should reflect the following assumptions that are noted in the report:

- The model runs for the 3 end-use sectors were not integrated and may overstate the effects of technology penetration (6/11/97 draft, p. 1.2).
- The analysis of costs is confined to technology costs, and does not assess policies or programs necessary to achieve market acceptance (p. xvi).
- The assessment of cost-effectiveness ignored implementation costs (p. xvi).
- The high efficiency/low carbon case invokes the announcement effect, but does not specify a numeric change in the rate of energy efficiency improvement (p. 1.6).
- The high efficiency/low carbon case requires technology breakthroughs, not just accelerated diffusion, to achieve emissions reductions in the transportation sector (p. 1.7).
- Emissions reductions under both scenarios require additional public sector programs and funding (p. x).

p. 6: The discussion of prices in the economy should note that the total costs to society of a cap and trade program should be lower than the costs of the subsidies listed in the second and third bullets.

Sectors Papers:

Need for a common emissions reductions methodology: The papers use several different models to estimate the reductions within each sector. Autos and Light Trucks, Buildings, and Industry use Markal-Macro; Freight, Aircraft, and Rail use the DOE Labs Study; and Electric uses DRI 1.25 w/o carbon price (assumes announcement effect with E/GDP of -1.25/year but no cap and trade program). This creates two problems. First, an assessment to determine the cost-effectiveness of achieving 1990 levels in 2010 should be integrated. Since these models employ different assumptions, they will yield different sectoral targets for achieving the 1990 goal. A goal for a sector in Markal is dependent on the goals for other sectors (and the costs of reaching those goals) in Markal. Providing estimates from Markal, DRI, and the 5 Labs Study ignores the dependence of the sectoral estimates. A range of estimates representing these different modeling efforts could better illustrate sectoral responses. Second, since the costs of achieving goals are dependent on the costs in other sectors, estimates of the cost-effectiveness of technology adoption will likely be skewed under a non-integrated approach. Again, a range of costs could better describe the state of knowledge on technology adoption.

Cars and Light Trucks Costs: This paper still needs an annualized cost of technology adoption. Based on the information provided in the paper, we estimate the cost to be \$18 billion to \$28 billion per year starting in 2010. For the lower bound, we multiplied the cost of a new car at 30% of the PNGV goal, \$1,200 per car¹, times the number of cars and light duty trucks sold in a year, which we estimate to be 15 million². For the upper bound, we used the cost estimates in the Labs Study for cars (\$2,000 per car) and light trucks (\$1,650 per truck) under the high efficiency/low carbon case and multiplied them by the approximate number of cars (9 million) and trucks (6 million) sold this past year. We readily admit that this is a gross representation of the cost, and we would obviously prefer a more precise estimate, but given the information in the paper, this is the best we could do.

Buildings

Costs: How are the energy savings calculated? What is the assumed electricity price? Did the analysis carefully ensure that no double-counting occurred (e.g., estimating energy savings from installing fluorescent lights, that increase the efficiency of energy, and "smart" lighting systems, that decrease the use of energy).

¹ This is the Markal-based estimate of the cost. The lower range in the paper reflects an analysis in the report "Energy Innovations" by a consortium of energy efficiency organizations. We employ \$1,200 because we believe it is appropriate to use the cost figure from the same analysis that generated the emissions reductions estimate.

² In 1994, 8.99 million passenger cars and 5.7 million light duty trucks were sold in the U.S. (1996 Statistical Abstract). The National Association of Business Economists estimate that 1997 vehicle sales will total 15.1 million (NABE Outlook and Policy Survey, 2/97, summary provided in AAMA webpage, <http://www.aama.com>). Given uncertainties about the demand for passenger cars and light trucks, we conservatively assume 15 million cars and light trucks will be sold in 2010.

Set 2:

p. 1: Transportation emissions growth projection is the DOE 5 Labs Study modification of the EIA AEO97 projection. Technically, it is not an EIA projection.

p. 3: The DOE Study indicates that emissions growth will be 380 million tons (not 377).

p. 3: The chart indicates that in the 3 major sectors, the growth in emissions is merely slowed, while utilities appear to be the only sector with negative growth in emissions. This implies the significance of an effective carbon tax. Without the price signal of a carbon permit, these reductions cannot be achieved. The tax ought to more explicitly reflect this.

p. 4: The projection of natural gas tripling under climate policy does not reflect the modeling results in the IAT report (5/19/97 draft, p. 14). The DRI-DRI Energy run in table 4 of the IAT report actually indicates a decrease in natural gas relative to the base case. The more appropriate comparison may be natural gas use under climate policy in 2010 to natural gas use under baseline conditions in 2010.

Autos and Light Trucks

Upper Chart: These carbon emissions are for the entire transportation sector, not just the autos and light trucks sector.

Key Trends, Second Bullet: This bullet notes that fuel economy is projected to grow to 31 mpg in 2010. The DOE Labs Study rejects this estimate given projected low fuel prices and an assumption of no change in CAFE standards. The argument provided by the Labs Study appears plausible. This would affect the content of this bullet and the lower chart.

Freight, Aircraft, and Rail

Costs: We need to obtain the details on the cost estimates from DOE: \$25 to \$40 billion is a large range.

Electric Power

Upper Chart: Estimates of carbon emissions under the "technology case" do not conform with the emissions reductions noted on p. 3. Does the case in this chart represent a DRI 1.25 case without climate policy? Doesn't 1.25 assume the announcement effect associated with adopting a policy?

Lower Chart: See above discussion on increase in gas use under climate policy.

Renewable Energy

Needed Technological Improvements: The electric power paper indicates that renewables as a share of electricity supply increase from 1.5% to 1.8% through 2010. This paper indicates a substantially higher growth rate. An explanation of this could clarify any potential confusion.



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SENIOR ECONOMIST

MEMORANDUM

TO: Bob Tuccillo

FROM: Jay Shogren and Joe Aldy *[Signature]*

DATE: July 23, 1997

RE: Comments on technology sector one-pagers

Below are our comments on the one-pagers. The first set of comments reflects issues that are relevant to all of the papers, and the second set addresses specific statements within the papers. Given the short turn-around necessary for these papers, we understand that some of our comments cannot be incorporated. However, we submit them to stimulate a discussion on these issues and to anticipate some of the questions that may be asked by the users of these papers.

General Comments

1) **Summary Chart:** A summary chart of all of the sector papers could be beneficial to the users. For example, such a chart could include the following categories: sector, energy use (quads or percentage of total use), 1990 emissions, 2010 baseline emissions, 2010 1.25 case emissions, cost of achieving reductions under 2010 1.25 case, and the likelihood of achieving 2010 1.25 case reductions. The papers already include most of this information, except for an explicit discussion of the probability of meeting the 2010 1.25 case reductions. For this category, a listing of issues that positively or negatively affect the probability would be as valuable as a quantified estimate of the probability. For example, the probability of success depends on, among other issues, the funding of federal R&D programs and CCAP programs, necessary R&D innovation, fuel price trends, etc. This one page chart could effectively tell the story embedded in the remaining ten pages and serve a purpose analogous to an executive summary. In addition, a chart with the breakdown of emissions by sector would be beneficial, because as the papers read now, someone who simply adds up the sectors' shares would find a value greater than one because of the accounting issue associated with electric power. Without appropriately accounting for the electric sector emissions, one could risk double counting emissions.

2) **Order of Papers:** Papers that address related sectors or issues should be paired together. For example, the freight, aircraft and rail paper should be paired with the autos and light trucks. Also, the electric power and renewable energy papers should be paired.

3) **Conformity of Charts:** The charts should all employ the same format and terminology. For example, we should decide on graphing trends through a line graph (e.g., freight paper) or bar

chart (e.g., industrial emissions). In addition, we should consider whether we want two trends (base and 1.25, as most of the bar charts have it), or one trend (as in the freight paper). The papers should all use the same term for the 2010 1.25 case (this case is referred to as 1.25, technology, and efficiency in different papers).

4) Reductions Potential: The papers should all explicitly state the emissions reduction potential within an industry -- this is implicit in the graphs, but it could be beneficial to have the numbers specified for each sector.

Specific Comments

Freight, Aircraft, and Rail Paper:

- 1) Are the costs and cost savings specified in the estimates present values?
- 2) Needs the funding value for PNGV. At present funding level (and administration's requested level, if it is different), what is the likelihood of achieving the PNGV goal in 2010?

Industrial Emissions Paper:

- 1) In the third bullet, the second sentence notes the GWP of non-carbon GHG. Since the carbon equivalence in MMTCE estimates captures GWP, do we need to also include the GWP measure? Multiple metrics may confuse some users.
- 2) Some of the statements on costs imply that these technologies are win-win. If that is the case, then why is government policy necessary to stimulate investment?
- 3) In the discussion on investment costs, it could benefit users to state the expected cost savings of these investments (in a similar fashion to most of the other papers).
- 4) How much will the necessary policies cost government to implement and spur the required investment?

Sector-Specific Section:

- 1) Estimates of expected emissions reductions in 2010 under 1.25 case for all of these technologies would be beneficial. In addition, costs of creating and adopting these technologies and anticipated cost savings would also be useful.
- 2) The Aluminum section notes that 4 MMT of PFCs are emitted annually. Are these 4 MMT or 4 MMTCE? If it is the latter, then we should note that, and ensure that MMTCE is used consistently through all of the papers.

Buildings Paper:

1) Do emissions, even under 1.25 case, still go up in 2010 relative to 1990? The chart gives that impression.

2) In the cost estimates, are the net savings \$10-\$19 billion or \$11-\$19 billion?

3) What is the likelihood of doubling the budget for federal programs?

4) Is the second chart necessary?

Renewable Energy:

1) To give some context to the prices of renewable energy sources, the price per kilowatt-hour for coal, hydro, and nuclear source electricity would be beneficial.

2) Third bullet ends awkwardly. The sentence could be rewritten as "...and as manufacturing achieves greater efficiencies."

3) The author may want to add a bullet on the effect of consumer choice in the electricity markets and the opportunity for "green" price premiums. (FYI, see today's WSJ, second section, front page.)

4) What are the returns or the cost-savings of the investments noted in the costs section?

Autos and Light Trucks:

1) In the fourth bullet, improved fuel economy will not maintain desired levels of VMT. Rather, improved fuel economy will maintain levels of emissions given an increase in VMT.

2) Authors of this and the freight paper should ensure that discussions on PNGV conform.

3) The two bullets under costs imply that PNGV will not be met. If so, should that be stated explicitly?

Electric Power:

1) Is the second chart necessary?



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SENIOR ECONOMIST

MEMORANDUM

TO: Bob Tuccillo

FROM: Jay Shogren and Joe Aldy

DATE: July 16, 1997

RE: Comments on climate change policy sectoral papers

The comments we have provided to the authors focus on the cost estimates and the issue of market barriers. To give you a sense of our thoughts on policy approaches to market barriers, we have drafted a short discussion of the differences between market failures and market barriers. If any of the authors talk to you with questions about policy discussions in their papers, feel free to share this with them. To provide you with some context for this issue, we have quoted passages from several papers below. If you have any questions about this, you can contact Joe at 395-1455.

Statements about Policies and Market Barriers

Transportation Policy: Light Duty Vehicles and Carbon Emissions, p. 2, second paragraph:
"Many of these technologies have already emerged in the market, lacking only appropriate policy signals to accelerate their diffusion, or to redirect their use toward fuel economy instead of improving other vehicle attributes."

Freight, Aircraft, and Rail Emissions Projections and Potential for Reduction, p. 2, second bullet:
"The DOE five-lab study stipulates that carbon emissions reduction at the low end of the ranges in the last column of the table above are likely, so long as the government institutes appropriate policies and research efforts are intensified."

The Carbon Reduction Potential in the U.S. Buildings Sector, p. 3, second full paragraph:
"The probability of realizing the potential savings estimated thus is largely dependent upon the effectiveness of policies in removing the barriers to these investments."

Industrial Emissions and Economic Impacts, p. 1, fifth bullet:
"These energy savings and reduction in carbon emissions are unlikely to happen without policy measures driving the improvement in the industrial capital stock."

Market Failure Versus Market Barriers: Why the Distinction Matters for Policy

Throughout the discussions on the development and adoption of technology in the climate change context, people often use the phrases “market failure” and “market barrier” interchangeably. While both market failures and market barriers can slow the diffusion of technology, there are important distinctions that extend beyond semantics. Policy intervention to eliminate a market failure may make society better off, depending on the costs of the intervention. Policy intervention to eliminate a market barrier cannot make society better off and usually makes society worse off, regardless of the implementation mechanism. In cases that consider the potential carbon emissions savings for various technologies, one should not expect to achieve that potential by pricing carbon (attempting to correct a market failure) because market barriers still affect the adoption of these technologies. This paper explains the distinction between market failures and market barriers and why the distinction matters for policy.

Definitions

Market Failures: Market failures represent flaws in private markets to transmit information fully to people in the market. For example, when supplying a public good, a person ignores some real costs. Thus, his or her private costs diverge from true social costs, resulting in an inefficient allocation of resources.

Market Barriers: Market barriers represent well-functioning, but occasionally complex, private markets. Information is fully transmitted among all those in the market, although some information may seem incomplete to non-participants (read: policy/market analysts). A person address all real costs, but these costs can go undetected by analysts, hence the term “hidden costs”. For market barriers, private costs match social costs, and resource allocation is efficient.

Examples

Market Failures: Economists have identified three major market failures in the climate change context: 1) information (public attributes); 2) moral hazard; and 3) pollution externalities.

Information has both public and private attributes. Market failure occurs because once information becomes public, (a) it is too costly to exclude others from using it, and (b) one person’s use of information does not preclude another person’s use. These characteristics lead to an undersupply of information on technology, because the information supplier can not gain benefits from the information users. The public good nature of information results in the undersupply of R&D investment and low adoption rates.

Moral hazard exists when one person imposes a cost on another person, and has insufficient incentive to stop. For example, with rented housing, the owner of the housing could pay for an energy efficiency investment, but since the renters benefit because they pay the utility bill, the owner has no incentive to invest.

Pollution externalities can cause the private marginal cost faced by individuals to be lower than the social marginal cost, resulting in an oversupply of pollution. For electricity, people do not pay for environmental costs from carbon when they buy coal-based electricity. This makes coal-based electricity more attractive than non-carbon energy sources (e.g., renewable energy).

Market Barriers: The literature has identified several barriers that explain the slow rate of technology adoption: 1) qualitative attributes differ across technologies; 2) private attributes of information; 3) private discount rate diverges from social rate; and 4) heterogeneous usage levels.

Qualitative attributes of technologies can affect adoption. Consumers of technology prefer technologies because of a set of characteristics, not just energy efficiency. For example, some technology consumers may purchase a product with a lower efficiency than another product because the former is more reliable than the efficiency-superior product.

Private attributes of information include the tasks of learning how a new technology works with one's existing suite of technologies and identifying technology suppliers. Transaction costs exist with these tasks. If opportunities for economic gains in supplying this information exist, one would expect arbitrage to occur where middlemen consultants would assess the needs of potential adopters and match them with the appropriate suppliers.

The social discount rates to evaluate new technologies may not fully capture the uncertainty and risks faced by individuals and firms. These private actors may use a much higher discount rate reflecting the uncertainty of future energy prices, the reliability of the technology, the irreversibility of a technology investment, and the constraints on their ability to borrow capital.

Heterogeneous use of energy-intensive technology can affect who benefits from efficiency investments and who does not. If a technology is cost-effective on average, it may not be cost-effective for individuals who do not use much energy.

Policy Implications

These examples illustrate the primary distinction between failures and barriers. Failures occur because people do not face all of the net benefits of adopting a technology, and so they underadopt--a socially inefficient resource allocation. Barriers occur because private actors do face all of the net benefits of adopting a technology, and because these net benefits are negative, they do not adopt--a socially optimal resource allocation.

This has two related implications for policy. First, estimates of technology adoption in response to climate policy must recognize that market barriers will prevent adoption to the levels predicted by engineering studies. High adoption rates will be realized once prices go high enough to eliminate the barrier, e.g., high carbon prices can provide the stimulus for some technologies to clear the barrier. Second, policies could be designed to try and eliminate barriers, but firms have found that these technologies are not cost-effective for them. Subsidies that increase their adoption will generate benefits less than the policies' costs.

Additional Reading

Cameron, Lisa J., Harry L. Foster, and W. David Montgomery. 1997. The economics of strategies to reduce greenhouse gas emissions. Charles River Associates, January 11, draft.

Jaffe, Adam B. and Robert N. Stavins. 1994. Energy-efficiency investments and public policy. *Energy Journal* 15(2): 43-65.

Jaffe, Adam B. and Robert N. Stavins. 1994. The energy-efficiency gap: What does it mean? *Energy Policy* 22(10): 804-810.

Nichols, Albert L. 1994. Demand-side management: Overcoming market barriers or obscuring real costs? *Energy Policy* 22(10): 840-847.

EXECUTIVE OFFICE OF THE PRESIDENT
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WASHINGTON, D.C. 20502

MEMORANDUM

TO: Eric Petersen and Jim Turner
FROM: Jay Shogren and Joe Aldy 
DATE: July 11, 1997
RE: Comments on Electric Power and Renewable Energy Papers

Below we have provided several comments on your papers. If you have any questions, please feel free to contact Joe at 395-1455.

Given that these two papers address many similar issues, we provide one set of comments. It could be beneficial to coordinate these papers, and consider integrating them into one paper. For example, coordinating the presentation of data is of paramount importance. On our first read through of these papers, it appears that the Markal-Macro and DRI models forecast either a 35% increase in non-hydro renewables in 2010 under GHG stabilization (electric power paper) or a more than threefold increase in renewables in 2010 under GHG stabilization (for M-M only in renewables paper). Given the potential uses of these papers, the same set of analytical results should be employed in all discussions.

Electric Power Sector

1) Changing the rate of retirement: Coal plants are, for the most part, fully depreciated. Therefore, the costs of coal-based electricity result from variable cost factors only. Switching to new forms of power requires significant capital investments. This situation puts renewables at a competitive disadvantage with coal, but this situation reflects a market barrier, not a market failure. Since effective policy should focus on failures and not barriers, policy should only affect the rate of retirement by getting the "price right" for carbon emissions.

2) Comparing renewable energy sources to coal-based energy: The modeling efforts anticipate significant decreases in the costs of renewable sources of energy with more R&D investment in the near future. How does the increase in carbon prices affect the investment in cost-reducing technologies for coal power? Do the higher prices stimulate investment in technologies that improve the efficiency of coal-fired power plants? Is there the possibility that utilities could adopt post-combustion carbon sequestration technologies, possibly analogous, in function if not in form, to SO₂ scrubbers?

Renewable Energy Sector

1) Note on biomass fuels: While they may not emit any net carbon, chemical intensive crops for ethanol still have a net positive effect on atmospheric loadings of greenhouse gases through fertilizer applications and escape of nitrous oxides. In addition, growing crops does require the consumption of fossil fuel energy. Further, there is the issue of transporting the biomass. For biomass fuels in cogeneration, which I understand could be scrub grown on marginal agricultural lands, this may not be as serious of an issue. This isn't to say that relative to coal, biomass is a loser, but just to point out that calling biomass a net zero contributor ignores several effects.

Also, the debate on biomass fuels tends to neglect the fact that it reallocates environmental bads from carbon dioxide emissions to chemical runoff and habitat modification.

2) Wind and solar power vary spatially: It would be interesting to know where wind power and solar power are most cost-effective. Some regions can definitely support one or the other better than other regions. However, is this an issue with deregulation of the utility industry? How could state rules on the use of renewable sources of energy by utilities affect allocation of wind- and solar-based electricity from regions with significant wind- and solar-generation to regions with less generation?

3) Factors that accelerate use of renewable energy: The author identifies four factors. Actually, the first two factors are the same: consumer choice and the opportunity to pay a price premium for "green" energy. The third factor is that states may require utilities to pass some renewable energy portfolio standards -- such standards eliminate the likelihood of a green energy premium, since consumers could not differentiate between utilities if they all provide green energy. The fourth factor is that lower renewable energy costs will spur more investments, especially relative to rising fossil fuel costs. Note that firms might invest in renewables even more under deregulation if the price premium effect becomes apparent.

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MEMORANDUM

TO: Eric Petersen
FROM: Jay Shogren and Joe Aldy 
DATE: July 11, 1997
RE: Comments on Buildings Sector Paper

Below we have provided several comments on your paper. If you have any questions, please feel free to contact Joe at 395-1455.

1) Barriers to adoption: The author notes that there "is clear evidence that many of the potential reductions are not being realized in the current market system because of a number of institutional, organizational, and other barriers that work against the diffusion of energy-efficient technologies." The list of barriers include: insufficient information, lack of expertise for design, lack of low cost sources of capital, and inability for efficiency purchasers to fully capture rents. Barriers are not an indication of market failure. Market barriers reflect the real costs of adopting a technology that may not be included in the explicit price for the technology. For example, this could include the transaction costs of determining how well a new technology works with the building's existing technology. This inadequate information is a private good, not a public good, problem. Therefore, it represents a market barrier, not a market failure. While it is an explanation for why a technology has not been adopted, it is not rationale for policy intervention. Further, without an analysis of these barriers, it is impossible to determine how adoption rates will change under different carbon prices. We shouldn't just assume away the barriers.

2) Cost savings of technologies: The author notes that an array of technologies can have an annualized cost of \$14-\$24 billion/year with an annual energy bill savings of \$33 billion. We would like to see this broken down by each technology, or technology class (some may be big winners and others could be losers). Also, we would like to know the cost assumptions in estimating energy bills (since the modeling efforts presume significant increases in electricity prices). Have there been sensitivity analyses done to estimate if there is some floor price on carbon that would make the technology adoption more costly than the energy bill savings?

EXECUTIVE OFFICE OF THE PRESIDENT
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WASHINGTON, D.C. 20502

MEMORANDUM

TO: Skip Laitner
FROM: Jay Shogren and Joe Aldy 
DATE: July 11, 1997
RE: Comments on Industrial Emissions and Economic Impacts Paper

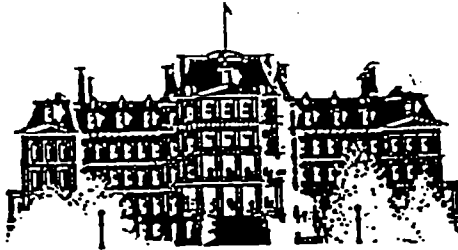
Below we have provided several comments on your paper. If you have any questions, please feel free to contact Joe at 395-1455.

1) Win-win claim: The author argues that "since these new technologies tend to lower the overall cost of doing business, investments in energy efficient technologies may actually improve the competitive position of many industries." Then why haven't private firms already adopted these technologies? If a private benefit-cost analysis on an energy efficient technology is positive, then there is no need for policy to stimulate the adoption of the technology. Perhaps the slow rate of adoption reflects unaccounted costs in this analysis, such as high costs of capital or high costs of private information.

2) Rates of return: Heat recovery and cogeneration systems can "save 10% of energy use with an internal rate of return of 30-60%." This may be the case, but the omission in this discussion highlights what is probably the case: high capital costs, even with good returns, can serve as a barrier to action.

3) Understated benefits: The author notes that efficiency technologies "often" yield reduced labor and other material costs that are not captured in a discussion of the benefits. On the other hand, assessments of these technologies may not account for firms' opportunity costs for investing capital. If a firm has a fixed pool of investment capital in any period, even if an efficiency technology has a positive benefit-cost analysis relative to doing nothing, it may not be positive relative to the option of improving the quality of the product manufactured.

EXECUTIVE OFFICE OF THE PRESIDENT



THE OLD EXECUTIVE OFFICE BUILDING

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NO. OF PAGES (inc cover) 3

DATE: _____

SUBJECT: Climate change costs/emissions chart

MESSAGE:

Table: A Sectoral Comparison of Emissions and Costs of Climate Change

Sector	1990 C Emissions	2010 Base C Emissions	2010 Stabilization of 1990 Level Emissions	Reductions	Costs	Govt Costs	Issues Affecting Probability of Achieving Emissions Goals
Transportation	432 (AEO97, DOE5: viii)	616 (DOE5: viii)	485 - 513* (DOE5: 5.5, xiii)	103 - 131	\$43 - 68b/yr (CEA, DOE5)	?	1) PNGV funding 2) gasoline prices 3) intermodal switching
Cars & Lt. Trucks			(M-M)		\$18 - 28b/yr (CEA)	?	
Freight, Air, Rail	185 (AEO97: Gorte)	(AEO97)	244 (DOE5: Gorte)		\$25 - 40b/yr (DOE5: Gorte)	?	
Industry	452 (AEO97, DOE5: viii)	534 (AEO97, DOE5: viii)	(M-M) 461 - 483 (DOE5: xiii)	51 - 73	\$3.6b/yr (DOE5: 4.14)	?	1) flexibility with other envl rules 2) incentives to retire capital 3) tax reform to spur feedstock recycling
Buildings	460 (AEO97, DOE5: viii)	571 (AEO97, DOE5: viii)	(M-M) 525 - 530 (DOE5: xiii)	41 - 46	\$14b/yr (DOE5: 3.5)	?	1) CCAP funding 2) electricity prices
Electric			-157 - -138** (DOE5: xiii)	138 - 157	\$6 - 10b/yr (EPA-IPM:Turner) <\$6b/yr (DOE5: xviii)	?	1) natural gas response 2) deregulation 3) R&D
Renewable			-20 (Petersen)		\$4 - 6b/yr (Petersen)	?	
TOTAL (rounded)	1340 (AEO97, DOE5: viii)	1720 (DOE5: viii)	1314 - 1388	332 - 406	\$67 - 96b/yr		

* DOE5 provides an estimate of emissions under the high efficiency/low carbon case of 485 mmtce on p. 5.5 and another estimate of 513 mmtce on p. xiii. Since we cannot discern which is the appropriate estimate, we provide both as a range.

** DOE5 accounts for all reductions in carbon from decreased electricity demand with the end-use sectors, and all carbon reductions from fuel switching to the electric sector.

AEO97: Annual Energy Outlook 1997, published by DOE Energy Information Administration

DOE5: U.S. Carbon Reductions by 2010 and Beyond, report by 5 DOE labs

M-M: Markal-Macro model runs

DRI: DRI model runs

CEA: Council of Economic Advisors in-house analysis

EPA-IPM: EPA used their IPM model to estimate electric sector costs

Note on cost and emissions estimates: The cost estimates, in several cases, represent the upper bound of the estimates provided in the sector papers. We employ the upper bound because the upper values represent the DOE5 high efficiency/low carbon case. This is the case that generates emissions reductions to achieve 1990 levels. The lower bound in the sector papers represents the efficiency case, which does not achieve 1990 levels. The DOE5 estimates of emissions in 2010 do not include a range as well, since the upper bound of the range (representing fewer emissions reductions) occurs under the efficiency case.

CEA cost estimate for cars and light trucks: We use two sets of information to calculate a range of costs for this sub-sector. For the lower range, we use the \$1,200 value provided in the paper which reflects the Markal model runs. We multiply this by the number of cars and light trucks in 2010, which we conservatively assume is the same number as today, 15 million. For the second number, we take the cost estimates from DOE5 (5.49) of \$2,000 for cars and \$1,650 for light trucks and multiply these by a rough number of cars and light trucks sold this year (9 million and 6 million respectively).

DOE5 cost estimates ignore implementation costs of technology adoption.

8/13/97 mtg

Four Levels of Project Costs

I. Project Impacts

Sector	Savings Potential	IRR	Payback
Res	X	X	X
Comm	X	X	X
Ind	X	X	X
Trans	X	X	X
Util	X	X	X

II. Scenario Impacts

Case	Investment	Savings
Res	X	X
Comm	X	X
Ind	X	X
Trans	X	X
Util	X	X
Total	X	X

III. Federal Impacts

R&D Investments
 Market Transformation Costs
 Tax and Other Fiscal Incentives

IV. Other Impacts

Progress Ratios and Experience Costs (Impact on Costs)
 Return on R&D Investments
 Other

Minicam



ma_wise @ ccmil.pnl.gov

02/19/98 01:03:00 PM

Record Type: Record

To: Daniel K. Chang

cc:

Subject: Re: follow up with modelers

I can give you a few papers, but I don't have one that definitively describes the model, since it is often changing. Can we FedEx them to you? If so, what is your address and phone number? Or, I could fax a bried paper.

I've tried to answer some questions below...

Reply Separator

Subject: follow up with modelers

Author: Daniel_K._Chang@oa.eop.gov at -SMTPLink

Date: 2/17/98 5:07 PM

Message Creation Date was at 17-FEB-1998 17:07:00

Hi Marshall,

In short we're just looking for some documentation, but some more specific questions are enclosed in the following e-mail. I'll call you tomorrow afternoon, and hopefully we can touch base then.

-Dan

----- Forwarded by Daniel K. Chang/CEA/EOP on 02/17/98 05:03 PM

Joseph E. Aldy
02/14/98 01:09:04 PM
Record Type: Record

To: Daniel K. Chang/CEA/EOP

cc:

Subject: follow up with modelers

Dan,

Over the next week, could you do some work following up with the climate change modelers? We need more info from the following models:

EMF-14 Runs:

Minicam (Battelle -- call Chris MacCracken 646-5274 -- he'll pass you on to

Marshall Wise)
CETA (Peck and Teisberg)
CRTM (Charles River Associates)
CPBRIVM (Dutch Team)

Kyoto Analyses:
MRT (Charles River Associates)
G-Cubed (Bob Shackleton, EPA)

Regarding the EMF-14 models and G-Cubed, we would like

- 1) any documentation they may have on their models
 - a) specifically, we would like to know technology assumptions (e.g., what is the implied autonomous energy efficiency improvement in the model),

****This isn't so simple. This isn't really a question about the model, but about what was assumed for the EMF runs? And, there isn't just one number for all time, for all regions. The model itself just uses what is assumed for a scenario. For the EMF runs, I assumed about 0.5%/yr for the developed world and 1-2% for the developing countries, with the higher value linked to higher periods of economic growth.
b) how other regions are modeled (e.g., what is assumed about the cost curves in other countries),

All regions modeled the same as the US. It isn't based on cost curves, but instead a more detailed description of the energy sector which would go behind making up any cost curves.
c) as well as the general make-up of the model (e.g., how many sectors, how does it handle international trade, price elasticities of energy, etc.),

11 regions. International trade in oil, gas, coal, carbon permits, and agriculture. Energy sectors are electricity producers, transportation, buildings, and industry. Demand for energy is a function of population, income, technical change, and energy prices. Fuel mix is determined by relative costs of using competing fuels. There is not just one price elasticity, since there is more detail.
d) the prices are in what year's dollars (e.g., SGM is in 92 US\$) -- could you pass this info on to Jenny, she is working with some of the model results.
1990

- 2) Cites to any published papers with their models -- if they are willing to fax us those papers, great, otherwise, you may need to get them through our library

One basic source, though a bit out of date is the book, Global Energy: Assessing the Future. by Edmonds and Reilly, Oxford press.

Regarding MRT, we would like all of the above, plus

- 1) description of how the model handles 6 gases.

Mainly CO2

- 2) description of how the model handles sinks

- 3) assumptions about "hot air" or "paper tons" in eastern Europe and Russia

Not a simple question. The model can handle any way you tell it. This wasn't relevant to the EMF cases. The allocations were as prescribed for the EMF

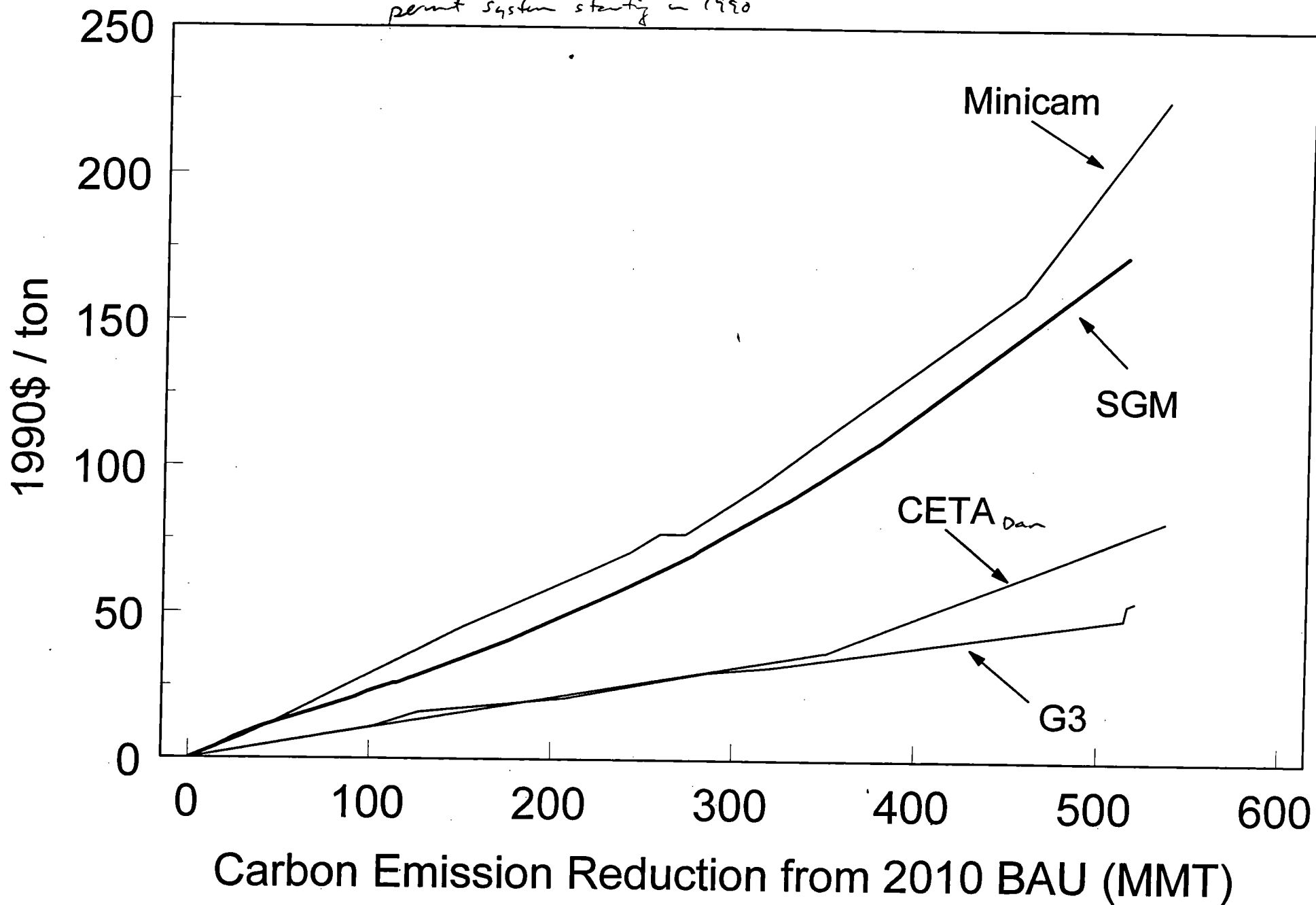
4) assumptions about the clean development mechanism/JI Not sure what this means.

Could you draft summary one-pagers on the models after you collect all of this information?

If you have questions about this, feel free to talk to Randy -- he is familiar with these models and what we are doing with them.

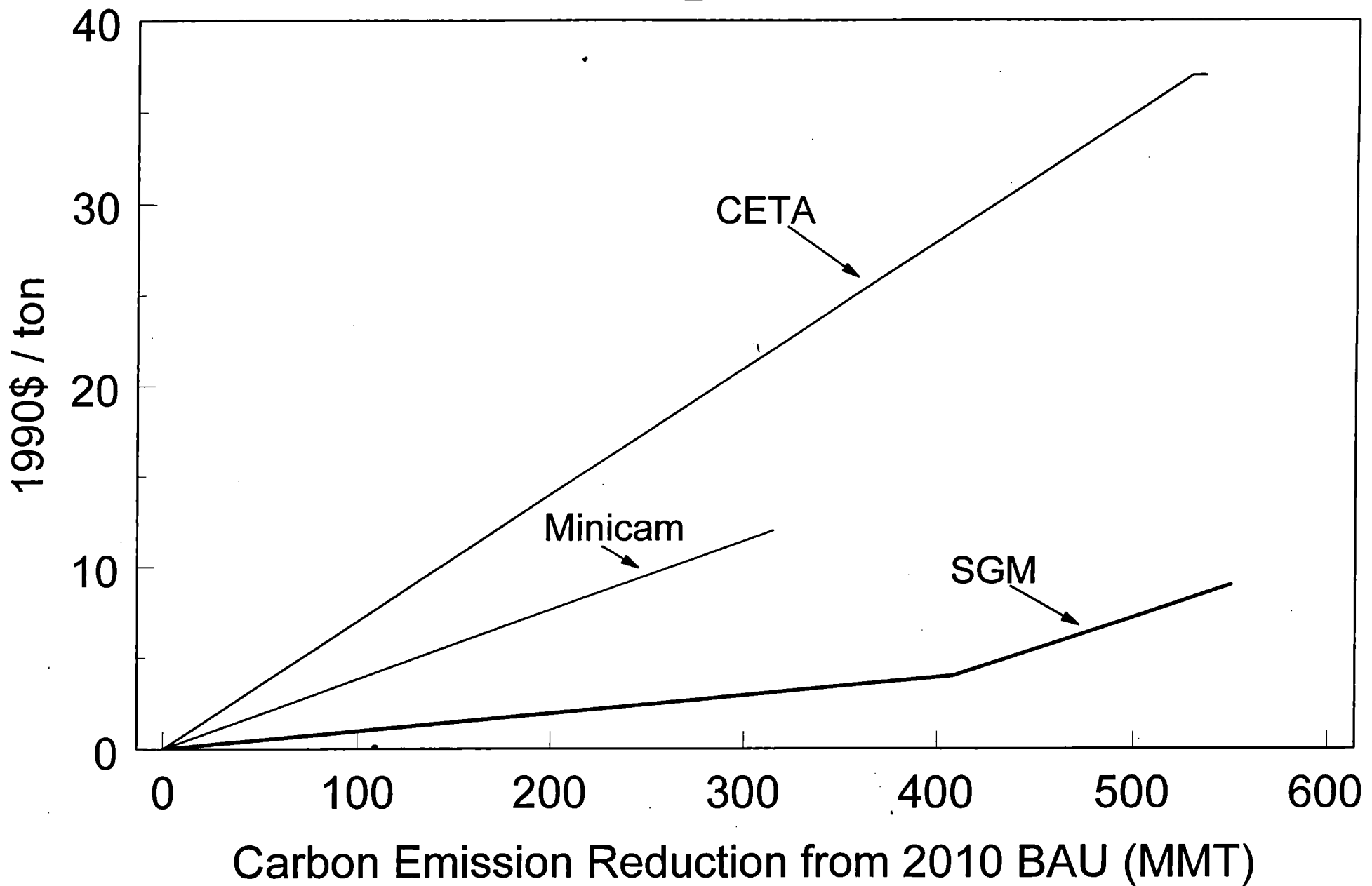
CO₂ Cost Curves for the U.S.

permit system starting in 1990



Note: Minicam -- Battelle, SGM -- Pacific Northwest Labs, CETA -- Teisberg Assoc., G3 -- Shackleton, EPA.

World CO₂ Cost Curves



Note: Minicam -- Battelle, SGM -- Pacific Northwest Labs, CETA -- Teisberg Assoc..

Office of Economic Policy

Department of the Treasury • Washington, D. C. 20220

FAXDate: August 20, 1997 at 11:38 AMNumber of pages including cover sheet: 8

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	JOE ALDY		

From:	Robert Gillingham	202-622-2633	202-622-2220
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REMARKS: ☐ Urgent ☒ For your review ☐ Reply ASAP ☐ Please comment

See what you think.

COMMENTS ON *SCENARIOS OF U.S. CARBON REDUCTIONS*

Scenarios of U.S. Carbon Reductions, commonly known as the "5-labs study," examines the "potential for energy-efficient and low-carbon technologies to reduce carbon emissions in the United States." This study does a very nice job of cataloging the current state and likely future path of technological developments. What it does not do, however, is shed much light on what role technology is likely to play in mitigating the growth of carbon emissions, or on what government can or should do to enhance this role.

As a tool for developing and implementing a technology policy, the report is hampered by the fact that it does not address any of the processes that determine the rate at which technology is developed and implemented. Rather, it catalogs technologies that currently exist, are likely to exist or could possibly exist by 2010, determines whether they are "cost-effective," and then makes somewhat arbitrary assumptions about the rate at which they are implemented. Although the analysis is couched in terms of the adoption of cost-effective technologies, cost-effectiveness is not rigorously defined; no evidence is presented on whether decision-makers are or are not acting in their best interest. It is important to recognize that the paper *does not demonstrate an irrational unwillingness to invest in energy efficiency*. The paper suggests that the adoption of standards and codes is necessary to ensure appropriate consumer behavior; again, *no such demonstration is made*. In other words, the study does not and cannot present evidence on the costs to either society or individual consumers and businesses of alternative technology paths.

The study reaches three overarching conclusions:

- A vigorous national commitment to develop and deploy cost-effective energy-efficient and low-carbon technologies has the potential to substantially reduce energy consumption and carbon emissions.
 - ◆ We would not argue with this conclusion. Rather we question (1) the level of government involvement—government R&D, tax incentives, efficiency standards, etc.—that would be necessary in the absence of energy-price increases and (2) whether the substantial increases in relative energy prices that would likely accompany constraints on carbon emissions would not be the most important component of any national commitment to reduce emissions.
- Carbon emissions can be reduced in ways that reduce energy costs more than they increase other societal costs.
 - ◆ We question this assertion. The study makes only rudimentary cost-benefit calculations that ignore important considerations that reasonably effect decisions to invest in energy efficiency. It also substantially understates the costs of government policies to promote technology.
- The next generation of energy-efficient and low-carbon technologies promises to

enable the continuation of an aggressive pace of cost-effective carbon reductions over the next quarter century.

- ◆ Again, absent a careful cost-benefit analysis, this conclusion is overly speculative. For instance, with respect to the transportation sector, the report concedes that future technological breakthroughs will be necessary to develop and implement the high-efficiency, low-carbon technologies. It is a stretch to *assume* that these breakthroughs will be forthcoming and that they will pass rigorous cost-benefit tests, especially in the absence of strong price signals.

The methodology used in the report is to analyze sequentially the three major end-users of energy—the residential and commercial building, industry and transportation sectors—and separately analyze the electric utility sector. For each sector, the study develops three scenarios—business-as-usual, efficiency, and high-efficiency/low carbon. They are conceptually defined as follows:

- *Business-as-usual (BAU)*. Best estimate of future energy use given current trends in service demand, stock turnover and natural progress in the efficiency of new equipment. Assumes no change in federal policies.¹
- *Efficiency (EFF)*. Likely market penetration of “cost-effective,” energy-efficient technologies given “an invigorated effort to promote energy efficiency through enhanced public and private-sector R&D and market transformation activities.”
- *High-efficiency/low-carbon (HE/LC)*. Optimistic but feasible market penetration for energy efficient and low-carbon technologies given a “greater commitment to reduce carbon emissions resulting from actions that might include the creation of a market value for carbon of \$25 and \$50 per tonne.”

With the exception of the range of carbon emission charges, which seems out of place and is largely ignored in the study, these conceptual definitions are very vague. The operational definitions vary by sector and will be discussed in turn below.

BUILDINGS

For buildings, the business-as-usual scenario is the Annual Energy Outlook (AEO) reference case. The efficiency scenario assumes that 35 percent of the “cost-effective energy savings potential” relative to the BAU is achieved. The high-efficiency/low-carbon scenario assumes that 65 percent of these savings are achieved. We have a number of problems with this analysis.

The cost-effective energy saving potential is badly defined. The study makes two critical assumptions in defining cost effectiveness. First, the analysis takes as given

¹ The report provides relatively little analysis of past trends and their determinants. The past has certainly informed our view of the future, and a more detailed analysis of the price and quantity paths, both past and in the BAU scenario, would be very useful.

that engineering estimates of energy use for alternative technologies are known with certainty and independent of the age of the capital good in which the technology is embodied. There is evidence that adopting these estimates is likely to overestimate savings (e.g., attic insulation may not be perfectly installed; consumers may increase usage rates for energy-efficient appliances or consumers may add more windows when their energy costs are reduced).² Second, the analysis ignores the trends and uncertainty around these trends in the future prices of both capital goods and energy as well as the potential irreversibility of investment decisions (proper treatment of these issues goes a long way toward explaining high measured internal rates of return, which are often confused with high discount rates).³ As a result of these two assumptions, the study almost certainly exaggerates the "cost-effectiveness" of investments in energy efficiency.

The assumed take-up rates of 35 percent and 65 percent are arbitrary. The study makes no attempt to model behavior; rather it makes arbitrary assumptions about the rate at which energy-saving investments are made. With no idea what determines the rate at which new technologies are adopted, we have no basis for informed policy-making. The HE/LC case includes substantial price increases in energy, yet the study simply raises the take-up rate for technologies deemed cost-effective under a different—and much lower—scenario of energy prices. The assumed take-up rate under the EFF case is bad enough, but the failure to explain how a carbon price would change the decision-making calculus in the HE/LC case is even worse.

A number of the examples are based on 1997 technologies. For instance, the refrigerator example assumes adoption of an energy-efficient 1995 model. This ignores the fact that refrigerator efficiency has been improving at a rapid rate for over 20 years (6.2 percent per year from 1972 to 1991). What does the AEO assume for the 1995 to 2010 period? Is it reasonable to assume that the type of saving assumed in the EFF case should be incorporated in the BAU case? Or is the BAU unnecessarily pessimistic?

The bulk of the savings in buildings are largely unexplained, coming from "miscellaneous electricity uses." The study admits that because of the importance of these uses, "it is crucial that more research be carried out, both to characterize how energy is used in the miscellaneous category and to identify technologies for improving the efficiency of sub-categories." With no clear understanding of these fundamental aspects of electricity use, how can we be confident to assume that this

² See, e.g., Gilbert Metcalf and Kevin Hassett, "Measuring the Energy Savings from Home Improvement Investments: Evidence from Monthly Billing Data," National Bureau of Economic Research Working Paper 6074, June 1997.

³ See Robert Pindyck, "Irreversibility, Uncertainty, and Investment," *Journal of Economic Literature* 29, 1991, for a review of some of these issues. Also, see Gilbert Metcalf and Donald Rosenthal, "The 'New' View of Investment Decisions and Public Policy Analysis: An Application to Green Lights and Refrigerators," *Journal of Policy Analysis and Management*, Vol. 14, No. 4, 1995, for an application.

category accounts for most of the presumed savings?

INDUSTRY

For the industrial sector, the study relies on the Long-Term Industrial Energy Forecasting (LIEF) model, an econometric forecasting model, to explain investment in conservation technology; it uses the industrial module of the National Energy Modeling System (NEMS), which does not model investment, to assess the effect of that investment on energy use. The business-as-usual scenario is the Annual Energy Outlook (AEO) reference case. The efficiency scenario assumes that the "capital recovery factor" (CRF) for energy-efficient investment in the LIEF is reduced from 33 percent to 15 percent.⁴ The high-efficiency/low-carbon scenario assumes, in addition, that the penetration rates for energy-efficient technology are doubled relative to the BAU scenario. This analysis suffers from problems similar to those in the analysis of the buildings sector.

The study models investment in the EFF and HE/LC scenarios by arbitrarily assuming that the return criterion for energy-efficient investment is reduced by more than 50 percent. No rationale is provided for this approach, nor are any policies posited that would lead to this result. Rather, it is simply a device to increase investment. As noted above, arbitrary assumptions about hurdle rates beg critical questions about the effect of uncertainty, changing relative prices and irreversibility on investment behavior. The approach used provides no insights into investment behavior; it implicitly assumes that behavior.

The HE/LC scenario depends on an arbitrary assumption about penetration rates and ignores price effects. The LIEF model "provides a mechanism for evaluating general investment in conservation technology as a function of energy prices, capital recovery rates, and other prices." Yet in evaluating the HE/LC scenario, the study ignores the postulated \$25 and \$50 carbon prices that are part of this scenario. Instead it assumes a doubling of penetration rates for new technology and retirement rates for old capital. The study makes no attempt to demonstrate that an increase in penetration/retirement rates is economically motivated.

Although no policies are modeled or advocated, the study lists a number of potentially costly and/or intrusive policies that could promote energy efficiency. These include accelerated depreciation, rebates or tax credits, regulation and efficiency standards, pricing and fiscal policies, and "other economic incentive programs."

TRANSPORTATION

For the transportation sector, the business-as-usual scenario is the Annual

⁴ A \$50 carbon fee would certainly increase investment in energy efficiency, as does the drop in the CRF. The latter approach is not the right way to model expected relative price increases, however. Again, uncertainty and irreversibility should be explicitly modeled, making it clear that a high *apparent* hurdle rate is not the same as a high discount rate.

Energy Outlook (AEO) reference case, adjusted to reduce the assumed improvement in light-duty vehicle fuel economy. The efficiency scenario assumes earlier introduction of advanced fuel economy technology and adds certain key technologies that are not in the BAU. The high-efficiency/low-carbon scenario postulates future "breakthroughs" in technology. As with the other sectors, this analysis provides few insights for technology policy.

The efficiency scenario assumes accelerated adoption of existing technologies, but provides no reason why this might occur. Unlike the analysis of the other sectors, the analysis of the transportation sector does not even include any economic assumptions that might imply its conclusions. As a result, it promises no medium or longer-term gains.

The HE/LC scenario is even more ephemeral; it requires technological breakthroughs, primarily in fuel-cell technology. As the report notes, the EFF and HE/LC scenarios "differ from each other less in effort than in outcome. . . . In contrast, because the outcomes postulated in the high-efficiency/low-carbon scenario require technological breakthroughs, they require a certain degree of luck to be achieved by 2010." In other words, we do not need to try any harder to achieve the HE/LC scenario; we just have to be lucky.

The analysis raises the AEO energy baseline, but not the emissions baseline. Since it raises the AEO energy baseline, the study should also adjust the emissions baseline. As a result, the savings postulated relative to the AEO baseline would be reduced.

ELECTRICITY

The analysis of the electricity sector describes how the electricity demands inherent in the BAU, EFF and HE/LC scenarios can be met with lower carbon emissions. The BAU scenario is a fully competitive bulk-power market in the year 2010. The demands on this system are then adjusted to reflect the effects on electricity demand and supply of the EFF and HE/LC scenarios. These results are used in the sector analyses to evaluate carbon savings attributable to reductions in electricity consumption. They are also used to evaluate the opportunities for reducing carbon emissions in electricity generation in response to \$25 and \$50 carbon prices.

The EFF and HE/LC scenarios predict substantial reductions in electricity demand from baseline. The two scenarios predict reductions of 9 and 16 percent, respectively, in end-use electricity demand relative to BAU. In fact, they assume essentially zero growth in electricity demand between 1997 and 2010. To put this into perspective, electricity sales increased at an annual rate of 2.0 percent annual rate so far in the 90s and at more than a 3 percent rate over the past 25 years.

IMPLICATIONS OF THE STUDY

As the above discussion demonstrates, the study is primarily a catalog of

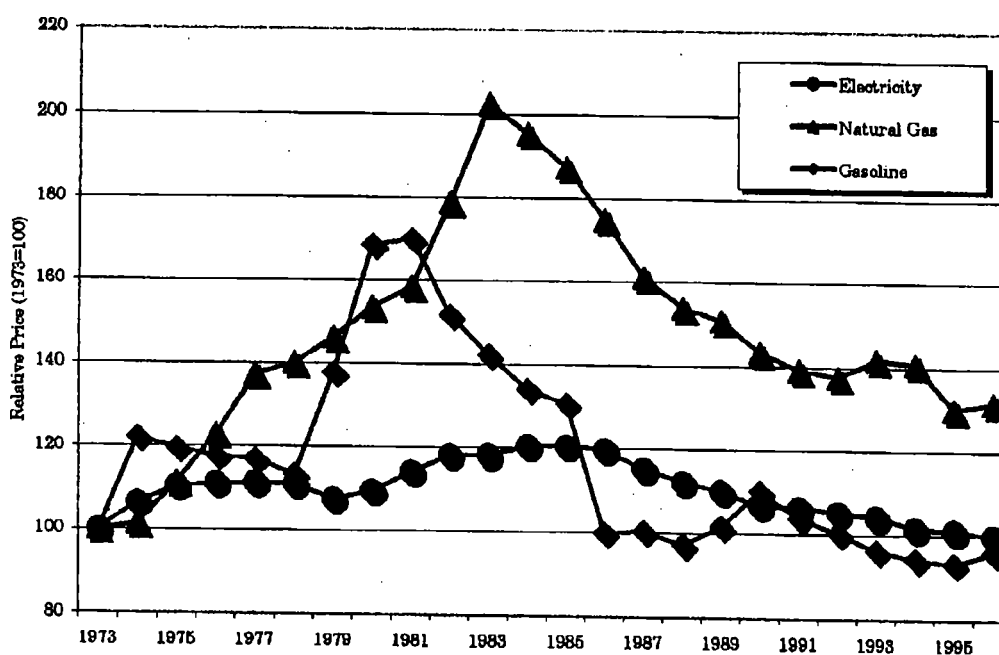
potential improvements in energy efficiency. Neither the determinants of these improvements, nor their implications for energy demand behavior are examined. Rather, the study provides an *accounting* of two very stylized scenarios. Without developing and detailing the relationship between the study's scenarios and the policy mixes that would have to accompany them, it would be inappropriate to draw any conclusions from the study about the role of technology, much less the role of technology policy, in addressing global warming. Although the study provides no policy recommendations, it does hint at possibilities. Listing them provides some insight into the potential difficulties in making the scenarios "come true."

- *Aggressive R&D, both public and private.* The study continually refers to the need for aggressive R&D, but provides no suggestions as to how it could be fostered and at what cost.⁵ The EFF scenario is basically an extrapolation of the Climate Change Action Plan; the likely success of this effort is at best problematic. Some have suggested a more vigorous effort, similar to the Apollo project. Although this sounds good, we should remember that the Apollo project required rechanneling 0.4 percent of the entire GDP of the 1960s into this one government project. Many of the climate change modeling efforts predict that reducing emissions levels to 1990 levels in 2010 would not cost much more than that in the absence of a technology program.
- *Tax incentives.* Investment tax credits, accelerated depreciation, and other tax incentives are available to spur the development and adoption of energy-saving technology. This approach has two problems. First, energy-efficiency investments should not be singled out unless they impose special costs. If they do, *disincentives* for using energy are more efficient than *incentives* for saving energy. Second, any substantial incentives would have to be "paid for" with other tax increases and spending cuts. As recent history has demonstrated, reaching consensus is not easy.
- *Regulations and standards.* Implicit in this study is the idea that regulations and standards could go a long way toward achieving the EFF and HE/LC scenarios. The types of standards that would be needed, however, would be very pervasive and potentially very intrusive. For instance, standards would have to be applied to building components (windows, insulation, etc.) and constructions techniques, consumer and commercial appliances, utility and industrial equipment, etc. If standard setting is a major policy instrument, achieving the standards could be very costly. Standards work best if they impose little cost, as the report alleges they often would. Basing policy on this assumption moves us quickly to the idea that better results depend less on effort than on luck.

⁵ The study (arbitrarily) assumes that government costs to promote energy conservation are equal to 7 percent of *energy savings*. This is very optimistic. For instance, a 10 percent tax credit would cost 10 percent of the total cost of all qualifying investment, even that which would have taken place in the absence of the credit. The load factor for explicit government subsidies would be roughly 10 times as large.

- **Higher prices.** The most obvious policy to spur energy conservation is to increase energy prices. The study presumes a substantial increase in prices in its HE/LC scenario, but never draws out the implications of higher prices for the development and adoption of advanced technology. The study points out how rapidly energy efficiency improves prior to the late 80s and 90s. This is not surprising, given price trends. As the chart below demonstrates, consumer energy prices, relative to other prices, grew very rapidly during the 70s and into the 80s. A commitment to reduce emissions and internal climate costs would presumably result in substantial increase in relative prices and accompanying increases in efficiency.

RELATIVE PRICES OF CONSUMER ENERGY



Under almost any feasible scenario that reduces carbon emissions, the pace of technological advance in energy conservation will increase. The importance and role of technology are not in question. What is in question is the value of looking at technology in a vacuum. The 5-labs study provides a plethora of useful information. It does not present this information in a form that is useful for policymaking, however. To be useful, it needs to be merged with careful analysis of the determinants of both consumer and business investment in energy-saving technology.



CLIMATE POLICIES AND PROGRAMS DIVISION
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To: Joe Aldy
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From: Bill Hohenstein
Phone: 202 260-7019
Fax: 202 260-6405
Date: January 30, 1998

Pages including cover sheet: 5

Joe:

Here is a paper done before Kyoto examining options to deal with Russian Paper tons. The protocol most closely resembles Option 3: constrain paper ton to those created during the first budget period. I've also attached a file with the EIA projections on it.

I have not yet received the forest and land use change estimates from Rich Birdsey, but I just spoke with him. He is done with his analysis and is looking over the results before he sends them out.

Bill

Options for Addressing "Hot" and "Super Heated Air" In A Post-2000 Kyoto Agreement

Problem Statement: Russia and Eastern Europe carbon emissions from the energy sector have declined significantly since 1990 and are expected to be below 1990 levels through 2012. Emissions are expected to bottom out in 1995 at 67% of 1990 levels and to rise gradually through 2012 when they will be roughly 90% of 1990 levels. Internal Russian energy projections are consistent with US EIA projections. Russian estimates forecast that emissions will be 84-91% of 1990 levels in 2010. These trends raise two issues for an emissions trading system.

Hot Air: Should Russia and Eastern Europe be allowed to "trade" the residual amount below their 1990 levels during the first budget period to other Annex I countries. The US position supports international emissions trading during budget periods, even though we recognize that the Russians and Eastern Europeans will be below 1990 levels during the first budget period (2008-2012). The European Union has referred to these credits as "hot air". We estimate that Russia and Eastern Europe will have 810 MMTC of hot air.

Super-heated Air: In addition, the Russians and Eastern Europeans would like "early credit" starting in 1990 -- basically allowing them to sum the entire amount below 1990 levels for use in the first budget period and beyond. The European Union refers to these credits as "super heated air". Allowing Russia and Eastern Europe to bank all of their reductions below 1990 levels results in 5,916 MMTC of credits by 2012 (the end of the first budget period), of which 5,106 MMTC are "super heated air".

The Options

There are several options to engage Russia and Eastern Europe (who will negotiate for as many credits as possible) and the European Union (who will want to minimize the use of hot and super heated air).

Option I: Allow Russia and Eastern Europe to bank from their 1990 baseline: Allowing Russia and Eastern Europe to bank and trade their super heated air will mean that Annex I will have to do nothing to meet a stabilization commitment. This is because the other Annex I countries will only have baseline growth of 3,998 MMTC over 1990 levels during the entire first budget period.

Option II: Select a 1995 base year: This option would eliminate the Russia all "super heated and hot air", since Russia and Eastern Europe were at 67% of their 1990 emissions in 1995. Russia would have an extremely difficult time meeting a commitment to stabilize emissions at 1995 levels since emissions are expected to increase by 31% from 1995 to 2010, and of course would be highly unlikely to agree to this new baseline. An important consideration with this option is that the US becomes the low-cost country and "sells" permits to other countries.

Option III: Select a 1990 base year – constrain banking to first budget period: Russia and Eastern Europe could be constrained from banking “super heated air” and only allowed to trade credits derived during the first budget period. Since Russia and Eastern Europe are expected to be under 1990 levels throughout the 2008-2012 time period, they will be in a position to trade credits before they take any action (“hot air”). EIA estimates that the amount of “hot air” is roughly 810 MMTC of credits during the first budget period before taking any action. (20% of the overall Annex I emissions reduction goal for the first budget period).

Option IV: Cap the level of banking at a fixed amount tons. This option would allow negotiators to broker a deal. The environmental, cost, and equity implications of this option would be determined by how the deal is structured. For our analysis we assumed that Russia would be allowed to bank tons beginning in 2005. The pool of “super heated tons” could be restricted or expanded by choosing alternative “start years” or by negotiating a fixed amount.

Option V: Exclude Russia and Eastern Europe from Annex I trading: The EU has threatened to push for this if the Russian and Eastern Europe “super heated air” are not taken off the table. This would severely constrain the availability of low cost reductions. Russia and Eastern Europe are expected to be the major emissions trading partner with the US. Under a scenario where Russia and Eastern Europe were excluded, the US would become the low-cost producer of emission credits and would be in a position to “sell” credits. In fact, SGM analysis indicates that the “Annex I Trading” permit price is roughly \$130/ton. The US can meet its commitments without trading for \$82/ton.

Option VI: Cap emissions at 2000 levels from 2003-2007: This option will substantially reduce (but not entirely eliminate) the Russian hot air problem. Russian emissions are expected to grow by 417 MMTC over 2000 levels between 2003 and 2007. Capping emissions from 2003-2007 at 2000 levels will force Russia and Eastern Europe to borrow against the 2008-2012 budget period. As a result, Russia and Eastern Europe will have only 393 MMTC of hot air remaining in the 2008-2012 budget period -- if they remain on their baseline trajectory. This option meets EU requests to start actions before 2008. It would allow the US to credit early action by US companies and to begin the process of compliance before the much more stringent budget period of 2008-2012.

Recommendation:

Support Option III: Constrain banking to the first budget period. This option provides Russia and Eastern Europe with a target that will require them to do nothing during the first budget period while receiving a large amount of financial assistance. We estimate the total value of this package to Russia and Eastern Europe is \$18.6 Billion over 5 years. The US alone will most likely purchase 331 MMTC of hot air over the 5 year budget period and spend \$7.6 Billion – reducing our domestic commitments by 17.5%. This option also provides Russia and Eastern Europe the opportunity to begin to pursue financing and trades before 2008. Early trading agreements will allow Russia and Eastern Europe to rebuild its infrastructure and to finance low-greenhouse gas emitting technologies well before 2008. The Russians and Eastern Europeans may not agree to this. As a fall back position, the US could consider Option 4, which would allow Russia and Eastern Europe a limited volume of “super heated air”.

Table 1: Cumulative Emission Reduction Commitments 2008-2012

Region	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6 (2003- 2007)	Option 6 (2008- 2012)	Option 6 Total
US	1,888	1,490	1,888	1,888	1,888	472	1,888	2,360
Japan	785	522	785	785	785	156	785	941
Canada	226	197	226	226	226	60	226	286
Australia/NZ	135	75	135	135	135	34	135	169
European Union	964	974	964	964	964	325	964	1,290
Russia/ Eastern Europe	-5,916	1,419	-810	-1,491		417	-810	-393
Annex I Reductions	-1,918	4,677	3,188	2,507	3,998	1,465	3,188	4,653

ata source: EIA International Energy Annual, 1997

Option 6 totals include reductions taken from 2003-2007

Table II: Costs of the Hot Air and Super Heated Air Options

	Option 1 ¹	Option 2 ²	Option 3	Option 4 ⁴	Option 5	Option 6
Annex I Permit Price (\$96)	\$9	\$76	\$23	\$19 ⁵	\$131	\$40
Russian and Eastern Europe Hot Air Sales 2008- 2012 (MMTC)	3998	0	810	1491	0	393
Total Value of Russian and Eastern Europe Hot Air (Billion \$96)	\$36.0	\$0.0	\$18.6	\$28.3	\$0.0	\$15.7
US Purchases of Hot Air 2008-2012 (MMTC)	1,888	0	331 ³	609	0	160
US Expenditures on Hot Air Sales 2008-2012 (Billion \$96)	\$17.0	\$0.0	\$7.6	\$11.6	\$0.0	\$6.4

Based on Second Generation Model Analysis

1. Assumes Russia charges \$9/ton — the value available from unlimited global JI
2. NOTE: The US sells permits under this option (the US permit price w/out trading is \$66/ton)
3. Based on the proportion of hot air purchased by the US from SGM analyses
4. Assumes that Russia and Eastern Europe get "super heated air" from 2005 -2008
5. Interpolated from other data

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
USA	1,344	1,330	1,348	1,374	1,397	1,424	1,448	1,471	1,495	1,519	1,543	1,562	1,581	1,601	1,620	1,639	1,656	1,672	1,689	1,706	1,722	1,738	1,753	1,769	1,784	1,799	
CANADA	137	131	135	137	140	143	146	150	153	156	160	162	163	167	170	172	174	176	178	180	182	184	186	188	190	192	
JAPAN	308	321	324	335	351	361	369	377	385	393	401	407	413	419	425	432	438	445	452	459	466	471	477	482	487	492	
Australia/NZ	100	99	98	97	95	112	111	111	113	114	114	115	117	118	120	121	122	123	125	126	127	128	129	131	132	133	
UK	173	175	166	167	168	170	170	171	172	173	174	175	176	178	179	180	182	183	184	186	187	189	191	192	194	196	
FRANCE	113	119	116	110	106	110	111	112	114	115	117	119	121	123	125	128	130	132	134	136	138	141	143	146	148	150	
GERMANY	279	263	260	254	244	241	245	250	254	258	262	265	267	270	272	275	277	279	281	283	284	287	290	292	293	298	
ITALY	118	120	120	114	114	124	125	125	126	126	128	128	129	131	132	134	135	136	138	139	141	142	143	144	145	147	
NETHERLANDS	61	62	61	62	63	67	67	67	67	67	68	68	69	69	70	70	71	71	72	72	72	73	73	74	74	74	
OTHER EU	272	285	285	284	292	303	309	316	322	329	335	340	345	350	355	360	365	370	375	380	385	391	397	402	408	414	
EU Sub-total	1,016	1,025	1,009	992	987	1,014	1,028	1,041	1,054	1,068	1,081	1,094	1,107	1,120	1,134	1,147	1,159	1,171	1,184	1,196	1,208	1,222	1,236	1,250	1,264	1,279	
FSU	1,029	946	905	814	711	653	669	685	701	717	733	747	761	774	788	802	816	830	844	858	872	884	897	909	921	933	
EASTERN EUROPE	309	277	254	245	239	240	248	256	263	271	278	281	284	287	290	293	296	298	301	303	306	308	311	313	316	318	
FSU/EE Subtotal	1,339	1,224	1,159	1,058	949	893	917	940	964	988	1,012	1,028	1,045	1,062	1,078	1,095	1,112	1,128	1,145	1,161	1,178	1,193	1,207	1,222	1,236	1,279	
Total Annex 1	4,244	4,130	4,073	3,994	3,922	3,947	4,019	4,092	4,165	4,238	4,310	4,369	4,428	4,487	4,546	4,605	4,661	4,717	4,773	4,828	4,884	4,936	4,989	5,041	5,094	5,146	
Banking all credits under 1990 through 2012 levels																											
FSU Underage	-83	-124	-216	-319	-377	-361	-345	-328	-312	-296	-282	-269	-255	-241	-228	-214	-199	-185	-171	-157	-145	-133	-121	-109	-97	-85	
EE Underage	-32	-55	-55	-71	-69	-61	-54	-46	-39	-31	-28	-25	-22	-19	-16	-13	-11	-9	-6	-4	-1	1	3	5	7	9	
Total Underage	-115	-180	-280	-389	-446	-422	-398	-375	-351	-327	-310	-294	-277	-260	-244	-227	-211	-194	-177	-161	-146	-132	-118	-104	-90	-76	
Banking credits during 1st Budget Period 2008-2012																											
FSU Underage																		-185	-171	-157	-145	-133	-121	-109	-97	-85	
EE Underage																		-9	-6	-4	-1	1	3	5	7	9	
Total Underage																		-194	-177	-161	-146	-132	-118	-104	-90	-76	

Summary Descriptions of Potential Signature Actions

Preliminary Draft

Below are very brief descriptions of potential signature initiatives. They should be viewed as very preliminary and are provided to illustrate the basic thrust of each initiative.

Energy Star Equipment	Develop more advanced, low cost efficient equipment and accelerated deployment of equipment through Energy Star, partnerships and incentives
Buildings for the 21st Century	Develop improved building designs, materials and systems and accelerated deployment through State and local partnerships; establish partnerships with builders, suppliers, insurers, state and local governments, and federal regulators to develop and construct more efficient, attractive and affordable housing
Industries of the Future	Enhance industry/government research partnerships in energy intensive industries such as chemicals and forest products to develop and deploy technologies that cut emissions while improving productivity
Efficiency Incentives	Launch innovative technology deployment actions that accelerate the use of efficient motors, compressed air, steam and other common systems across industry.
PNGV for Autos and Trucks	Increase funding of PNGV to ensure development of an 80 mpg mid-size car by 2005 and development of PNGV light truck/sport-utility vehicles and PNGV heavy trucks for freight and military applications
Advanced Aircraft	Develop advanced aircraft technologies and air traffic control practices that will produce a 35% reduction in greenhouse gases per passenger miles traveled by 2020
Voluntary Emissions Reductions	Expand the current Climate Challenge effort that encourages electric utilities to reduce emissions on a voluntary basis so that gas utilities and others can participate
Power Plant Efficiency	Develop innovative incentives and technology development that allow existing fossil fuel power plants to increase electrical generation efficiency by as 5% over current levels
Million Solar Roofs	Establish partnerships with cities, communities, utilities and solar manufacturers to install one million solar rooftop systems by 2010 to provide energy and bring down technology costs
Combined Heat and Power	Accelerate development of advanced turbines, fuel cells and other technologies and streamline permitting and other statutory and regulatory reforms to accelerate use of highly efficient combine heat and power systems
Credit for Early Action	Establish a system through which the federal government provides credits to entities that take actions to reduce emissions before formal domestic emissions trading in order to motivate early emission reductions

Low Carbon Transportation Fuels	Accelerate RD&D on energy crops, harvesting and fuel conversion processes to significantly expand use of biomass fuels for automobiles and other vehicles; develop low-carbon diesel fuels from natural gas
Renewable Energy R&D and Accelerated Deployment	Expand research partnerships for key renewable technologies such as wind, photovoltaics, geothermal, biomass and hydropower to accelerate cost reductions and performance improvements; coordinate demonstrations, incentives, State and local government partnerships and other deployment actions
Optimizing Existing Nuclear Power	Develop and deploy technologies to maximize efficiency of current nuclear plants
Advanced Fossil Energy Technologies	Develop of advanced gas generation technologies such as large combined cycle turbines and fuel cells; develop very efficient, very low carbon coal technologies
Emissions Trading	Design a domestic emissions cap and trading system that will enable private U.S. entities to trade permits; such a system would require Congressional approval and the resolution of a number of key administrative issues
Sequestration R&D	Research and develop technologies that enable separation of carbon from energy sources and long-term storage of that carbon
Energy Plexes R&D	Research and develop long-term technologies that will allow for the construction of "closed loop" energy complexes that integrate the production of power, fuels and chemicals that minimizes energy use and minimizes emissions
Global Environmental Science	Expand research on global climate science to better understand the long term effects on the biosphere of increased atmospheric concentrations of greenhouse gases
Cross-cutting Energy Technology Research	Conduct research on a wide array of subjects - including combustion, chemistry, materials, genetic engineering, geosciences and computation - that supports advanced technology development
Program Evaluation	Ongoing evaluation of actions performance with respect to established performance metrics
Innovative (Federal) Financing	Establish large, innovative financing mechanisms that enable federal facilities managers to "purchase" energy efficiency from private contractors, thereby improving facility energy performance
(Federal) Efficient/Alternative Fuel Vehicles	Purchase high efficiency and alternative fuel vehicles for federal civilian vehicle fleets
(Military) Efficient/Alternative Fuel Vehicles	Purchase high efficiency and alternative fuel vehicles for military vehicle fleets
Facility Efficiency	Provide information, tools, training and financing mechanisms that enable military facility commanders to reduce energy consumption emissions



Joseph E. Aldy
09/05/97 11:08:53 AM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:

Subject: chart

I made a modification to the description of the temperature and concentration model used in our results. Insert the following file (not the one I sent last night), into the paper.



T&T_CHRT.WP[

a/10

T&T_CHRT2.WP[

Scen-
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B

Model ID	Scenario	Model	Modelers	Target	Timetable	Trading	Permit Allocation	Revenue Recycling	Burden Sharing	BAU Emissions Path Assumption	AEEI	Ramp-up	Time Path	Outputs PDV (3%; 2000-2050) Foregone Consumption	Permit Prices: 2010	Permit Prices: 2025	Permit Prices: 2050	Electricity Prices: 2010, 2025, 2050
SGM1	BAU	SGM	Battelle	n/a	n/a	n/a	n/a	n/a	n/a	IA1	1.0	n/a	-->2050, -->2100 (climate)	\$183,155 billion (BAU consumption)	\$0	\$0	\$0	
SGM2	1990 in 2010	SGM	Battelle	1990 emissions level	stabilize in 2010	domestic only	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$1126 billion	\$110	\$191	\$582	
SGM3	1990 in 2010	SGM	Battelle	1990 emissions level	stabilize in 2010	Annex I	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	384 billion	\$42	\$84	\$149	
SGM4	1990 in 2010	SGM	Battelle	1990 emissions level	stabilize in 2010	worldwide	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$5 billion	\$16	\$23	\$32	
SGM5	1995 in 2010	SGM	Battelle	1995 emissions level	stabilize in 2010	domestic only	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$737 billion	\$62	\$131	\$317	
SGM6	1995 in 2010	SGM	Battelle	1995 emissions level	stabilize in 2010	Annex I	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	~~very small~~ \$645 billion	\$74	\$119	\$201	
SGM7	1995 in 2010	SGM	Battelle	1995 emissions level	stabilize in 2010	worldwide	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$38 billion	\$27	\$32	\$41	
SGM8	-10% if 1990 in 2010	SGM	Battelle	-10% 1990 emissions level	stabilize in 2010	domestic only	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$1630 billion	\$175	\$304	\$924	
SGM9	-10% if 1990 in 2010	SGM	Battelle	-10% 1990 emissions level	stabilize in 2010	Annex I	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$808 billion	\$91	\$137	\$238	
SGM10	-10% if 1990 in 2010	SGM	Battelle	-10% 1990 emissions level	stabilize in 2010	worldwide	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$63 billion	\$33	\$37	\$45	
SGM11	Peak in 2015	SGM	Battelle	2010 BAU emissions in 2015; 1990 level in 2040	stabilize in 2040	domestic only	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$498 billion	\$0	\$84	\$559	
SGM12	Peak in 2015	SGM	Battelle	2010 BAU emissions in 2015; 1990 level in 2040	stabilize in 2040	Annex I	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	\$125 billion	\$0	\$47	\$155	
SGM13	Peak in 2015	SGM	Battelle	2010 BAU emissions in 2015; 1990 level in 2040	stabilize in 2040	worldwide	auction	lump-sum	no LDC part.	IA1	1.0	no	-->2050, -->2100 (climate)	-\$16 billion	\$0	\$14	\$33	
MM1	BAU	Markal	DOE	n/a	n/a	n/a	n/a	n/a	n/a	IA1	-1.0	n/a	-->2025	n/a	\$0	\$0	n/a	
MM2	1990 in 2010	Markal	DOE	1990 emissions level	stabilize in 2010	domestic only	auction	lump-sum	no LDC part.	IA1	-1.0	n/a	-->2025		\$148	\$192	n/a	
MM3	1995 in 2010	Markal	DOE	1995 emissions level	stabilize in 2010	domestic only	auction	lump-sum	no LDC part.	IA1	-1.0	n/a	-->2025		\$136	\$146	n/a	
MM4	1990 in 2020	Markal	DOE	1990 emissions level	stabilize in 2020	domestic only	auction	lump-sum	no LDC part.	IA1	-1.0	n/a	-->2025		\$0	\$198	n/a	
MM5	Peak in 2015	Markal	DOE	2010 BAU emissions in 2015; 1990 level in 2040	stabilize in 2040	domestic only	auction	lump-sum	no LDC part.	IA1	-1.0	n/a	-->2025		\$0	\$99	n/a	
	550ppm Least-Cos	MERGE	Richels	550ppm concentration														

2000-2050
very small
\$645 billion
\$38 billion
\$1630 billion
\$808 billion
\$63 billion
\$498 billion
\$125 billion
-\$16 billion
n/a
\$148
\$136
\$0
\$0

[illegible]

	A	B	C	D
1	Year	CO2 Emissions 1000 mtc	10 Year	Total Energy Consump
2	1950	696069	696069	33.08
3	1951	716717		35.47
4	1952	697920		35.3
5	1953	714462		36.27
6	1954	680491		35.27
7	1955	745973		38.82
8	1956	781912		40.38
9	1957	775115		40.48
10	1958	750766		40.35
11	1959	781360		42.14
12	1960	799544	799544	43.8
13	1961	801875		44.46
14	1962	831489		46.53
15	1963	875633		48.32
16	1964	912912		50.5
17	1965	948264		52.68
18	1966	999673		55.66
19	1967	1039174		57.57
20	1968	1080969		61
21	1969	1132028		64.19
22	1970	1155779	1155779	66.43
23	1971	1162650		67.89
24	1972	1215253		71.26
25	1973	1262913		74.28
26	1974	1218402		72.54
27	1975	1167836		70.55
28	1976	1248095		74.36
29	1977	1252334		76.29
30	1978	1274009		78.09
31	1979	1278610		78.9
32	1980	1236297	1236297	75.96
33	1981	1195706		73.99
34	1982	1139230		70.85
35	1983	1143714		70.52
36	1984	1184227		74.14
37	1985	1202453		73.96
38	1986	1224096		74.3
39	1987	1268062		76.89
40	1988	1340168		80.22
41	1989	1360885		81.32

	E
1	10 year
2	33.08
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	43.8
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	66.43
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	75.96
33	
34	
35	
36	
37	
38	
39	
40	
41	

	A	B	C	D
42	1990	1293219	1293219	84.09
43	1991	1310386		83.99
44	1992	1333718		85.52
45	1993	1361342		87.34
46	1994	1387256		89.21

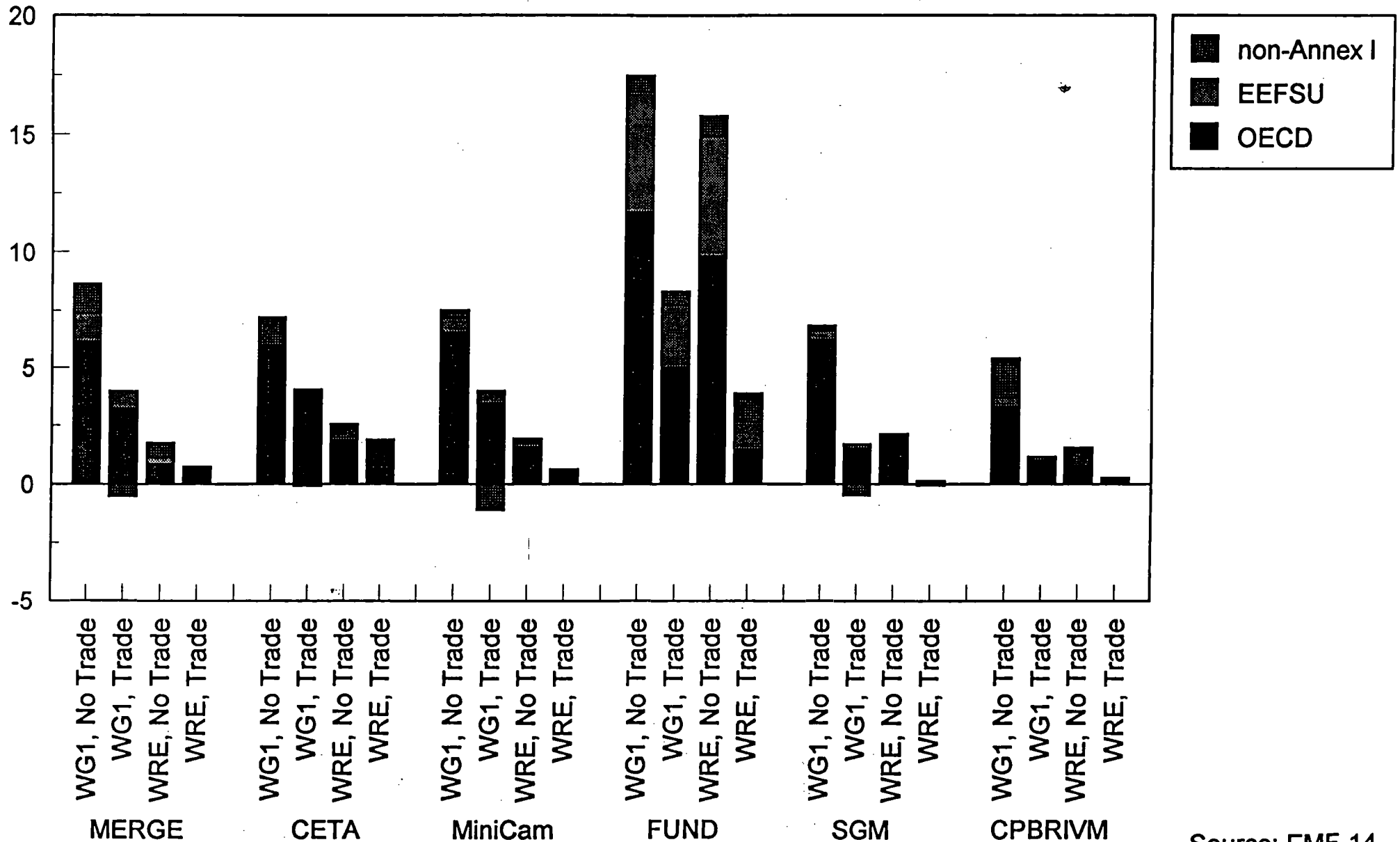
	E
42	84.09
43	
44	
45	
46	

Model	Scenario	OECD	EEFSU	non-Annex I
MERGE	WG1, No Trade	6.121	1.258	1.282
MERGE	WG1, Trade	3.237	0.738	-0.517
MERGE	WRE, No Trade	0.851	0.275	0.631
MERGE	WRE, Trade	0.604	0.028	0.127
CETA	WG1, No Trade	5.94		1.27
CETA	WG1, Trade	4.03		-0.09
CETA	WRE, No Trade	1.83		0.71
CETA	WRE, Trade	1.86		0.03
MiniCam	WG1, No Trade	6.51	0.66	0.34
MiniCam	WG1, Trade	3.44	0.53	-1.12
MiniCam	WRE, No Trade	1.58	0.13	0.21
MiniCam	WRE, Trade	0.54	0.09	-0.01
FUND	WG1, No Trade	11.71	5.09	0.669
FUND	WG1, Trade	4.97	2.7672	0.574
FUND	WRE, No Trade	9.8197	5.071	0.8709
FUND	WRE, Trade	1.4731	1.1907	1.2077
SGM	WG1, No Trade	6.172	0.412	0.25
SGM	WG1, Trade	1.482	0.2	-0.487
SGM	WRE, No Trade	1.844	0.067	0.208
SGM	WRE, Trade	0.127	0.013	-0.059
CPBRIVM	WG1, No Trade	3.25	0.4	1.72
CPBRIVM	WG1, Trade	0.99	0.15	0
CPBRIVM	WRE, No Trade	0.64	0.13	0.77
CPBRIVM	WRE, Trade	0.17	0.02	0.08

OECD, No Trade			
Model	WRE	WG1	WRE/WG1
MERGE	0.851	6.121	0.139
CPBRIVM	0.64	3.25	0.197
MiniCam	1.58	6.51	0.243
SGM	1.844	6.172	0.299
CETA	1.83	5.94	0.308
FUND	9.8197	11.71	0.839
OECD, Trade			
Model	WRE	WG1	WRE/WG1
SGM	0.127	1.482	0.086
MiniCam	0.54	3.44	0.157
CPBRIVM	0.17	0.99	0.172
MERGE	0.604	3.237	0.187
FUND	1.4731	4.97	0.296
CETA	1.86	4.03	0.462

Cost to World of Stabilizing CO₂ Concentrations at 550ppmv PDV of Foregone Consumption through 2100

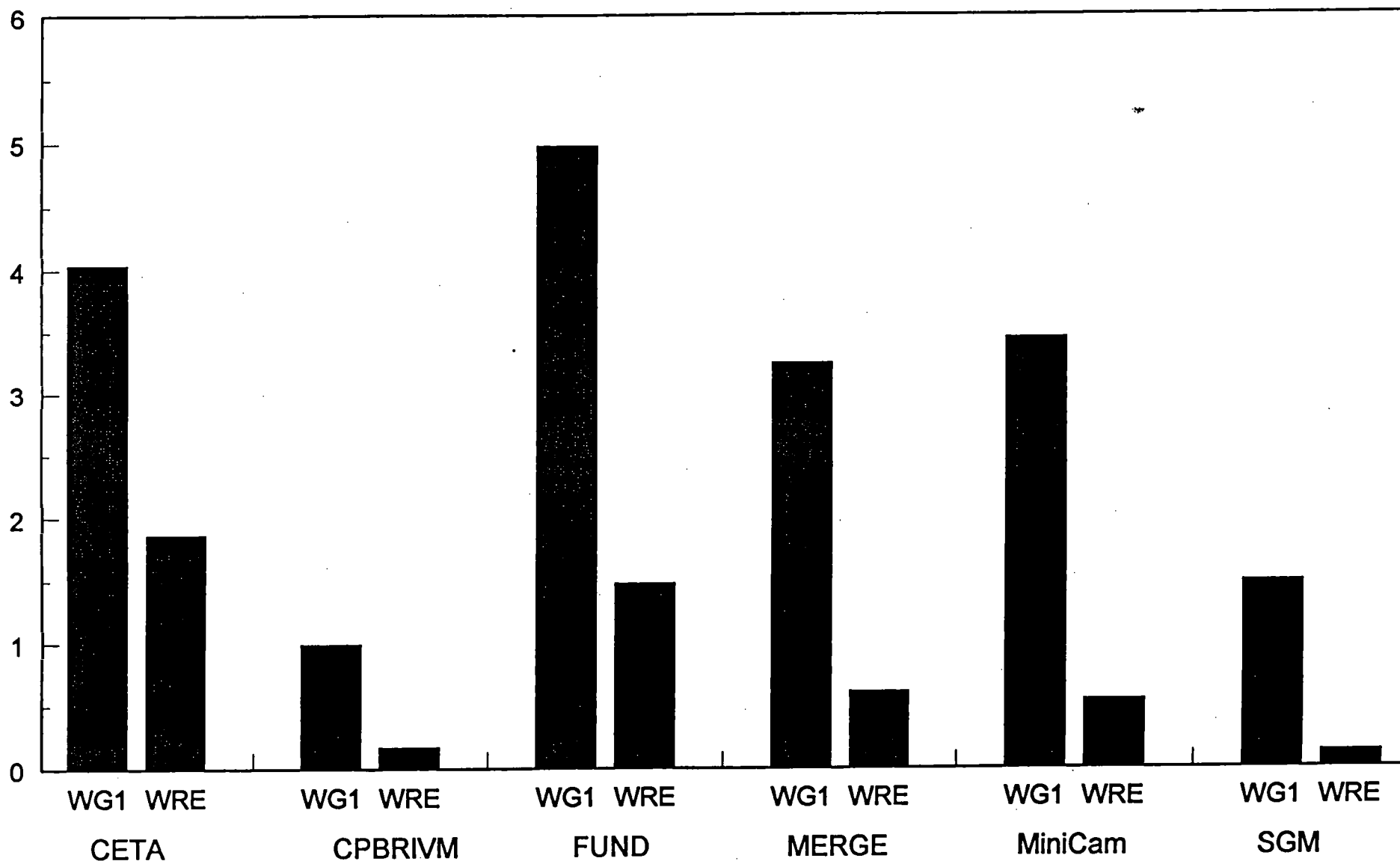
trillions of 1990 U.S. dollars



Source: EMF-14

Cost to OECD, with Trading, of Stabilizing CO₂ Concentrations at 550ppmv, PDV of Foregone Consumption through 2100

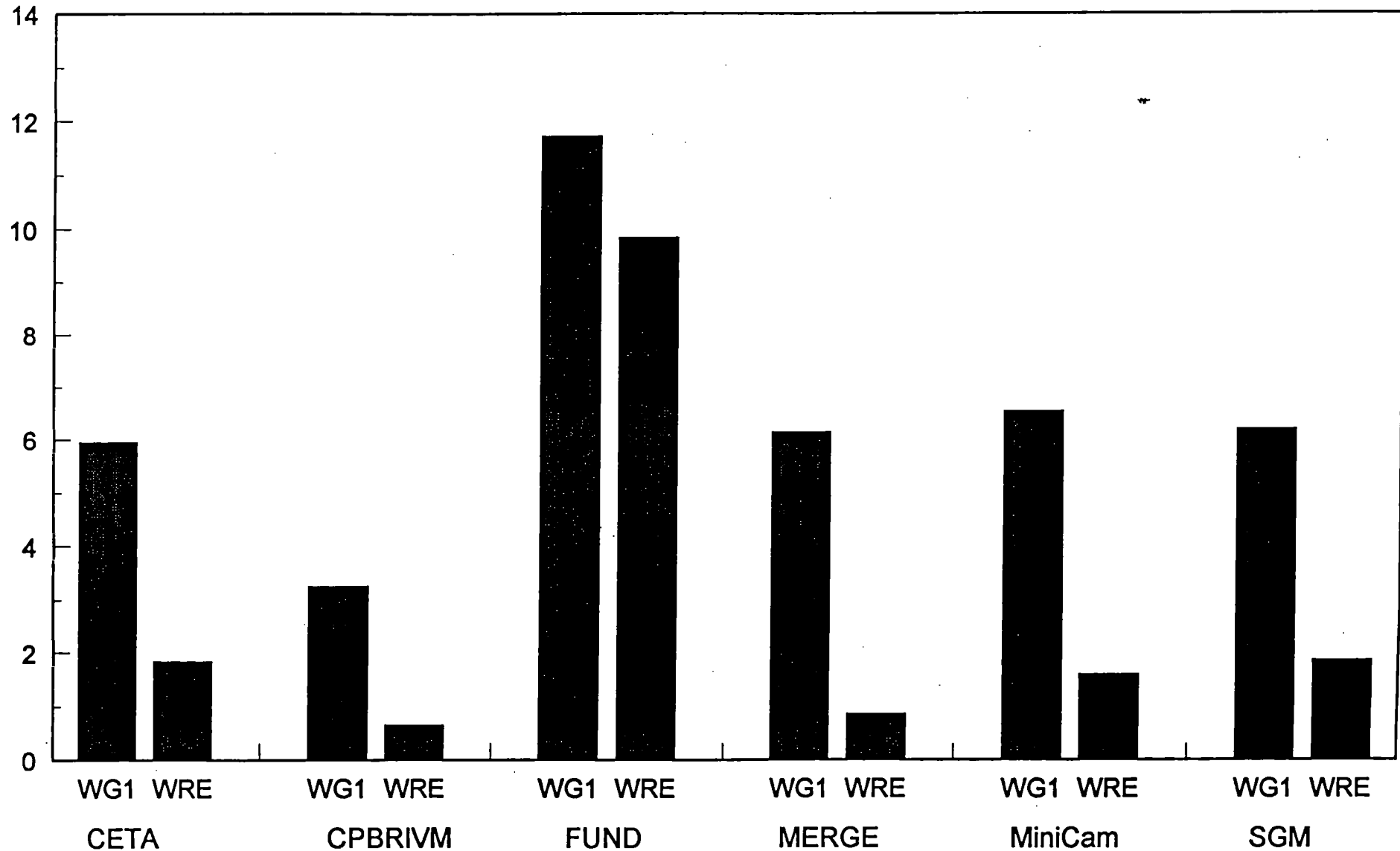
trillions of 1990 U.S. dollars



Source: EMF-14

Cost to OECD, without Trading, of Stabilizing CO₂ Concentrations at 550ppmv, PDV of Foregone Consumption through 2100

trillions of 1990 U.S. dollars



Source: EMF-14

Three kinds of model experiments and results:

1. Full cost-benefit optimization (in Integrated Assessment models [Nordhaus et al])

- General conclusion: optimal path shows emissions continuing to rise (though at a reduced rate) at least until 2080.
- Criticisms:
 - Insufficient weight to the probability of a discontinuously-large catastrophe
 - Insufficient weight to the welfare of future generations that will bear the costs of climate change (the discount rate is too high).
 - Neglects basic uncertainty about all parameters.
 - Omits a basic point about political credibility: an announcement that stringent policy measures will be taken 50 years or more into the future will not be credible.

2. Comparison of costs of alternative paths to reach a given goal for concentrations & climate effects [Energy Modeling Forum, WRE, Manne and Richels]

- Moderate paths have Annex I emissions continuing to rise for several decades, peaking around 2010-2025, returning to 1990 levels around 2040, and falling thereafter, in order to reach terminal concentrations of twice pre-industrial levels.
 - WRE path
 - least-cost path
 - "peak in 2015, 1990 levels by 2040"
- Aggressive paths have emissions turning down almost immediately, returning to 1990 levels or below by 2010, but ultimately producing the same terminal concentrations.

3. Comparison of effects of alternative proposed dates by which to stabilize emissions.

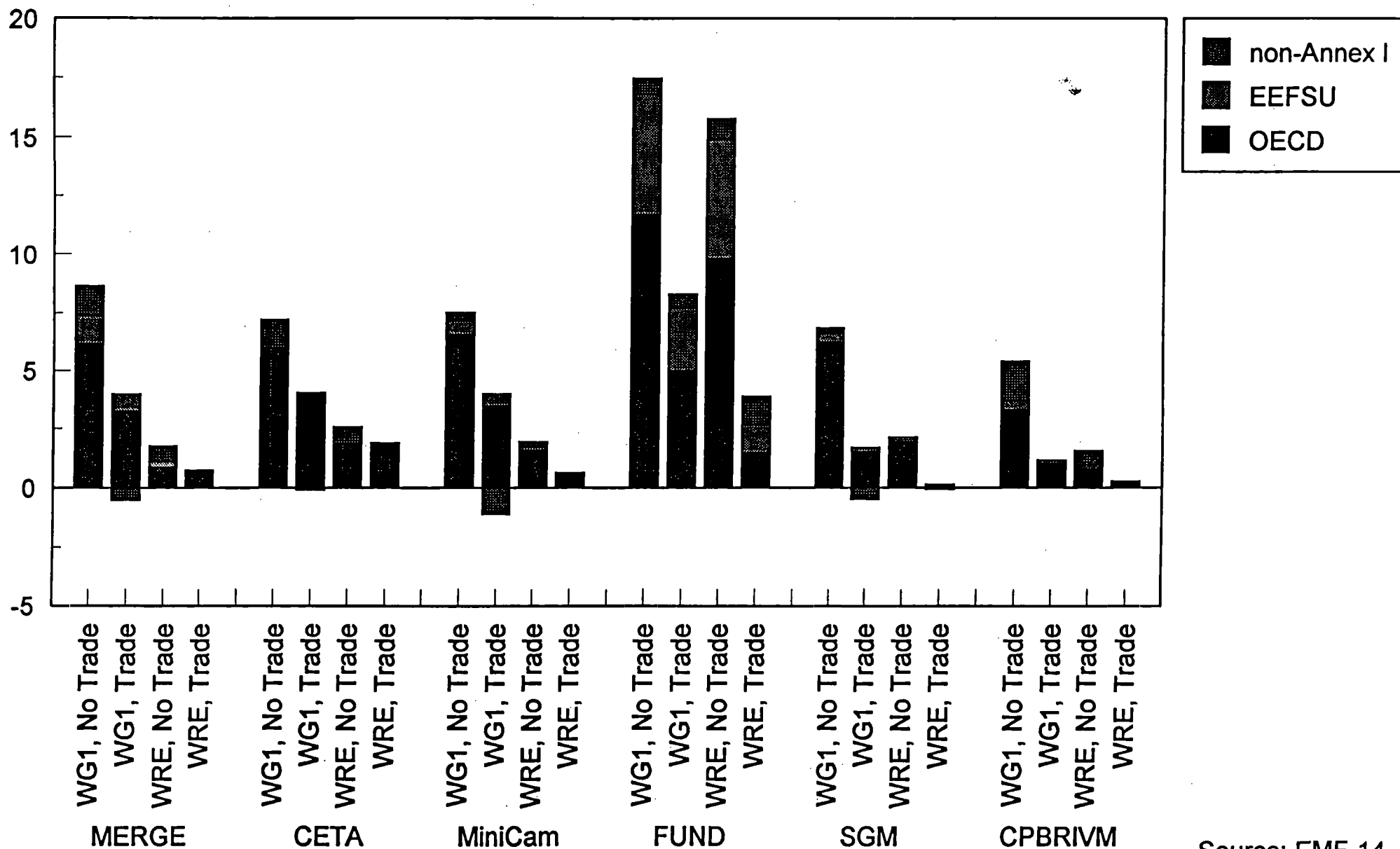
trillions of 1990 dollars (U.S.)

Model	Scenario	OECD	EEFSU	non-Annex I
MERGE	WG1, No Trade	6.121	1.258	1.282
MERGE	WG1, Trade	3.237	0.738	-0.517
MERGE	WRE, No Trade	0.851	0.275	0.631
MERGE	WRE, Trade	0.604	0.028	0.127
CETA	WG1, No Trade	5.94		1.27
CETA	WG1, Trade	4.03		-0.09
CETA	WRE, No Trade	1.83		0.71
CETA	WRE, Trade	1.86		0.03
MiniCam	WG1, No Trade	6.51	0.66	0.34
MiniCam	WG1, Trade	3.44	0.53	-1.12
MiniCam	WRE, No Trade	1.58	0.13	0.21
MiniCam	WRE, Trade	0.54	0.09	-0.01
FUND	WG1, No Trade	11.71	5.09	0.669
FUND	WG1, Trade	4.97	2.7672	0.574
FUND	WRE, No Trade	9.8197	5.071	0.8709
FUND	WRE, Trade	1.4731	1.1907	1.2077
SGM	WG1, No Trade	6.172	0.412	0.25
SGM	WG1, Trade	1.482	0.2	-0.487
SGM	WRE, No Trade	1.844	0.067	0.208
SGM	WRE, Trade	0.127	0.013	-0.059
CPBRIVM	WG1, No Trade	3.25	0.4	1.72
CPBRIVM	WG1, Trade	0.99	0.15	0
CPBRIVM	WRE, No Trade	0.64	0.13	0.77
CPBRIVM	WRE, Trade	0.17	0.02	0.08

OECD, No Trade			
Model	WRE	WG1	WRE/WG1
MERGE	0.851	6.121	0.139
CPBRIVM	0.64	3.25	0.197
MiniCam	1.58	6.51	0.243
SGM	1.844	6.172	0.299
CETA	1.83	5.94	0.308
FUND	9.8197	11.71	0.839
OECD, Trade			
Model	WRE	WG1	WRE/WG1
SGM	0.127	1.482	0.086
MiniCam	0.54	3.44	0.157
CPBRIVM	0.17	0.99	0.172
MERGE	0.604	3.237	0.187
FUND	1.4731	4.97	0.296
CETA	1.86	4.03	0.462

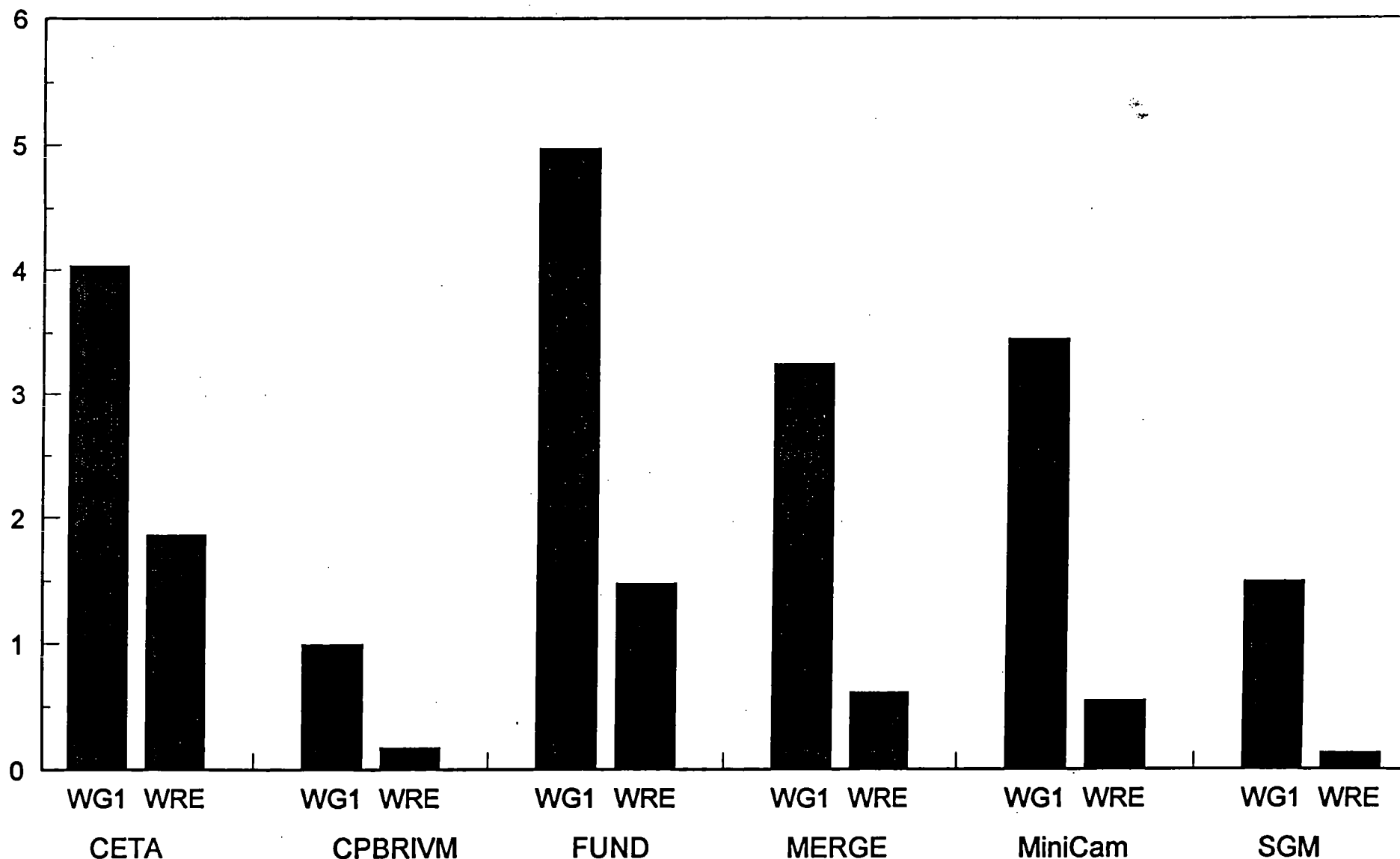
Cost to World of Stabilizing CO₂ Concentrations at 550ppmv PDV of Foregone Consumption through 2100

trillions of 1990 U.S. dollars



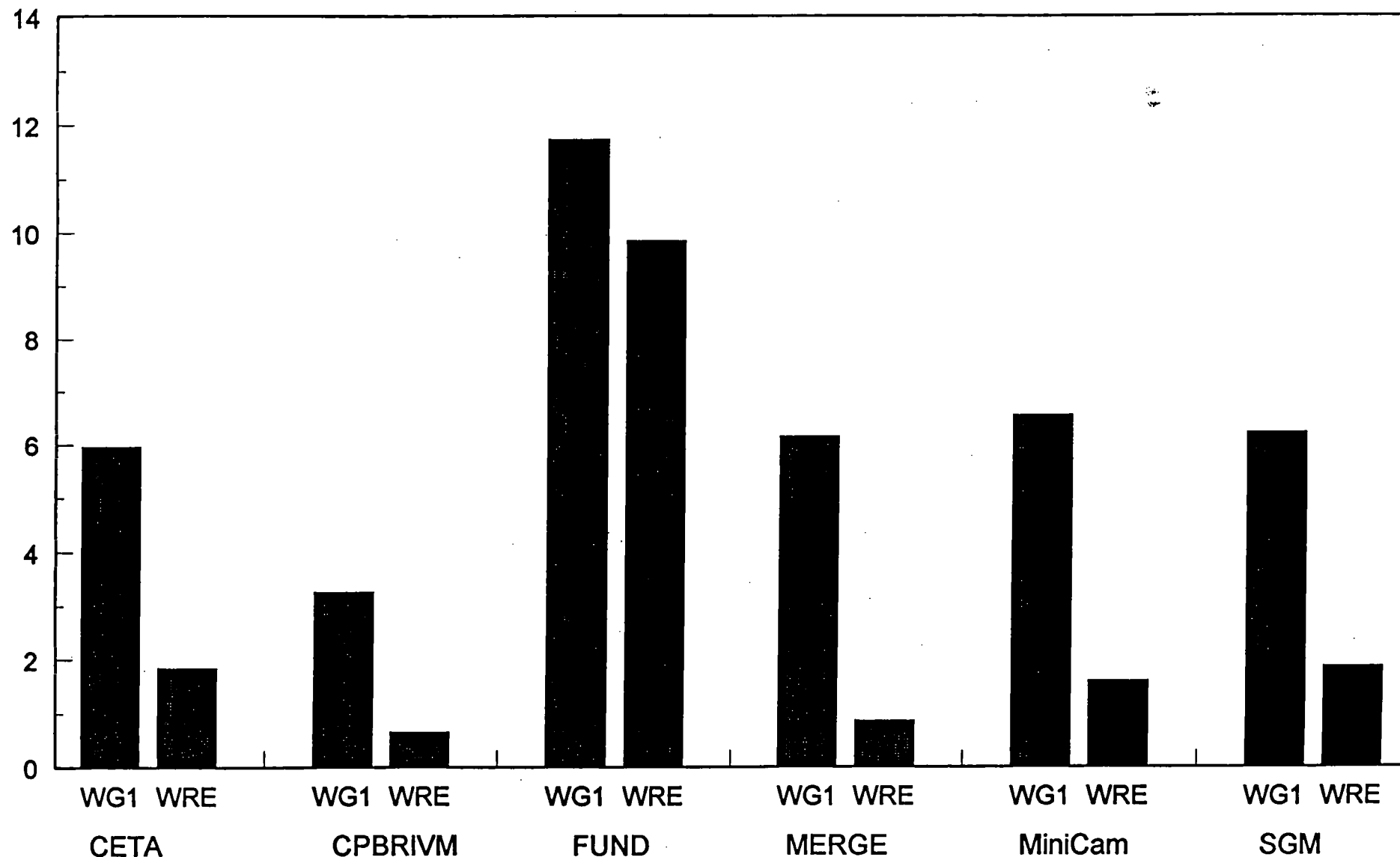
Cost to OECD, with Trading, of Stabilizing CO₂ Concentrations at 550ppmv, PDV of Foregone Consumption through 2100

trillions of 1990 U.S. dollars



Cost to OECD, without Trading, of Stabilizing CO₂ Concentrations at 550ppmv, PDV of Foregone Consumption through 2100

trillions of 1990 U.S. dollars



[illegible]

for SCM people

Annex I Emissions

	BAU	Jeff
1985	3773	3773
1990	4102	4102
1995	3821	3821
2000	4053	4053
2005	4317	4316
2010	4601	4599
2015	4804	4801
2020	4981	4663
2025	5114	4523
2030	5202	4355
2035	5295	4203
2040	5427	4075
2045	5547	4102
2050	5648	4101

(1) We wanna peak at 2010 BAU?

(2) Why is 2005 & 2010 so close to BAU?

(3) Even so, why is 2010 permit $p=0$?

(4) What is their "world under study" role mean when non-Annex I countries aren't participating (in e-target commitments)