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Partial Staff Only Review Docs - [Climate Change] [2]

Stack:	Row:	Section:	Shelf:	Position:
S	21	1	11	2

MEMORANDUM

TO: Jon Gruber
FROM: Joe Aldy
DATE: 12/8/97
RE: Annex I Trading without EU Participation

If the EU does not participate in an Annex I permit trading market, the total costs for Annex I countries to comply with a target and timetable increase, but the U.S., Japan, Australia, and Canada are all better off without EU participation. The EU and Eastern European and Former Soviet Union countries are all made worse off by EU non-participation.

To illustrate the effects of EU non-participation, I assessed country-specific marginal abatement cost curves derived from SGM outputs for the 1990 in 2010 target and timetable. The first chart illustrates the difference in the total economic effects of these two trading regimes. The two charts that follow show permit prices, domestic emissions abatement, purchases and transfers of permits on the Annex I market, and total costs of Annex I trading with EU participation and a trading regime without EU participation.

Difference in Economic Costs of Trading Regimes with and without EU Participation

Country/Region	Total Costs under Trading with EU (abatement cost + transfers)	Total Costs under Trading without EU (abatement cost + transfers)	Change in Costs (- means costs decrease w/o EU participation)
U.S.	$12.0b	$7.6b	-$4.4b
Australia	$0.8b	$0.5b	-$0.3b
Canada	$1.9b	$1.1b	-$0.8
Japan	$3.5b	$2.0b	-$1.5b
Eastern Europe	net gain: $3.7b	net gain: $1.9b	$1.8b
Former Soviet Union	net gain: $12.3b	net gain: $6.2b	$6.1b
Russia1	net gain: $7.9b	net gain: $4.0b	$3.9b
EU2	$8.1b	$18.9b	$10.8b
ANNEX I, total abatement cost	$10.3b	$21.9b	$11.6b

Annex I Trading with EU Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$41.30	177	202	$3.7b	-$8.3b	$12.0b
Australia	$41.30	11	15	$0.2b	-$0.6b	$0.8b

Canada	$41.30	13	39	$0.3b	-$1.6b	$1.9b
Japan	$41.30	21	75	$0.4b	-$3.1b	$3.5b
Eastern Europe	$41.30	27	-105	$0.6b	+$4.3b	net gain: $3.7b
Former Soviet Union	$41.30	168	-382	$3.5b	+$15.8b	net gain: $12.3b
Russia1	$41.30	109	-248	$2.3b	+$10.2b	net gain: $7.9b
EU2	$41.30	83	156	$1.7b	-$6.4b	$8.1b

Annex I Trading without EU Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$23	101	278	$1.2b	$6.4b	$7.6b
Australia	$23	7	19	$0.08b	$0.4b	$0.5b
Canada	$23	8	44	$0.09b	$1.0b	$1.1b
Japan	$23	12	84	$0.1b	$1.9b	$2.0b
Eastern Europe	$23	15	-93	$0.2b	-$2.1b	net gain: $1.9b
Former Soviet Union	$23	118	-332	$1.4b	-$7.6b	net gain: $6.2b
Russia1	$23	77	-216	$0.9b	-$4.9b	net gain: $4.0b
EU2	$158	239	0	$18.9b	0	$18.9b

Notes:

		Trading		
	none	Annex I, ex EU	Global, incl. EU	Global, ex. EU
US permit price	≈ $1[illegible]	$23	≈ $20	$12 or 13

EU Bubble Countries:

Austria
Belgium
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Portugal
Spain
Sweden
United Kingdom

Western Europe in SGM:

EU bubble countries plus
Iceland (1990: 0.6 MMTCE CO2)
Norway (1990: 14.3 MMTCE CO2)
Switzerland (1990: 11.6 MMTCE CO2)
Turkey (1990: 39.7 MMTCE CO2)

Joseph E. Aldy
12/04/97 10:07:17 PM

Record Type: Record

To: Janet L. Yellen/CEA/EOP, Jeffrey A. Frankel/CEA/EOP, Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:
Subject: GCC: effects of Annex I trading and global JI on Russia

More fun stuff for Gruber. The bottom line is that Russia is a much bigger winner with Annex I trading alone than with Annex I trading AND JI. See attached table that I faxed over to Treasury.

Joe

CONSTRD3.WPI

The Effects of Annex I Trading and Ideal Global JI on Russia

Scenario	Permit Price ($/ton)	FSU Permit Sales (MMTC)	FSU TR (billions $)	Russia TR (billions $)	FSU TC (billions $)
100% Paper Tons*	$15.8	294	$4.65	$3.02	$0.63
50% Paper Tons	$20.3	215	$4.36	$2.84	$1.10
No Paper Tons*	$25.9	130	$3.37	$2.19	$1.68

Model: SGM

* From model runs. 50% paper tons case based on interpolations from constructed marginal abatement cost curves.

Russian revenues and costs are assumed to be 65% of FSU revenues and costs, given that the Russian economy was approximately 65% the size of all FSU countries' economies in 1995.

Total costs are calculated assuming that the marginal abatement cost curve is linear in those sections of the curve.

All dollars are expressed in 1992 $.

These analyses assume that there are no constraints on the ability of other Annex I countries to purchase emissions reductions abroad.

The Effects of Annex I Trading Alone on Russia

Scenario	Permit Price ($/ton)	FSU Permit Sales (MMTC)	FSU TR (billions $)	Russia TR (billions $)	FSU TC (billions $)
100% Paper Tons*	$41.3	382	$15.8	$10.27	$3.5
50% Paper Tons	$55	319	$17.5	$11.38	$5.8
No Paper Tons*	$71.6	251	$18.0	$11.70	$9.0

Model: SGM

* From model runs. 50% paper tons case based on interpolations from constructed marginal abatement cost curves.

Russian revenues and costs are assumed to be 65% of FSU revenues and costs, given that the Russian economy was approximately 65% the size of all FSU countries' economies in 1995.

Total costs are calculated assuming that the marginal abatement cost curve is linear in those sections of the curve.

All dollars are expressed in 1992 $.

These analyses assume that there are no constraints on the ability of other Annex I countries to purchase emissions reductions abroad.

MEMORANDUM

TO: Ray Squitieri
FROM: Joe Aldy
DATE: December 2, 1997
RE: The Effects of Trading Constraints on Permit Prices and Income Flows

To assess the effects of trading constraints on U.S. permit prices and income flows, I reviewed several model runs from SGM. While unconstrained trading would result in minimizing the compliance costs with binding targets, some have proposed constraining the amount of emissions reductions allowed to be achieved through international permit trading and joint implementation. The following table presents the permit prices and the quantity of permits purchased abroad under various percentage-based constraints.

U.S. Permit Prices for Meeting 1990 in 2010 under Various Trading Constraints

% of Reductions Allowed to be Purchased from Other Countries	Annex I Trading Only (permits purchased abroad)	Annex I Trading + Joint Implementation (permits purchased abroad)
100% (no constraint)	$41/ton (202 MMTCE)	$16/ton (312 MMTCE)
0% (no trading, no JI)	$108/ton (0 MMTCE)	$108/ton (0 MMTCE)
10%	$93/ton (38 MMTCE)	$93/ton (38 MMTCE)
25%	$72/ton (95 MMTCE)	$72/ton (95 MMTCE)
50%	$45/ton (190 MMTCE)	$45/ton (190 MMTCE)

model: SGM

Constraints on Trade

This analysis provides four interesting points. First, in an unconstrained world, the U.S. buys 53% of its emissions reductions abroad with Annex I trading and 82% of reductions with JI and Annex I trading. Note in the second table that the U.S. buys less as a share of reductions than other Annex I countries (however, EEFSU countries are sellers). Second, any split between JI and Annex I trading (e.g., no more than 5% through trading, no more than 5% through JI) is irrelevant to the U.S. permit price so long as the total constraint (e.g., 10%) is less than the percentage of emissions reductions the U.S. would buy under no constraints. Third, Russia sells more permits than China under JI (but less than it would with an Annex I trading only world) because it has so many paper tons. Fourth, any constraint less than 60% implies that EEFSU countries would not be able to sell all of their paper tons.

Percent of Emissions Reductions Purchased Abroad with No Constraints on Trading and JI

Country/Region	Annex I Trading Only	Annex I Trading + Joint Implementation
Canada	75%	88%
Japan	78%	91%
Western Europe	65%	86%
Australia	58%	81%
U.S.	53%	82%

model: SGM

Income Flows

Not only do constraints on trade negatively impact the buyers of permits by increasing permit prices, but they also decrease the flows of income to countries that sell. In a no-constraint world, the sellers of permits would receive $20 billion in 2010 under Annex I trading and more than $10 billion in 2010 under Annex I trading and JI. However, a constraint of 10% emissions reduction through foreign purchases would result in income transfers of only $600 million under Annex I trading and $200 million under Annex I trading plus JI. This 10% constraint results in EIT and developing countries receiving only 2-3% of the income they would have received without the constraint.

Preliminary Draft

MEMORANDUM

TO: Jon Gruber
FROM: Joe Aldy
DATE: 12/8/97
RE: Annex I Trading without EU Participation

If the EU does not participate in an Annex I permit trading market, the total cost for Annex I countries to comply with a target and timetable increases, but the U.S., Japan, Australia, and Canada are all better off without EU participation. The EU and Eastern European and Former Soviet Union countries are all made worse off by EU non-participation. The cost for the EU increases if it does not participate because it must achieve all of its emissions reductions at home, instead of in lower cost countries such as Russia. Eastern European and Former Soviet Union countries are worse off because the EU would be the second largest buyer of permits under full Annex I-wide trading. Losing a major buyer decreases total demand for their permits, resulting in EEFSU countries selling fewer permits at lower prices. All other Annex I countries benefit, because as buyers of permits, the loss of a major competitor means they can buy more emissions reductions in EEFSU at lower permit prices.

To illustrate the effects of EU non-participation, I assessed country-specific marginal abatement cost curves derived from SGM outputs for the 1990 in 2010 target and timetable. The first chart illustrates the difference in the total economic effects of these two trading regimes. The two charts that follow show permit prices, domestic emissions abatement, purchases and transfers of permits on the Annex I market, and total costs of Annex I trading with EU participation and a trading regime without EU participation.

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Japan	$3.5b	$2.0b	-$1.5b
Eastern Europe	net gain: $3.7b	net gain: $1.9b	$1.8b
Former Soviet Union	net gain: $12.3b	net gain: $6.2b	$6.1b
Russia[1]	net gain: $7.9b	net gain: $4.0b	$3.9b
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ANNEX I, total abatement cost	$10.3b	$21.9b	$11.6b

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Former Soviet Union	$41.3	168	-382	$3.5b	+$15.8b	net gain: $12.3b
Russia[1]	$41.3	109	-248	$2.3b	+$10.2b	net gain: $7.9b
EU[2]	$41.3	83	156	$1.7b	-$6.4b	$8.1b

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Eastern Europe	$23	15	-93	$0.2b	-$2.1b	net gain: $1.9b
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Russia[1]	$23	77	-216	$0.9b	-$4.9b	net gain: $4.0b
EU[2]	$158	239	0	$18.9b	0	$18.9b

Notes:

1. Russia is calculated as 65% of FSU because its economy in 1995 was 65% the size of the economies of all FSU countries.

2. SGM models the Western Europe region including 19 countries, 4 of which are not in the EU bubble. However, the 15 countries in the bubble comprised about 93% of CO_2 emissions in 1990 of the 19 countries in the modeled region. See the attached list of countries to review the distinctions between the Western Europe region modeled in SGM and the EU bubble.

EU Bubble Countries:

Austria
Belgium
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Portugal
Spain
Sweden
United Kingdom

Western Europe in SGM:

EU bubble countries plus
Iceland (1990: 0.6 MMTCE CO_2)
Norway (1990: 14.3 MMTCE CO_2)
Switzerland (1990: 11.6 MMTCE CO_2)
Turkey (1990: 39.7 MMTCE CO_2)

Preliminary Draft

MEMORANDUM

TO: Jon Gruber
FROM: Joe Aldy
DATE: 12/8/97
RE: Umbrella Annex I Trading with neither EU nor Eastern European Participation

If neither the EU nor Eastern European countries participate in full Annex I permit trading market, the total cost for Annex I countries to comply with a target and timetable increases, but the U.S., Japan, and Canada are all better off with a smaller Annex I "Umbrella" (trading between U.S., Japan, Canada, Australia, and FSU countries). Australia has roughly the same costs (domestic abatement costs plus transfers for emissions reductions abroad) under this umbrella as under full Annex I trading. Eastern Europe actually benefits under a regime where it does not participate in the umbrella but it does sell permits with the EU (a European-only trading regime) relative to full Annex I trading. As the only seller of permits to the EU, Eastern Europe does not have to compete with cheap permits from FSU countries, and thus can sell more permits at higher permit prices than under full Annex I trading. The three major buyers of permits in the Umbrella, U.S., Canada, and Japan, benefit, because as buyers of permits, the loss of a major competitor means they can buy more emissions reductions in EEFSU at lower permit prices.

Former Soviet Union countries and the EU are worse under this scenario of two trading blocks (the Umbrella and the European-only trading) than under full Annex I trading. The cost for the EU increases under European-only trade relative to full trading because it cannot take advantage of low cost emissions reductions in FSU countries, such as Russia. Former Soviet Union countries are worse off even though they don't have to compete with Eastern European countries in the sellers market because the EU would be the second largest buyer of permits under full Annex I-wide trading. Losing a major buyer decreases total demand for their permits and thus the price more so than losing competitors contracts the supply and pushes up the permit price.

To illustrate the effects of EU non-participation, I assessed country-specific marginal abatement cost curves derived from SGM outputs for the 1990 in 2010 target and timetable. The first chart illustrates the difference in the total economic effects of these two trading regimes. The two charts that follow show permit prices, domestic emissions abatement, purchases and transfers of permits on the Annex I market, and total costs of Annex I trading with EU participation and a trading regime without EU participation.

Umbrella: U.S, Canada, Japan, Australia, FSU
European-Only Bloc: EU, Eastern Europe

Winners with Two Trading Blocs Relative to Full Annex I Trading: U.S, Canada, Japan, Eastern Europe
Losers with Two Trading Blocs Relative to Full Annex I Trading: EU, FSU
No Difference Between the Trading Blocs: Australia

Difference in Economic Costs of Trading Regimes with and without EU, Eastern European Participation

Country/Region	Total Costs under Full Trading (abatement cost + transfers)	Total Costs under Trading without EU, Eastern Europe (abatement cost + transfers)	Change in Costs (- means costs decrease w/o EU, Eastern Europe participation)
U.S.	$12.0b	$10.2b	-$1.8b
Australia	$0.8b	$0.8b	0
Canada	$1.9b	$1.5b	-$0.4b
Japan	$3.5b	$2.9b	-$0.6b
Former Soviet Union	net gain: $12.3b	net gain: $9.7b	$2.6b
Russia[1]	net gain: $7.9b	net gain: $6.2b	$1.7b
Eastern Europe	net gain: $3.7b	net gain: $5.8b	-$1.9b
EU[2]	$8.1b	$10.6b	$2.5b
ANNEX I, total abatement cost	$10.3b	$12.2b	$1.9b

Annex I Trading with Full Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$41.3	177	202	$3.7b	-$8.3b	$12.0b
Australia	$41.3	11	15	$0.2b	-$0.6b	$0.8b
Canada	$41.3	13	39	$0.3b	-$1.6b	$1.9b
Japan	$41.3	21	75	$0.4b	-$3.1b	$3.5b
Former Soviet Union	$41.3	168	-382	$3.5b	+$15.8b	net gain: $12.3b
Russia[1]	$41.3	109	-248	$2.3b	+$10.2b	net gain: $7.9b
Eastern Europe	$41.3	27	-105	$0.6b	+$4.3b	net gain: $3.7b
EU[2]	$41.3	83	156	$1.7b	-$6.4b	$8.1b

Annex I Trading without EU or Eastern Europe Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$33.6	151	228	$2.5b	$7.7b	$10.2b
Australia	$33.6	9	17	$0.2b	$0.6b	$0.8b
Canada	$33.6	12	40	$0.2b	$1.3b	$1.5b
Japan	$33.6	18	78	$0.3b	$2.6b	$2.9b
Former Soviet Union	$33.6	149	-363	$2.5b	-$12.2b	net gain: $9.7b
Russia[1]	$33.6	97	236	$1.7b	-$7.9b	net gain: $6.2b
Eastern Europe	$59.7	40	-118	$1.2b	-$7.0b	net gain: $5.8b
EU[2]	$59.7	121	118	$3.6b	$7.0b	$10.6b

Notes:

1. Russia is calculated as 65% of FSU because its economy in 1995 was 65% the size of the economies of all FSU countries.

2. SGM models the Western Europe region including 19 countries, 4 of which are not in the EU bubble. However, the 15 countries in the bubble comprised about 93% of CO_2 emissions in 1990 of the 19 countries in the modeled region. See the attached list of countries to review the distinctions between the Western Europe region modeled in SGM and the EU bubble.

EU Bubble Countries:

Austria
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Ireland
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Netherlands
Portugal
Spain
Sweden
United Kingdom

Western Europe in SGM:

EU bubble countries plus
Iceland (1990: 0.6 MMTCE CO_2)
Norway (1990: 14.3 MMTCE CO_2)
Switzerland (1990: 11.6 MMTCE CO_2)
Turkey (1990: 39.7 MMTCE CO_2)

ESCAPE CLAUSE 9/17/97

- ***"Price-trigger" escape clause*** would focus on the price of energy per ton of carbon: If the price rises to level P, then government(s) are prepared to sell at P however many emission permits are demanded (beyond the shares already allocated to countries, and to citizens by their governments). The effect would be to convert the quantity limit into a price instrument under circumstances when the burden would otherwise be too burdensome.

- ***Analogies from trade policy:***
  - Safeguards: GATT Article 19 (seems to work, despite its admitted vagueness)
  - Tariff-Rate Quotas: imports free up to a pre-assigned quota; additional imports allowed under a pre-set penalty rate.

- ***Insurance version:*** P would be set at "best-guess," say $100/ton. Or perhaps "best guess plus one standard deviation," e.g., $150. The intent is to safeguard against unexpectedly large economic costs of emissions reductions -- costs that could turn out to be unexpectedly large if the economic growth rate turned out higher than expected, or if unrealistic estimates regarding the ease of reducing emissions were built into treaty targets

- ***Political version:*** The price could be set low, e.g., $25. The effect would be to assure constituents that the program will not be too costly. Such a price could be justified:

(I) if one believes claims of the wishful-thinking free-lunch technology optimists
(ii) conditioned on the U.S. obtaining international agreement on all our demands, including not only international trading but also some serious participation by developing countries, or
(iii) even knowing that conditions (I) and (ii) are unlikely to be met. Then the escape clause could be explicitly acknowledged as probably converting a quantity target into a price target.

- ***Technical points:***
- Who would sell permits? Could be:

(i) national governments (in countries with domestic emissions-trading schemes) or
(ii) a supra-national authority (in which case would have to decide how to split the proceeds).

- What is time path? Would have to pre-set one price for 2010 and another for 2020.

(Could also interpolate more points along the path; but banking and borrowing should have the same effect.)

- ***Scholarly references***: Nordhaus (1997), McKibbin and Wilcoxen (1997) and Pizer (1996) have proposed plans under which there is a cap on how much the price of carbon can rise and argued that it has a number of desirable properties.

McKibbin, Warwick, and Peter Wilcoxen, 1997, "A Better Way to Slow Global Climate Change," The Brookings Institution, Washington, DC, March.

Nordhaus, Bill, 1997, "Climate Allowances Protocol (CAP): Comparison of Alternative Global Tradable Emissions Regimes," Yale University, June 17.

Pizer, William A, 1996, "Optimal Choice of Policy Instrument and Stringency Under Uncertainty: The Case of

ESCAPE CLAUSE: INTERNATIONAL ASPECTS

Multilateral version:

- A supranational authority, presumably the same one that is to monitor countries' emission levels under any sort of agreement, stands ready to sell permits (beyond the basic agreed-to target levels) to whatever *national governments* wish to purchase them at a pre-determined price P.

- In the basic agreement, countries agree to emission targets, but reserve the right to whatever manner of domestic implementation they desire (as in current US position against "common policies and measures").

- Parties would have to agree in advance how to divide up the revenue.

- International trade in permits is superfluous in this case, but would do no harm.

Why couldn't individual firms also buy permits from the supra-national authority? In the multilateral version, it is suggested that only national governments be allowed to buy permits from the supra-national authority. Only they can be held internationally responsible for meeting their countries' aggregate emissions commitment. If permits could be purchased by individual firms, the government might be able to explain away any excedence of its target by claiming that domestic firms might have paid for the extra permits in private transactions.. (This is also an argument why, aside from escape clauses, international trading probably needs to be done via national governments.) It might work for governments to act as the agents for individual firms in making international purchases.

National version:

- National governments stand ready to sell additional permits *to their own citizens* at a predetermined price P.

- In the basic agreement, countries agree to a common plan for domestic implementation: a scheme of tradable permits.

- It does not matter whether the initial allocation of permits in a particular country is done by auction or arbitrary allocation, insofar as the workability of the escape clause is concerned. All that matters is that the initial allocation is the quantity agreed to in the treaty.

- Each government would get to keep the revenue raised.

- International trade in permits is again superfluous in this case. Indeed, it might be necessary to rule it out. Otherwise an irresponsible government (think "transition economies") could flood the market with permits, which it prints at the cost of the paper while receiving real money for them. (Of course such a country would be grossly out of compliance with the international treaty. But one does not wish to structure a treaty in such a way that a single irresponsible government can result in the breaching of intended emission limits, not just by its own economy, but worldwide.)

Why couldn't countries retain their own domestic implementation schemes? If some countries implemented their emission limits by means other than tradable permits, whether taxes or regulation, then it would be difficult to enforce the principle that the country's total emissions are to be limited by their initial allocation plus those demanded at the marginal cost P. The "marginality" becomes suspect. There would be nothing to stop a country from abolishing its existing energy taxes and regulations (or even adding energy subsidies!) and selling a lot of permits to its citizens because the true marginal cost of emission overruns would be far below P.

Wimp versions

The two versions described above pre-suppose a desire for an honest and workable system. It is possilbe that the multilateral version would be viewed as unacceptable because of aversion to supra-national authorities, and the national version as unacceptable because of aversion to insistence on á common domestic implementation measures. Is there some other way that the U.S. could tell its businesses they will be protected against a price higher than P?

(1) The U.S. could insist that the U.S. government be the only one with the right to sell additional permits at price P. If this were accepted, it would have the desirable efficiency properties, while simultaneously transferring potentially huge amounts of money from other countries to the U.S. It is hard to see why any other country would be willing to consider this.

(2) The U.S. (and other countries if they wished) could assure its citizens that if the price were to rise above P, with scope for buying emission permits internationally already having been exploited, then *the country would borrow, as agreed to internationally, however many permits were necessary* to keep the domestic (and world) price from rising above P. This is perfectly workable institutionally. But it is hard to see why it would be any easier to attain quantity targets in 2015, and simultaneously pay back past borrowings, if the 2010 targets have turned out to be prohibitively expensive to meet.

Preliminary Draft

MEMORANDUM

TO: Ray Squitieri
FROM: Joe Aldy
DATE: December 2, 1997
RE: The Effects of Trading Constraints on Permit Prices and Income Flows

To assess the effects of trading constraints on U.S. permit prices and income flows, I reviewed several model runs from SGM. While unconstrained trading would result in minimizing the compliance costs with binding targets, some have proposed constraining the amount of emissions reductions allowed to be achieved through international permit trading and joint implementation. The following table presents the permit prices and the quantity of permits purchased abroad under various percentage-based constraints.

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0% (no trading, no JI)	$108/ton (0 MMTCE)	$108/ton (0 MMTCE)
10%	$93/ton (38 MMTCE)	$93/ton (38 MMTCE)
25%	$72/ton (95 MMTCE)	$72/ton (95 MMTCE)
50%	$45/ton (190 MMTCE)	$45/ton (190 MMTCE)

model: SGM

Constraints on Trade

This analysis provides four interesting points. First, in an unconstrained world, the U.S. buys 53% of its emissions reductions abroad with Annex I trading and 82% of reductions with JI and Annex I trading. Note in the second table that the U.S. buys less as a share of reductions than other Annex I countries (however, EEFSU countries are sellers). Second, any split between JI and Annex I trading (e.g., no more than 5% through trading, no more than 5% through JI) is irrelevant to the U.S. permit price so long as the total constraint (e.g., 10%) is less than the percentage of emissions reductions the U.S. would buy under no constraints. Third, Russia sells more permits than China under JI (but less than it would with an Annex I trading only world) because it has so many paper tons. Fourth, any constraint less than 60% implies that EEFSU countries would not be able to sell all of their paper tons.

Percent of Emissions Reductions Purchased Abroad with No Constraints on Trading and JI

Country/Region	Annex I Trading Only	Annex I Trading + Joint Implementation
Canada	75%	88%
Japan	78%	91%
Western Europe	65%	86%
Australia	58%	81%
U.S.	53%	82%

model: SGM

Income Flows

Not only do constraints on trade negatively impact the buyers of permits by increasing permit prices, but they also decrease the flows of income to countries that sell. In a no-constraint world, the sellers of permits would receive $20 billion in 2010 under Annex I trading and more than $10 billion in 2010 under Annex I trading and JI. However, a constraint of 10% emissions reduction through foreign purchases would result in income transfers of only $600 million under Annex I trading and $200 million under Annex I trading plus JI. This 10% constraint results in EIT and developing countries receiving only 2-3% of the income they would have received without the constraint.

MEMORANDUM

TO: Ray Squitieri
FROM: Joe Aldy
DATE: December 3, 1997
RE: Constraints on Annex I Permit Trading: Paper Tons and Purchase Caps

To assess the effects of constraining the percentage of paper tons EEFSU countries can sell as well as the percentage of emissions reductions occurring abroad other Annex I countries can buy, I reviewed model outputs from SGM. Both of these constraints can increase the price of a carbon permit, depending on the stringency of the constraint.

In most cases, a stringent purchase cap (e.g., no country can buy more than 10% of its emissions reductions abroad) drives the U.S. permit price (see attached table). For the scenarios with paper tons and 10% purchase caps, EEFSU countries cannot even sell all of their paper tons. For the scenarios with paper tons and 25% purchase caps, EEFSU countries do sell all of their paper tons, and some tons representing actual emissions reductions relative to BAU.

However, constraints on the extent of allowable paper ton sales and loose purchase caps (e.g., 50%) are driven by the paper ton constraint. In the case of a 50% paper ton constraint and a 50% purchase cap, non-EEFSU countries buy 49% of their emissions reductions from EEFSU countries. In the case of no paper tons and a 50% purchase cap, non-EEFSU countries buy 38% of their emissions reductions from EEFSU countries.

Constraints	U.S. Permit Price ($/ton)	Permits Purchased Abroad by U.S. (MMTCE)
100% paper tons, no purchase caps (no constraints)	$41*	202
50% paper tons, no purchase caps	$55	149
no paper tons, no purchase caps	$72*	97
100% paper tons, 10% purchase cap	$93	38
100% paper tons, 25% purchase cap	$72	95
100% paper tons, 50% purchase cap	$45	190
50% paper tons, 10% purchase cap	$93	38
50% paper tons, 25% purchase cap	$72	95
50% paper tons, 50% purchase cap	$55	151
no paper tons, 10% purchase cap	$93	38
no paper tons, 25% purchase cap	$72	95
no paper tons, 50% purchase cap	$72	97

*From model runs. All other estimates are derived from assessing the constructed marginal abatement cost curves depicted in attached graphs.

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Received: by localhost with Microsoft MAPI; Wed, 03 Dec 1997 14:34:41 -0500
Organization: Forum One
X-Mailer: Microsoft Internet E-mail/MAPI - 8.0.0.4211

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INFOMGT @ A1@CD@LNGTWY
newsdesk @ usnewswire.com@INET@LNGTWY
usnwire @ access.digex.com@INET@LNGTWY

---------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Joseph E. Aldy
12/04/97 10:07:17 PM

Record Type: Record

To: Janet L. Yellen/CEA/EOP, Jeffrey A. Frankel/CEA/EOP, Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:

Subject: GCC: effects of Annex I trading and global JI on Russia

More fun stuff for Gruber. The bottom line is that Russia is a much bigger winner with Annex I trading alone than with Annex I trading AND JI. See attached table that I faxed over to Treasury.

Joe

CONSTRD3.WPI

---------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Joseph E. Aldy
12/08/97 11:29:41 AM

Record Type: Record

The Effects of Annex I Trading and Ideal Global JI on Russia

Scenario	Permit Price ($/ton)	FSU Permit Sales (MMTC)	FSU TR (billions $)	Russia TR (billions $)	FSU TC (billions $)
100% Paper Tons*	$15.8	294	$4.65	$3.02	$0.63
50% Paper Tons	$20.3	215	$4.36	$2.84	$1.10
No Paper Tons*	$25.9	130	$3.37	$2.19	$1.68

Model: SGM

* From model runs. 50% paper tons case based on interpolations from constructed marginal abatement cost curves.

Russian revenues and costs are assumed to be 65% of FSU revenues and costs, given that the Russian economy was approximately 65% the size of all FSU countries' economies in 1995.

Total costs are calculated assuming that the marginal abatement cost curve is linear in those sections of the curve.

All dollars are expressed in 1992 $.

These analyses assume that there are no constraints on the ability of other Annex I countries to purchase emissions reductions abroad.

The Effects of Annex I Trading Alone on Russia

Scenario	Permit Price ($/ton)	FSU Permit Sales (MMTC)	FSU TR (billions $)	Russia TR (billions $)	FSU TC (billions $)
100% Paper Tons*	$41.3	382	$15.8	$10.27	$3.5
50% Paper Tons	$55	319	$17.5	$11.38	$5.8
No Paper Tons*	$71.6	251	$18.0	$11.70	$9.0

Model: SGM

* From model runs. 50% paper tons case based on interpolations from constructed marginal abatement cost curves.

Russian revenues and costs are assumed to be 65% of FSU revenues and costs, given that the Russian economy was approximately 65% the size of all FSU countries' economies in 1995.

Total costs are calculated assuming that the marginal abatement cost curve is linear in those sections of the curve.

All dollars are expressed in 1992 $.

These analyses assume that there are no constraints on the ability of other Annex I countries to purchase emissions reductions abroad.

To: Janet L. Yellen/CEA/EOP, Jeffrey A. Frankel/CEA/EOP, Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:
Subject: GCC: unbelievable bna report

U.S. may give up developing country requirement in Kyoto. See below.

---------------------- Forwarded by Joseph E. Aldy/CEA/EOP on 12/08/97 11:30 AM ---------------------------

JRamses @ UWyo.Edu
12/08/97 11:21:00 AM

Record Type: Record

To: Joseph E. Aldy

cc:
Subject: unbelievable bna report

Gore Hints of U.S. Acceptance if Separate
Pacts Reached With Developing Countries

KYOTO, Japan--Vice President Gore Dec. 8 left open the possibility that the Clinton administration would accept a new climate change treaty if it contained all the elements it wants save one--action by developing countries.

If the new pact has the provisions the administration wants--and if the United States hammers out side agreements on greenhouse gas emission reductions with key developing countries such as China--the administration might send the treaty to the Senate for advice and consent to ratification, Gore suggested.

Such a scenario might spark "a real knock-down, drag-out debate that would be great for the country," the vice president told reporters. "I think it'd be a lot of fun. I would look forward to it. But we're not there yet."

Gore reaffirmed the Clinton administration stance that for the U.S. to accept a new climate change treaty under negotiation here, large developing countries will have to agree in some format to limit their greenhouse gas emissions.

"We've said from the beginning that we have to have

meaningful participation by
key developing countries" in the new treaty that negotiators hope to finish by
Dec. 10, Gore told reporters. "If we don't get that, it won't meet our conditions"
for agreeing to be bound by greenhouse gas emission limits in the pact, he
said.

When asked what would constitute "meaningful participation," Gore replied,
"We'll know it when we see it, and if we see it, we hope the Senate will see it."
The Senate must give its advice and consent to ratification of the accord before
the United States would be bound by it.

Congressional Reaction.

Senate and House observer delegations here also emphasized that the Kyoto
accord should include participation by developing countries in limiting
greenhouse gas emissions. However, legislators were divided on what the form
of those commitments should be, although they agreed that China has to be
involved.

Sen. Joseph Lieberman (D-Conn) said, "China has to be part of this." He noted
that China is the world's second largest emitter of greenhouse gas emissions
after the United States.

Rep. Jim Sensenbrenner (R-Wis), head of the House delegation and chairman
of the House Science Committee, said, "The vice president missed a golden
opportunity today to make clear that the Clinton-Gore administration will not
sign any treaty that does not include China, India, Mexico, Brazil, and every
other country in the world." He told reporters that a climate change accord
without emission limitation action by the 134 developing countries "does not
pass the smell test."

Sensenbrenner said he would find the treaty more palatable if the larger
emitters of the developing world "had some legally binding goals" that were "not
as severe" as goals for the industrialized countries.

Lieberman said, "We can't get this ratified by the Senate until [developing countries] do something." He agreed with earlier observations by Republican senators that the expected new treaty would not meet the criteria of S Res 98.

The resolution, which the Senate passed last July on a 95-0 vote, declared that the Senate will not support a climate pact that does not include developing countries, or that would cause harm to the U.S. economy (144 DEN AA-1, 7/28/97).

Sen. John Kerry (D-Mass) said the Senate would reject any agreement with "a permissiveness that permits the richer developing countries to reach the U.S. level" of greenhouse gas emissions "and then negotiate" an emission control strategy. Developing countries must accept that they "are part of the solution" to climate change, he said, adding that there is no intent to deprive these nations of economic growth.

Gore said although S Res 98 and the Clinton administration use different terminology for developing country involvement, they hold a common position.

"We share with them the view that developing countries that are meaningfully contributing to the problem [of climate change] have to meaningfully contribute to the solution," Gore said.

By Cheryl Hogue

120811E2.TXT

--------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Adele C. Morris 12/08/97 02:44:19 PM

Record Type: Record

To: Janet L. Yellen/CEA/EOP, Jeffrey A. Frankel/CEA/EOP, Joseph E. Aldy/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:
Subject: Clean Development Fund vs. JI

A thought about comparing Clean Development Funds with JI and safety valves:

From the U.S. perspective, a Clean Development Fund is essentially the same as a safetly valve, but it's not interchangeable with JI with credit. There are important efficiency differences.

With JI, presumably projects are undertaken for which the cost of carbon reductions is less than or equal to the traded price of permits. Firms get credit for the certified carbon reductions from baseline that their projects generate, and sell the credits.

With a Clean Development Fund, there is no guarantee that the cost of carbon reduction projects undertaken by the Fund bears any resemblance to the penalty, or safety valve, price. The Fund would be administered by a bureaucracy that probably would have very different incentives than firms interested in generating saleable credits. The efficiency of the Fund matters because carbon reductions they don't achieve with that money could come out of the US's hide some day in the future when global emissions are deemed still too high.

Thus, if we care that carbon is reduced efficiently -- and I think we should -- we should support JI with credit over a Clean Development Fund.

--------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Joseph E. Aldy
12/08/97 04:46:39 PM

Record Type: Record

To: Janet L. Yellen/CEA/EOP, Jeffrey A. Frankel/CEA/EOP, Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:
Subject: GCC: Annex I trading without EU participation

Jon Gruber called me a couple of hours ago asking what we might have to say on Annex I trading without EU participation (specifically, what might model results imply). The following memo presents the major effects of excluding the EU from trading (permit prices, emissions abatement costs, capital flows). The bottom line is that excluding the EU from trading increases the total cost of abatement for 1990 by 2010 for Annex I, but it actually helps the US, Canada, Japan, and Australia. It hurts the EU (since all of their abatement is achieved at home) and EEFSU countries (because excluding the EU depresses the demand and therefore the price for EEFSU paper tons and reductions). If you have comments on this, please get them to me by 6pm -- I need to fax this over by 6:30. Thanks.

Joe

NOEUTRD1.WPI

--------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Janet L. Yellen
12/09/97 05:38:31 PM

Record Type: Record

To: Joseph E. Aldy/CEA/EOP, Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:
Subject: JI

I discovered that there is a web site containing a listing of recent US JI projects, if you need some for ERP purposes . The address is http://www.ji.org

--------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Joseph E. Aldy
12/09/97 06:05:09 PM

Record Type: Record

To: Janet L. Yellen/CEA/EOP, Jeffrey A. Frankel/CEA/EOP, Adele C. Morris/CEA/EOP, Randall W. Lutter/CEA/EOP

cc:
Subject: GCC: analyses done for Gruber last night

FYI. The following two files include analyses I did for Gruber last night.

File 1: compares a world with full Annex I trading to a world with two trading blocs: umbrella (US, Jap,

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Can, Aus, Russia) and Europe-only (EU plus eastern Europe)

File 2: provides charts assuming differentiated targets (including US at -2% of 1990)
Chart 1: Full Annex I trading with these targets
Chart 2: Same comparison as in file 1 with new targets
Chart 3: Same comparison as in file 1 but no country can buy more than 50% of their emissions reductions abroad and with new targets
Chart 4: Same comparison as in file 1 with new targets and the Umbrella countries can also participate in JI

NOEXTEU1.WP NOEXTEU2.WP

---------------------- Forwarded by Randall W. Lutter/CEA/EOP on 06/09/98 03:35 PM ---------------------------

Michele Jolin
12/09/97 07:07:48 PM

Record Type: Record

To: Keith O. Fuglie/CEA/EOP, Randall W. Lutter/CEA/EOP, Sandra F. Daigle/CEA/EOP
cc:
Subject: comments on air quality/climate chapters of cea draft report attached

---------------------- Forwarded by Michele Jolin/CEA/EOP on 12/09/97 07:06 PM ---------------------------

Linda Lance
12/09/97 07:02:49 PM

Record Type: Record

To: Michele Jolin/CEA/EOP
cc: Wesley P. Warren/CEQ/EOP, David B Sandalow/CEQ/EOP, Shelley N. Fidler/CEQ/EOP
Subject: comments on air quality/climate chapters of cea draft report attached

CEAREPOR.12ɕ

thanks for the chance to review.

MEMORANDUM

TO: Jon Gruber
FROM: Joe Aldy
DATE: 12/8/97
RE: Annex I Trading without EU Participation

If the EU does not participate in an Annex I permit trading market, the total costs for Annex I countries to comply with a target and timetable increase, but the U.S., Japan, Australia, and Canada are all better off without EU participation. The EU and Eastern European and Former Soviet Union countries are all made worse off by EU non-participation.

To illustrate the effects of EU non-participation, I assessed country-specific marginal abatement cost curves derived from SGM outputs for the 1990 in 2010 target and timetable. The first chart illustrates the difference in the total economic effects of these two trading regimes. The two charts that follow show permit prices, domestic emissions abatement, purchases and transfers of permits on the Annex I market, and total costs of Annex I trading with EU participation and a trading regime without EU participation.

Difference in Economic Costs of Trading Regimes with and without EU Participation

Country/Region	Total Costs under Trading with EU (abatement cost + transfers)	Total Costs under Trading without EU (abatement cost + transfers)	Change in Costs (- means costs decrease w/o EU participation)
U.S.	$12.0b	$7.6b	-$4.4b
Australia	$0.8b	$0.5b	-$0.3b
Canada	$1.9b	$1.1b	-$0.8
Japan	$3.5b	$2.0b	-$1.5b
Eastern Europe	net gain: $3.7b	net gain: $1.9b	$1.8b
Former Soviet Union	net gain: $12.3b	net gain: $6.2b	$6.1b
Russia1	net gain: $7.9b	net gain: $4.0b	$3.9b
EU2	$8.1b	$18.9b	$10.8b
ANNEX I, total abatement cost	$10.3b	$21.9b	$11.6b

Annex I Trading with EU Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$41.30	177	202	$3.7b	-$8.3b	$12.0b
Australia	$41.30	11	15	$0.2b	-$0.6b	$0.8b

Canada	$41.30	13	39	$0.3b	-$1.6b	$1.9b
Japan	$41.30	21	75	$0.4b	-$3.1b	$3.5b
Eastern Europe	$41.30	27	-105	$0.6b	+$4.3b	net gain: $3.7b
Former Soviet Union	$41.30	168	-382	$3.5b	+$15.8b	net gain: $12.3b
Russia1	$41.30	109	-248	$2.3b	+$10.2b	net gain: $7.9b
EU2	$41.30	83	156	$1.7b	-$6.4b	$8.1b

Annex I Trading without EU Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$23	101	278	$1.2b	$6.4b	$7.6b
Australia	$23	7	19	$0.08b	$0.4b	$0.5b
Canada	$23	8	44	$0.09b	$1.0b	$1.1b
Japan	$23	12	84	$0.1b	$1.9b	$2.0b
Eastern Europe	$23	15	-93	$0.2b	-$2.1b	net gain: $1.9b
Former Soviet Union	$23	118	-332	$1.4b	-$7.6b	net gain: $6.2b
Russia1	$23	77	-216	$0.9b	-$4.9b	net gain: $4.0b
EU2	$158	239	0	$18.9b	0	$18.9b

Notes:

EU Bubble Countries:

Austria
Belgium
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Portugal
Spain
Sweden
United Kingdom

Western Europe in SGM:

EU bubble countries plus
Iceland (1990: 0.6 MMTCE CO2)
Norway (1990: 14.3 MMTCE CO2)
Switzerland (1990: 11.6 MMTCE CO2)
Turkey (1990: 39.7 MMTCE CO2)

MEMORANDUM

TO: Jon Gruber
FROM: Joe Aldy
DATE: 12/8/97
RE: Umbrella Annex I Trading with neither EU nor Eastern European Participation

If neither the EU nor Eastern European countries participate in full Annex I permit trading market, the total cost for Annex I countries to comply with a target and timetable increases, but the U.S., Japan, and Canada are all better off with a smaller Annex I "Umbrella" (trading between U.S., Japan, Canada, Australia, and FSU countries). Australia has roughly the same costs (domestic abatement costs plus transfers for emissions reductions abroad) under this umbrella as under full Annex I trading. Eastern Europe actually benefits under a regime where it does not participate in the umbrella but it does sell permits with the EU (a European-only trading regime) relative to full Annex I trading. As the only seller of permits to the EU, Eastern Europe does not have to compete with cheap permits from FSU countries, and thus can sell more permits at higher permit prices than under full Annex I trading. The three major buyers of permits in the Umbrella, U.S., Canada, and Japan, benefit, because as buyers of permits, the loss of a major competitor means they can buy more emissions reductions in EEFSU at lower permit prices.

Former Soviet Union countries and the EU are worse under this scenario of two trading blocks (the Umbrella and the European-only trading) than under full Annex I trading. The cost for the EU increases under European-only trade relative to full trading because it cannot take advantage of low cost emissions reductions in FSU countries, such as Russia. Former Soviet Union countries are worse off even though they don't have to compete with Eastern European countries in the sellers market because the EU would be the second largest buyer of permits under full Annex I-wide trading. Losing a major buyer decreases total demand for their permits and thus the price more so than losing competitors contracts the supply and pushes up the permit price.

To illustrate the effects of EU non-participation, I assessed country-specific marginal abatement cost curves derived from SGM outputs for the 1990 in 2010 target and timetable. The first chart illustrates the difference in the total economic effects of these two trading regimes. The two charts that follow show permit prices, domestic emissions abatement, purchases and transfers of permits on the Annex I market, and total costs of Annex I trading with EU participation and a trading regime without EU participation.

Umbrella: U.S, Canada, Japan, Australia, FSU
European-Only Bloc: EU, Eastern Europe

Winners with Two Trading Blocs Relative to Full Annex I Trading: U.S, Canada, Japan, Eastern Europe
Losers with Two Trading Blocs Relative to Full Annex I Trading: EU, FSU
No Difference Between the Trading Blocs: Australia

Difference in Economic Costs of Trading Regimes with and without EU, Eastern European Participation

Country/Region	Total Costs under Full Trading (abatement cost + transfers)	Total Costs under Trading without EU, Eastern Europe (abatement cost + transfers)	Change in Costs (- means costs decrease w/o EU, Eastern Europe participation)
U.S.	$12.0b	$10.2b	-$1.8b
Australia	$0.8b	$0.8b	0
Canada	$1.9b	$1.5b	-$0.4b
Japan	$3.5b	$2.9b	-$0.6b
Former Soviet Union	net gain: $12.3b	net gain: $9.7b	$2.6b
Russia1	net gain: $7.9b	net gain: $6.2b	$1.7b
Eastern Europe	net gain: $3.7b	net gain: $5.8b	-$1.9b
EU2	$8.1b	$10.6b	$2.5b
ANNEX I, total abatement cost	$10.3b	$12.2b	$1.9b

Annex I Trading with Full Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$41.3	177	202	$3.7b	-$8.3b	$12.0b
Australia	$41.3	11	15	$0.2b	-$0.6b	$0.8b
Canada	$41.3	13	39	$0.3b	-$1.6b	$1.9b
Japan	$41.3	21	75	$0.4b	-$3.1b	$3.5b
Former Soviet Union	$41.3	168	-382	$3.5b	+$15.8b	net gain: $12.3b
Russia1	$41.3	109	-248	$2.3b	+$10.2b	net gain: $7.9b
Eastern Europe	$41.3	27	-105	$0.6b	+$4.3b	net gain: $3.7b
EU2	$41.3	83	156	$1.7b	-$6.4b	$8.1b

Annex I Trading without EU or Eastern Europe Participation

Country/ Region	Permit Price	Domestic Reductions	Reductions Purchased Abroad	Domestic Abatement Cost	Capital Flow	Total Cost
U.S.	$33.6	151	228	$2.5b	$7.7b	$10.2b
Australia	$33.6	9	17	$0.2b	$0.6b	$0.8b
Canada	$33.6	12	40	$0.2b	$1.3b	$1.5b
Japan	$33.6	18	78	$0.3b	$2.6b	$2.9b
Former Soviet Union	$33.6	149	-363	$2.5b	-$12.2b	net gain: $9.7b
Russia1	$33.6	97	236	$1.7b	-$7.9b	net gain: $6.2b
Eastern Europe	$59.7	40	-118	$1.2b	-$7.0b	net gain: $5.8b
EU2	$59.7	121	118	$3.6b	$7.0b	$10.6b

Notes:

T&T:
U.S., Japan, Canada: 2% below 1990
Australia: 5% above 1990
FSU, Eastern Europe: 1990
EU: 10% below 1990

Full Annex I Trading

Country/ Region	permit price	domestic reductions	reductions purchased abroad	domestic abatement cost	transfers	total cost
U.S.	$51.6	215	191	$5.5b	$9.9b	$15.4b
Canada	$51.6	16	38	$0.4b	$2.0b	$2.4b
Japan	$51.6	26	75	$0.6b	$3.9b	$4.6b
Australia	$51.6	13	5	$0.3b	$0.2b	$0.6b
FSU	$51.6	415	0	$5.2b	-$21.4b	net gain: $16.2b
EU	$51.6	105	218	$2.7b	$11.2b	$13.9b
Eastern Europe	$51.6	112	0	$0.9b	-$5.8b	net gain: $4.9b

Two Permit Trading Blocs: Annex I Umbrella and Europe-Only

Country/ Region	permit price	domestic reductions	reductions purchased abroad	domestic abatement cost	transfers	total cost
U.S.	$36.6	159	247	$2.9b	$9.0b	$11.9b
Canada	$36.6	13	41	$0.2b	$1.5b	$1.7b
Japan	$36.6	19	82	$0.3b	$3.0b	$3.3b
Australia	$36.6	10	8	$0.2b	$0.3b	$0.5b
FSU	$36.6	378	0	$3.0b	-$13.8b	net gain: $10.8b
EU	$101	178	145	$9.0b	$14.6b	$23.6b
Eastern Europe	$101	145	0	$3.4b	-$14.6	net gain: $11.2b

Two Permit Trading Blocs: Annex I Umbrella and Europe-Only and 50% Constraint

Country/ Region	permit price (domestic)	domestic reductions	reductions purchased abroad	domestic abatement cost	transfers	total cost
U.S.	$48	203	203	$4.9b	$3.0b	$7.9b
Canada	$101	27	27	$1.4b	$0.4b	$1.8b
Japan	$119	50	51	$3.0b	$0.8b	$3.8b
Australia	$32	9	9	$0.1b	$0.1b	$0.2b
FSU	$15	289	0	$0.5b	-$4.3b	net gain: $3.8b
EU	$101	178	145	$9.0b	$14.6b	$23.6b
Eastern Europe	$101	145	0	$3.4b	-$14.6b	net gain: $11.2b

Two Permit Trading Blocs: Annex I Umbrella + Global JI and Europe-Only (no JI)

Country/ Region	permit price	domestic reductions	reductions purchased abroad	domestic abatement cost	transfers	total cost
U.S.	$12	50	356	$0.3b	$4.4b	$4.7b
Canada	$12	4	50	$0.02b	$0.6b	$0.6b
Japan	$12	7	94	$0.04b	$1.2b	$1.2b
Australia	$12	4	14	$0.02b	$0.2b	$0.2b
FSU	$12	280	0	$0.4b	-$3.5b	net gain: $3.1
EU	$101	178	145	$9.0b	$14.6b	$23.6b
Eastern Europe	$101	145	0	$3.4b	-$14.6b	net gain: $11.2b
China	$12	170	0	$1.1b	-$2.1b	net gain: $1.0b
India	$12	21	0	$0.1b	-$0.3b	net gain: $0.2b
Korea	$12	2	0	$0.01b	-$0.02b	net gain: $0.01b
Mexico	$12	11	0	$0.07b	-$0.1b	net gain: 0.03b
ROW	$12	30	0	$0.2b	-$0.4b	net gain: 0.2b

EU Bubble Countries:

Austria
Belgium
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Portugal
Spain
Sweden
United Kingdom

Western Europe in SGM:

EU bubble countries plus
Iceland (1990: 0.6 MMTCE CO2)
Norway (1990: 14.3 MMTCE CO2)
Switzerland (1990: 11.6 MMTCE CO2)
Turkey (1990: 39.7 MMTCE CO2)

MEMORANDUM

TO: Jay Shogren

FROM: Joe Aldy and Quindi Franco

DATE: August 11, 1997

RE: Review of DOE Labs Study, June 10 Draft

We provide an assessment of *U.S. Carbon Reductions by 2010 and Beyond: The Potential Impact of Energy-Efficient and Low-Carbon Technologies* (DOE Labs Study, June 10 draft). The report identifies carbon reductions and their associated costs in the buildings, industry, transportation, and electric power sectors under two hypothetical climate policy scenarios. The study finds that, with unspecified "very aggressive policies" and a $50/ton permit price, carbon emissions can be stabilized at 1990 levels by 2010. In reviewing the report, we believe it is beneficial to highlight several limitations of the study. First, the authors do not provide descriptions of the government programs necessary to stimulate the necessary technology adoption to reduce emissions of 180 million metric tons of carbon equivalent (MMTCE). Based on the actual history of CCAP, we estimate the costs of government programs to achieve these reductions could total $45 billion (1995$), depending on the form of the marginal cost curve. We annuitized this figure and found that government programs could cost $1.1 billion annually into perpetuity. These are costs in addition to existing program costs to improve energy efficiency technology development and adoption. Second, the analyses across sectors are not integrated. Therefore, the penetration rate of energy efficient technologies may be overestimated because the separate sectoral analyses do not account for declines in fuel prices. Third, the industry sector analysis ignores the costs of accelerating capital retirement, resulting in either an overestimate of reductions or an underestimate of costs. Fourth, the transportation sector — requires "luck" in terms of technological innovation to achieve the projected emissions reductions. Fifth, the utilities sector analysis resulted in double counting of emissions reductions. These examples of the qualifications can provide additional insight into the projections of emissions reductions and costs. Upon receiving the final version of the report and documentation of the analyses, we will update this review.

Overview of Report

The Labs Study estimated the carbon emissions reduction opportunities available through technology development and adoption and fuel switching. The Study employs the Energy Information Administration's 1997 baseline (AEO97) for the buildings and industry sectors. For the transportation sector, the authors changed the AEO97 assumption of increasing fuel efficiency in automobiles to constant fuel efficiency. For the utility sector, the baseline was modified to reflect a fully competitive bulk-power market in the year 2010. Discharge, shutdown, repowering, and new construction decisions were optimized to select the amount of capacity that minimized the cost of the power-supply system plus the cost of unserved energy. Compared to AEO97, the final baseline has slightly lower energy prices, larger electricity sales, and a greater share of gas generation. The study provides emissions reductions from this baseline for two scenarios: 1) "efficiency" and 2)"high efficiency/low carbon", over the period 1998-2010. The study describes neither the policies necessary to achieve emissions reductions nor the costs of federal programs for these scenarios, only their outcomes: increased adoption rates and better technologies.

Efficiency Scenario

This case assumes that all technologies adopted are at zero or negative net cost to the user given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. The Study estimates that 120 MMTCE will be reduced at negative net cost in this scenario. None of these reductions occur in the utility sector as a function of fuel switching or technology adoption to increase combustion efficiency.

High Efficiency/Low Carbon Scenario

This case assumes a "greater commitment" to reduce emissions through federal policies, in concert with state and private activities and a $50/ton permit price that stimulates low carbon technologies (read: primarily fuel switching). The policy is announced in 2000 and the policy's restrictions are phased-in through 2010. There is an assumed announcement effect (although an AEEI is not specified), increased domestic and international R&D in low-carbon technologies, and a "change in psychology". The Study estimates reductions of 180 MMTCE from the baseline through energy efficient technology adoption at negative net cost (see high efficiency without low carbon technology in chart below). The carbon permits will yield an additional 150-200 MMTCE of reductions through low-carbon technology adoption. Given that these occur at a permit price of $50/ton, the Study estimates the upper limits of these costs to be $10 billion per year in 2010.

Carbon Emissions (MMTCE): 1990 - 2010

1990	2010 Baseline	2010 Efficiency	2010 High Efficiency (w/o Low Carbon Tech)	2010 High Efficiency/Low Carbon
1340	1720	1600	1540	1340 - 1390

Review

The Lab Study employs several important assumptions in the analyses. Learning about these qualifications can enhance one's understanding of the estimates regarding cost-effectiveness and emissions reductions in this study. We present several of the most significant assumptions and discussions of their impact below.

The Study Does Not Specify Policies to Achieve Carbon Reductions

> "Cost effectiveness is improved because R&D, in combination with increased deployment efforts, result in declining capital costs. We do not specify the policies, economic conditions, or exogenous events that could precipitate such changes" (p. 1.4).

The entire study is premised on two sets of undefined policies: an "aggressive" or "invigorated" public sector effort to stimulate energy efficient technology adoption (efficiency case) and a "very aggressive" public sector effort to stimulate technology development and adoption (high efficiency/low carbon case). The only specific policy instrument mentioned in the report is a $50/ton tradeable permit. The study makes vague references to policies and only provides details on what these unidentified policies would result in: 1) "better technology" (p. 1.5); 2) "higher penetration rates" (p. 1.6); 3) "changing the capital recovery factor [in industry sector] from 33% to 15%" (p. 4.8); and 4) "technological breakthroughs" (p. 5.3). These policy effects would result in reductions of 180 MMTCE for "free": firms and individuals receive energy cost-savings in excess of technology adoption and implementation costs.

The report specifically states that the efficiency case reduces, but does not eliminate, market barriers (p. x) and that implementation costs are ignored (p. xvi). First, we will discuss the implications of reducing market barriers, and then we will address the cost issue. Market barriers occur in 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 or market analysts). A person addresses 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. Policy intervention to eliminate a market barrier cannot make society better off and usually makes society worse off, regardless of the implementation mechanism.[1]

The economics 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.

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[1] In contrast, policy intervention to eliminate a market failure (such as carbon emissions) may make society better off, depending on the costs of the intervention.

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.

These four types of market barriers illustrate the economic behavior that explains the apparent under adoption of energy efficiency technology (the "efficiency gap"). These barriers clearly demonstrate the difference between the technological maximum adoption (which only assumes technology costs) and the economic maximum adoption (which assumes total costs). A set of climate change policies to stimulate technology adoption could increase efficiency, but only because they also decrease the effect of a market failure (carbon emissions). Social welfare is improved because the net benefits of indirectly fixing the market failure exceed the costs of removing the barriers. If carbon emissions are appropriately priced (assuming in this case that $50/ton is the correct carbon price), a policy to remove a barrier (e.g., lower the capital recovery factor from 33% to 15%), will generate negative net benefits. High adoption rates will be realized once prices rise enough for some technologies to clear the barriers.

From the literature on market barriers, we know that the costs of reducing barriers are greater than their benefits. In this case, the authors of the Labs Study do not provide an estimate of the costs to government to lower market barriers to achieve these substantial reductions (and they only provide benefits in terms of projected emissions reductions). We calculated estimates of the costs of emissions reductions programs based on the government's experience with the Climate Change Action Plan (CCAP). CCAP promotes carbon reductions through a broad array of voluntary programs that stimulate "cost-effective" technology adoption by private firms. Participation by a firm in a CCAP program implies that carbon is reduced and the firm gains financially.[2] CCAP received appropriations totaling $494 million (1995$) during the FY95 - FY97 period. During this period, the Department of Energy and the Environmental Protection Agency can account for reductions of 14 MMTCE (see attached table). Each ton of carbon reduced in CCAP cost the federal government, on average, $35.29 (1995$) over this three year period. Assuming a flat marginal cost curve (MC = AC of CCAP) to reduce 180 MMTCE beyond the baseline, the government costs of the unidentified policies in the Labs Study would

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[2] Note that CCAP efforts are incorporated in the AEO97 baseline.

exceed $6.3 billion. To account for the opportunity cost of capital through time, we annuitized this value and found that government costs would run about $150 million annually into perpetuity.[3] However, the marginal costs of technology adoption in the efficiency and high efficiency/low carbon scenarios are definitely higher than the average cost of 14 million metric tons reduced in the baseline scenario, especially as more and more efforts to reduce emissions are undertaken. Assuming that costs increase 10% for every 10 million metric tons of carbon reduced, then the government cost would total $16.1 billion (annuity of $375 million). This is a slowly increasing marginal cost curve given baseline assumptions of gains in energy efficiency. Assuming that costs increase 20% for every 10 million metric tons of carbon reduced, then the cost to government would exceed $45.2 billion (annuity of $1.1 billion) (see attached chart).

The Sectoral Analyses Are Not Integrated

> "The model runs for each of the three end-use sectors were not integrated and therefore may overstate the effects of technology penetration. In an integrated modeling effort, fuel prices might fall as consumption declines, resulting in less penetration of energy-conserving technologies" (p. 1.1).

The analyses of the various sectors assume that the reduction of 180 MMTCE occurs through energy efficient technology adoption without any price effect. This implies that, with government programs, private agents will adopt technologies because the benefits (energy cost-savings) exceed the costs of adoption. The authors claim that these reductions occur at zero or negative net costs. By failing to account for the effect of decreased energy demand due to energy efficiency technology adoption, some of those adoption decisions that occur on the margin would no longer generate positive net benefits for private consumers. The Labs Study indicates that energy consumption will decline from the baseline by 11.6% under the high efficiency/low carbon case (p. xi). This decrease in demand should result in a decrease in the price of energy, and cause some energy efficient technologies to become unattractive to private agents.

In addition, the absence of an integrated analysis precludes an assessment of the economy-wide effects of a tradeable permit system. As previous studies have indicated, the nature of the permit allocation (e.g., grandfathering, auction, or a hybrid) and the characteristics of the revenue recycling (e.g., various adjustments to existing taxes) can affect economy-wide investment. Understanding the effects on investment is instrumental in assessing the likelihood of success of these scenarios, given that they rely on substantial R&D and technology adoption.

The Industry Sector Analysis Ignores the Costs of Accelerated Retirement

> "When the economic losses of accelerated retirement are accounted for this means that, at the margin, all investments are not likely to be cost effective at our assumed 15% CRF [capital recovery factor]. Since we do not have a model to

[3] We employed a 7% discount rate to calculate the annuities in this paper.

account for this potential early retirement and the economic losses, we must caveat our estimates of investment and net costs. ...the investment cost may be understated by the amount of loss due to any early retirement that may occur" (p. 4.15).

This assumption implies that one of three results should be accounted for in the analysis. First, the projected emissions reduction should be revised downward, because the assessment of the industry sector overestimates technology adoption by ignoring these costs. Second, the cost of reducing emissions, if the reduced carbon from this sector remains constant, should increase, with some technology adoption decisions occurring at positive net costs. Third, if the authors maintain the same costs and emissions estimates, then the costs of government programs to somehow force down the CRF from 33% to 15% would increase.

The Transportation Sector Requires "Luck" to Achieve Carbon Reductions

> "[B]ecause the [transportation sector] outcomes postulated in the high efficiency/low carbon scenario require technological breakthroughs, they require a certain degree of luck to be achieved by 2010. There are no credible methods to accurately gauge the probability of such breakthroughs -- we believe they stand a decent chance of occurring with an intensification of research efforts, but we stop short of claiming they are a likely outcome of such an intensification" (p. 5.3).

Note that this statement includes two qualifications: luck on top of intensified research efforts. To achieve just the efficiency level of emissions reductions for this sector (73 MMTCE), these intensified research efforts may require two to ten times existing funding on transportation (p. 5.3). To gain a sense of the magnitude of what such an increase in funding might be, consider that the Partnership for a New Generation of Vehicles (PNGV) alone is funded at the federal level at $263 million. Private sector costs of participating in the PNGV are in addition to this large sum. Further, the estimates of costless (on net) carbon reductions relies on a series of tenuous assumptions: commercial development of the fuel cell for passenger cars, commercial availability of cellulosic ethanol (and the elimination of the ethanol excise tax exemption), and an apparently arbitrary 30% reduction in costs for "certain key technologies" (p. 5.24). These technologies are not identified, and the report does not provide documentation for the NEMS model runs conducted for the transportation sector.

Interactions Ignored, Double Counting "Likely" in Utilities Sector Analysis

> "Chapter 7 considers other electricity supply technology options, including: converting coal-based power plants to natural gas; cofiring coal with biomass; efficiency improvements in generation and transmission and distribution systems; extending the life of existing nuclear plants; increasing generation and capacity of existing hydropower plants; and constructing new powerplants using advanced coal technologies. Each of these options is assessed independently. Thus,

interactions between the options are not taken into account, and the possibility of double counting is therefore likely" (p. 7.1).

The emissions reductions in the electricity sector come from two sources. First, utilities undertake fuel switching at the $50/ton permit price through carbon-ordered dispatching. Second, utilities modify their capital stock through several technology options such as those listed in the above quotation. As electricity production moves away from coal in the first analysis, fewer and fewer plants (and therefore potential emissions reductions) will be available for conversion to natural gas or cofiring with biomass. The second set of analyses were "static" and did not optimize unit/plant production cost, dispatch, or system load. Conversations with one of the co-authors (Stanley Hadley of Oak Ridge National Laboratory) indicate that 10 GW of coal-to-gas conversions (approximately 9 million tons of carbon reductions) were double-counted.[4]

Furthermore, the analysis of specific options did not examine the effect of increasing fuel prices (from gas demand due to coal-to-gas repowering). Given the range of assumptions considered in the study, the authors actually estimated that repowering coal plants for natural gas could result in carbon reductions between 5 million and 269 million tons (p. 7.2), depending on the gas/coal price differential, the cost of carbon, and the costs of sulfur dioxide and nitrous oxide emissions. This is quite a substantial range. The Labs Study estimates that natural gas consumption will increase 14% to 191% above 2010 baseline consumption. However, the DRI 1.25 run in the IAT report indicates a 16% decline in natural gas consumption, while the SGM run resulted in only a negligible decline and Markal-Macro generated a 6% increase in natural gas consumption. These three models indicate that a non-integrated analysis that does not account for the price change in natural gas may overestimate natural gas substitution for coal and emissions reductions from fuel switching.

[4] Hadley noted that a subsequent draft of the report should address at least some of the double counting, but he did not provide details.

Summary of Greenhouse Gas Emissions-Reduction Actions

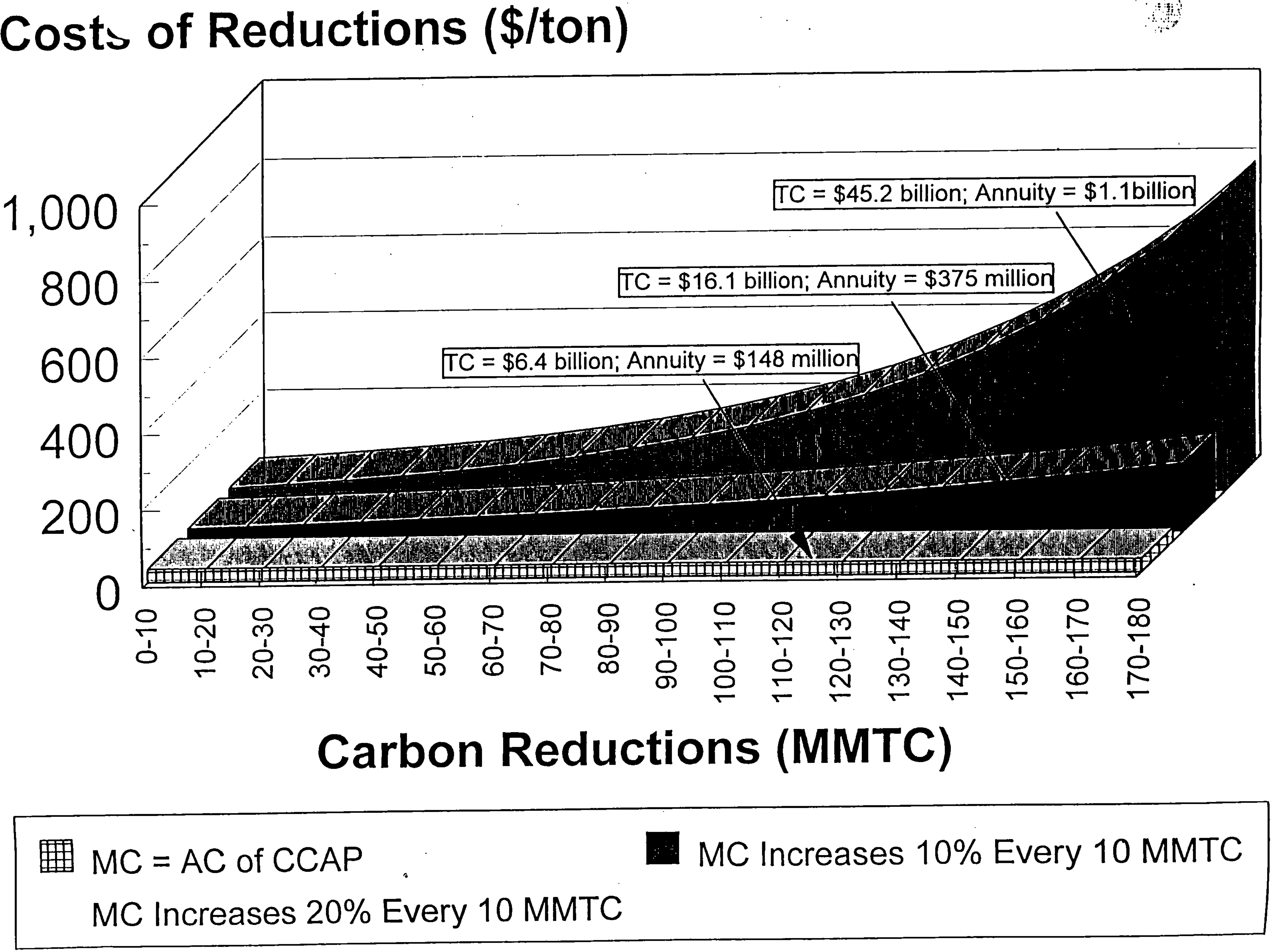
Million Metric Tons of Carbon Equivalent

Source: U.S. Climate Action Report—1997

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
Residential & Commercial Sector Actions		26.9	10.3	–
New	Rebuild America	2.0	1.6	–
1 and 2	Expanded Green Lights and Energy Star Buildings	3.6	3.3	–
3	State Revolving Fund for Public Buildings	1.1	Terminated	
4 5	Cost-Shared Demonstrations of Emerging Technologies Operation and Maintenance Training for Commercial Building Facility Managers and Operators	3.8	0.0	–
6	Energy Star Products	5.0	4.3	–
7	Residential Appliance Standards	6.8	0.2	–
8 and 11 9 10	Energy Partnerships for Affordable Housing Cool Communities Update State Building Codes	4.4	0.4	–
New	Construction of Energy-Efficient Commercial and Industrial Buildings		0.1	–
New	Superwindow Collaborative		0.0	–
New	Expand Markets for Next-Generation Lighting Products		0.2	–
New	Fuel Cells Initiative		0.0	–
Industrial Sector Actions		19.0	4.8	–
12	Motor Challenge	8.8	1.8	–
13 14	Industrial Golden Carrot Programs Accelerate the Adoption of Energy-Efficient Process Technologies	2.9	Merged into Action 12 Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	–
17 18	Improve Efficiency of Fertilizer Nitrogen Use Reduce the Use of Pesticides	2.7	0.8 Terminated	–
Transportation Sector Actions		8.1	5.3	–
19 20 21	Cash Value of Parking Innovative Transportation Strategies Telecommuting Program	6.6	4.6	–
22	Fuel Economy Labels for Tires	1.5	0.7	–
Energy Supply Actions		10.8	1.3	–
23	Increase Natural Gas Share of Energy Use Though Federal Regulatory Reform	2.2	Terminated	

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
24	Promote Seasonal Gas Use for Control of Nitrogen Oxides	2.8	0.5	--
25	High-Efficiency Gas Technologies	0.6	Terminated	
26	Renewable-Energy Commercialization	0.8	0.3	--
27	Expand Utility Integrated Resource Planning	1.4	Terminated	
28	Profitable Hydroelectric Efficiency Upgrades	2.0	0.0	--
29 30	Energy-Efficient Distribution Transformer Standards Energy Star Distribution Transformers	0.8	0.5	--
31	Transmission Pricing Reform	0.8	Terminated	
New	Green Power Network	Not included	0.0	--
Land-Use Change & Forestry Actions		10.0	2.4	--
43	Private Depletion of Nonindustrial Private Forests	4.0	Terminated	
44	Accelerate Tree Planting in Nonindustrial Private Forests	0.5	0.4	--
16	Waste Minimization	4.2	2.0	--
9	Expand Cool Communities	0.5	To be determined	
Methane Actions		16.3	15.5	--
32	Expand Natural Gas STAR	3.0	3.4	--
33	Increase Stringency of Landfill Rule	4.2	6.3	--
34	Landfill Methane Outreach Program	1.1	1.9	--
35	Coalbed Methane Outreach Program	2.2	2.6	--
36	RD&D for Coal Mine Methane	1.5	Terminated	
37	RD&D for Landfill Methane	1.0	Terminated	
38	AgSTAR Program	1.5	0.3	--
39	Ruminant Livestock Efficiency Program	1.8	1.0	--
Actions to Address Other Greenhouse Gases		16.3	25.4	--
17	Improved Fertilizer Management	4.5	5.3	--
40	Significant New Alternatives Program	5.0	6.4	--
41	HFC-23 Partnerships	5.0	5.0	--
42	Voluntary Aluminum Partnership	1.8	2.2	--
New	Environmental Stewardship Initiative	Not included	6.5	--
Foundation Actions			11.3	--
	Climate Wise	Not estimated	1.8	--
	Climate Challenge	Not estimated	7.6	--
	State and Local Outreach Programs	Not estimated	1.9	--
Total GHG Emission Reductions From CCAP		108.6	76.0	14.0

Data is not readily available for cumulative emissions reductions for many CCAP programs. Emissions reductions of about 5 MMTCE can be attributed to DOE's CCAP programs. EPA's Office of Air and Radiation is responsible for emissions reductions of about 9 MMTCE through their CCAP programs.


Costs of Reductions ($/ton)
1,000
800
600
400
200
0
TC = $45.2 billion; Annuity = $1.1billion
TC = $16.1 billion; Annuity = $375 million
TC = $6.4 billion; Annuity = $148 million
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170
170-180
Carbon Reductions (MMTC)
MC = AC of CCAP
MC Increases 10% Every 10 MMTC
MC Increases 20% Every 10 MMTC

DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220
September 4, 1997

MEMORANDUM FOR T. J. GLAUTHIER

FROM: Robert Gillingham RG
Jonathan Gruber JG

SUBJECT: 5-Labs Revision

We think this revision is a substantial improvement. Most of our comments are editorial (see attached draft). The major exceptions revolve, not surprizingly, around the treatment of "cost" estimates. We continue to feel that the analysis presents scenarios that *could* be achieved, rather than scenarios that *should* be achieved—regardless of climate benefits—on the basis of cost savings. To address this concern, we recommend (1) eliminating the modifier "cost-effective" when referring to technologies, (2) deleting Table 1.5 and substantially modifying or eliminating the discussion of costs on pp. 15 through 18, and (3) weakening the claim of rough cost/benefit parity in the second overarching conclusion in the executive summary (*e.g.*, recognizing that energy savings are a substantial offset without arguing relative magnitude).

We continue to believe the scenarios are informative primarily in terms of what is technically feasible. We do not believe the paper demonstrates the validity of the criteria used for selecting "cost-effective" technologies. The reasons for this skepticism are outlined in our earlier comments - the underlying model of the costs of technology adoption is not economically rigorous, with limitations that include low discount rates, and in particular extremely low implementation costs.

We view these criteria as one way of selecting technologies that could be adopted; the paper then does a very good job of quantifying the impact of adopting these technologies on energy use and carbon emissions. A possible substitute for Table 1.5 might be a table of reductions in energy consumption valued at today's (or 2010's) prices to quantify the *energy-cost* saving, with the appropriate caveat that it would take a full-blown general-equilibrium analysis (beyond the scope of the paper) to determine what prices would actually obtain. Going further than that, in our opinion, is too ambitious and—for the purposes of this paper—is not critical.

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

...IOR ECONOMIST

MEMORANDUM

TO: Joe Romm
Acting Assistant Secretary for Energy Efficiency and Renewable Energy

FROM: Randy Lutter and Joe Aldy

DATE: September 4, 1997

RE: Comments on revised executive summary and chapter one of *Scenarios of U.S. Carbon Reductions*

We appreciate the opportunity to review the August 29 draft of the executive summary and chapter one of *Scenarios of U.S. Carbon Reductions*. In this draft, we note that the authors addressed many of our comments made at the August 19 meeting. Since this is a Department of Energy labs report, and not an interagency or CEA report, we do not intend to hold up the report simply because the views presented do not conform in all respects to our own. However, two modifications to chapter one should be made prior to the release of the report.

- First, all references to the "cost-effectiveness" of technologies should be removed and the estimates of costs and benefits in table 1.5 should be deleted. As we noted in our August 22 comments, the report does not appropriately account for all of the costs associated with technology adoption decisions. Without an assessment of the behavioral responses to policies aimed at stimulating technology adoption, the private cost of achieving these emission reductions is unknown. Further, the report insufficiently details the costs of government programs, and does not ascribe any costs to society of standards. Thus, claims of "cost-effectiveness" are premature at best.

  The benefits resulting from energy cost savings do not reflect appropriate energy prices and should not be provided in this table. Since the analyses are not integrated, the energy prices do not reflect declines in demand, resulting decreases in prices, and the behavioral responses of consumers. However, qualitative statements could be included in the text, such as: "The adoption of energy efficient technologies would result in substantial energy cost savings to consumers."

- Second, chapter one should clarify the divergence between the report's BAU case and the Annual Energy Outlook 1997 reference case. We understand that transportation emissions under the BAU reflect a modified assumption about fuel efficiency improvements in the AEO reference case. However, we do not understand the discrepancy in emissions for the buildings and industry sectors between the two reports (see comment 8 in August 22 memorandum). A discussion of the assumptions that resulted in this divergence, or a modification of the projected emissions would be appropriate.

We look forward to receiving your responses to our August 22 memorandum in the near future.

Comments on $500 million/year Technology Proposal

DOE's response does not appear to have answered the request of the Principals for a detailed description of the "technology option" in terms of specific policies (dollars spent on R&D, dollars spent on diffusion, imposition of standards, price measures, and moral suasion) and their best-guess estimated effects. At first DOE seems to say that the predicted effects are pure R&D, and then it turns out that there are hidden assumptions about public awareness changing or standards being changed. We continue to believe that much, if not all, of the R&D is probably worth doing, particularly along the lines of the PCAST report. But we also continue to believe in a pessimistic bottom line for the odds of incremental payoffs in terms of carbon reductions by 2010. As John Holdren said in his 9/28 presentation, the time lag for the payoff, even to applied R&D, is simply too long to expect that by 2010 we would get more than "diddly" from new spending.

DOE stated that this proposal is based on the efficiency case in the 5 Labs Study. In a review of the proposal presented on 9/29, it appears that there are numerous divergences from the 5 Labs Study efficiency case. In light of the inconsistencies apparent in the proposal, and the substantial methodological flaws in the 5 Labs Study, it seems imprudent to base significant policy decisions on information received thus far. The point was raised at the 8/19/97 meeting on the 5 Labs Study that this study should not go to or be used by principals. To date, there appears to be insufficient justification to modify this view.

General Comments

- The 5 Labs Study indicates that government programs, utility programs, and state programs cost 15% of technology costs (p. 1.13). Since DOE apportions all carbon savings in their proposal to the federal programs listed in the summary chart, we assume that all costs accrue to the federal government. In the "optimistic" assessment of the costs and benefits, DOE claims that government programs will likely only cost about 7% of technology costs, because half of emissions reductions occur through standards (see below). Assuming that this is true, and that the technology costs of the efficiency case range between $26 - $49 billion/year in the optimistic assessment (p. 1.14), then government programs should cost between $1.82 - $3.49 billion/year. However, using a 13.5% government cost stipulation (based on a 15% government program cost, minus 10% [instead of 50%] of these costs because of standards), the costs of government programs would range between $3.51 - $6.62 billion/year. The proposal presented on 9/29 costs 3 to 13 times less than projected by the 5 Labs Study, and yet generates greater carbon savings.

- The proposal employs standards to a much lesser extent than the 5 Labs Study. In the Study, "at least half of the efficiency occurs as a result of federal policies (e.g., standards and carbon permit charges)" (p. 1.13). Since the efficiency case does not include a carbon permit system, we assume that half of the carbon savings in the efficiency case result from standards. However, in this proposal, only about 10% of the emissions reductions occur due to standards (on the high ends of the ranges, 20 MMTCE out of 206 MMTCE).

- The projected carbon savings for 2010, while indicated as approximately 155 MMTCE, has a range of 127-206 MMTCE. Note that this large range does not overlap with the 5 Labs Study projection of 126 MMTCE (p. 1.12).

- The efficiency case is portrayed in the 5 Labs Study as carbon savings that occur because of already available and cost-effective technologies. In effect, government policies are only necessary to overcome market barriers. However, this proposal appears to be more reliant on R&D than on deployment and diffusion of existing technologies. Using the upper bounds of the ranges of carbon savings, we find that more than half of emissions reductions (104 of 206 MMTCE) result from R&D programs.

Specific Comments

Buildings Sector

Two programs claim to achieve 17-29 MMTCE. Note that under the 5 Labs efficiency case, 25 MMTCE of potential reductions were identified (p. 1.12), with a different penetration assumption than the one provided in the summary chart. The Study employed a 35% penetration rate assumption (p. 3.3), while this summary chart claims to be based on a 15-25% assumption for equipment efficiency and a 25% assumption for 21st Century Housing. With the lower penetration rate assumed in this proposal, we would assume that the carbon savings would be less than those found in the 5 Labs Study -- instead, they are greater. Based on these assumptions and the information provided by the 5 Labs Study, we would expect carbon savings to range between 11-18 MMTCE.

Equipment Efficiency: The 5 Labs Study indicates that a total of 25 MMTCE can be reduced in residential and commercial buildings under the efficiency case. The 9/26 memo describes this set of programs to include fuel cells, even though fuel cells are not in the 5 Labs efficiency case (they only come into play in high efficiency case, although the text is very unclear about whether fuel cells actually generate any benefits prior to 2020).

21st Century Housing: There is insufficient detail provided in the 9/26 memo to identify the appropriate carbon savings in the 5 Labs Study.

Transportation Sector

The 5 Labs Study projects 73 MMTCE reductions in emissions under the efficiency case (p. 1.12), while this proposal estimates carbon savings ranging between 65 - 87 MMTCE. Note that this upper bound is almost equivalent to the high efficiency case with a $25/ton permit fee in the Study (88 MMTCE).

Two PNGV Categories: The 5 Labs Study indicates that annual PNGV funding is approximately $250 million/year (p. 5.2). The two categories of increased PNGV programs would sum to $140 million/year in FY99 and $260 million/year in FY03. This increase is much less than believed necessary to achieve the goals of the PNGV program. The authors of the 5 Labs Study note that for PNGV to be successful, "substantial additional funding for R&D will be required, perhaps two to ten times what is presently being spent" (p. 5.7). The proposal increases funding to just the lower end of this required spending level.

Industry Sector

The 5 Labs Study projects 28 MMTCE of carbon emissions reductions under its efficiency case (p. 1.12). This proposal estimates carbon savings under three categories of programs ranging between 30 - 65 MMTCE. Note that the upper end of this range is 11 MMTCE more than the high efficiency case with a $25/ton permit fee in the 5 Labs Study.

Industries of the Future: In the 5 Labs Study, the list of heavy manufacturing industries in table 4.6 (p. 4.10) corresponds to the list of the Industries of the Future on the DOE webpage (http://www.oit.doe.gov/iof/industry.html). In this table, these industries account for only 9 MMTCE in the efficiency case and 21 MMTCE in the high efficiency case ($50/ton permit system). However, the proposal notes that Industries of the Future programs can achieve carbon reductions ranging between 10 - 20 MMTCE.

Utilities Sector

Three categories of programs claim to generate carbon savings of 15-25 MMTCE. However, the efficiency case in the 5 Labs Study does not project any reductions in carbon emissions in this sector (p. 1.12). Further, the carbon sequestration R&D category of programs is not described in the 9/26 memo.

For additional review of the methodological flaws in the sectoral analyses, refer to earlier memos that provide comments on the 5 Labs Study.

—

DOE Labs Study: Potential Reductions in Carbon Emissions in 2010

We estimated the emissions reductions under the high efficiency/low carbon with $50/ton permit scenario. The data are insufficient to calculate the emissions reductions for the $25/ton permit scenario, and in the efficiency scenario all reductions result from non-price policy influences.[1]

Buildings:

The study states that the penetration rate of cost-effective technologies under the high efficiency case is 65%: 60% results from unspecified programs and 5% from the permit price. We estimated the emissions reductions for each technology by multiplying the emissions reduction by 0.923 (60/65) to calculate the reductions from non-price policy responses. The remaining reductions were appropriated to the price response.

Note: Because of rounding in the numbers presented in appendix C-2, the technology reductions for commercial and residential buildings do not sum to the totals for this sector.

87% of the emissions reductions occur through non-price policy induced technology adoption.

Utilities:

All reductions occur because of the permit price.

Transportation:

Without documentation, it is impossible to discern the effects of specific technologies on the transportation sector. The report merely provides details on how these technology improvements can result in a percentage increase in fuel efficiency. In computing cost-effectiveness, the study assumed constant fuel prices at $1.20/gallon (p. 5.45). Since there is no assumed increase in fuel prices, we assume that all carbon reductions in this sector should be appropriated to the non-price policy response category.

Industry:

The analysis for this sector is not very revealing: the documentation from their model runs would be quite helpful. However, we can break it down by industry in several cases. The report does provide a set of examples of energy efficiency technologies, but does not indicate the extent of their adoption in this analysis.

62% of carbon emissions occur as a result of non-price policy influences on behavior.

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[1] While we assume that the efficiency scenario causes technology adoption through non-price policy response, the report does occasionally state that fuel taxes could be one policy option in this scenario (e.g., p. 5.3).

Review of DOE Labs Study

Unspecified Policies:

- *No Program Descriptions:* The authors do not estimate the costs or even describe the programs necessary to stimulate the adoption of the new energy-efficient technology they find could reduce emissions of approximately 200 million metric tons of carbon equivalent (MMTCE) by 2010. These reductions correspond to about ½ of the reductions needed to attain 1990 levels by 2010. In the absence of cost estimates this information is of little use in the evaluation of alternative policy options.

- *Costs of Programs*: Given reasonable assumptions, government programs may cost many tens of billions of dollars per year above the costs of existing programs to reduce 200+ million tons of carbon. The marginal cost of emissions reductions, including the cost of the government program, is likely to greatly exceed the permit price. As a result these programs may be less cost-effective than a cap-and-trade emissions control program.

- *Luck*: The transportation sector requires "luck" in terms of technological innovation to achieve the projected emissions reductions. Without a permit price, this luck appears likely only through stringent standards, such as increasing CAFE.

Overestimates Reductions/Underestimates Costs:

- *Behavioral Changes Ignored:* The analysis appears to ignore the behavioral changes that offset the energy efficiencies promised by the new technologies. For example, more efficient windows lead to houses with more glass, and more efficient cars lead to more vehicle miles traveled. Thus these innovations offer real value to consumers, but smaller energy savings than engineers forecast.

- *Cost Effectiveness Calculated Using Average, Not Marginal Prices*: Many of the innovations in electrical use appear to be assumed to be cost effective based on an assumption of average, not marginal electricity prices. The marginal prices may be half as much as the average prices. ← incl sunk costs?

- *Price Declines Resulting from Reductions in Energy Demand Are Not Taken into Account*: The study assumes a 12% decrease in energy use, but does not account for this effect on price when calculating cost effectiveness for energy efficient technologies.

- *Study Double Counts Emissions Reductions Occurring Under Business-As-Usual*: The labs study double counts 22 MMTCE in reductions in the efficiency case that will occur under the business-as-usual case.

- *Interactions Ignored, Double Counting "Likely" in Utilities Sector Analysis*: The double counting of dispatching and retooling coal plants to natural gas results in about 9 MMTCE of overestimated reductions.

- *Industry Sector Analysis Ignores the Costs of Accelerating Retirement.*

DOE Labs Study

Double Counting:

Reductions in BAU Double Counted 197 ~~[illegible]~~ millions CE AEEI 0.1 ?, About half Reconverted

Reductions in Utilities Sector Double Counted e.g. Fuel switching dispatching with existing plant – Refuel coal plants for natural gas

Cost Effectiveness Flaws

time horizon for alt view
Cost effectiveness
calculations: 18 yrs in bldgs
A-1.9

	Com	Res	
lighting	12	1	lifetime
other	~~8~~ 7	10	
	C-2.12	C-2.8	

Appendix C

Ignores Implementation Costs

Ignores Behavioral Changes e.g. more glass more vehicle miles traveled

Ignores Capital Retirement Acceleration

Ignores Falling Energy Prices from new tech.

many admitted

Using Average Costs Over-Estimates Energy Savings

Policies

How can we get there without a roadmap?

What will it cost us?

Focused on only 1 goal: 1990 in 2010

DOE Labs Study

Double Counting

Reductions in BAU Double Counted — 20 m tons of 0.1 % AEI double counted

Reductions in Utilities Sector Double Counted — e.g. fuel-switching with existing plant — Retooling for natural gas

Cost Effectiveness Flaws

Ignores Implementation Costs

Ignores Behavioral Changes

Ignores Capital Retirement Acceleration

Ignores Falling Energy Prices

Using Average Costs Over Estimates Energy Savings

Policies

How can we get there without a roadmap?

What will it cost us?

Focused on only 1 goal: 1990 in 2010

Table 1.5 Estimated Costs and Benefits of the Efficiency and High-Efficiency/Low-Carbon Scenarios : Optimistic and Pessimistic View Estimates (billions of 1995$, annualized)

	Efficiency Case[a]			High-Efficiency/Low-Carbon Case[b]		
	Benefits[c] (billion 1995$)	Costs[d] (billion 1995$)	Carbon[c] Savings MtC	Benefits (billion 1995$)	Costs (billion 1995$)	Carbon Savings MtC
Energy Efficiency						
Buildings	14-17	7-14	20-25	26-33	14-26	49-62
Industry	6-7	3-5	18-22	12-15	8-13	66-82
Transportation	22-27	16-30	58-73	32-40	23-43	82-103
Electricity Dispatch	0	0	0	0	2	44-55
Electricity Repowering	0	0	0	0	2	32-40
Other Low-Carbon Techologies	0	0	0	0	2	33-41
Total	**42-51**	**26-49**	**96-120**	**70-88**	**51-88**	**306-383**

Compare w/ 8/1 draft

[a] Energy efficiency category includes ethanol in transportation.

[b] Benefits and carbon savings in the HE/LC case are relative to BAU case.

[c] Benefits are calculated as annual energy savings. The scenarios are meant to be point estimates. In the "pessimistic" case, we have assumed that only 80% of the carbon savings are achieved, even though the technology and implementation costs are unchanged. The range on carbon savings represents this assumption.

[d] Costs are calculated from differing viewpoints: the "optimistic" case uses discount rates that vary between 7% and 12.5% for the different sectors, as described in the text. For the "pessimistic" case, the discount rates used to annualize costs vary between 15% and 20%. Also in this case, the cost of implementing programs (30%) and an overall package of programs and policies (15%) is taken to be twice that of the "optimistic" case.

The range of estimates in Table 1.5 reflects our attempt to "bound" optimistic and pessimistic assessments. There are clearly other ways in which these bounds could be described, just as there are many scenarios that could have been analyzed. However, we believe that the assumption that 80% of the carbon reductions are achieved at the costs identified, valuation of costs and benefits at discount rates noticeably higher than the likely cost of capital, and doubling the cost of programs and policies from typical experience today is a strong reflection of pessimism in costs for our cases. It is worth noting that if the implementation costs were taken to be much higher than we believe to be reasonable – 50% of investments costs for programs and 25% overall – this would add about $10 billion per year to the costs of the high-efficiency/low-carbon in the pessimistic case.

In addition to these costs, one needs to calculate the impact of the cases on natural gas demand. In all of these cases, natural gas replaces very large quantities of coal. Higher natural gas demand would result in higher natural gas prices, which in turn would increase the cost of substituting natural gas for coal in power production, etc. As it turns out, our scenarios have somewhat reduced gas demand compared with the BAU case (or with AEO97 baseline for 2010, on which the price of natural gas in our work is based). Specifically, demand for natural gas in the HE/LC ($50/tonne) case declines in 2010 by 2 quads compared with the business-as-usual case. This is the result of declines of 0.5 quads for buildings, 1.0 quads for industry, and 0.5 quads for electricity. The latter occurs because of the balance among three factors:

- Increase in gas demand because of the large-scale substitution of natural gas for coal
- Decrease of gas demand because of the use of many low-carbon technologies that do not use natural gas (wind, nuclear power plant extensions, power plant efficiency upgrades, hydropower expansion, co-firing with biofuels), and

Joseph E. Aldy
09/04/97 09:26:24 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:
Subject: Read before you talk to Mark Mazur: DOE 5 labs study

Jeff,

I thought about the 5 labs study during my jog, and I have changed my mind. I really don't think we should have them include energy savings in the report (the renaming of benefits I mentioned in my earlier email). I think their numbers are absolute trash, and we should make that very clear. I don't think we want to be fighting these numbers once they get out. Mark may ask you why we have such serious problems with their estimates -- although we highlight many failings in our August 22 memo. Here are some key points:

Benefits/Energy Savings

--> The energy savings calculations do not incorporate behavioral responses that would lead to an increase in energy use. If air conditioners use less energy per output, people run them more often. If cars are more fuel efficient, people will drive more.

--> The energy savings calculations do not incorporate the price decline associated with reduced demand for energy. Energy consumption in the high efficiency case declines 12% relative to BAU -- while Mark claimed to me that this is "just a second order effect", I think 12% appears substantial.

--> The energy savings calculations for buildings use average cost, not marginal cost, of electricity, and therefore overestimate energy savings.

--> The economics literature has found that actual energy savings do not compare to engineers' dreams of energy savings because real people live in real houses and work in real firms, not in ideal model houses and ideal model firms (Metcalf and Hassett 6/97 NBER paper).

Costs

--> The government cost estimates are "made up" according to Mark. Our estimate indicates that the cost to government could be tens of billions of dollars per year. Further, they do not assess the costs of standards (e.g., CAFE, national building codes, appliance standards) which account for half of all emission reductions.

--> The industry sector analysis ignores the costs of accelerating capital retirement.

--> Without any empirical or theoretical justification, the transportation sector analysis assumes that a whole set of technologies will come into play and will achieve 100% penetration in 20 years at NO NET COST. This is the "luck" that is required by the analysis.

Joseph E. Aldy
09/05/97 03:17:12 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:
Subject: Gruber and 5 labs

Jeff,

I just spoke with Jon about the 5 labs study. He agrees that we should stand by our guns on this one. He asked me to call Mark Mazur and tell him that the bottom line is that we (CEA and Treasury) will not sign off on the report so long as that chart and references to the costs stay in. I just left a message for Mark with his secretary. Jon said he would also call TJ and relay this to him. What happens if we don't sign off and they release the report as is?

Joe

DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220

September 4, 1997

MEMORANDUM FOR T. J. GLAUTHIER

FROM: Robert Gillingham RG
Jonathan Gruber JG

SUBJECT: 5-Labs Revision

We think this revision is a substantial improvement. Most of our comments are editorial (see attached draft). The major exceptions revolve, not surprizingly, around the treatment of "cost" estimates. We continue to feel that the analysis presents scenarios that *could* be achieved, rather than scenarios that *should* be achieved—regardless of climate benefits—on the basis of cost savings. To address this concern, we recommend (1) eliminating the modifier "cost-effective" when referring to technologies, (2) deleting Table 1.5 and substantially modifying or eliminating the discussion of costs on pp. 15 through 18, and (3) weakening the claim of rough cost/benefit parity in the second overarching conclusion in the executive summary (*e.g.*, recognizing that energy savings are a substantial offset without arguing relative magnitude).

We continue to believe the scenarios are informative primarily in terms of what is technically feasible. We do not believe the paper demonstrates the validity of the criteria used for selecting "cost-effective" technologies. The reasons for this skepticism are outlined in our earlier comments - the underlying model of the costs of technology adoption is not economically rigorous, with limitations that include low discount rates, and in particular extremely low implementation costs.

We view these criteria as one way of selecting technologies that could be adopted; the paper then does a very good job of quantifying the impact of adopting these technologies on energy use and carbon emissions. A possible substitute for Table 1.5 might be a table of reductions in energy consumption valued at today's (or 2010's) prices to quantify the *energy-cost* saving, with the appropriate caveat that it would take a full-blown general-equilibrium analysis (beyond the scope of the paper) to determine what prices would actually obtain. Going further than that, in our opinion, is too ambitious and—for the purposes of this paper—is not critical.

Joseph E. Aldy
09/29/97 04:53:56 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:
Subject: for your 5pm: technology and 5 labs

Jeff,

3 numbers to think about for your meeting:

1) 5 Labs predicts economic costs from private investment of $26-$49 billion/year for the efficiency case (the basis of today's technology discussion). This gets you ~120 MMTCE (or 155 in today's discussion). This cost number is in addition to government costs (estimated today at $500 million/year).

2) A back of the envelope estimate of how much it costs per ton to generate 120 MMTCE of carbon savings at a price tag of $50 billion would be more than $400/ton. (Simply dividing $50 b/120 MMTCE.)

3) To gain a sense of context about what $50 billion/year in private investment means, consider that net income to corporations in 1993 was about $500 billion.

Joseph E. Aldy
09/04/97 06:56:18 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:
Subject: conversation with Mark Mazur

Jeff,

I just got off the phone with Mark. He called regarding our comments on the 5 labs study we faxed over today. The good news: our second point on the baseline will be addressed. The bad news: they want to keep their benefits and costs numbers in there. Regarding benefits, they would be willing to change the term to energy savings, but they don't want to change the costs. He suggested that they could include a statement that this is not a full social benefit-cost analysis. I expressed concern that the numbers in the charts, even with caveats in the text, could be misused. I told him I would talk to you about this. I stated that I could live with changing benefits to energy-savings, but I had serious reservations about keeping costs in there. Regarding our concern about cost-effectiveness, Mark said that they would go through and remove some, and be more careful about their use of the term, but that they would likely keep the term in there in some cases.

Mark also asked me what we are doing on T&T, following up from the meeting this afternoon. I said that we were thinking about the issue. He said that Gardiner is concerned about us using "his researchers" -- bascially, Battelle. Mark asked if we had asked Battelle to do runs for us, and I said we had asked for a couple. Mark then asked me if we were using any DOE staff, and I told him that we asked Phil Tseng to do 3-4 runs for us a couple of weeks ago. He then asked me if were using any other EPA folks (G-cubed or DRI), and I told him that we had talked to some EPA folks 3-4 weeks ago for some of the outputs from IAT runs, but we had not asked them to do any model runs for us. I hope I didn't say too much -- Mark said that while I wasn't a fountain of knowledge, I was less evasive than you.

Mark will call you in the morning to discuss both the 5 labs study and the T&T issue. Have fun.

Joe

MEMORANDUM

TO: Jay Shogren

FROM: Joe Aldy and Quindi Franco

DATE: August 11, 1997

RE: Review of DOE Labs Study, June 10 Draft

We provide an assessment of *U.S. Carbon Reductions by 2010 and Beyond: The Potential Impact of Energy-Efficient and Low-Carbon Technologies* (DOE Labs Study, June 10 draft). The report identifies carbon reductions and their associated costs in the buildings, industry, transportation, and electric power sectors under two hypothetical climate policy scenarios. The study finds that, with unspecified "very aggressive policies" and a $50/ton permit price, carbon emissions can be stabilized at 1990 levels by 2010. In reviewing the report, we believe it is Yes beneficial to highlight several limitations of the study. First, the authors do not provide descriptions of the government programs necessary to stimulate the necessary technology adoption to reduce emissions of 180 million metric tons of carbon equivalent (MMTCE). Based on the actual history of CCAP, we estimate the costs of government programs to achieve these ? reductions could total $45 billion (1995$), depending on the form of the marginal cost curve. Really? We annuitized this figure and found that government programs could cost $1.1 billion annually into perpetuity. These are costs in addition to existing program costs to improve energy efficiency technology development and adoption. Second, the analyses across sectors are not integrated. Therefore, the penetration rate of energy efficient technologies may be overestimated because the separate sectoral analyses do not account for declines in fuel prices. Third, the industry sector analysis ignores the costs of accelerating capital retirement, resulting in either an overestimate of reductions or an underestimate of costs. Fourth, the transportation sector requires "luck" in terms of technological innovation to achieve the projected emissions reductions. Fifth, the utilities sector analysis resulted in double counting of emissions reductions. These examples of the qualifications can provide additional insight into the projections of emissions reductions and costs. Upon receiving the final version of the report and documentation of the analyses, we will update this review.

Overview of Report

The Labs Study estimated the carbon emissions reduction opportunities available through technology development and adoption and fuel switching. The Study employs the Energy Information Administration's 1997 baseline (AEO97) for the buildings and industry sectors. For the transportation sector, the authors changed the AEO97 assumption of increasing fuel efficiency in automobiles to constant fuel efficiency. For the utility sector, the baseline was Double counting. modified to reflect a fully competitive bulk-power market in the year 2010. Discharge, shutdown, repowering, and new construction decisions were optimized to select the amount of capacity that minimized the cost of the power-supply system plus the cost of unserved energy. Compared to AEO97, the final baseline has slightly lower energy prices, larger electricity sales, and a greater share of gas generation. The study provides emissions reductions from this baseline for two scenarios: 1) "efficiency" and 2)"high efficiency/low carbon", over the period 1998-2010. The study describes neither the policies necessary to achieve emissions reductions nor the costs of federal programs for these scenarios, only their outcomes: increased adoption rates and better technologies.

Efficiency Scenario

This case assumes that all technologies adopted are at zero or negative net cost to the user given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. The Study estimates that 120 MMTCE will be reduced at negative net cost in this scenario. None of these reductions occur in the utility sector as a function of fuel switching or technology adoption to increase combustion efficiency.

High Efficiency/Low Carbon Scenario

This case assumes a "greater commitment" to reduce emissions through federal policies, in concert with state and private activities and a $50/ton permit price that stimulates low carbon technologies (read: primarily fuel switching). The policy is announced in 2000 and the policy's restrictions are phased-in through 2010. There is an assumed announcement effect (although an AEEI is not specified), increased domestic and international R&D in low-carbon technologies, and a "change in psychology". The Study estimates reductions of 180 MMTCE from the baseline through energy efficient technology adoption at negative net cost (see high efficiency without low carbon technology in chart below). The carbon permits will yield an additional 150-200 MMTCE of reductions through low-carbon technology adoption. Given that these occur at a permit price of $50/ton, the Study estimates the upper limits of these costs to be $10 billion per year in 2010.

Carbon Emissions (MMTCE): 1990 - 2010

1990	2010 Baseline	2010 Efficiency	2010 High Efficiency (w/o Low Carbon Tech)	2010 High Efficiency/Low Carbon
1340	1720	1600	1540	1340 - 1390

Review

The Lab Study employs several important assumptions in the analyses. Learning about these qualifications can enhance one's understanding of the estimates regarding cost-effectiveness and emissions reductions in this study. We present several of the most significant assumptions and discussions of their impact below.

The Study Does Not Specify Policies to Achieve Carbon Reductions

> "Cost effectiveness is improved because R&D, in combination with increased deployment efforts, result in declining capital costs. We do not specify the policies, economic conditions, or exogenous events that could precipitate such changes" (p. 1.4).

The entire study is premised on two sets of undefined policies: an "aggressive" or "invigorated" public sector effort to stimulate energy efficient technology adoption (efficiency case) and a "very aggressive" public sector effort to stimulate technology development and adoption (high efficiency/low carbon case). The only specific policy instrument mentioned in the report is a \$50/ton tradeable permit. The study makes vague references to policies and only provides details on what these unidentified policies would result in: 1) "better technology" (p. 1.5); 2) "higher penetration rates" (p. 1.6); 3) "changing the capital recovery factor [in industry sector] from 33% to 15%" (p. 4.8); and 4) "technological breakthroughs" (p. 5.3). These policy effects would result in reductions of 180 MMTCE for "free": firms and individuals receive energy cost-savings in excess of technology adoption and implementation costs.

The report specifically states that the efficiency case reduces, but does not eliminate, market barriers (p. x) and that implementation costs are ignored (p. xvi). First, we will discuss the implications of reducing market barriers, and then we will address the cost issue. Market barriers occur in 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 or market analysts). A person addresses 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. Policy intervention to eliminate a market barrier cannot make society better off and usually makes society worse off, regardless of the implementation mechanism.[1]

The economics 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.

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[1] In contrast, policy intervention to eliminate a market failure (such as carbon emissions) may make society better off, depending on the costs of the intervention.

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.

These four types of market barriers illustrate the economic behavior that explains the apparent under adoption of energy efficiency technology (the "efficiency gap"). These barriers clearly demonstrate the difference between the technological maximum adoption (which only assumes technology costs) and the economic maximum adoption (which assumes total costs). A set of climate change policies to stimulate technology adoption could increase efficiency, but only because they also decrease the effect of a market failure (carbon emissions). Social welfare is improved because the net benefits of indirectly fixing the market failure exceed the costs of removing the barriers. If carbon emissions are appropriately priced (assuming in this case that $50/ton is the correct carbon price), a policy to remove a barrier (e.g., lower the capital recovery factor from 33% to 15%), will generate negative net benefits. High adoption rates will be realized once prices rise enough for some technologies to clear the barriers.

From the literature on market barriers, we know that the costs of reducing barriers are greater than their benefits. In this case, the authors of the Labs Study do not provide an estimate of the costs to government to lower market barriers to achieve these substantial reductions (and they only provide benefits in terms of projected emissions reductions). We calculated estimates of the costs of emissions reductions programs based on the government's experience with the Climate Change Action Plan (CCAP). CCAP promotes carbon reductions through a broad array of voluntary programs that stimulate "cost-effective" technology adoption by private firms. Participation by a firm in a CCAP program implies that carbon is reduced and the firm gains financially.[2] CCAP received appropriations totaling $494 million (1995$) during the FY95 - FY97 period. During this period, the Department of Energy and the Environmental Protection Agency can account for reductions of 14 MMTCE (see attached table). Each ton of carbon reduced in CCAP cost the federal government, on average, $35.29 (1995$) over this three year period. Assuming a flat marginal cost curve (MC = AC of CCAP) to reduce 180 MMTCE beyond the baseline, the government costs of the unidentified policies in the Labs Study would

[2] Note that CCAP efforts are incorporated in the AEO97 baseline.

exceed $6.3 billion. To account for the opportunity cost of capital through time, we annuitized this value and found that government costs would run about $150 million annually into perpetuity.[3] However, the marginal costs of technology adoption in the efficiency and high efficiency/low carbon scenarios are definitely higher than the average cost of 14 million metric tons reduced in the baseline scenario, especially as more and more efforts to reduce emissions are undertaken. Assuming that costs increase 10% for every 10 million metric tons of carbon reduced, then the government cost would total $16.1 billion (annuity of $375 million). This is a slowly increasing marginal cost curve given baseline assumptions of gains in energy efficiency. Assuming that costs increase 20% for every 10 million metric tons of carbon reduced, then the cost to government would exceed $45.2 billion (annuity of $1.1 billion) (see attached chart).

The Sectoral Analyses Are Not Integrated

> "The model runs for each of the three end-use sectors were not integrated and therefore may overstate the effects of technology penetration. In an integrated modeling effort, fuel prices might fall as consumption declines, resulting in less penetration of energy-conserving technologies" (p. 1.1).

The analyses of the various sectors assume that the reduction of 180 MMTCE occurs through energy efficient technology adoption without any price effect. This implies that, with government programs, private agents will adopt technologies because the benefits (energy cost-savings) exceed the costs of adoption. The authors claim that these reductions occur at zero or negative net costs. By failing to account for the effect of decreased energy demand due to energy efficiency technology adoption, some of those adoption decisions that occur on the margin would no longer generate positive net benefits for private consumers. The Labs Study indicates that energy consumption will decline from the baseline by 11.6% under the high efficiency/low carbon case (p. xi). This decrease in demand should result in a decrease in the price of energy, and cause some energy efficient technologies to become unattractive to private agents.

In addition, the absence of an integrated analysis precludes an assessment of the economy-wide effects of a tradeable permit system. As previous studies have indicated, the nature of the permit allocation (e.g., grandfathering, auction, or a hybrid) and the characteristics of the revenue recycling (e.g., various adjustments to existing taxes) can affect economy-wide investment. Understanding the effects on investment is instrumental in assessing the likelihood of success of these scenarios, given that they rely on substantial R&D and technology adoption.

The Industry Sector Analysis Ignores the Costs of Accelerated Retirement

> "When the economic losses of accelerated retirement are accounted for this means that, at the margin, all investments are not likely to be cost effective at our assumed 15% CRF [capital recovery factor]. Since we do not have a model to

[3] We employed a 7% discount rate to calculate the annuities in this paper.

> account for this potential early retirement and the economic losses, we must caveat our estimates of investment and net costs. ...the investment cost may be understated by the amount of loss due to any early retirement that may occur" (p. 4.15).

This assumption implies that one of three results should be accounted for in the analysis. First, the projected emissions reduction should be revised downward, because the assessment of the industry sector overestimates technology adoption by ignoring these costs. Second, the cost of reducing emissions, if the reduced carbon from this sector remains constant, should increase, with some technology adoption decisions occurring at positive net costs. Third, if the authors maintain the same costs and emissions estimates, then the costs of government programs to somehow force down the CRF from 33% to 15% would increase.

The Transportation Sector Requires "Luck" to Achieve Carbon Reductions

> "[B]ecause the [transportation sector] outcomes postulated in the high efficiency/low carbon scenario require technological breakthroughs, they require a certain degree of luck to be achieved by 2010. There are no credible methods to accurately gauge the probability of such breakthroughs -- we believe they stand a decent chance of occurring with an intensification of research efforts, but we stop short of claiming they are a likely outcome of such an intensification" (p. 5.3).

Note that this statement includes two qualifications: luck on top of intensified research efforts. To achieve just the efficiency level of emissions reductions for this sector (73 MMTCE), these intensified research efforts may require two to ten times existing funding on transportation (p. 5.3). To gain a sense of the magnitude of what such an increase in funding might be, consider that the Partnership for a New Generation of Vehicles (PNGV) alone is funded at the federal level at $263 million. Private sector costs of participating in the PNGV are in addition to this large sum. Further, the estimates of costless (on net) carbon reductions relies on a series of tenuous assumptions: commercial development of the fuel cell for passenger cars, commercial availability of cellulosic ethanol (and the elimination of the ethanol excise tax exemption), and an apparently arbitrary 30% reduction in costs for "certain key technologies" (p. 5.24). These technologies are not identified, and the report does not provide documentation for the NEMS model runs conducted for the transportation sector.

Interactions Ignored, Double Counting "Likely" in Utilities Sector Analysis

> "Chapter 7 considers other electricity supply technology options, including: converting coal-based power plants to natural gas; cofiring coal with biomass; efficiency improvements in generation and transmission and distribution systems; extending the life of existing nuclear plants; increasing generation and capacity of existing hydropower plants; and constructing new powerplants using advanced coal technologies. Each of these options is assessed independently. Thus,

interactions between the options are not taken into account, and the possibility of double counting is therefore likely" (p. 7.1).

The emissions reductions in the electricity sector come from two sources. First, utilities undertake fuel switching at the $50/ton permit price through carbon-ordered dispatching. Second, utilities modify their capital stock through several technology options such as those listed in the above quotation. As electricity production moves away from coal in the first analysis, fewer and fewer plants (and therefore potential emissions reductions) will be available for conversion to natural gas or cofiring with biomass. The second set of analyses were "static" and did not optimize unit/plant production cost, dispatch, or system load. Conversations with one of the co-authors (Stanley Hadley of Oak Ridge National Laboratory) indicate that 10 GW of coal-to-gas conversions (approximately 9 million tons of carbon reductions) were double-counted.[4]

Furthermore, the analysis of specific options did not examine the effect of increasing fuel prices (from gas demand due to coal-to-gas repowering). Given the range of assumptions considered in the study, the authors actually estimated that repowering coal plants for natural gas could result in carbon reductions between 5 million and 269 million tons (p. 7.2), depending on the gas/coal price differential, the cost of carbon, and the costs of sulfur dioxide and nitrous oxide emissions. This is quite a substantial range. The Labs Study estimates that natural gas consumption will increase 14% to 191% above 2010 baseline consumption. However, the DRI 1.25 run in the IAT report indicates a 16% decline in natural gas consumption, while the SGM run resulted in only a negligible decline and Markal-Macro generated a 6% increase in natural gas consumption. These three models indicate that a non-integrated analysis that does not account for the price change in natural gas may overestimate natural gas substitution for coal and emissions reductions from fuel switching.

[4] Hadley noted that a subsequent draft of the report should address at least some of the double counting, but he did not provide details.

Summary of Greenhouse Gas Emissions-Reduction Actions

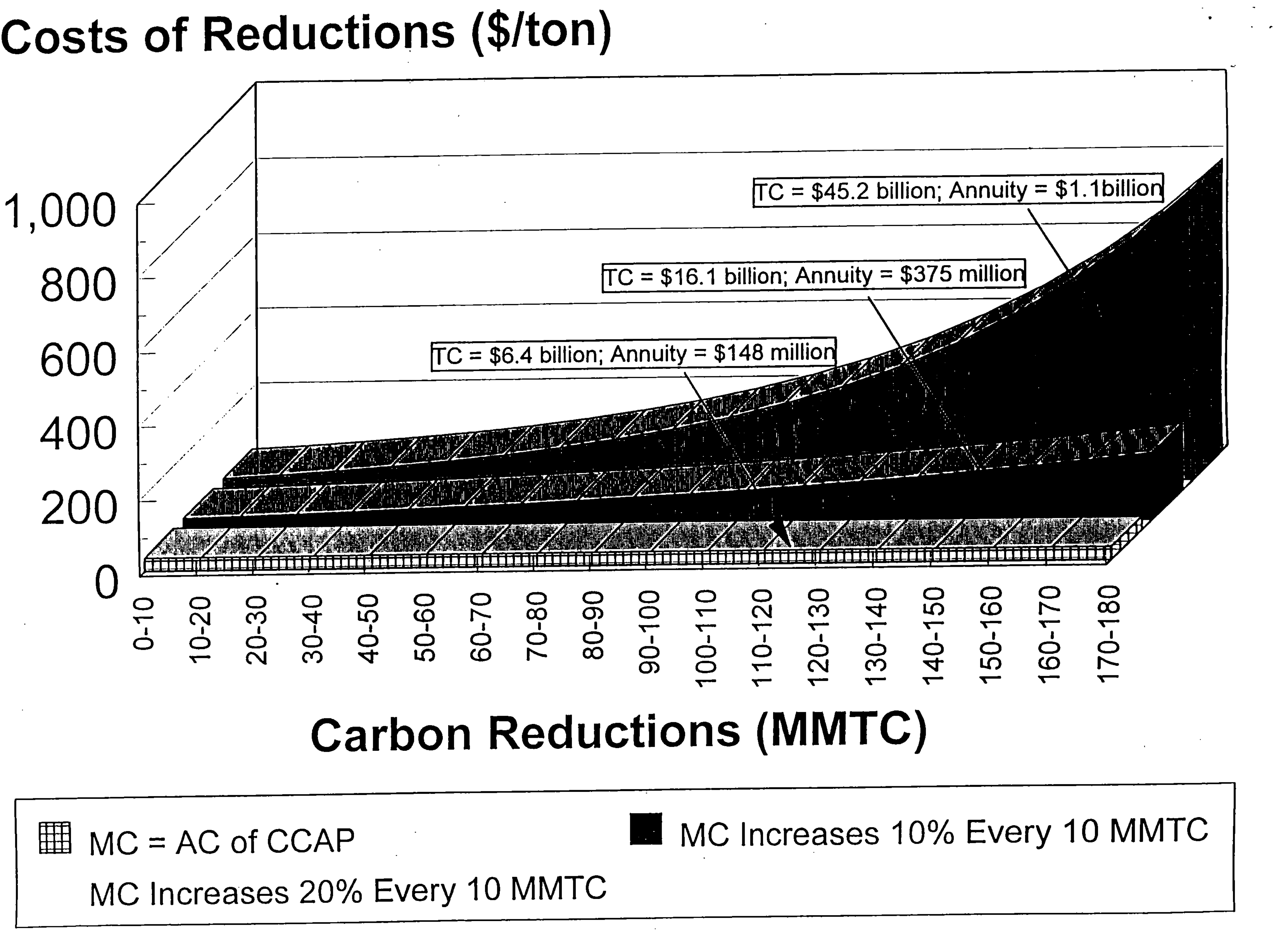
Million Metric Tons of Carbon Equivalent

Source: U.S. Climate Action Report—1997

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
Residential & Commercial Sector Actions		26.9	10.3	–
New	Rebuild America	2.0	1.6	–
1 and 2	Expanded Green Lights and Energy Star Buildings	3.6	3.3	–
3	State Revolving Fund for Public Buildings	1.1	Terminated	
4 5	Cost-Shared Demonstrations of Emerging Technologies Operation and Maintenance Training for Commercial Building Facility Managers and Operators	3.8	0.0	–
6	Energy Star Products	5.0	4.3	–
7	Residential Appliance Standards	6.8	0.2	–
8 and 11 9 10	Energy Partnerships for Affordable Housing Cool Communities Update State Building Codes	4.4	0.4	–
New	Construction of Energy-Efficient Commercial and Industrial Buildings		0.1	–
New	Superwindow Collaborative		0.0	–
New	Expand Markets for Next-Generation Lighting Products		0.2	–
New	Fuel Cells Initiative		0.0	–
Industrial Sector Actions		19.0	4.8	–
12	Motor Challenge	8.8	1.8	–
13 14	Industrial Golden Carrot Programs Accelerate the Adoption of Energy-Efficient Process Technologies	2.9	Merged into Action 12 Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	–
17 18	Improve Efficiency of Fertilizer Nitrogen Use Reduce the Use of Pesticides	2.7	0.8 Terminated	–
Transportation Sector Actions		8.1	5.3	–
19 20 21	Cash Value of Parking Innovative Transportation Strategies Telecommuting Program	6.6	4.6	–
22	Fuel Economy Labels for Tires	1.5	0.7	–
Energy Supply Actions		10.8	1.3	–
23	Increase Natural Gas Share of Energy Use Though Federal Regulatory Reform	2.2	Terminated	

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
24	Promote Seasonal Gas Use for Control of Nitrogen Oxides	2.8	0.5	--
25	High-Efficiency Gas Technologies	0.6	Terminated	
26	Renewable-Energy Commercialization	0.8	0.3	--
27	Expand Utility Integrated Resource Planning	1.4	Terminated	
28	Profitable Hydroelectric Efficiency Upgrades	2.0	0.0	--
29 30	Energy-Efficient Distribution Transformer Standards Energy Star Distribution Transformers	0.8	0.5	--
31	Transmission Pricing Reform	0.8	Terminated	
New	Green Power Network	Not included	0.0	--
Land-Use Change & Forestry Actions		10.0	2.4	--
43	Private Depletion of Nonindustrial Private Forests	4.0	Terminated	
44	Accelerate Tree Planting in Nonindustrial Private Forests	0.5	0.4	--
16	Waste Minimization	4.2	2.0	--
9	Expand Cool Communities	0.5	To be determined	
Methane Actions		16.3	15.5	--
32	Expand Natural Gas STAR	3.0	3.4	--
33	Increase Stringency of Landfill Rule	4.2	6.3	--
34	Landfill Methane Outreach Program	1.1	1.9	--
35	Coalbed Methane Outreach Program	2.2	2.6	--
36	RD&D for Coal Mine Methane	1.5	Terminated	
37	RD&D for Landfill Methane	1.0	Terminated	
38	AgSTAR Program	1.5	0.3	--
39	Ruminant Livestock Efficiency Program	1.8	1.0	--
Actions to Address Other Greenhouse Gases		16.3	25.4	--
17	Improved Fertilizer Management	4.5	5.3	--
40	Significant New Alternatives Program	5.0	6.4	--
41	HFC-23 Partnerships	5.0	5.0	--
42	Voluntary Aluminum Partnership	1.8	2.2	--
New	Environmental Stewardship Initiative	Not included	6.5	--
Foundation Actions			11.3	--
	Climate Wise	Not estimated	1.8	--
	Climate Challenge	Not estimated	7.6	--
	State and Local Outreach Programs	Not estimated	1.9	--
Total GHG Emission Reductions From CCAP		108.6	76.0	14.0

Data is not readily available for cumulative emissions reductions for many CCAP programs. Emissions reductions of about 5 MMTCE can be attributed to DOE's CCAP programs. EPA's Office of Air and Radiation is responsible for emissions reductions of about 9 MMTCE through their CCAP programs.


Costs of Reductions ($/ton)
1,000
800
600
400
200
0
TC = $45.2 billion; Annuity = $1.1billion
TC = $16.1 billion; Annuity = $375 million
TC = $6.4 billion; Annuity = $148 million
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100
100-110
110-120
120-130
130-140
140-150
150-160
160-170
170-180
Carbon Reductions (MMTC)
MC = AC of CCAP
MC Increases 10% Every 10 MMTC
MC Increases 20% Every 10 MMTC

J
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~~Jeff Frankel~~

DEPARTMENT OF THE TREASURY
WASHINGTON, D.C. 20220
August 21, 1997

MEMORANDUM FOR T. J. GLAUTHIER
JOE ROMM

FROM: Robert Gillingham RG
Jonathan Gruber

SUBJECT: Comments on the "5-labs" Study

The 5-labs 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 government can or should do to enhance the role technology will play in mitigating the growth of carbon emissions. In particular, the contribution of the report is to document energy savings and emissions reductions that would accrue if U.S. consumers and businesses move closer to the current (and, in some cases, reasonably anticipated) technology frontier. Despite its efforts to justify these moves as "cost-effective," the report does not address the policies that would be needed to actually get consumers and businesses to adopt the technologies described in the report, nor does it present a rigorous assessment the societal costs that would accrue if they did. We believe that the results of the report should be presented as an accounting of what can, and might, be done, but not as a description of what should be done or how to do it. For instance, the analysis of refrigerators is best interpreted as a description of the energy and emissions that would be saved if 35 or 65 percent bought particular, energy-efficient models, rather than a policy goal or prescription. It is premature, furthermore, to argue that other choices would be against the best interests of the consumers actually making purchase decisions. The accounting of energy and emissions in the study is much more rigorous than the accounting of costs and welfare.

We appreciated the opportunity to read and comment on the report. We have attached more detailed comments that we hope you find useful.

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 in 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

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[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

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[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

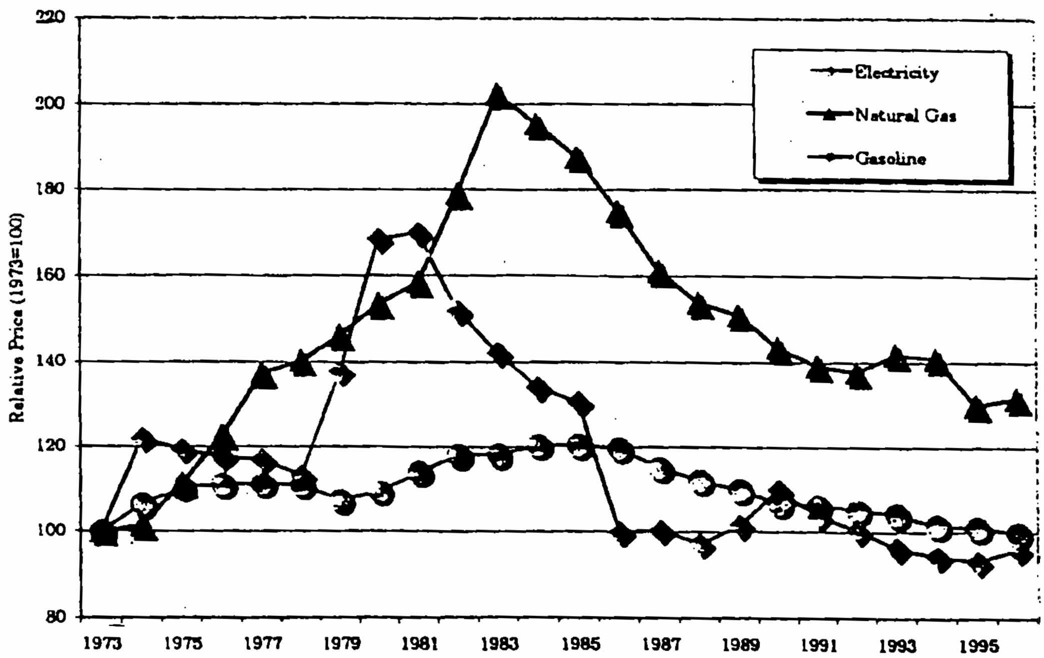
As the above discussion demonstrates, the study is primarily a catalog of potential improvements in energy efficiency. Neither the determinants of these improvements, nor their implications for energy demand behavior are examined. Rather, the study provides an *accounting* of two very stylized scenarios. 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.

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

SENIOR ECONOMIST

MEMORANDUM

TO: Joe Romm
Acting Assistant Secretary for Energy Efficiency and Renewable Energy

FROM: Randy Lutter and Joe Aldy

DATE: September 4, 1997

RE: Comments on revised executive summary and chapter one of *Scenarios of U.S. Carbon Reductions*

We appreciate the opportunity to review the August 29 draft of the executive summary and chapter one of *Scenarios of U.S. Carbon Reductions*. In this draft, we note that the authors addressed many of our comments made at the August 19 meeting. Since this is a Department of Energy labs report, and not an interagency or CEA report, we do not intend to hold up the report simply because the views presented do not conform in all respects to our own. However, two modifications to chapter one should be made prior to the release of the report.

- First, all references to the "cost-effectiveness" of technologies should be removed and the estimates of costs and benefits in table 1.5 should be deleted. As we noted in our August 22 comments, the report does not appropriately account for all of the costs associated with technology adoption decisions. Without an assessment of the behavioral responses to policies aimed at stimulating technology adoption, the private cost of achieving these emission reductions is unknown. Further, the report insufficiently details the costs of government programs, and does not ascribe any costs to society of standards. Thus, claims of "cost-effectiveness" are premature at best.

  The benefits resulting from energy cost savings do not reflect appropriate energy prices and should not be provided in this table. Since the analyses are not integrated, the energy prices do not reflect declines in demand, resulting decreases in prices, and the behavioral responses of consumers. However, qualitative statements could be included in the text, such as: "The adoption of energy efficient technologies would result in substantial energy cost savings to consumers."

- Second, chapter one should clarify the divergence between the report's BAU case and the Annual Energy Outlook 1997 reference case. We understand that transportation emissions under the BAU reflect a modified assumption about fuel efficiency improvements in the AEO reference case. However, we do not understand the discrepancy in emissions for the buildings and industry sectors between the two reports (see comment 8 in August 22 memorandum). A discussion of the assumptions that resulted in this divergence, or a modification of the projected emissions would be appropriate.

We look forward to receiving your responses to our August 22 memorandum in the near future.

Review of DOE Labs Study, August 1 Draft

We review *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond* (DOE Labs Study, August 1 draft). The report identifies carbon reductions from the adoption of specific identified technologies in the buildings, industry, transportation, and electric power sectors. The study finds that unspecified "very aggressive policies" and a $50/ton permit price would stabilize carbon emissions at 1990 levels by 2010. We believe several limitations of the study should be highlighted; some of these are serious.

- First, the authors do not estimate the costs or even describe the programs necessary to stimulate the adoption of the new energy-efficient technology they find could reduce emissions of 197 million metric tons of carbon equivalent (MMTCE) by 2010. These reductions correspond to about ½ of the reductions needed to attain 1990 levels by 2010. In the absence of cost estimates this information is of little use in the evaluation of alternative policy options.

  --The recent history of CCAP suggests that nearly a half billion dollars of government investment achieved just 14 million tons of carbon reductions. There are important unanswered questions about emissions reductions in the outyears, and the extent of diminishing returns associated with the expansion of existing government programs. We believe, however, that

  o reasonable assumptions about answers to these questions would imply that government programs to achieve emissions reductions of 197 million tons of carbon may cost many tens of billions of dollars per year above the costs of existing programs. (See below for an illustrative calculation.)

  o The marginal cost of emissions reductions, including the cost to the taxpayer of the government program, is likely to greatly exceed the permit price. As a result these programs may be less cost-effective than a cap-and-trade emissions control program.

  --The efficiency improvements in the vehicle sectors and in the building sectors appear to be so large as to be likely to be achievable only with substantially more stringent new mandatory national standards, i.e., corporate automobile efficiency standards, or national building codes. In addition, the phase in periods for these codes may be quite rapid.
  have to be

- Second, the analysis appears to ignore the behavioral changes that offset the energy efficiencies promised by the new technologies. For example, more efficient windows lead to houses with more glass, and more efficient cars lead to more vehicle miles traveled. Thus these innovations offer real value to consumers, but smaller energy savings than engineers might forecast.

- Third, the analysis appears to ignore the value of delaying investments in capital goods which are rapidly improving in efficiency. The price of compact fluorescent lights has declined by nearly 50 percent over the last decade; the energy efficiency of refrigerators has improved at a similar pace. Given these changes, accepting a few years of the high energy bills associated with an existing capital stock, and investing later in a mature new technology, may be less costly than investing earlier in innovations that are better than the old technology, but have rapidly declining prices or improving efficiencies.

  Similarly, many of the innovations in electrical use appear to assumed to be cost effective based on an assumption of average, not marginal electricity prices. The marginal prices may be half as much as the average prices.

- Fourth, the industry sector analysis ignores the costs of accelerating capital retirement.

- Fifth, the transportation sector requires "luck" in terms of technological innovation to achieve the projected emissions reductions.

- Sixth, the utilities sector analysis resulted in double counting of emissions reductions.

- Seventh, the labs study double counts 22 MMTCE in reductions in the efficiency case that will occur under the business-as-usual case.

Upon receiving the final version of the report and documentation of the analyses, we will update this review.

Overview of Report

The study provides emissions reductions for three scenarios: 1) "efficiency"; "high efficiency/low carbon with $25/ton permits" and 2)"high efficiency/low carbon with $50/ton permits", over the period 1998-2010. The study describes neither the policies necessary to achieve emissions reductions ~~nor the costs of federal programs for these~~ scenarios, only their outcomes: increased adoption rates and better technologies through technology development and adoption and fuel switching.

The Study employs the Energy Information Administration's 1997 baseline (AEO97) for the buildings and industry sectors. For the transportation sector, the authors changed the AEO97 assumption of increasing fuel efficiency in automobiles to constant fuel efficiency. For the utility sector, the baseline was modified to reflect a fully competitive bulk-power market in the year 2010. Discharge, shutdown, repowering, and new construction decisions were optimized to select the amount of capacity that minimized the cost of the power-supply system plus the cost of unserved energy. Compared to AEO97, the final baseline has slightly lower energy prices, larger electricity sales, and a greater share of gas generation.

Efficiency Scenario

This case assumes that all technologies adopted are at zero or negative net cost to the user given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. The Study estimates that in this scenario 120 MMTCE will be reduced at negative net cost. We believe that the methodology inappropriately neglects the greater cost savings from adopting more efficient innovations later. None of these reductions occur in the utility sector as a function of fuel switching or the adoption of technologies to increase combustion efficiency.

High Efficiency/Low Carbon Scenarios[1]

This case assumes a "greater commitment" to reduce emissions through federal policies, in concert with state and private activities and either a $25/ton permit price or a $50/ton permit price to stimulate low carbon technologies (read: primarily fuel switching). The policy is announced in 2000 and the policy's restrictions are phased-in through 2010. There is an assumed announcement effect (although an autonomous energy efficiency index (AEEI) is not specified), increased domestic and international R&D in low-carbon technologies, and a "change in psychology". The Study estimates reductions of 152 MMTCE from the baseline through energy efficient technology adoption under the $25/ton permit and 197 MMTCE under the $50/ton permit. The carbon permits will yield an additional 74-186 MMTCE of reductions through low-carbon technology adoption (the range is based on the $25/ton and $50/ton permits).

Carbon Emissions (MMTCE): 1990 - 2010

1990	2010 Baseline	2010 Efficiency	2010 High Efficiency/Low Carbon + $25/ton permit	2010 High Efficiency/Low Carbon +$50/ton permit
1340	1720	1600	1490	1340

Estimated Costs

The study calculates two sets of costs: "best estimate" and an "alternative view". The best estimate case employs discount rates of 7% for buildings, 10% for transportation, and 12.5% for industry. The study assumes that the total costs of government programs to promote energy efficiency are 7% of technology costs. The alternative view case uses discount rates of 15% for buildings, and 20% for transportation and industry. Government programs are assumed to cost 15% of technology costs in this case. The study does not provide discount rates for the utility sector.

Under the best estimate case, the study calculates annual total costs of $50 billion and annual total benefits from energy-savings of $87 billion. In the alternative view, the study estimates annual total costs of $81 billion and annual total benefits of $87 billion. Note that under the alternative view, U.S. carbon emissions in 2010 would be 1383 MMTCE.

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[1] We combine our discussion on both permit prices here because the 8/1/97 draft does very little to distinguish between the two scenarios. In fact, the chapters on buildings, industry, and transportation do not mention a $25/ton permit price.

Review

The Lab Study employs several important assumptions in the analyses. We discuss several of the most significant assumptions below.

The Study Does Not Specify Policies to Achieve Carbon Reductions

> "Cost effectiveness is improved because R&D, in combination with increased deployment efforts, result in declining capital costs. We do not specify the policies, economic conditions, or exogenous events that could precipitate such changes" (p. 1.4).

The entire study is premised on two sets of undefined policies: an "aggressive" or "invigorated" public sector effort to stimulate energy efficient technology adoption (efficiency case) and a "very aggressive" public sector effort to stimulate technology development and adoption (high efficiency/low carbon case). The only specific policy instrument mentioned in the report is a tradeable permit at prices of $25/ton and $50/ton. The study merely asserts that these unidentified policies would result in: 1) "better technology" (p. 1.5); 2) "higher penetration rates" (p. 1.6); 3) "changing the capital recovery factor [in industry sector] from 33% to 15%" (p. 4.8); and 4) "technological breakthroughs" (p. 5.3). These policy effects would result in reductions of 180 MMTCE for "free": firms and individuals receive energy cost-savings greater than or equal to technology adoption costs. ?

The report specifically states that the efficiency case reduces, but does not eliminate, market barriers (p. x) and that implementation costs are ignored (p. xvi). Policy intervention to eliminate a market barrier cannot make society better off and generally makes society worse off to the extent that it imposes costs. In particular, a set of climate change policies to stimulate technology adoption could increase efficiency, but only because they also decrease the effect of a market failure (carbon emissions). Social welfare is improved because the net benefits of indirectly fixing the market failure exceed the costs of removing the barriers. If carbon emissions are appropriately priced (assuming in this case that $50/ton is the correct carbon price), a policy to remove a barrier will generate negative net benefits. High adoption rates will be realized once prices rise enough for some technologies to clear the barriers.[2]

The economics literature has identified several barriers that help explain the slow rate of technology adoption.

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

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[2] In contrast, policy intervention to address a market failure (such as unpriced carbon emissions) may make society better off, depending on the stringency of the intervention.

- New technologies may be costly to integrate with existing ones. Until all components of a complex system are fully depreciated it may make sense to replace energy inefficient components with another like-wise inefficient component.

- Uncertainty of future energy prices, or constraints on ability to borrow capital may make households act as if they have implausibly high implicit discount rates.

- Just because a technology is cost-effective on average does not mean that it is cost-effective for all individuals. Those who may use the device less intensively may find it optimal to purchase a less efficient model.

These barriers clearly demonstrate that investments to minimize energy costs are different from investments to minimize the total costs of production.

The Labs Study does not provide an estimate of the costs to government to lower market barriers to achieve the estimated emissions reductions. A sense of the likely costs can be derived by evaluating the experience of the Climate Change Action Plan (CCAP). CCAP promotes carbon reductions through a broad array of voluntary programs that stimulate "cost-effective" technology adoption by private firms. Participation by a firm in a CCAP program is supposed to reduce carbon emissions and to offer financial returns.[3] We do not address an important threshold question of why cost-minimizing firms would ever need any [illegible]d help from government programs to take actions that would lower their costs. CCAP received appropriations totaling $494 million (1995$) during the FY95 - FY97 period. We assume that these costs are distributed uniformly over the three years. During this period, the Department of Energy and the Environmental Protection Agency can account for reductions of 14 MMTCE (see attached table). Evaluating the cost effectiveness of these programs requires an assumption about emissions reductions in the outyears. Since the programs are persuading firms to adopt innovations that offer financial returns, we believe that the firms would soon have adopted them in the absence of the programs. Thus the emissions reductions might last for several years. To develop illustrative cost estimates we assume between 2 and 7 years of emissions reductions. We describe our estimates given the assumption of 2 years; the method for the assumption of 7 years is identical.[4] Assuming constant effectiveness of program expenditures, the emissions reductions attributable to past expenditures would grow from 2.8 million tons in the first year to 5.6 million in the second year and third years, and then decline to 2.8 million tons in the 4th year, before falling to 0 in the 5th and subsequent years. The ratio of the present value of these costs and of these tons is $33/ton using a 7 percent discount rate. Thus taking into account the lag

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[3] Note that CCAP efforts are incorporated in the AEO97 baseline.

[4] This analysis was conducted based on the June 10 draft that stated 180 MMTCE of reductions associated with government programs could be expected under a "very aggressive" set of policies. Since the August 1 draft notes that 197 MMTCE of reductions would be expected, the cost estimates provided in this discussion underestimate the program costs associated with this greater number of reductions.

between program expenditures and emissions reductions, the average cost effectiveness is \$33/ton (with a 7 year assumption the cost effectiveness is \$13/ton). Assuming constant program effectiveness would imply Federal costs of \$5.9 billion per year (with the 7 year assumption the total cost estimate would be half as much.) We believe that there are several good reasons to think that the cost of reducing emissions will rise, however, as these or similar programs are expanded. For example, if the potential adopters differed in terms of their cost savings (or willingness to adopt innovations) then the government program would encounter diminishing returns as it tried to reach the less receptive users of technology. Suppose that the (marginal) program cost effectiveness deteriorated by 10 percent every time the annual reductions in emissions grew by as much as the annual reductions implied by the current program. In this instance the marginal cost of achieving 180 million tons of emissions reductions would be about 21 times greater than the marginal cost of the existing program, and far in excess of reasonable values for a ton of carbon emissions averted. In this case the total cost of the program would be \$45 billion per year. Similar assumptions for the 7 year case would lead to total costs of nearly \$7 billion per year, and marginal costs of \$80/ton. Thus we believe that the cost of a government program to ensure energy reductions of 180 million metric tons of carbon could easily run into many tens of billions of dollars per year. In addition, the marginal cost-effectiveness of these programs could substantially exceed reasonable estimates of the value of carbon emissions reductions.

Of course the government might choose to achieve these reductions using command and control type regulations, such as national building codes, or increasingly stringent CAFE standards. These would substitute private sector costs for government administrative costs.

Price Declines Resulting from Reductions in Energy Demand Are Not Taken into Account

> "The model runs for each of the three end-use sectors were not integrated and therefore may overstate the effects of technology penetration. In an integrated modeling effort, fuel prices might fall as consumption declines, resulting in less penetration of energy-conserving technologies" (p. 1.1).

The analyses of the various sectors assume that the reduction of 197 MMTCE occurs through energy efficient technology adoption without any energy price effect. This implies that, with government programs, private agents will adopt technologies because the benefits (energy cost-savings) exceed the costs of adoption. The authors claim that these reductions occur at zero or negative net costs. However, if the energy prices fall due to the decline in energy demand, some of those adoptions would no longer generate positive net benefits for private consumers. The Study indicates that energy consumption will decline from the baseline by 11.6% under the high efficiency/low carbon case (p. xi). This decrease in demand should result in a decrease in the price of energy, and cause some energy efficient technologies to become unattractive to private agents.

The efficiency scenario should be modified to reflect the downward effect on prices resulting from decreased energy consumption. The high efficiency scenario should reflect two counteracting effects on prices: the decline in energy consumption and the $50/ton permit fee.[5] The Study ignores the former effect and insufficiently incorporates the latter effect. For example, in the buildings chapter, the penetration rate is assumed to be 65% instead of 60% of the maximum cost-effective technical potential in this scenario because of the $50/ton permit price.[6] However, the energy-cost savings calculations for buildings technologies assume the same energy price as in the business as usual scenario. Since the study assumes that exogenous, undefined policy influences drive the penetration rates, the penetration rate should be set at 60% and the energy cost-savings should be recalculated with the appropriate energy price. In the industry chapter, the high efficiency penetration rate is assumed to be double the rate used in the efficiency scenario, which is the undefined "normal" rate. It is impossible to determine how much of this doubling of penetration results from undefined, aggressive policy efforts and how much results from the permit price.

The Industry Sector Analysis Ignores the Costs of Accelerated Retirement

> "When the economic losses of accelerated retirement are accounted for this means that, at the margin, all investments are not likely to be cost effective at our assumed 15% CRF [capital recovery factor]. Since we do not have a model to account for this potential early retirement and the economic losses, we must caveat our estimates of investment and net costs. ...the investment cost may be understated by the amount of loss due to any early retirement ~~that may occur~~" (p. 4.15).

The omission of costs related to the early retirement of capital implies that either

- the projected emissions reduction should be revised downward, because less technology will be adopted; or

- the cost of reducing emissions should be revised upward; or

- the cost of government programs to somehow force down the CRF from 33% to 15%

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[5] The August 1 draft does not mention the $25/ton permit in the chapters or appendices on buildings, industry, and transportation. It is impossible to identify how energy prices may have been incorporated in this scenario. We only address the available details on the $50/ton permit scenario here.

[6] The assumptions about penetration rates cast more doubts about the "true" cost-effectiveness of energy-efficient technologies. Why would an aggressive policy effort (efficiency scenario) result in the adoption of only 30% of cost-effective technologies between now and 2010? Why would a very aggressive policy effort (high efficiency/low carbon scenario) result in only a 65% rate of adoption -- and this is with a $50/ton permit fee? Clearly, these penetration rates demonstrate that the cost-effective technical potential ignores real costs of technology adoption.

would increase.

The Transportation Sector Requires "Luck" to Achieve Carbon Reductions

> "[B]ecause the [transportation sector] outcomes postulated in the high efficiency/low carbon scenario require technological breakthroughs, they require a certain degree of luck to be achieved by 2010. There are no credible methods to accurately gauge the probability of such breakthroughs -- we believe they stand a decent chance of occurring with an intensification of research efforts, but we stop short of claiming they are a likely outcome of such an intensification" (p. 5.3).

Note that this statement includes two qualifications: luck on top of intensified research efforts. These intensified research efforts may require two to ten times existing funding on transportation (p. 5.3). For perspective on what this might mean, it is worth keeping in mind that the Partnership for a New Generation of Vehicles (PNGV) alone is funded at the federal level at $263 million, and there are substantial additional private sector costs.

The "luck" apparently pertains to a number of tenuous technological assumptions: commercial development of the fuel cell for passenger cars, commercial availability of cellulosic ethanol (and the elimination of the ethanol excise tax exemption), and an apparently arbitrary 30% reduction in costs for "certain key technologies" (p. 5.24). These technologies are not identified, and the report does not provide documentation for the NEMS model runs conducted for the transportation sector.

Interactions Ignored, Double Counting "Likely" in Utilities Sector Analysis

> "Chapter 7 considers other electricity supply technology options, including: converting coal-based power plants to natural gas; cofiring coal with biomass; efficiency improvements in generation and transmission and distribution systems; extending the life of existing nuclear plants; increasing generation and capacity of existing hydropower plants; and constructing new powerplants using advanced coal technologies. Each of these options is assessed independently. Thus, interactions between the options are not taken into account, and the possibility of double counting is therefore likely" (p. 7.1).

The emissions reductions in the electricity sector come from two sources. First, utilities undertake fuel switching at the $50/ton permit price through carbon-ordered dispatching. Utilities would change their fuel mix by dispatching more electricity from their lower carbon-emitting facilities (e.g., nuclear, hydropower, and natural gas) and less from coal plants. Second, utilities modify their capital stock through several technology options such as those listed in the above quotation. As electricity production moves away from coal through modified dispatching, fewer and fewer plants (and therefore potential emissions reductions) will be available for conversion to natural gas or cofiring with biomass. The second set of analyses were "static" and did not optimize unit/plant production cost, dispatch, or system load. Conversations with one of the co-authors (Stanton Hadley of Oak Ridge National Laboratory) indicate that 10 GW of coal-to-gas conversions (approximately 9 million tons of carbon reductions, or 7% of reductions for dispatching and conversions) were double-counted.[7]

Study Double Counts Emissions Reductions Occurring Under Business-As-Usual

E/GDP Ratios for Business-As-Usual Case

AEO97 BAU	Labs Study BAU	CEA-Adjusted BAU
0.9%	0.77%	0.87%

The study states that it employs the Annual Energy Outlook business-as-usual (BAU) forecast for the buildings and industry sectors, with modifications that are "not greatly different from the EIA case" (p. 1.2) for the transportation sector.[8] The one modification stated in the study affects the fuel efficiency of the light duty vehicle fleet. While AEO97 assumes that fuel efficiency will increase in the future, the labs study assumes that fuel efficiency will remain constant. This change should result in a slower rate of energy efficiency improvement in the economy under business as usual conditions.

It's hard to tell what this is saying.

The AEO97 BAU forecast assumes an improvement of energy efficiency of 0.9% per year through 2015 (annual E/GDP = -0.9%). The study assumes energy efficiency improvement under BAU occurs at a rate of 0.77%. This difference appears to be somewhat significant. CEA contacted Art Andersen at the Energy Information Administration to determine how much of an effect holding fuel efficiency constant would have on the E/GDP ratio.[9] According to Andersen, constant fuel efficiency would be "rounding error" on the E/GDP ratio. He stated that this assumption would result in energy use increasing by 0.6 quads in 2010 over the BAU case. CEA recalculated the E/GDP ratio used in the AEO97 BAU to account for this extra energy use (assuming GDP remains the same across these cases), and found that annual E/GDP would decrease 0.87% under the constant fuel efficiency assumption. The labs study BAU assumes fewer energy efficiency improvements than should be expected under the appropriate BAU.

The labs study BAU has two implications. First, it should have a higher estimate of BAU emissions in 2010, since it assumes a smaller E/GDP ratio than AEO97. However, the lab study uses the AEO97 emissions estimate. The study assumes that this analysis results in emissions stabilization at 1990 levels in 2010 when the levels are actually above 1990 levels. Second, by

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[7] Hadley noted that a subsequent draft of the report should address at least some of the double counting, but he did not provide details. We could not identify any changes made to the analysis to account for changes in the dispatch that may affect the calculated emissions reductions by retooling coal plants to operate on natural gas.

[8] The labs study also modified the electricity sector forecast, but that modification is not relevant to our discussion of the energy efficiency of the economy.

[9] Art Andersen is the Director of the Energy Demand and Integration Division, EIA.

This section unclear

calculating emissions reductions from the inappropriate BAU, the labs study double counts emissions reductions that will occur under the appropriate BAU. The CEA-generated BAU accounts for 18% of the E/GDP gains assumed in the efficiency case.[10] Assuming that E/GDP and carbon reductions are perfectly correlated (given that the efficiency case involves no fuel switching, this is reasonable), then the efficiency case overestimates emissions reductions by 22 MMTCE. Overestimates in the high efficiency cases would be greater than this.

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[10] The AEO97 BAU would capture 25% of the efficiency gains in the efficiency scenario.

EXECUTIVE OFFICE OF THE PRESIDENT

COUNCIL OF ECONOMIC ADVISERS
17TH AND PENNSYLVANIA AVENUE, NW
WASHINGTON, DC 20500

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FROM: Randy Lutter and Joe Aldy

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DOE Labs Study

- *No Description of Policies:* The Study does not specify the policies and programs necessary to achieve emissions reductions. Instead, the authors employ the premise that policies are implemented that significantly lower the barriers to technology adoption. In effect, this assumes the magical wand of government intervention is waved to lower technology marginal costs enough to get 180 million tons of carbon reductions for "free"!

- *Lack of Transparent Methodologies:* The methodologies used in the study are insufficiently transparent to understand how the emissions reductions will occur and what their costs will be. The transportation sector paper does not provide any documentation, the industry paper only provides limited documentation on fuel-switching, and the buildings paper, while it provides a fair amount of documentation in an appendix, the emissions reductions in the appendix do not match the reductions provided in the text of the report.

- *Lack of Integrated Modeling:* The modeling efforts for each sector are separate, and they use some different assumptions. They are basically a set of partial equilibrium analyses added together to paint a picture of the economy under energy efficient technology adoption. They note that an integrated effort may yield results with lower energy efficient technology penetration.

Potential Reductions	in C Emissions				
	Efficiency Case	HE (w/o lo carbon tech)	HE/LC	HE/LC: lower bound	HE/LC: upper bound
Buildings					
Energy Efficiency	25	39	39	39	39
Fuel Cells	0		2 to 7	2	7
Industry					
Energy Efficiency	22	40	40	40	40
Advanced Turbine Systems	0		5 to 17	5	17
Aluminum Technologies	0		2 to 4	2	4
Biomass Gasification	0		2 to 10	2	10
Cement	0		2	2	2
Transportation					
Energy Efficiency and Ethanol	73	103	103	103	103
Utility Supply Options					
Carbon-Ordered Dispatching	0		77	77	77
Converting coal-based plants to natural gas	0		50	50	50
Cofiring coal with biomass	0		5 to 20	5	20
Nuke plant life extensions	0		2 to 5	2	5
Hydropower expansions	0		4 to 5	4	5
Total	120	182	333 to 379	333	379

5 Lab

Carbon Emissions by Sector (table A-2)				
Sector	1990	2010 Base	2010 Efficiency	2010 HE/LC
Buildings	460	571	546	525 to 530
Industry	452	534	512	461 to 483
Transportation	432	616	543	513
Utilities	--	--	--	-157 to -138
Total (rounded)	1340	1720	1600	1340 to 1390

Carbon Emissions by Technology (from appendix C-2)							
Buildings, Residential							
Fuel	End-Use	1990	2010 Base	2010 Efficienc	Eff. Red.	2010HE/L	HE/LC Red.
Electricity	space heating	15	23	22	1	21	2
	space cooling	27	23	23	0	21	2
	water heating	18	18	17	1	14	4
	refrigeration	27	15	14	1	13	2
	cooking	8	7	7	0	6	1
	clothes dryers	9	10	10	0	8	2
	freezers	8	4	4	0	3	1
	lighting	15	17	15	2	9	8
	other uses	36	97	90	7	71	26
	sub-total	163	214	202	12	166	48
Natural Gas	space heating	45	56	56	0	55	1
	space cooling	0	0	0	0	0	0
	water heating	16	20	19	1	18	2
	cooking	3	2	2	0	2	0
	clothes dryers	1	1	1	0	1	0
	other uses	1	1	1	0	1	0
	sub-total	66	80	79	1	77	3
Distillate Oil	space heating	15	13	13	0	13	0
	water heating	2	2	2	0	2	0
	other uses	0	0	0	0	0	0
	sub-total	17	15	15	0	15	0
LPG	space heating	4	5	5	0	5	0
	water heating	1	2	1	1	1	1
	cooking	1	1	0	1	0	1
	other uses	0	0	0	0	0	0
	sub-total	6	8	6	2	6	2
Renewables	wood	0	0	0	0	0	0
Other Fuels	coal and kerosene	3	2	2	0	2	0
Total		255	319	304	15	266	53

Buildings, Commercial							
Fuel	End-Use	1990	2010 Base	2010 Efficienc	Eff. Red.	2010HE/L	HE/LC Red.
Electricity	space heating	6	6	5	1	4	2
	space cooling	29	25	23	2	19	6
	water heating	9	7	7	0	6	1
	ventilation	9	9	9	0	7	2
	cooking	2	1	1	0	1	0
	lighting	59	63	60	3	52	11
	refrigeration	7	8	7	1	6	2
	PC off equip.	2	5	5	0	5	0
	non-PC off equip.	8	12	12	0	12	0
	other uses	20	52	48	4	38	14
	sub-total	151	188	177	11	150	38
Natural Gas	space heating	20	20	18	2	17	3
	space cooling	0	0	0	0	0	0
	water heating	7	8	7	1	7	1
	cooking	2	3	3	0	3	0
	other uses	13	20	20	0	19	1
	sub-total	42	51	48	3	46	5
Distillate Oil	space heating	4	3	3	0	3	0
	water heating	1	1	1	0	0	1
	other uses	4	3	3	0	3	0
	sub-total	9	7	7	0	6	1
Renewables	wood	0	0	0	0	0	0
Other Fuels	coal and kerosene	7	7	7	0	7	0
Total, Commercial		209	253	239	14	209	44
Total, Buildings		464	572	543	29	475	97

**Background Information Sheet: Interlab Study on U.S.
Energy Efficiency and Greenhouse Gas Emissions
Assumptions for Energy Efficiency Calculations: Residential Sector**

(Miscellaneous Energy)

Product/end-use description

Miscellaneous residential energy use involves end-uses in the home that are not currently allocated to other end-uses, namely refrigeration, space conditioning, lighting, cooking, and water heating. While miscellaneous energy (particularly electricity) can encompass a variety of activities in one's home, for the purposes of this study we have divided miscellaneous energy into the following categories shown in table 2 below:

Table 1: Miscellaneous Energy Use

Fuel	Category	Main end-uses in category
electricity	electronics	color televisions, Video cassette recorders, cable boxes, computers
electricity	motors	Furnace fans, ceiling/ventilation fans, pumps (e.g. pool, well), evaporative cooler
electricity	heating	waterbed heaters, coffee makers, crankcase heaters, irons, electric blankets, spas/hot tubs, toasters
natural gas oil & other petroleum products		pool heaters, gas fireplaces

Base Year Energy Use

Miscellaneous electricity use was estimated at 23% of residential primary energy use (4.4 quads) in 1997 (AEO, 1996). Natural gas and oil end-uses account for another quad of primary energy in 1997. Estimates by main end-use category are shown in the table below based on (AEO, 1996; LBNL, 1997)

Table 2: 1997 Miscellaneous Energy Use

End-use Category	Share	Quads Primary
electronics	35.9%	1.6
motors	37.4%	1.6
heating	26.7%	1.2
Total electricity		4.4
natural gas		0.9
oil & other petroleum products		0.1
Total Miscellaneous		5.4

End-use Lifetime

End-use lifetime was estimated at 12 years. This lifetime was determined as the energy-use weighted average of the lifetimes of various miscellaneous end-uses.

Average Unit Energy Consumption (UEC)

Average UECs per household are derived from US DOE (1996).

∴ climate policy in 97
→ full stock turnover
by 2010 in this
analysis (and the
subsequent big reductions)

Commercial: motors, fans, pumps

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

SENIOR ECONOMIST

MEMORANDUM

TO: Joe Romm
Acting Assistant Secretary for Energy Efficiency and Renewable Energy
U.S. Department of the Energy

FROM: Jason Shogren and Joe Aldy

DATE: August 22, 1997

RE: Review of 5-Labs Report: *Scenarios of U.S. Carbon Reductions*

Enclosed you will find our comments on the report *Scenarios of U.S. Carbon Reductions*. We appreciate the opportunity to review the report and we trust you will incorporate our comments.

939-3460
FAX

Comments on "Scenarios of U.S. Carbon Reductions" (5 Labs Study)

General comment

The report, *Scenarios of U.S. Carbon Reductions*, presents a useful cataloging of the technological options that could play a key role in reducing greenhouse gas emissions. The report does not present the specific policies or the behavioral responses that will trigger the adoption or diffusion of these technologies. As such, the report cannot serve as the basis of decision-making by top policy-makers (as opposed to background detail that others may find useful). The report as written, however, leaves the impression that these technologies are policy, which they are not. The U.S. government does not have directly under its control the decisions of private firms and consumers whether to adopt these technologies. The report must be either redone to reflect how likely these technologies will be used given the behavioral responses to likely policies, or reframed to reflect what it is--a catalog of technologies that might be used to address global climate change. The latter path is more straightforward and could readily be accomplished. *Among other changes, it is essential that DOE remove references to "net savings" from the report because this does not reflect the actual costs of implementing these policies.*

Our specific comments follow.

Executive Summary

1) paragraph 3: The point regarding the opportunity to reduce emissions through "a vigorous national commitment" should be explicit that this commitment is implemented through federal policies. To state that 120 MMTCE can be reduced by "energy efficiency alone" seems to imply that these reductions are free. These reductions through energy efficiency are induced by aggressive policies, and the statement should reflect that. The subsequent discussion of reductions with carbon permits should also reflect that the level of reductions can occur only through a carbon pricing policy in addition to any non-price policies (e.g., standards).

2) Paragraph 4: Estimates of energy cost savings should not be provided unless and until an adequate estimation approach is used to calculate cost savings.

3) Paragraph 5: This paragraph should really concentrate on the point that this study identifies a vast array of technologies that may reduce carbon emissions through climate policy. This is the true strength of the study, and it should be emphasized more.

4) The entire study is premised on two sets of undefined policies: an "aggressive" or "invigorated" public sector effort to stimulate energy efficient technology adoption (efficiency case) and a "very aggressive" public sector effort to stimulate technology development and adoption (high efficiency/low carbon case). The only specific policy instrument mentioned in the report is a tradeable permit at prices of $25/ton and $50/ton. The study merely asserts that these unidentified policies would result in: 1) "better technology" (p. 2.5); 2) "higher penetration rates" (p. 2.5); 3) "changing the capital recovery factor [in industry sector] from 33% to 15%" (p. 4.6); and 4) "technological breakthroughs" (p. 5.3). These policy effects would result in reductions of about 200 MMTCE for "free": firms and individuals receive energy cost-savings greater than or equal to technology adoption costs.

The report specifically states that the efficiency case reduces, but does not eliminate, market barriers and that implementation costs are ignored. Policy intervention to eliminate a market barrier cannot make society better off and generally makes society worse off to the extent that it imposes costs. In particular, a set of climate change policies to stimulate technology adoption could increase efficiency, but only because they also decrease the effect of a market failure (carbon emissions). Social welfare is improved because the net benefits of indirectly fixing the market failure exceed the costs of removing the barriers. If carbon emissions are appropriately priced (assuming in this case that $50/ton is the correct carbon price), a policy to remove a barrier will generate negative net benefits. High adoption rates will be realized once prices rise enough for some technologies to clear the barriers.[1]

The economics literature has identified several barriers that help explain the slow rate of technology adoption.[2]

- 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 consumers may purchase a product with a lower efficiency because the former is more reliable than the efficiency-superior product.

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[1] In contrast, policy intervention to address a market failure (such as unpriced carbon emissions) may well make society better off, depending on the stringency of the intervention.

[2] For a review of these issues, see 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; Jeffrey A. Dubin and Daniel L. McFadden, "An Econometric Analysis of Residential Electric Appliance Holdings and Consumption," *Econometrica*, vol. 52, no. 2, 1984; Adam B. Jaffe and Robert N. Stavins, "Energy-Efficiency Investments and Public Policy", *Energy Journal*, vol. 15, no. 2, 1994; Albert L. Nichols, "Demand-Side Management: Overcoming Market Barriers or Obscuring Real Costs?" *Energy Policy*, vol. 22, no. 10, 1994; Jerry Hausman, "Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables," *Bell Journal of Economics*, vol. 10, 1979.

- New technologies may be costly to integrate with existing ones. Until all components of a complex system are fully depreciated it may make sense to replace energy inefficient components with another like-wise inefficient component.

- Uncertainty of future energy prices, or constraints on the ability to borrow capital may make households act as if they have implausibly high implicit discount rates.

- Just because a technology is cost-effective on average does not mean that it is cost-effective for all individuals. Those who may use the device less intensively may find it optimal to purchase a less efficient model.

These barriers clearly demonstrate that investments to minimize energy costs are different from investments to minimize the total costs of production.

The study provides a crude estimate of the costs to government of lowering market barriers to achieve the estimated emissions reductions. A sense of the likely costs can be derived by evaluating the experience of the Climate Change Action Plan (CCAP). CCAP promotes carbon reductions through a broad array of voluntary programs that stimulate "cost-effective" technology adoption by private firms. Participation by a firm in a CCAP program is supposed to reduce carbon emissions and to offer financial returns.[3] We do not address an important threshold question of why cost-minimizing firms would ever need any need help from government programs to take actions that would lower their costs.

CCAP received appropriations totaling $494 million (1995$) during the FY95 - FY97 period. We assume that these costs are distributed uniformly over the three years. During this period, the Department of Energy and the Environmental Protection Agency can account for reductions of 14 MMTCE (see attached table). Evaluating the cost effectiveness of these programs requires an assumption about emissions reductions in the outyears. Since the programs are persuading firms to adopt innovations that offer financial returns, we believe that the firms would soon have adopted them in the absence of the programs. Thus the emissions reductions might last for several years. To develop illustrative cost estimates we assume between 2 and 7 years of emissions reductions. We describe our estimates given the assumption of 2 years; the method for the assumption of 7 years is identical.[4] Assuming constant effectiveness of program expenditures, the emissions reductions attributable to past expenditures would grow from 2.8 million tons in the first year to 5.6 million in the second year and third years, and then decline to 2.8 million tons in the 4th year, before falling to 0 in the 5th and subsequent years. The ratio of

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[3] Note that CCAP efforts are incorporated in the AEO97 baseline.

[4] This analysis was conducted based on the June 10 draft that stated 180 MMTCE of reductions associated with government programs could be expected under a "very aggressive" set of policies. Since the August 1 draft notes that more non-price policy induced reductions would be expected, the cost estimates provided in this discussion underestimate the program costs associated with this greater number of reductions.

the present value of these costs and of these tons is $33/ton using a 7 percent discount rate. Thus taking into account the lag between program expenditures and emissions reductions, the average cost effectiveness is $33/ton (with a 7 year assumption the cost effectiveness is $13/ton). Assuming constant program effectiveness would imply Federal costs of $5.9 billion per year (with the 7 year assumption the total cost estimate would be half as much.)

We believe that there are several good reasons to think that the cost of reducing emissions will rise, however, as these or similar programs are expanded. For example, if the potential adopters differed in terms of their cost savings (or willingness to adopt innovations) then the government program would encounter diminishing returns as it tried to reach the less receptive users of technology. Suppose that the (marginal) program cost effectiveness deteriorated by 10 percent every time the annual reductions in emissions grew by as much as the annual reductions implied by the current program. In this instance the marginal cost of achieving 180 million tons of emissions reductions would be about 21 times greater than the marginal cost of the existing program, and far in excess of reasonable values for a ton of carbon emissions averted. In this case the total cost of the program would be $45 billion per year. Similar assumptions for the 7 year case would lead to total costs of nearly $7 billion per year, and marginal costs of $80/ton. Thus we believe that the cost of a government program to ensure energy reductions of 180 million metric tons of carbon could easily run into many tens of billions of dollars per year. In addition, the marginal cost-effectiveness of these programs could substantially exceed reasonable estimates of the value of carbon emissions reductions.

Of course the government might choose to achieve these reductions using command and control type regulations, such as national building codes, or increasingly stringent CAFE standards. These would substitute private sector costs for government administrative costs.

5) 1.1, paragraph 1: Sentence 3 should note that "the improved performance and increased penetration of efficient and low-carbon technologies" are program- and price-induced.

6) 1.1, section 1.1, purpose 1: The statement about a "vigorous national commitment" should be explicit that this means a commitment through government programs.

7) 1.4, Table 1.1: The study notes that it employs EIA's Annual Energy Outlook 1997 projections for the business-as-usual case in 2010 with a modification to the transportation sector. However, the numbers in this chart do not match up with the numbers in the AEO97 reference case. In fact, they are much closer to the AEO97 low economic growth case (for industry and buildings). We assume that the labs study is using the reference case from AEO97 since it uses the reference case carbon emissions for 2010. If this is the case, then the following should be the sectoral breakdown of energy consumption (AEO97, pp. 97-99, and pp. 125-127):

Buildings:	36.81 quads
Residential:	20.83 quads
Commercial:	15.98 quads
Industrial:	39.69 quads
Transportation:	31.39+ quads[5]
Total:	107.89+ quads

If the labs study employs the low economic growth case, then it should state so explicitly in the report and explain why this case, as opposed to the reference or other cases, was selected. Otherwise, the AEO97 numbers should be used.

8) 1.6, Table 1.2: The 2010 BAU carbon emissions for buildings and industry seem not to match the AEO97 reference case emissions for these sectors. AEO97 projects carbon emissions to be 576.1 MMTCE for buildings (residential: 321.4; commercial: 254.7) and industry to be 548.5 MMTCE in 2010. This implies that, with the adjusted transportation emissions, BAU should total 1740 MMTCE, not 1720.

9) 1.8, Table 1.3: The study states that it employs the Annual Energy Outlook business-as-usual (BAU) forecast for the buildings and industry sectors, with modifications that are "not greatly different from the EIA case" (p. 1.2) for the transportation sector.[6] The one modification stated in the study affects the fuel efficiency of the light duty vehicle fleet. While AEO97 assumes that fuel efficiency will increase in the future, the labs study assumes that fuel efficiency will remain constant. This change should result in a slower rate of energy efficiency improvement in the economy under business as usual conditions.

The AEO97 BAU forecast assumes an improvement of energy efficiency of 0.9% per year through 2015 (annual E/GDP = -0.9%) (AEO97, p. 4). The study assumes energy efficiency improvement under BAU occurs at a rate of 0.77%. This difference appears to be somewhat significant. Inferring from the transportation chapter (table 5.1), this report states that energy use would increase 0.9 quads over the AEO97 reference case. CEA contacted Art Andersen at the Energy Information Administration to determine how much of an effect holding fuel efficiency constant would have on the E/GDP ratio.[7] According to Andersen, constant fuel efficiency would "disappear in the rounding" in the E/GDP ratio. He stated that this assumption would

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[5] The 1997 AEO projects transportation energy consumption to be 31.39 quads in 2010. With the labs study assumption regarding constant fuel efficiency, the projected energy consumed in this sector should increase. Although the text never explicitly states the extent of this increase, we inferred that it is 0.9 quads. However, since Andersen informed us that the increase would be 0.6 quads, we assessed both in a subsequent comment.

[6] The labs study also modified the electricity sector forecast, but that modification is not relevant to our discussion of the energy efficiency of the economy.

[7] Art Andersen is the Director of the Energy Demand and Integration Division, EIA.

result in energy use increasing by 0.6 quads in 2010 over the reference case. CEA recalculated the E/GDP ratio used in the AEO97 BAU to account for this extra energy use (assuming GDP remains the same across these cases), and found that annual E/GDP would decrease 0.86% under the constant fuel efficiency assumption (0.6 quads case). With the inference from the transportation chapter, the annual E/GDP rate would be -0.85% (0.9 quads case). The labs study BAU assumes fewer energy efficiency improvements than should be expected under these adjusted BAU scenarios.

Two related implications arise from this. First, since the study employs a modified version of the AEO97 energy use forecast, it should modify the AEO97 carbon emissions forecast. With a slower improvement in energy efficiency under the lab study assumptions, the 2010 BAU carbon emissions should be greater than the 1722.4 MMTCE in AEO97 (AEO97, p. 120). As we note in the previous comment, by incorporating the AEO97 reference case carbon emissions for buildings and industry, the BAU should be about 1740 MMTCE. This obviously implies that more reductions will be necessary to stabilize emissions at the 1990 level in 2010.

Second, the carbon reductions calculated for the various scenarios in this study are based on this -0.77% E/GDP BAU. This implies that some of the carbon reductions claimed under the efficiency and high efficiency cases actually occur in the -0.86% BAU. This double-counting could be significant. The CEA-generated BAU (0.6 quads case) accounts for 17% of the E/GDP gains assumed in the efficiency case (see attached chart).[8] The alternative CEA-generated BAU (0.9 quads case) accounts for 15% of the E/GDP gains assumed in the efficiency case. Assuming that E/GDP and carbon reductions are perfectly correlated (given that the efficiency case involves no fuel switching, this is reasonable), then the efficiency case overestimates emissions reductions by 18 to 20 MMTCE.

The text should explain why the lab study E/GDP ratio differs from the AEO97 ratio since it does not seem to result exclusively from keeping fuel efficiency constant. Further, the 2010 BAU emissions reductions should reflect the E/GDP ratio (whether it is -0.77%, -0.85%, -0.86%, or some other rate) used in the study.

10) 1.11, Table 1.4: It would be valuable to understand the effect of non-price policies and permit prices on the carbon reductions. Could you break down the high efficiency cases into two categories: non-price policy induced and permit induced technology adoption?

11) 1.12, paragraph 1: The discussion on government programs costing 15% of investment costs should include references to the literature that have estimated this percentage. Does the literature describe the marginal costs for government programs, or does it just provide this average cost value? Consistent with the literature on technology adoption, the marginal costs should not be

[8] The AEO97 BAU would capture 25% of the efficiency gains in the efficiency scenario.

assumed to be the same for all units of adoption. In fact, it is likely that the marginal costs increase for higher rates of adoption.

12) 1.12, paragraph 1: The text in this paragraph notes that government costs in the best estimate case are 15% of total investment costs, while figure A-1.1 on p. A-1.2 indicates that the costs are 7% of investment costs for the end-use sectors and 1% for the electricity sector. Which costs are correct?

13) 1.12, paragraph 1: The text notes that "one could argue that... a social discount rate" of 3% or 7% should be used. Alternatively, one could argue that since these analyses assess private decisions on technology adoption, that private marginal rates of time preference should be used that reflect "current market behavior". This analysis is not attempting to conduct a social benefit-cost analysis. Rather, it is attempting to model the private individual or firm's benefits and costs associated with a technology adoption decision. Since this report projects technology adoption assuming a set of aggressive policies, the rates of time preference actually used by individuals and firms should be used in assessing the extent of adoption.

Further, the report should not rely on government fiat to lower discount rates. It is very difficult to lower people's time preferences through policy. Government programs do not increase adoption rates by lowering time preferences, but by lowering the costs of adoption or increasing the benefits of adoption. For example, government programs cost-share the adoption of environmentally-benign agricultural production techniques through the Environmental Quality Incentives Program. Farmers still employ the same discount rate, but their stream of costs are lower because of the government subsidy, and so adoption increases. The report should not assume that government policies can lower private time preference rates, but rather that government policies can affect the stream of costs and benefits of an adoption decision.

14) 1.12, paragraph 5: Again, until the complete costs of investment and accurate cost-savings can be estimated, the text on net benefits should be deleted.

15) 1.13, Table 1.5: The estimates of carbon reductions under the alternative view do not appear to match with the carbon reductions in table A-1.2 on p. A-1.5. It seems implausible that discount rates could double and have no effects on any technology adoption decision in this report. Are the numbers in the appendix the right set? Is it true that every single energy efficient technology adoption decision is cost-effective under the "best estimate" discount rate and the "alternative view" discount rate? If these technologies are such big winners, then why aren't people and firms already adopting them?

16) 1.14: Unless and until the costs and cost-savings issues are adequately addressed, estimates of net savings should be omitted.

17) 1.15, paragraph 3: As stated in the executive summary comments, the text should not state "energy efficiency alone can take the nation 30 to 50% of the way to 1990 levels." If energy

efficiency could achieve these reductions "alone", there would be no need for an invigorated federal policy effort. It should be explicitly stated that policy instruments to achieve this goal are omitted from the analysis.

Chapter 2

18) 2.6, transportation sector bullet: The text states that the transportation sector analysis uses a 5 year time horizon. However, the description of the best estimate and alternative view cost effectiveness calculations on p. A-1.10 indicate that a time horizon of 14 years was used. Further, the transportation chapter indicates that the cost effectiveness analyses were conducted using a 6% discount rate in combination with a decline in usage and depreciation to calculate fuel savings (p. 5.45). The footnote to table 5.9 implies that the analyses used a 14 year time horizon as well. The report should clarify these inconsistencies.

Chapters 3-7

19) There does not appear to be any discussion of the $25/ton permit scenario in these chapters. Further, the appendices do not explicitly detail this case. The results from this scenario need to be documented in the text and in the appendices. For example, it is impossible to identify the penetration rate for this scenario in the buildings chapter (see p. 3.3). The industry chapter discusses three scenarios: BAU, efficiency, and high efficiency (p. 4.2). The descriptions of the high efficiency case in transportation on p. 5.3 and p. 5.31 do not even mention a permit price. The electricity sector appears to only consider a $50/ton permit (p. 6.9).

20) The results from the alternative view cost analysis should be incorporated in these chapters.

Chapter 3

21) 3.3: In the context of fully incorporating the effects of climate policy on energy prices, the analyses on buildings technologies should be modified. Under the efficiency case, energy consumption declines. This scenario should be changed to reflect the downward effect on prices resulting from this decreased energy consumption. The result would be to reduce the net improvement in energy use resulting from technological advances. The high efficiency scenario should reflect two counteracting effects on prices: the decline in energy consumption and the $50/ton permit fee. The study ignores the former effect and insufficiently incorporates the latter effect. For example, in the buildings chapter, the penetration rate is assumed to be 65% instead of 60% of the maximum cost-effective technical potential in this scenario because of the $50/ton permit price. However, the energy-cost savings calculations for buildings technologies assume the same energy price as in the business as usual scenario. Since the study assumes that exogenous, undefined policy influences drive the penetration rates, the penetration rate should be set at 60% and the energy cost-savings should be recalculated with the appropriate energy price. In addition, the assumed energy use for these technologies should be based on consumers' responses to the lower operating costs. For example, if running an air conditioner becomes less

expensive with a new energy efficient technology, people will run the air conditioner more. This latter effect decreases the carbon reductions associated with each adoption decision.

22) 3.9 and Appendix C-1: The study uses the average cost of electricity to calculate the energy cost savings of these technologies. Many of the electricity-dependent technologies are only cost effective based on the assumption of average, not marginal electricity prices. Since marginal prices may be much lower than average prices, especially in cases where households use less electricity, this may overestimate the extent of cost effective technologies. The analysis should be modified using marginal electricity prices.

23) 3.23, box: The text in the box is not clear on the inclusion of fuel cell technology in the high efficiency scenarios. The first paragraph states that fuel cells were not included in the main building sector scenarios. However, emissions reductions of 3 MMTCE from fuel cells are listed under buildings in Table 1.4 on p. 1.11. Further, the discussion on fuel cells in the text outside of this box implies that fuel cell technology will not be available until 2020 (since it falls in the section "Potential for Advanced Technologies in 2020"). If the study relies on ADL's analysis of fuel cell adoption, then the assumptions of ADL's assessment should be provided in an appendix. Two issues should be addressed here. First, if fuel cells are projected to be adopted under the high efficiency scenarios, then this discussion should be placed in the appropriate section of this chapter (not the 2020 section), and the inconsistencies in the text should be remedied. Second, if fuel cells are adopted, then a discussion of the carbon emissions accounting should be provided to ensure that the study does not double count emissions reductions from energy efficient technology adoption and from switching energy sources to fuel cells.

24) 3.29, summary bullet two: This states that the high efficiency scenario yields 91 MMTCE of carbon reductions from the BAU emissions level. However, Table 1.4 indicates that only 44 MMTCE of reductions occur under the $25/ton permit price and only 62 MMTCE of reductions occur under the $50/ton permit price. Which carbon reduction estimate is correct?

Chapter 4

25) 4.6, paragraph 4: The analysis assumes that the capital recovery factor falls by more than half. This appears to be an arbitrary reduction. Did industry behave as if it operated under a lower CRF during the 1970s oil shocks? There is no discussion of the economic behavior necessary to result in this outcome.

26) 4.6, paragraph 4: The high efficiency penetration rate is assumed to be double the rate used in the efficiency scenario, which is the undefined "normal" rate. It is impossible to determine how much of this doubling of penetration results from undefined, aggressive policy efforts and how much results from the permit price. It would be valuable to understand the relative impacts of both.

27) 4.13, paragraph 4: The text states that the high efficiency case causes an acceleration of capital retirement, but does not estimate these costs. Could you estimate the costs of early retirement? If not, can you provide some information on the extent of early retirement (e.g., percentage of capital retired early under this scenario)?

Chapter 5

28) Does this sectoral analysis consider the impact of a permit price? Neither the $25/ton permit nor the $50/ton permit are mentioned in the entire chapter. Do all improvements in fuel efficiency and cellulosic ethanol result from non-price policy responses? As the report states, a degree of "luck" is required to achieve the necessary technological breakthroughs to result in the projected carbon reductions. However, without a price incentive, the probability of the nation becoming "lucky" appears more unlikely. If this analysis does not incorporate the permit prices, then this should be made explicit in the discussion of the high efficiency case.

29) The methodology for this sector is insufficiently transparent to grasp easily the impact of technology development and adoption on carbon reductions. Further, the appendices for transportation do not provide the details to remedy the shortcomings in the chapter. It is difficult to compute carbon reductions from increases in fuel efficiency. The text should take the reader through the process of piecing together all of these energy efficient technologies, illustrating the final effect on fuel economy, and then translating this into carbon reductions.

30) 5.4, Table 5.1: Why do the energy consumption numbers for this sector in 1997 vary across scenarios? We understand that the start year for the scenario analyses is 1998 (e.g., refer to Table 4.8 on p. 4.12 that implies 1998 as the start year for assessing cumulative incremental investment).

31) 5.21, paragraph 2: Does the assumption about reducing technology costs reflect any empirical analysis on transportation technologies? For example, the 1970s oil shocks and fuel efficient imports spurred domestic fuel efficiency R&D. Does this analysis incorporate information about accelerating technology development and lowering technology costs that may be available from this earlier period?

32) 5.23, paragraph 3: As we have noted before, it is difficult to modify consumers' preferences. Assuming that the demand for horsepower will decrease because consumers will become "more green" over the next decade appears tenuous. This statement is repeated on p. 5.32. Is there any evidence that concern about global warming has affected consumers' purchase decisions to date?

33) 5.25, paragraph 1: If the turbocompound diesel engine and the advanced LE-55 heat engine are not available in the reference case (which implies that the earliest these are available is 2016), then how are they made available by 2003? Is there any precedent for accelerating transportation technology from a time horizon of at least 18 years to a horizon of only 5 years? How do these

engines conform to present emissions standards for particulates and NO_x and how will future standards under the new ozone and particulate matter rules affect them?

34) 5.25, paragraph 1: The efficiency case assumes that advanced drag reduction in heavy trucks has become available this year, but this is excluded from the reference case. First, has this actually occurred? Second, if it has already occurred, then why is it excluded from BAU?

35) 5.25, paragraph 4: Again, the assumption of reducing a technology price appears arbitrary. What is the basis for assuming that the trigger price for heavy truck technologies will fall?

36) 5.25, paragraph 5: The efficiency analysis assumes penetration rates of 100% for several of the heavy truck technologies over a 20 year period. This seems incongruous with the assumptions in the other sector analyses that imply much lower penetration rates. 100% penetration of a technology within 20 years, that is not expected to be available 18 years from now in the BAU, appears to be an extreme and unsubstantiated assumption.

37) 5.32, paragraph 1: The analysis assumes that fuel cells, because their costs are unknown, will be cost effective. This is an entirely arbitrary assumption, especially for a technology that is not even projected to become available in the BAU scenario. There is absolutely no economic basis for this assumption. This assumption is all the more extraordinary given that this analysis does not (apparently) incorporate the impacts of a carbon permit on fuel prices.

38) 5.36, Table 5.7: If the scenarios overestimate fuel economy, as stated in the footnote, then the numbers should be revised to remedy this error.

39) 5.38, paragraph 2: The modification of assumed improvement of fuel efficiency by multiplying the expected improvement by 0.7 to reflect offsetting performance effects, appears arbitrary. Why wouldn't the fraction be much smaller? The introduction to this chapter indicates that almost all improvements in fuel efficiency are offset by performance effects. Why would only 30% of fuel efficiency improvements in the future be offset?

40) 5.45: The chapter is not explicit about its accounting of fuel efficiency improvements in light duty vehicles and the change in the fuel mix reflecting an increase in cellulosic ethanol and the use of fuel cell technology. We cannot determine if carbon reductions are double counted. The study does not discuss how cellulosic ethanol and fuel cells are accounted for in the energy cost savings description on pp. 5.43-5.45. If the reductions from fuel efficiency and the reductions from cellulosic ethanol and fuel cells do not overlap, then this should be stated explicitly. Again, a more transparent presentation of the methodology would address the readers' uncertainty about this issue.

41) 5.45, Table 5.9: The cost effectiveness estimates assume a constant price of $1.20 per gallon through the life of the vehicles. The gasoline price should be adjusted down to reflect the impact of decreased gasoline consumption due to fuel efficiency. Further, vehicle miles traveled should

increase through time as cars become more fuel efficient, consistent with the trend to date, instead of held constant.

Chapter 7

42) 7.1, paragraph 2: If the report has eliminated the double counting in this sector evident in the June 10 draft, then the sentence that states that double counting is "a likely possibility" should be deleted. A reference to appendix G-2 should be inserted.

43) 7.2, paragraph 3: Again, if the double counting has been remedied by integrating the dispatching and repowering analyses, then the following sentence should be modified: "The analytical approach was static in that the cost of repowering was computed for each candidate power plant but the analysis did not optimize unit/plant production cost, dispatch, or system load."

44) 7.6, paragraph 5: The reference to appendix G-2 appears to be wrong. This reference implies that appendix G-2 provides a methodology for SO_2 and NO_X benefits. Nothing in the text of chapter 7 reads as if the double counting issue from the June 10 draft has been resolved.

Appendices

45) A-1.9: The alternative view cost-effective estimates for buildings assumes an 18 year time horizon. However, the methodology discussion on p. 2.5 states that a "technology is defined as 'cost-effective' if it delivers a good or service at equal or lower life-cycle costs relative to the current practice". If cost-effectiveness is measured in terms of a technology's life cycle, then shouldn't the time horizon for calculating the stream of benefits be constrained by the life of the product? It is not possible for a technology to generate cost savings beyond its lifetime. In the buildings case, the end uses with the largest potential carbon reductions in the high efficiency case are other uses (10 MMTCE commercial, 6 MMTCE residential) and lighting (7 MMTCE commercial, 6 MMTCE residential). These account for 29 of the 62 MMTCE of reductions for this sector. However, the lifetimes for these end uses are much shorter than 18 years. For other uses, the lifetime ranges from 7 (commercial) to 10 years (residential). For lighting, the lifetime ranges from 1 (residential) to 12 years (commercial). The cost effectiveness estimates should be recalculated using specific end use lifetimes.

Summary of Greenhouse Gas Emissions-Reduction Actions

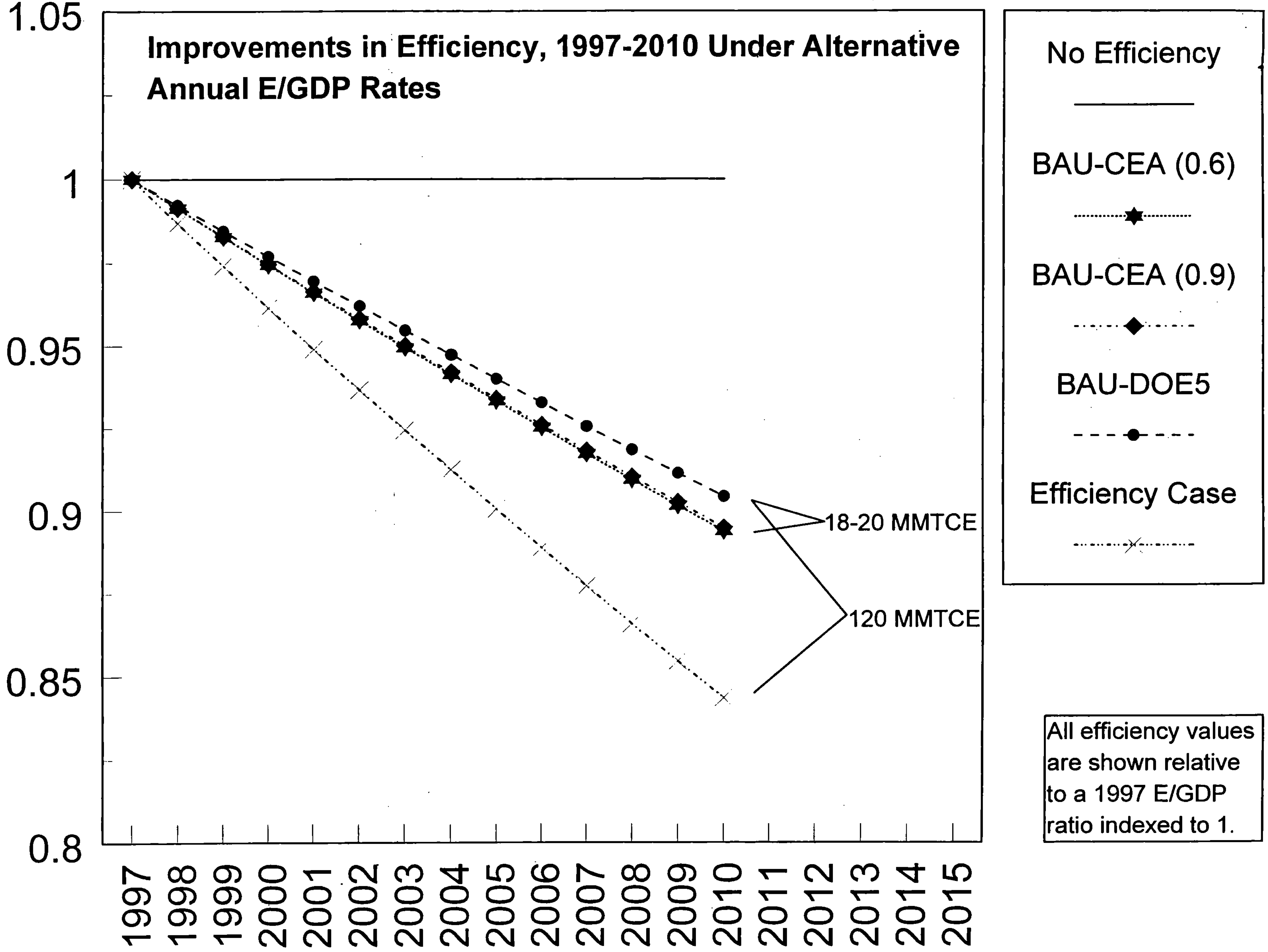
Million Metric Tons of Carbon Equivalent

Source: U.S. Climate Action Report—1997

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
Residential & Commercial Sector Actions		26.9	10.3	--
New	Rebuild America	2.0	1.6	--
1 and 2	Expanded Green Lights and Energy Star Buildings	3.6	3.3	--
3	State Revolving Fund for Public Buildings	1.1	Terminated	
4 5	Cost-Shared Demonstrations of Emerging Technologies Operation and Maintenance Training for Commercial Building Facility Managers and Operators	3.8	0.0	--
6	Energy Star Products	5.0	4.3	--
7	Residential Appliance Standards	6.8	0.2	--
8 and 11 9 10	Energy Partnerships for Affordable Housing Cool Communities Update State Building Codes	4.4	0.4	--
New	Construction of Energy-Efficient Commercial and Industrial Buildings		0.1	--
New	Superwindow Collaborative		0.0	--
New	Expand Markets for Next-Generation Lighting Products		0.2	--
New	Fuel Cells Initiative		0.0	--
Industrial Sector Actions		19.0	4.8	--
12	Motor Challenge	8.8	1.8	--
13 14	Industrial Golden Carrot Programs Accelerate the Adoption of Energy-Efficient Process Technologies	2.9	Merged into Action 12 Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	--
17 18	Improve Efficiency of Fertilizer Nitrogen Use Reduce the Use of Pesticides	2.7	0.8 Terminated	--
Transportation Sector Actions		8.1	5.3	--
19 20 21	Cash Value of Parking Innovative Transportation Strategies Telecommuting Program	6.6	4.6	--
22	Fuel Economy Labels for Tires	1.5	0.7	--
Energy Supply Actions		10.8	1.3	--
23	Increase Natural Gas Share of Energy Use Though Federal Regulatory Reform	2.2	Terminated	

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
24	Promote Seasonal Gas Use for Control of Nitrogen Oxides	2.8	0.5	--
25	High-Efficiency Gas Technologies	0.6	Terminated	
26	Renewable-Energy Commercialization	0.8	0.3	--
27	Expand Utility Integrated Resource Planning	1.4	Terminated	
28	Profitable Hydroelectric Efficiency Upgrades	2.0	0.0	--
29 30	Energy-Efficient Distribution Transformer Standards Energy Star Distribution Transformers	0.8	0.5	--
31	Transmission Pricing Reform	0.8	Terminated	
New	Green Power Network	Not included	0.0	--
Land-Use Change & Forestry Actions		10.0	2.4	--
43	Private Depletion of Nonindustrial Private Forests	4.0	Terminated	
44	Accelerate Tree Planting in Nonindustrial Private Forests	0.5	0.4	--
16	Waste Minimization	4.2	2.0	--
9	Expand Cool Communities	0.5	To be determined	
Methane Actions		16.3	15.5	--
32	Expand Natural Gas STAR	3.0	3.4	--
33	Increase Stringency of Landfill Rule	4.2	6.3	--
34	Landfill Methane Outreach Program	1.1	1.9	--
35	Coalbed Methane Outreach Program	2.2	2.6	--
36	RD&D for Coal Mine Methane	1.5	Terminated	
37	RD&D for Landfill Methane	1.0	Terminated	
38	AgSTAR Program	1.5	0.3	--
39	Ruminant Livestock Efficiency Program	1.8	1.0	--
Actions to Address Other Greenhouse Gases		16.3	25.4	--
17	Improved Fertilizer Management	4.5	5.3	--
40	Significant New Alternatives Program	5.0	6.4	--
41	HFC-23 Partnerships	5.0	5.0	--
42	Voluntary Aluminum Partnership	1.8	2.2	--
New	Environmental Stewardship Initiative	Not included	6.5	--
Foundation Actions			11.3	--
	Climate Wise	Not estimated	1.8	--
	Climate Challenge	Not estimated	7.6	--
	State and Local Outreach Programs	Not estimated	1.9	--
Total GHG Emission Reductions From CCAP		108.6	76.0	14.0

Data is not readily available for cumulative emissions reductions for many CCAP programs. Emissions reductions of about 5 MMTCE can be attributed to DOE's CCAP programs. EPA's Office of Air and Radiation is responsible for emissions reductions of about 9 MMTCE through their CCAP programs.


Improvements in Efficiency, 1997-2010 Under Alternative Annual E/GDP Rates
1.05
1
0.95
0.9
0.85
0.8
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
18-20 MMTCE
120 MMTCE
No Efficiency
BAU-CEA (0.6)
BAU-CEA (0.9)
BAU-DOE5
Efficiency Case
All efficiency values are shown relative to a 1997 E/GDP ratio indexed to 1.