

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.
- *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.*

Excerpt from the President's speech at American University, 9/9/97

"And we also need people who have the confidence in our ability to break new technological and scientific barriers to stand up and say, you cannot make me believe that we can't reduce greenhouse gas emissions substantially and still grow the American economy. We could reduce them 20 percent tomorrow with technology that is already available at no cost if we just changed the way we do things."

The President's statement reflects the result of a study conducted by five Department of Energy research laboratories titled *Scenarios of U.S. Carbon Reductions*. This study, still in draft form, claims that carbon emissions can be reduced to 1990 levels in 2010 at "net costs to the U.S. economy [that] are near or below zero in this time frame [1998-2020]" (p. 16, chapter 1, 8/29/97 draft). The Council of Economic Advisers and the Department of Treasury have reviewed this report and found the economic analyses to be inadequate to support this assertion. The study suffers two serious flaws. First, it merely assumes "aggressive" and "invigorated" government policies to stimulate technology adoption, without a discussion of the political feasibility of these policies or whether these technologies would be voluntarily adopted by private parties. The study does not provide reliable estimates of the costs of government programs nor does it estimate the costs of extensive and intrusive new regulations implied, including stringent CAFE standards, national building codes, and very aggressive appliance standards. This country's experience with the Climate Change Action Program implies that the government costs of achieving this goal would be in the billions of dollars annually. Second, the analyses on individuals' and firms' adoption decisions do not assess economic behavior, but rather invoke a set of engineering assumptions that generate substantial underestimates of complete adoption costs. The study ignores likely individuals' behavioral responses to climate policy (e.g., people drive more miles when cars become more fuel efficient), implementation costs, and the costs of accelerating capital retirement, but assumes that individuals live in model houses, drive model cars, and purchase products manufactured in model factories. The economic literature on technology adoption indicates that the actual net costs of energy efficient technologies are much greater than predicted by engineering studies like this study. *Scenarios of U.S. Carbon Reductions* is an engineering study, not an economic study. Given these inadequacies, neither CEA nor Treasury has signed off on the report.

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.

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).

Potential Reductions in Carbon Emissions in 2010 (MMTCE)

		Non-Price Response	Price Response
Buildings	Total	54.5	7.5
	Commercial	26.7	2.3
	Other uses	9.2	0.8
	Lighting	6.5	0.5
	Space heating	3.7	0.3
	Space cooling	3.7	0.3
	Water heating	1.8	0.2
	Refrigeration	0.9	0.1
	Ventilation	0.9	0.1
	Office equipment/non-PCs	0.0	0.0
	Kerosene	0.0	0.0
	Office equipment/PCs	0.0	0.0
	Cooking	0.0	0.0
	Biomass	0.0	0.0
Residential	Total	30.1	2.9
	Other uses	14.8	1.2
	Water heating	4.5	0.5
	Lighting	4.5	0.5
	Space heating	1.8	0.2
	Cooking	1.8	0.2
	Refrigeration	0.9	0.1
	Space cooling	0.9	0.1
	Clothes dryers	0.9	0.1
	Kerosene	0.0	0.0
	Freezers	0.0	0.0
	Biomass	0.0	0.0
Other	Total	0.0	3.0
	Fuel Cells	0.0	3.0
Utilities	Total	0.0	136.0
	Dispatching	0.0	55.0
	Conversion to Natural Gas	0.0	40.0
	Co-firing with Biomass	0.0	17.0
	Power plant efficiency	0.0	8.0
	Wind	0.0	7.0
	Nuclear plant life extension	0.0	5.0
	Hydro-power expansion	0.0	4.0

		Non-Price Response	Price Response
Transportation	Total	103.0	0.0
Cellulosic ethanol	Total	16.0	0.0
Transportation efficiency	Total	87.0	0.0
	Materials substitution		
	Aerodynamic drag reduction		
	Improved automatic transmissions		
	Engine friction reduction		
	Variable valve timing		
	Lean burn engines		
	Advanced tires		
	Hybrid electric power trains		
	DISC gasoline engines		
	TDI diesel engines		
	Fuel cell power trains		
	Fuel cells in trucks and locomotives		
	Train flywheels		
	Train oxygen enrichment		
	Natural gas locomotives		
	Plane ultrahigh bypass turbofans		
	Intelligent transportation systems		
Industry	Total	51.0	31.0
Heavy manufacturing	Total	16	0
	Pulp and paper	2.6	0.0
	Bulk chemicals	4.1	0.0
	Petroleum	4.3	0.0
	Glass	0.4	0.0
	Cement	0.5	0.0
	Iron and steel	2.6	0.0
	Aluminum	0.3	0.0
	Other	1.2	0.0
Light manufacturing	Total	24.0	0.0
Non-manufacturing	Total	10.8	0.0
Other	Total	0.0	31.0
	Advanced turbine systems	0.0	17.0
	Biomass and black liquor gasification, cement clinker replacement, aluminum technology	0.0	14.0
Total		210.6	175.2

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SUBJECT: Review of Labs Study

MESSAGE:

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.

- 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 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.

- 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 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 Scenarios¹

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.

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 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.

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 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 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

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%

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.

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

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.

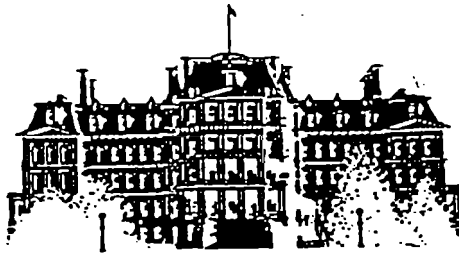
⁸ The labs study also modified the electricity sector forecast, but that modification is not relevant to our discussion of the energy efficiency of the economy.

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

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 over estimates emissions reductions by 22 MMTCE. Over estimates in the high efficiency cases would be greater than this.

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

EXECUTIVE OFFICE OF THE PRESIDENT



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NO. OF PAGES (inc cover) 8

DATE: 8/18/97

SUBJECT: DOE Labs Study

MESSAGE:

Ray - Here is the most recent version of our Labs
Study review - obviously, it needs revision given Friday's
release of the August 1 draft. We should talk this
afternoon about some of the modifications to the report.

Joe

Review of DOE Labs Study, June 10 Draft

We review *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 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 technology they find could reduce emissions of 180 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 180 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.

- 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 that 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 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.

- 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.

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 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 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 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 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 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. 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 \$50/ton tradeable permit. 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.¹

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 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.
- 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

¹ 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.

reduce carbon emissions and to offer financial returns.² 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. 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 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

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

“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 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. 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.³ 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

³ 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.

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% 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.⁴

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.

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Table 1.10 Passenger Car Efficiency

	Mileage		Fuel Consumption		Fuel Rate	
	Miles per Car	Index 1973=100.0	Gallons per Car	Index 1973=100.0	Miles per Gallon	Index 1973=100.0
1973....	10,256	100.0	771	100.0	13.30	100.0
1974....	9,606	93.7	716	92.9	13.42	100.9
1975....	9,690	94.5	716	92.9	13.52	101.7
1976....	9,785	95.4	723	93.8	13.53	101.7
1977....	9,879	96.3	716	92.9	13.80	103.8
1978....	9,835	95.9	701	90.9	14.04	105.6
1979....	9,403	91.7	653	84.7	14.41	108.3
1980....	9,141	89.1	591	76.7	15.46	116.2
1981....	9,186	89.6	575	74.7	15.94	119.8
1982....	9,428	91.9	566	73.4	16.65	125.2
1983....	9,475	92.4	553	71.7	17.14	128.9
1984....	9,558	93.2	536	69.5	17.83	134.1
1985....	9,560	93.2	525	68.1	18.20	136.8
1986....	9,608	93.7	526	68.2	18.27	137.4
1987....	9,878	96.3	514	66.7	19.20	144.4
1988....	10,121	98.7	509	66.0	19.87	149.4
1989....	10,332	100.7	509	66.0	20.31	152.7
1990....	10,548	102.8	502	65.1	21.02	158.0
1991....	10,757	104.9	496	64.3	21.69	163.1
1992....	11,100	108.2	512	66.4	21.68	163.0
1993....	11,760	114.7	559	72.5	21.04	158.2
1994....	11,210	109.3	504	65.4	22.24	167.2
1995a...	11,329	110.5	502	65.1	22.56	169.6

a Preliminary data.

Note: Geographic coverage is the 50 States and the District of Columbia.

Sources: Indices are prepared from statistics published by the U.S.

Department of Transportation, Federal Highway Administration, Federal Highway Statistics Division. • 1973-1985: Highway Statistics Summary to 1985, Table VM-201A. • 1986 forward: Highway Statistics, annual, Table VM-1.

Table 9.4 Motor Gasoline Retail Prices, U.S. City Average
(Cents per Gallon, Including Taxes)

	Leaded Regular	Unleaded Regular	Unleaded Premium	All Types ^a
1973 Average	38.8	NA	NA	NA
1974 Average	53.2	NA	NA	NA
1975 Average	56.7	NA	NA	NA
1976 Average	59.0	61.4	NA	NA
1977 Average	62.2	65.6	NA	NA
1978 Average	62.6	67.0	NA	65.2
1979 Average	65.7	90.3	NA	80.2
1980 Average	119.1	124.5	NA	122.1
1981 Average ^b	131.1	137.8	^c 147.0	135.3
1982 Average	122.2	129.6	141.5	128.1
1983 Average	115.7	124.1	138.3	122.5
1984 Average	112.9	121.2	136.6	119.8
1985 Average	111.5	120.2	134.0	119.6
1986 Average	85.7	92.7	108.5	93.1
1987 Average	89.7	94.8	109.3	95.7
1988 Average	89.9	94.6	110.7	96.3
1989 Average	99.8	102.1	119.7	106.0
1990 Average	114.9	116.4	134.9	121.7
1991 Average	NA	114.0	132.1	119.6
1992 Average	NA	112.7	131.6	119.0
1993 Average	NA	110.8	130.2	117.3
1994 Average	NA	111.2	130.5	117.4
1995 January	NA	112.9	132.4	119.0
February	NA	112.0	131.6	118.1
March	NA	111.5	130.6	117.3
April	NA	114.0	132.5	119.7
May	NA	120.0	138.3	125.6
June	NA	122.6	141.1	128.1
July	NA	119.5	138.4	125.2
August	NA	116.4	135.2	122.2
September	NA	114.8	133.2	120.6
October	NA	112.7	131.5	118.5
November	NA	110.1	129.2	116.1
December	NA	110.1	129.0	116.0
Average	NA	114.7	133.6	120.5
1996 January	NA	112.9	131.7	118.6
February	NA	112.4	131.1	118.1
March	NA	116.2	134.8	121.9
April	NA	125.1	143.1	130.5
May	NA	132.3	150.7	137.8
June	NA	129.9	148.1	135.4
July	NA	127.2	145.3	132.8
August	NA	124.0	142.1	129.8
September	NA	123.4	141.7	129.3
October	NA	122.7	140.8	128.7
November	NA	125.0	142.8	130.8
December	NA	126.0	143.8	131.8
Average	NA	123.1	141.3	128.8
1997 January	NA	126.1	144.1	131.8
February	NA	125.5	143.4	131.2
March	NA	123.5	141.5	129.3
April	NA	123.1	141.3	128.8

^a Also includes types of motor gasoline not shown separately.

^b In September 1981, the Bureau of Labor Statistics changed the weights used in the calculation of average motor gasoline prices. From September 1981 forward, gasohol is included in the average for all types, and unleaded premium is weighted more heavily.

^c Based on September through December data only.

NA=Not available.

Notes: • See Note 5 at end of section. • Geographic coverage for

1973-1977 is 56 urban areas. Geographic coverage for 1978 forward is 85 urban areas.

Sources: • Monthly Data: U.S. Department of Labor, Bureau of Labor Statistics, *Consumer Prices: Energy*. • Annual Data: 1973—*Platt's Oil Price Handbook and Oilmanac*, 1974, 51st Edition. 1974 forward—calculated by the Energy Information Administration as the simple averages of monthly data.

Data

	JAGDP	Gas Prices	Real Gas Prices	Fuel Efficiency	Dummy	VMT
.DESC	Gross Domestic Product: Chain-type Price Index (1992=100)					
73	35.3					
74	38.5					
75	42.1					
76	44.5					
77	47.4					
78	50.9	65.2	128.0943026	14.04	0	9835
79	55.2	88.2	159.7826087	14.41	1	9403
80	60.3	122.1	202.4875622	15.46	1	9141
81	66.0	135.3	205	15.94	1	9186
82	70.2	128.1	182.4786325	16.65	0	9428
83	73.2	122.5	167.3497268	17.14	0	9475
84	75.9	119.8	157.8392622	17.83	0	9558
85	78.5	119.6	152.3566879	18.2	0	9560
86	80.6	93.1	115.5086849	18.27	0	9608
87	83.1	95.7	115.1624549	19.2	0	9878
88	86.1	96.3	111.8466899	19.87	0	10121
89	89.7	106	118.1716834	20.31	0	10332
90	93.6	121.7	130.0213675	21.02	0	10548
91	97.3	119.6	122.9188078	21.69	0	10757
92	100.0	119	119	21.68	0	11100
93	102.6	117.3	114.3274854	21.04	0	11760
94	105.1	117.4	111.7031399	22.24	0	11210
95	107.8	120.5	111.7810761	22.56	0	11329
96	110.2	128.8	116.8784029		0	
97	#N/A					

SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.873014506					
R Square	0.762154328					
Adjusted R Squa	0.730441572					
Standard Error	421.5018896					
Observations	18					
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	2	8539608.856	4269804.428	24.03305229	2.09998E-05	
Residual	15	2664957.644	177663.8429			
Total	17	11204566.5				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	7497.761744	1507.692672	4.973004035	0.000166882	4284.188907	10711.33458
Real Gas Prices	-7.194186457	4.515227632	-1.593316449	0.131939065	-16.81817226	2.429799343
FE (MPG)	193.8692989	52.77429571	3.673555398	0.002258167	81.38348112	306.3551166

SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.880980753					
R Square	0.776127087					
Adjusted R Squa	0.72815432					
Standard Error	423.2863724					
Observations	18					
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	3	8696167.557	2898722.519	16.17849321	7.94031E-05	
Residual	14	2508398.943	179171.3531			
Total	17	11204566.5				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	7613.574388	1519.136268	5.011778436	0.000190314	4355.348246	10871.80053
Real Gas Prices	-9.678399692	5.25575337	-1.841486655	0.086834406	-20.95087958	1.594080196
FE (MPG)	203.0956012	53.90898143	3.76737968	0.002080659	87.47223264	318.7189698
Dummy	358.578264	383.6009218	0.934769036	0.365751428	-464.1646184	1181.321146

SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.880980753					
R Square	0.776127087					
Adjusted R Squa	0.72815432					
Standard Error	423.2863724					
Observations	18					
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	3	8696167.557	2898722.519	16.17849321	7.94031E-05	
Residual	14	2508398.943	179171.3531			
Total	17	11204566.5				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	7613.574388	1519.136268	5.011778436	0.000190314	4355.348246	10871.80053
Real Gas Prices	-9.678399692	5.25575337	-1.841486655	0.086834406	-20.95087958	1.594080196
FE (MPG)	203.0956012	53.90898143	3.76737968	0.002080659	87.47223264	318.7189698
Dummy	358.578264	383.6009218	0.934769036	0.365751428	-464.1646184	1181.321146

SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.873014506					
R Square	0.762154328					
Adjusted R Squa	0.730441572					
Standard Error	421.5018896					
Observations	18					
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	2	8539608.856	4269804.428	24.03305229	2.09998E-05	
Residual	15	2664957.644	177663.8429			
Total	17	11204566.5				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	7497.761744	1507.692672	4.973004035	0.000166882	4284.188907	10711.33458
Real Gas Prices	-7.194186457	4.515227632	-1.593316449	0.131939065	-16.81817226	2.429799343
FE (MPG)	193.8692989	52.77429571	3.673555398	0.002258167	81.38348112	306.3551166

Data

	JAGDP	Gas Prices	Real Gas Prices	Fuel Efficiency	Dummy	VMT
.DESC	Gross Domestic Product: Chain-type Price Index (1992=100)					
73	35.3					
74	38.5					
75	42.1					
76	44.5					
77	47.4					
78	50.9	65.2	128.0943026	14.04	0	9835
79	55.2	88.2	159.7826087	14.41	1	9403
80	60.3	122.1	202.4875622	15.46	1	9141
81	66.0	135.3	205	15.94	1	9186
82	70.2	128.1	182.4786325	16.65	0	9428
83	73.2	122.5	167.3497268	17.14	0	9475
84	75.9	119.8	157.8392622	17.83	0	9558
85	78.5	119.6	152.3566879	18.2	0	9560
86	80.6	93.1	115.5086849	18.27	0	9608
87	83.1	95.7	115.1624549	19.2	0	9878
88	86.1	96.3	111.8466899	19.87	0	10121
89	89.7	106	118.1716834	20.31	0	10332
90	93.6	121.7	130.0213675	21.02	0	10548
91	97.3	119.6	122.9188078	21.69	0	10757
92	100.0	119	119	21.68	0	11100
93	102.6	117.3	114.3274854	21.04	0	11760
94	105.1	117.4	111.7031399	22.24	0	11210
95	107.8	120.5	111.7810761	22.56	0	11329
96	110.2	128.8	116.8784029		0	
97	#N/A					

SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.869034731					
R Square	0.755221363					
Adjusted R Square	0.722584211					
Standard Error	0.041420829					
Observations	18					
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	2	0.079401661	0.03970083	23.13992876	2.60496E-05	
Residual	15	0.025735276	0.001715685			
Total	17	0.105136937				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	9.00958452	0.557360057	16.16474737	6.72458E-11	7.821598949	10.19757009
ln(Real Gas Prices)	-0.135092419	0.066581124	-2.028989755	0.060594851	-0.277006814	0.006821975
ln(Fuel Efficiency)	0.299555603	0.094322146	3.175877714	0.006265708	0.098512583	0.500598622

F(3,14)

SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.875584034					
R Square	0.7666474					
Adjusted R Square	0.716643272					
Standard Error	0.041861999					
Observations	18					
<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	3	0.080602959	0.026867653	15.33168208	0.000105599	
Residual	14	0.024533978	0.001752427			
Total	17	0.105136937				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	9.088164045	0.571235915	15.909651	2.32977E-10	7.862983769	10.31334432
ln(Real Gas Prices)	-0.163336405	0.075443229	-2.165024043	0.048149247	-0.325146183	-0.001526628
ln(Fuel Efficiency)	0.318489558	0.098031402	3.248852412	0.005825988	0.108232924	0.528746191
Dummy	0.030734841	0.037121494	0.827952681	0.421587483	-0.048882917	0.110352598

reg (ln, ND)

SUMMARY OUTPUT					
<i>Regression Statistics</i>					
Multiple R	0.869034731				
R Square	0.755221363				
Adjusted R Square	0.722584211				
Standard Error	0.041420829				
Observations	18				
<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	2	0.079401661	0.03970083	23.13992876	2.60496E-05
Residual	15	0.025735276	0.001715685		
Total	17	0.105136937			
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>
Intercept	9.00958452	0.557360057	16.16474737	6.72458E-11	7.821598949
ln(Real Gas Prices)	-0.135092419	0.066581124	-2.028989755	0.060594851	-0.277006814
ln(Fuel Efficiency)	0.299555603	0.094322146	3.175877714	0.006265708	0.098512583

Reg (ln)

SUMMARY OUTPUT					
<i>Regression Statistics</i>					
Multiple R	0.875584034				
R Square	0.7666474				
Adjusted R Square	0.716643272				
Standard Error	0.041861999				
Observations	18				
<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	3	0.080602959	0.026867653	15.33168208	0.000105599
Residual	14	0.024533978	0.001752427		
Total	17	0.105136937			
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>
Intercept	9.088164045	0.571235915	15.909651	2.32977E-10	7.862983769
ln(Real Gas Prices)	-0.163336405	0.075443229	-2.165024043	0.048149247	-0.325146183
ln(Fuel Efficiency)	0.318489558	0.098031402	3.248852412	0.005825988	0.108232924
Dummy	0.030734841	0.037121494	0.827952681	0.421587483	-0.048882917

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TO:

Quindi Franco
Council of Economic Advisors
(202) 395-4563
FAX (202) 395-6870

FROM:

Stanton W. Hadley
(423) 574-8018
FAX(423) 574-8884

August 12, 1997, 2:34 pm

This transmittal consists of 3 pages.

Subject: Romm study Appendix F

Comments:

Here are the first two pages of the Appendix F from the Romm study. It describes the inputs and outputs of the ORCED model.

Call if you have any questions.



Appendix F-1

APPENDIX F-1

INPUTS AND OUTPUTS OF THE ORCED MODEL

The ten tables presented in this appendix show the inputs and outputs for each of the five main runs of the Oak Ridge Competitive Electricity Dispatch (ORCED) used in this study. For each run, the first page shows the input sheet, with those values that are input rather than calculated in bold. The second page shows the outputs, highlighting the key results for each case. The identifying name can be found in the top left of each page. The five cases are:

- AEO 2010 (our approximation of the EIA's AEO '97 results)
- Restructure Case (using pricing on the margin and minimizing avoided costs)
- Efficiency Case (intermediate demand-side efficiency)
- High-Efficiency/Low-Carbon Case (maximum demand-side efficiency)
- Alternative Technology Case (using advanced production technologies defined by DOE's Office of Fossil Energy)

ORCED is a production-costing model that uses load-duration curves rather than chronological loads as inputs. The model is run twice for each year of simulation, once for an onpeak season and a second time for an offpeak season.

For each season, the model has available to it 26 generating units. The first 25 units are characterized in terms of capacity, forced and planned outage rates, fuel type, heat rate, variable O&M costs, fixed O&M costs, and annual capital costs (based on initial construction cost, year of completion, and capitalization structure). The last unit is an energy-limited hydro unit, for which the inputs include, in addition to those noted above, the plant's capacity factor (equivalent to its maximum energy output for the year). This treatment of hydro as energy-limited ensures that hydro displaces the most expensive energy (i.e., at the top of the load-duration curves).

The model dispatches these 26 generating units separately for the two seasons. Although the calculation process is the same for the two seasons, the results differ because of differences in the load-duration curves and because all the planned maintenance is assumed to occur in the offpeak season.

The plants are first dispatched against the load-duration curve on the basis of bid price, the default for which is variable (fuel plus variable O&M) costs. (If the user bids a zero price for a unit, the generator is treated as a must-run unit and is dispatched first by the model.) Because plants are not available 100% of the time, we also model forced outages on a probabilistic basis. Thus, the higher-cost plants will see demands not only from customers, but "equivalent demands" based on the probability that plants lower (i.e., less expensive) in the dispatch order will be undergoing a forced outage. The model creates an equivalent load-duration curve for each plant, which extends the amount of time the plant runs based on the forced-outage rates of the plants lower in the dispatch order.

INPUTS

The inputs at the top of the Input sheet (lines 1 through 13) are global inputs that determine the two load-duration curves, the number of generators that will be treated probabilistically (vs derated), the cost and carbon emissions per million Btu for each fuel type, and the financial characteristics of the generator owners (book and depreciation lifetimes, capitalization ratios, and return on bonds and common equity).

Appendix F-1

This portion of the sheet also allows the user to specify either the cost of unserved energy or a price elasticity. In the former case, whenever demand exceeds supply, customers pay and suppliers receive that rate for all the energy sold during that time period. If the elasticity option is used, the price of electricity increases beyond the cost of the most expensive unit then online until demand and supply equilibrate; the lower the elasticity value, the larger the price increase required to reduce demand to the level of available supply.

The user can also specify an uplift charge (analogous to that used in the UK), which is added to every kWh sold, a tax on carbon, or an annual capacity payment in \$/kW-year. These various unserved energy, price elasticity, uplift charge, and capacity-payment options allow one to test different structures for a competitive bulk-power market.

The model includes a user input on fuel plus O&M startup costs. This factor is used to ensure that low-capacity-factor units recover all their variable costs, including those associated with startup, shutdown, and no-load operations.

Rows 18 through 44 include the user inputs on the 26 generators that are used by ORCED to meet system load (as specified by the two load-duration curves). For each of the first 25 generators, the user specifies unit capacity, whether the plant is available for use during this particular analysis, forced and planned outage rates, fixed O&M costs, initial plant cost and year of completion (which are used by the fixed-charges rate routine to compute the annual unavoidable fixed cost), heat rate and fuel type (which determine the unit's fuel cost), variable O&M cost, and bid price (input as OP to use the unit's fuel plus variable O&M cost). Line 44 allows the user to input assumptions for an energy-limited hydro unit.

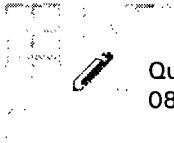
OUTPUTS

The Output sheet summarizes the results of the particular analysis. Key results are shown in the region A2:N11. These results show the system's overall variable cost per kWh, variable plus avoidable fixed cost per kWh, and total cost per kWh, as well as the average price of electricity, all computed at the generator busbar. The summary information also shows system reliability as measured by reserve margin and the loss of load probability and amounts of unserved energy in the two seasons. The amount of unserved energy, in combination with the assumed onpeak price elasticity, determines the cost of unserved energy (N46). The model calculates the number of plants that are unprofitable relative to avoidable fixed costs (G3) and relative to total fixed costs (G4), with details shown in the region A47:D75. The summary shows the distribution of system capacity, energy production, and cost by type of generation. Finally, the summary shows total carbon emissions for this analysis year (N41). Since ORCED is modeling 2% of the national total, this value (as well as overall sales and peak) should be multiplied by 50 to get national totals for these values.

The middle part of Output shows operating results, revenues, and costs for each of the 26 generators specified in Input. These results show each unit's output, capacity factor, and time on the margin for the year of analysis. These operating results are then used to determine revenues, variable costs, fixed costs, and net revenues.

The lower left portion of this Output sheet (A47:D75) shows the earnings for each generator relative to variable and avoidable fixed costs (but not unavoidable fixed costs, which are primarily related to capital costs). Negative numbers reflect losses per kW, and show the capacity surcharge that would be necessary to keep them operating.

The chart shows the generating price of power at the busbar for the peak and offpeak seasons. These prices are higher during the fraction of each season when higher-cost plants are required to operate to meet demand.



Quindi C. Franco
08/12/97 02:52:07 PM

Record Type: Record

To: Joseph E. Aldy/CEA/EOP
cc:
Subject: ORCED model for Romm study

In case you have time this afternoon...

Q

----- Forwarded by Quindi C. Franco/CEA/EOP on 08/12/97 02:48 PM -----



hadleysw @ ornl.gov
08/12/97 02:33:00 PM

Record Type: Record

To: Quindi C. Franco
cc:
Subject: ORCED model for Romm study

Mr. Franco,

Per your request, attached is a zip file containing ORCED3.XLS and ROMResul.XLS. They are Excel 5.0 spreadsheets I run on my Mac. ORCED3 is the model I developed for dispatching the plants; ROMResul contains the input sheets for each run and the key results from them all. (I've pulled out a couple of integrating cases that haven't been finalized yet to avoid confusion.)

To see the results of any one run, you copy the sheet containing the inputs from Romresul.xls and paste it into Input in ORCED3.xls. You then type cntl-A to start it running. Results will be in the Output worksheet.

I'm faxing you the two pages from the Appendix that explain the input and output more fully.

The inputs were developed through synthesis of a number of pieces of data. It involved collapsing the list of existing plants into twenty-six representative plants for dispatching purposes, calculation of national load curves by summing the hourly demands for over 200 utilities, and using the EIA's inputs and results from their model runs for the Annual Energy Outlook to determine base plant additions and retirements, demands in 2010, and fuel costs. There were also other sources, such as NERC and EPRI, for powerplant characteristics such as forced and planned outage rates.

As explained in the chapter, we first created a set of inputs for 1995 and 2010 that correspond to the AEO reference case. We then used either the Solver function of Excel or a third-party genetic algorithm to minimize avoidable costs by changing the capacities of the various powerplants, retiring existing plants and building more or less of the plants yet to be built.

Also, because we believe the future will involve more real-time pricing of electricity, we recalculated the demand curve based on the change in prices over the year versus a flat price assumed for the initial load curve. We reoptimized again using the new demands to get our final cases.

Please call if you have further questions. I believe our model gives a good representation of what could happen given the various policies studied.

Stan Hadley



081214DP.MA



081214DQ.TX



081214DR.T

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).

The authors assume that policies are implemented that significantly lower the barriers to technology adoption without any discussion of their costs. 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”: firms and individuals receive energy cost-savings in excess of the 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.

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.

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.

addressing market failures for emissions market 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.¹ 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 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.² 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

¹ Note that CCAP efforts are incorporated in the AEO97 baseline.

² We employed a 7% discount rate to calculate the annuities in this paper.

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-intensive 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 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) indicates that 10 GW of coal-to-gas conversions (approximately 9 million tons of carbon reductions) were double-counted.³

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*

³ Hadley noted that a subsequent draft of the report should address at least some of the double counting, but he did not provide details.

Wilcox

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,

I find it really small

180 tons is only 1/3 of the way might be steeply increasing marginal cost

Doesn't the analysis also ignore implementation costs?

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.

with more electricity and more gas generation and more gasoline consumption, aren't we consuming a lot more energy in the baseline

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.

Does this make sense with lower prices?

What is this sentence saying?

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 AEE 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~~

discuss
~~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~~ *merely reports that* ~~to 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.

I thought these were ignored?
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" can 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

This is so text-bookish. Could insert material here from next page.
The economics literature has identified several barriers *may help* 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~~.

Incident • Energy efficiency is not the only thing that matters to consumers. 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.

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.

• New technologies may be costly to integrate with existing ones. Until 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. ^{all components of a complex system are fully depreciated} it may make sense to replace an energy-inefficient component with another likewise-inefficient component.

No

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.

If investment is irreversible, social = private, doesn't it?

Heterogeneous use of energy-intensive technology can affect who benefits from efficiency investments and who does not. ^{just because} If a technology is cost-effective on average, ^{it does not mean that it is} cost-effective for all individuals, who do not use much energy. ^{Those who may use the device less intensively may find it optimal to purchase a less efficient model.}

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.~~

Can move some of this to previous page.

~~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 reduction 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. 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~~

reducing emissions. ^{firm's participation in} ^{benefit financially in return for}

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

I think stocks & flows are confused here.

Need footnote questioning why any gov't action is required to attain truly "cost effective" reductions.

Attaining the 180 MMTCE reduction per year

exceed \$6.3 billion. To account for the opportunity cost of capital through time, we annualized this value and found that government costs would run about \$150 million annually into perpetuity. However, the marginal costs of technology adoption in the efficiency and high efficiency/low carbon scenarios are ~~definitely~~ ^{as is almost surely the case} 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~~ ^{per year}). 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).

Price declines resulting from reductions in energy demand ~~The Sectoral Analyses Are Not Integrated~~ are not taken into account.

Are the price increases induced by the permit scheme 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).

Is this right? Why bother with the \$50/ton fee?

Add FN

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.~~ ^{however, if the energy prices fall due to the decline in} The ~~Los~~ 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.

I'd like to see this really hammer 2 points:

- (1) Firms will do what is profitable regardless of gov't programs;
- (2) Assumed hurdle rate for industry is ~~exogenously~~ reduced from 33% to 15%.

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 cost related to early retirement of capital implies that this assumption implies that one of three results should be accounted for in the analysis. First, either 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, because 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.

? This doesn't flow logically

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, and there are substantial additional 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 ~~tenous~~ 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.

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 of participating in the PNGV are in addition to this large sum.

If the "luck" apparently pertains to a number of tenuous technological

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

What
"first"
analysis?

— express as a % of something

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.

message is a bit murky.
what point?

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

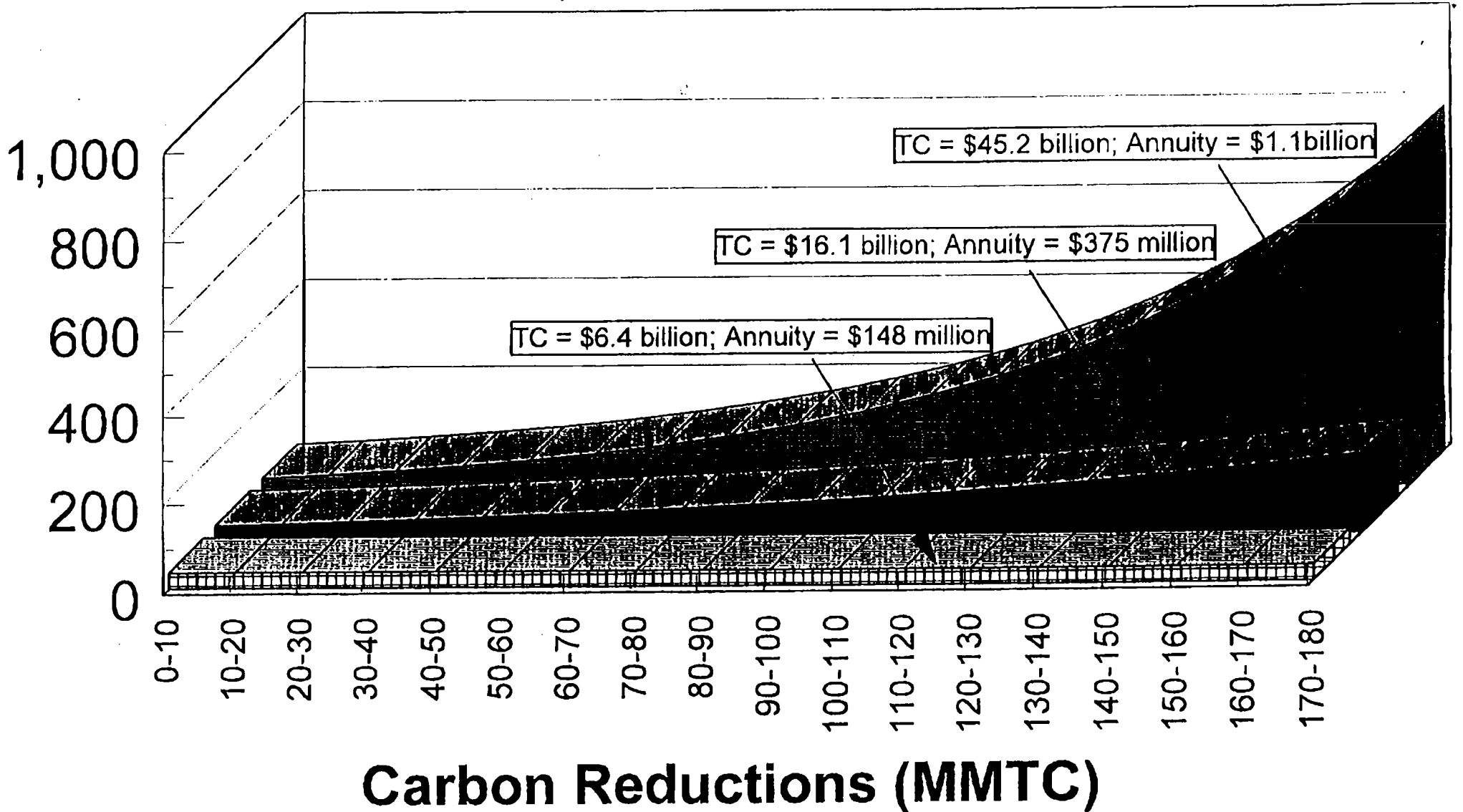
Source: U.S. Climate Action Report—1997

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	Cost-Shared Demonstrations of Emerging Technologies			
5	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	Energy Partnerships for Affordable Housing			
9	Cool Communities	4.4	0.4	--
10	Update State Building Codes			
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	Industrial Golden Carrot Programs	2.9	Merged into Action 12	
14	Accelerate the Adoption of Energy-Efficient Process Technologies		Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	--
17	Improve Efficiency of Fertilizer Nitrogen Use	2.7	0.8	--
18	Reduce the Use of Pesticides		Terminated	
Transportation Sector Actions		8.1	5.3	--
19	Cash Value of Parking			
20	Innovative Transportation Strategies	6.6	4.6	--
21	Telecommuting Program			
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 Through 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	Energy-Efficient Distribution Transformer Standards	0.8	0.5	--
30	Energy Star Distribution Transformers			
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)



- -
 -
- MC = AC of CCAP MC Increases 10% Every 10 MMTC
- MC Increases 20% Every 10 MMTC

MEMORANDUM

TO: Jay Shogren
FROM: Joe Aldy and Quindi Franco
DATE: August 7, 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 "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 of the caveats the authors explicitly state. First, the authors do not provide descriptions of the government programs necessary to stimulate the necessary technology adoption to reduce 180 million tons of carbon emissions. We devised an estimate of the costs of government programs to achieve these reductions based on the nation's experience with CCAP, and found that program costs could total \$45 billion (1995\$). 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 cross-sector interactions (e.g., in energy 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 conduct a more thorough review.

emissions
by

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,

neither

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". The study ~~does not~~ describe 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

This case assumes that all technologies adopted are cost-effective given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. Since these technologies are cost-effective, they all have a net cost less than or equal to zero. The Study estimates that 120 ~~MMTC~~ 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

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 180 ~~MMTC~~ ^{reductions of} of carbon emissions reductions 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 ~~MMTC~~ 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 (MMTC): 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

(20

186

Review

The authors of the Lab Study are forthright about many of the assumptions underlying the analysis. 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).

The authors assume that policies are implemented that significantly lower the barriers to technology adoption without any discussion of their costs. 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": firms and individuals receive energy cost-savings in excess of the technology adoption and implementation costs.

CEA Alternative Cost Estimates

Since the authors do not provide an estimate of the costs to government to lower market barriers to achieve these substantial 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.¹ 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 ~~14 million~~ ^{reductions of} ~~metric tons of reduced carbon~~ ^{14 MM TCE} (see attached table). Each ton of carbon reduced in CCAP cost the federal government \$35.29 (1995\$). Assuming a flat marginal cost curve (MC=AC) to reduce ~~180 million metric tons of carbon~~ ^{14 MM TCE} beyond the baseline, the government costs of the unidentified policies in the Labs Study would exceed \$6.3 billion. However, the marginal costs of technology adoption ~~are definitely higher than~~ ^{required for emissions reductions} the average cost of the first 14 million metric tons, 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 come to \$16.1 billion. This is 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.

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The Sectoral Analyses Are Not Integrated

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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 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).

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“[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 million tons), 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 alone is funded at the federal level at \$263 million. 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).

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² Hadley noted that a subsequent draft of the report should address at least some of the double counting, but he did not provide details.

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.

Action Number	Action Title	1993 Action Plan Estimate for 2000	1997 U.S. CAR Revised Estimate for 2000	Actual Reductions to Date
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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	Energy-Efficient Distribution Transformer Standards	0.8	0.5	--
30	Energy Star Distribution Transformers			
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.

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	Cost-Shared Demonstrations of Emerging Technologies			
5	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	Energy Partnerships for Affordable Housing			
9	Cool Communities	4.4	0.4	--
10	Update State Building Codes			
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	Industrial Golden Carrot Programs	2.9	Merged into Action 12	
14	Accelerate the Adoption of Energy-Efficient Process Technologies		Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	--
17	Improve Efficiency of Fertilizer Nitrogen Use	2.7	0.8	--
18	Reduce the Use of Pesticides		Terminated	
Transportation Sector Actions		8.1	5.3	--
19	Cash Value of Parking			
20	Innovative Transportation Strategies	6.6	4.6	--
21	Telecommuting Program			
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 Through Federal Regulatory Reform	2.2	Terminated	

for mmt in efficiency costs
1st ignored/unacknowledged costs
→ policies
implementation
mkt acceptance

MEMORANDUM

TO: Jay Shogren
FROM: Joe Aldy and Quindi Franco
DATE: August 7, 1997
RE: Review of DOE Labs Study, June 10 Draft

(program costs) / 3 → arg

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 “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 of the caveats the authors explicitly state. First, the authors do not provide descriptions of the government programs necessary to stimulate the necessary technology adoption to reduce 180 million tons of carbon emissions. We devised an estimate of the costs of government programs to achieve these reductions based on the nation’s experience with CCAP, and found that program costs could total \$45 billion (1995\$). 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 cross-sector interactions (e.g., in energy 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 conduct a more thorough review.

be more explicit
e what they will say in press release

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”. The study does not describe 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.

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This case assumes that all technologies adopted are cost-effective given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. Since these technologies are cost-effective, they all have a net cost less than or equal to zero. 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.

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7	Residential Appliance Standards	6.8	0.2	--
8 and 11	Energy Partnerships for Affordable Housing			
9	Cool Communities	4.4	0.4	--
10	Update State Building Codes			
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	Industrial Golden Carrot Programs	2.9	Merged into Action 12	
14	Accelerate the Adoption of Energy-Efficient Process Technologies		Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	--
17	Improve Efficiency of Fertilizer Nitrogen Use	2.7	0.8	--
18	Reduce the Use of Pesticides		Terminated	
Transportation Sector Actions		8.1	5.3	--
19	Cash Value of Parking			
20	Innovative Transportation Strategies	6.6	4.6	--
21	Telecommuting Program			
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 Through Federal Regulatory Reform	2.2	Terminated	

MEMORANDUM

TO: Jay Shogren

FROM: Joe Aldy and Quindi Franco

DATE: August 7, 1997

RE: Review of DOE Labs Study, June 10 Draft

Based on the actual history of CCAP, we estimate...

RANDI'S evil eye

insufficient

limitations of the study

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 "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 of the caveats the authors explicitly state. First, the authors do not provide descriptions of the government programs necessary to stimulate the necessary technology adoption to reduce 180 million tons of carbon emissions. We devised an estimate of the costs of government programs to achieve these reductions based on the nation's experience with CCAP, and found that program costs could total \$45 billion (1995\$). 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 cross-sector interactions (e.g., in energy 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 conduct a more thorough review.

should have been used to tech costs

partial in fuel price

Add \$/ton marginal marg.

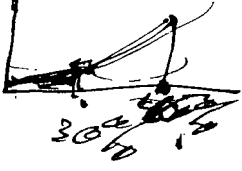
source of error not clear

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,

With changing fleet mix towards bigger sport vehicles, hasn't efficiency recently been falling?



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". The study does not describe 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 \$25? zero net cost to the user.

This case assumes that all technologies adopted are ~~cost-effective~~ given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. Since these technologies are ~~cost-effective~~, they all have a net cost less than or equal to zero. 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.

*Free. usually...
reception*

High Efficiency/Low Carbon Scenario @ \$50/t

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 180 mmtce of carbon emissions reductions 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 authors of the Lab Study are forthright about many of the assumptions underlying the analysis. 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.

~~~~~

1) Does a delay in effect of these programs require adjustment to C/E calculation?

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).

The authors assume that policies are implemented that significantly lower the barriers to technology adoption without any discussion of their costs. 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”: firms and individuals receive energy cost-savings in excess of the technology adoption and implementation costs.

Since the authors do not provide an estimate of the costs to government to lower market barriers to achieve these substantial 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.¹ 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 14 million metric tons of reduced carbon (see attached table). Each ton of carbon reduced in CCAP cost the federal government \$35.29 (1995\$). Assuming a flat marginal cost curve (MC=AC) to reduce 180 million metric tons of carbon beyond the baseline, the government costs of the unidentified policies in the Labs Study would exceed \$6.3 billion. However, the marginal costs of technology adoption are definitely higher than the average cost of the first 14 million metric tons, 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 come to \$16.1 billion. This is 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.

good to have other evidence on how fast MC rise

¹ Note that CCAP efforts are incorporated in AEO97.

reverse



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 180 million tons of carbon reduction occurs through energy efficient technology adoption without the price effect of a \$50/ton permit. 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 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-intensive 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.

zero on permit
Do we have an estimate of how much they over-predict?

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).

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).

are these costs included in your life k?

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 million tons), 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 alone is funded at the federal level at \$263 million. 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) indicates that 10 GW

of coal-to-gas conversions (approximately 9 million tons of carbon reductions) were double-counted.²

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.

² 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

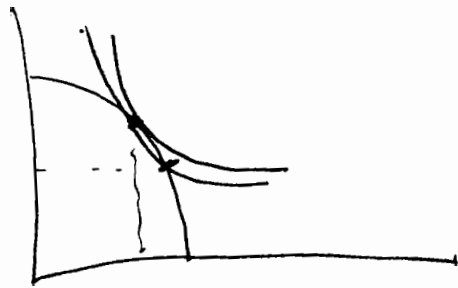
Million Metric Tons of Carbon Equivalent

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	Cost-Shared Demonstrations of Emerging Technologies			
5	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	Energy Partnerships for Affordable Housing			
9	Cool Communities	4.4	0.4	--
10	Update State Building Codes			
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	Industrial Golden Carrot Programs	2.9	Merged into Action 12	
14	Accelerate the Adoption of Energy-Efficient Process Technologies		Terminated	
15	Industrial Assessment Centers	0.5	CCAP Component Terminated	
16	Waste Minimization	4.2	2.1	--
17	Improve Efficiency of Fertilizer Nitrogen Use	2.7	0.8	--
18	Reduce the Use of Pesticides		Terminated	
Transportation Sector Actions		8.1	5.3	--
19	Cash Value of Parking			
20	Innovative Transportation Strategies	6.6	4.6	--
21	Telecommuting Program			
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	Energy-Efficient Distribution Transformer Standards	0.8	0.5	--
30	Energy Star Distribution Transformers			
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.



DRAFT

6/10/97

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Buildings: Mark Levine, Nathan Martin, and Lynn Price (LBNL), George Courville, Mike MacDonald, Jeff Muhs, John Tomlinson, Jim Van Coevering, Robert Wendt (ORNL)

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Improved Electricity Supply Technologies: David Kline and Ralph Overend (NREL), Jack Siegel (Energy Resources International, Inc.), and Mike Sale (ORNL)

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Additional valuable comments on earlier drafts of this report were received from John Sheffield (ORNL) and Jay Braitsch (DOE's Office of Fossil Energy). This extensive review process was conducted to ensure that the results were clear, credible, and defensible, and that the findings were presented in an even-handed and unbiased manner.



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From:

Ray Prineas

Date:

Pages:

, including the cover page.

fax

From the desk of...

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Secretary

R Prineas

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Residential Autonomous Energy Efficiency Improvement:			
Fuel:			
Electricity		Annual Percent Decrease (NW)	
	Refrigerators:	2.496730472	
	Freezers:	3.48015924	
	Water Heating:	3.283759295	
	Space Heating:	Data NA	
	Space Cooling:	Data NA	
	Cooking:	0	No means to reduce UEC
	Clothes Dryer:	0.589365232	
	Lighting:	Data NA	
	Other Uses:		
Natural Gas:			
	Space Heating:		
	Space Cooking:		
	Water Heating:	2.418892583	
	Cooking:	4.326923077	
	Clothes Dryer:	0	No means to reduce UEC
	Other Uses:		
Distillate Oil:			
	Space Heating:		
	Water Heating:	2.418892583	
	Other Uses:		
LPG:			
	Space Heating:		
	Water Heating:	2.418892583	
	Cooking:		
	Other Uses:		

Buildings, Commercial							
Fuel	End-Use	1990	2010 Base	2010 Efficiency	Eff. Red.	2010 HE/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

DOE 5-Labs Study: Carbon Emissions (MMT)

Sector	1990 C	2010 Base C	2010 Efficiency C	Gross Costs of Efficiency	Net Costs of Efficiency	1990 Level in 2010 C	Gross Costs of 1990	Net Costs of 1990	Govt Costs (eff, 1990)	Issues Affecting Probability
Transportation	432	616	543		≤ 0	513				
Industry	452	534	512	\$1.8b/yr	≤ 0	461 - 483	\$3.6b/yr			
Buildings	460	571	546	\$7b/yr	-\$11b/yr	525 - 530	\$14b/yr	-\$20b/yr		
Electricity	--	--	--		--	-157 - -138	≤ 6b/yr	≤ 6b/yr		
TOTAL (rounded)	1340	1720	1600		≤ 0	1340 - 1390				

2010 Base C Case: AEO97 projections for industry, buildings, and electricity. The authors modified the AEO97 transportation estimates by assuming that passenger car efficiency would remain unchanged through 2010.

2010 Efficiency C Case: The costs of efficiency scenario is based on the premise that “the nation actively pursues policies and programs to promote market acceptance of energy efficiency while expanding commitments to R&D” (DOE, 1997, p. xvi). All technology adoption is assumed to be cost-effective -- therefore, the costs of achieving this level of emissions reduction are zero or negative. Costs of efficiency assumes only the cost of technology when assessing cost-effectiveness: implementation costs are ignored and barriers are assumed to be reduced by government policies. This case “assumes 1) better technology and 2) higher penetration rates for energy efficiency technologies than the business-as-usual case” (p. 1-5).

1990 Level in 2010 C Case: This scenario assumes a “very strongly accelerated drive to promote energy efficiency” through government and public-private sector programs plus a \$50/ton carbon permit price in response to a climate policy. These programs could include efforts such as “market transformation” and “aggressive R&D”. The authors assume that a policy is announced in 2000 and its restrictions are phased in over 10 years. The C permit price rises steadily through 2010. They assume an “announcement effect” with this policy.

DOE 5 Labs Study: U.S. Carbon Reductions by 2010 and Beyond

The Department of Energy's 5 Labs Study estimated the carbon emissions reduction opportunities available through technology development and adoption. The Study employs the Energy Information Administration's 1997 baseline (with a minor modification of the transportation sector). The study provides emissions reductions from this baseline for two scenarios: 1) "efficiency" and 2) "high efficiency/low carbon". The study does not describe 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.

Defined how?
Efficiency: This case assumes that all technologies adopted are cost-effective given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. Since these technologies are cost-effective, they all have a net cost less than or equal to zero. 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. *so 25% for free? Over what time horizon?*

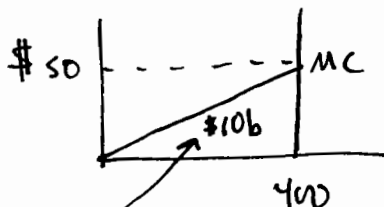
High Efficiency/Low Carbon: This case assumes a "greater commitment" to reduce emissions through federal policies, in concert with state and private activities and a \$50/ton permit price that stimulates low carbon technologies (read: primarily fuel switching). The policy is announced in 2000 and the 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 180 mmtce of carbon emissions reductions 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. *where is the \$25/t case*

Caveats: The Study does note three important qualifications to the analysis. First, the sectoral analyses are not integrated. The projected decline in consumption of energy is not reflected in the fuel prices, and technology penetration rates may be overestimated. *causes what problem?* Second, the Study did not assess the policies or programs necessary to achieve market acceptance of the energy efficient technologies: it confined its work to technology costs. *how high could these go?* Third, the Study ignored implementation costs. *what would these costs be?*

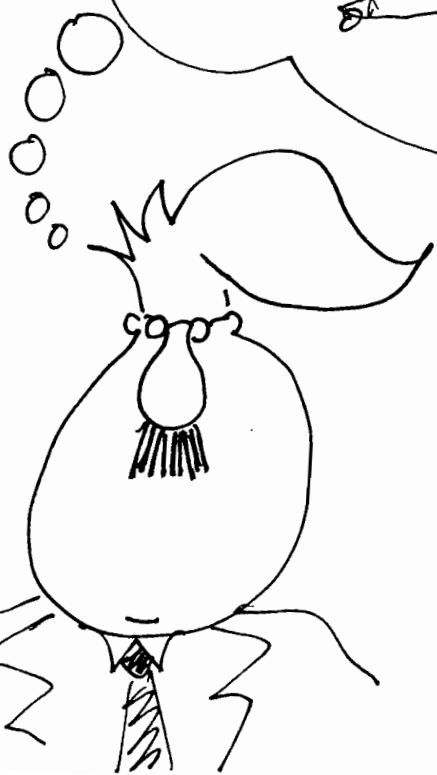
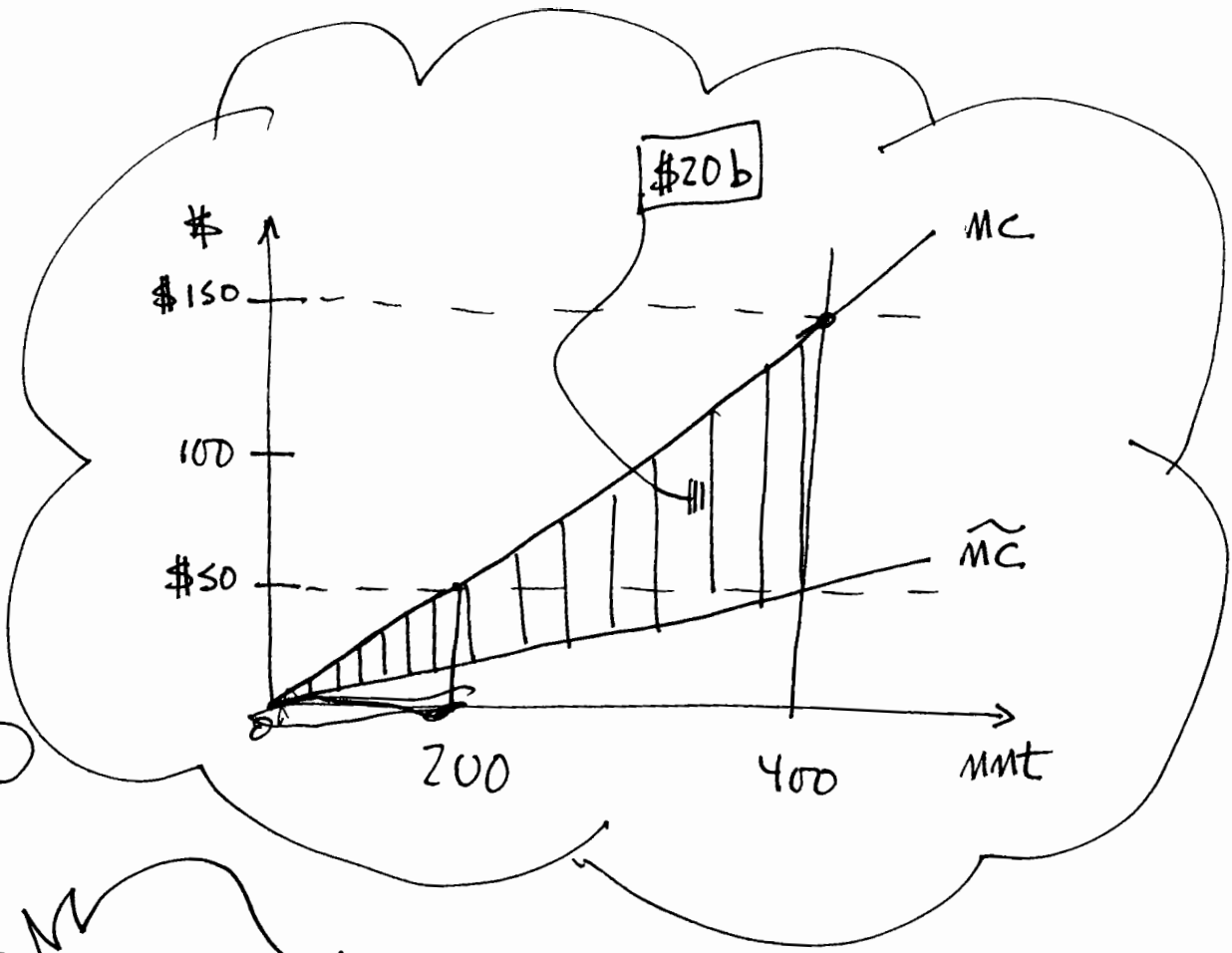
Carbon Emissions (mmtce): 1990 - 2010

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

\$25/t?



$$\frac{400 \times 50}{2} = \$10b$$



DOE 5 Labs Study: U.S. Carbon Reductions by 2010 and Beyond

The Department of Energy's 5 Labs Study estimated the carbon emissions reduction opportunities available through technology development and adoption. The Study employs the Energy Information Administration's 1997 baseline (with a minor modification of the transportation sector). The study provides emissions reductions from this baseline for two scenarios: 1) "efficiency" and 2) "high efficiency/low carbon". The study does not describe 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: This case assumes that all technologies adopted are cost-effective given more aggressive federal policies to stimulate development and diffusion of energy efficient technologies. Since these technologies are cost-effective, they all have a net cost less than or equal to zero. 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: 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 180 mmtce of carbon emissions reductions 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.

Caveats: The Study does note three important qualifications to the analysis. First, the sectoral analyses are not integrated. The projected decline in consumption of energy is not reflected in the fuel prices, and technology penetration rates may be overestimated. Second, the Study did not assess the policies or programs necessary to achieve market acceptance of the energy efficient technologies: it confined its work to technology costs. Third, the Study ignored implementation costs.

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

PRELIMINARY/DRAFT

**Comments on: DOE Labs Study --
US Carbon Reductions by 2010 & Beyond**

June 20, 1997

1. **Cannot assess value of enhanced technologies.** Three cases are studied -- baseline, efficiency, and "high efficiency." The high-efficiency case presents gains from energy efficiency technologies with a \$50/ton carbon regulatory regime, and reaches 1990 CO₂ levels at 2010 at a cost of 10 Billion per year. This case is not compared to the effect of the \$50/ton carbon regime by itself and thus overstates gains from new technologies.
2. **No Integrated Modeling** The analysis looks at three sectors separately -- buildings, industry, and transportation -- and never integrates the results. It also does not include dynamic changes in energy prices. One would think that, as demand for energy decreases from the many conservation gains, energy prices would fall. This should result in less penetration of energy efficiency technologies. The report says this effect would be negligible.
3. **Costs of "enhanced public- and private-sector efforts."** Analysis does not examine the costs or regulatory policies that would be necessary to induce these new technology adoption rates -- they are simply assumed to occur.
4. **Business as Usual Case.** Reference cases are "revised" from AEO projections. Why are some sectors revised, how, and what is the basis for revision?