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TJ's Technology Paper Global Climate Change [Binder] [2]

Stack:	Row:	Section:	Shelf:	Position:
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EXECUTIVE OFFICE OF THE PRESIDENT

THE OLD EXECUTIVE OFFICE BUILDING

COUNCIL OF ECONOMIC ADVISERS
17TH AND PENNSYLVANIA AVENUE, NW
WASHINGTON, DC 20502

****

TO: Bob Tuccillo **OFFICE:** OMB

FAX NUMBER: 395-5836 **TEL NUMBER:** 395-5609

***

FROM: JOE ALDY

FAX NUMBER: (202) 395-6809 **TEL NUMBER: (202) 395-1455**

ROOM: 317B

NO. OF PAGES (inc cover) 3 **DATE:**

SUBJECT: Climate change costs/emissions chart

MESSAGE:

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

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

* DOE5 provides an estimate of emissions under the high efficiency/low carbon case of 485 mmtce on p. 5.5 and another estimate of 513 mmtce on p. xiii. Since we cannot discern which is the appropriate estimate, we provide both as a range.
** DOE5 accounts for all reductions in carbon from decreased electricity demand with the end-use sectors, and all carbon reductions from fuel switching to the electric sector.

AEO97: Annual Energy Outlook 1997, published by DOE Energy Information Administration
DOE5: U.S. Carbon Reductions by 2010 and Beyond, report by 5 DOE labs
M-M: Markal-Macro model runs
DRI: DRI model runs
CEA: Council of Economic Advisors in-house analysis
EPA-IPM: EPA used their IPM model to estimate electric sector costs

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

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

DOE5 cost estimates ignore implementation costs of technology adoption.

8/13/97 mtj

Four Levels of Project Costs

I. Project Impacts

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

II. Scenario Impacts

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

III. Federal Impacts

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

IV. Other Impacts

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

Technology Costs and Savings

Skip Laitner, EPA/OAP

Pre-Decisional Working Document

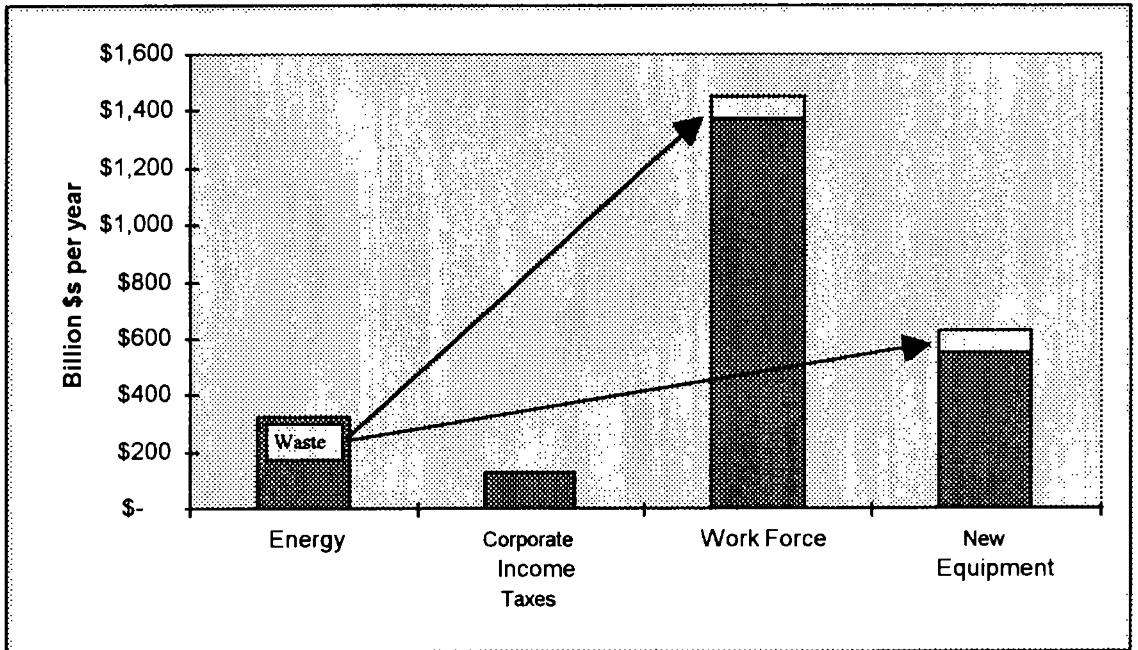
Do Not Quote or Cite

August 12, 1997

Technology Offers Economic Growth

- Paying energy bills is a "drag" on economic growth

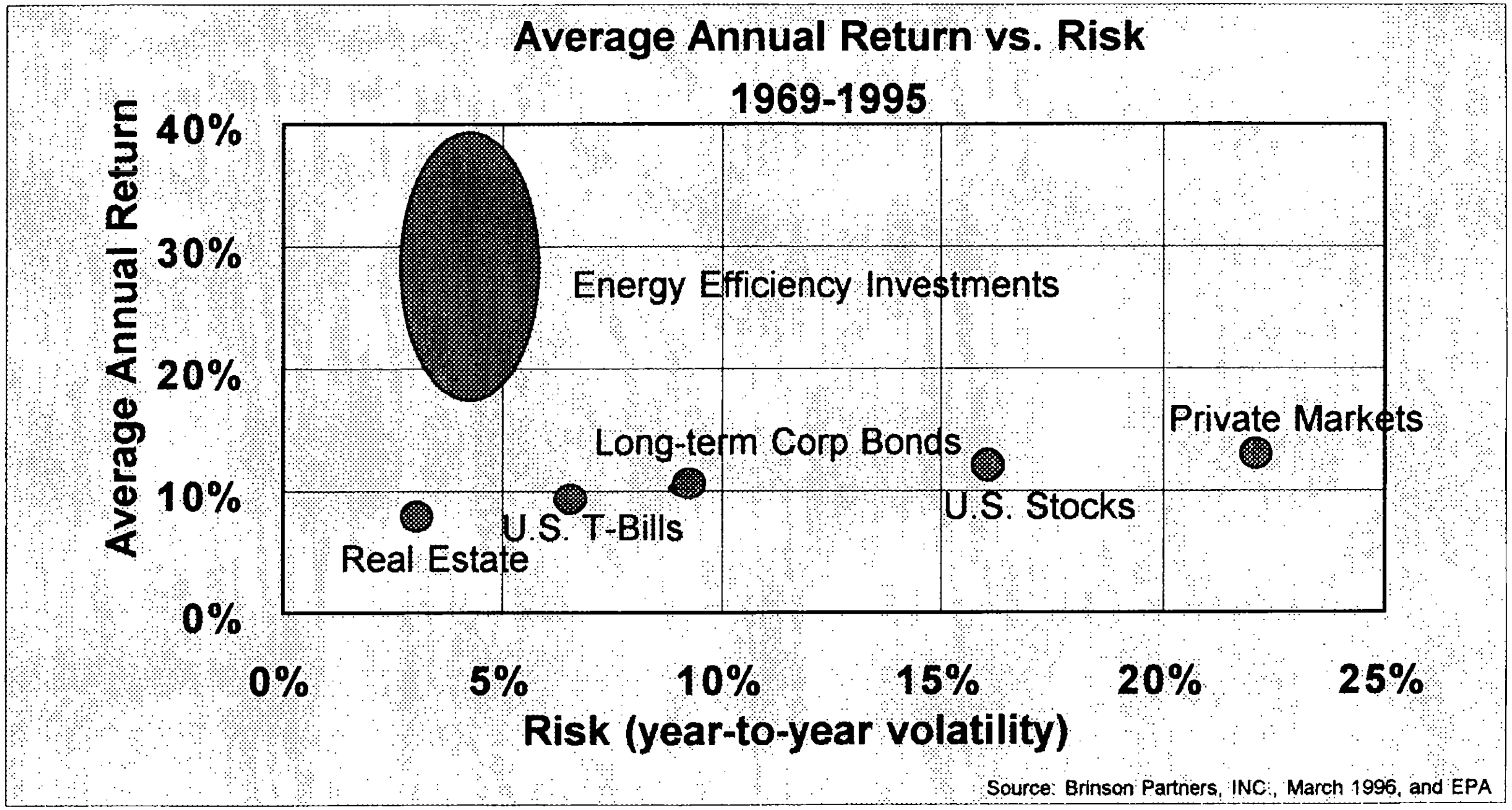
Business Expenditures



Source: AEO, 1994 and Statistical Abstract of the United States, 1994

- Paying energy bills is <u>low</u> on list of economically productive activities

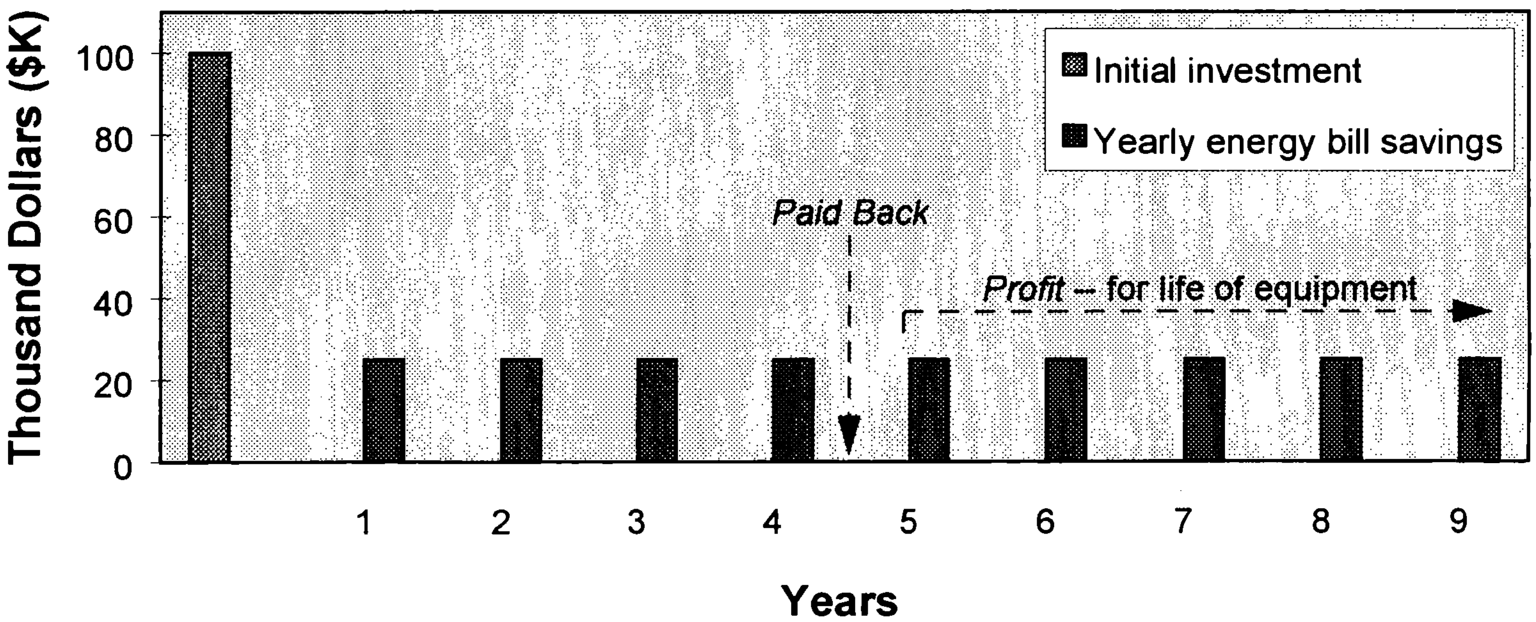
Technology Offers Low Risk / High Return Investment Opportunities



- Today's efficient technologies are vastly underutilized
  - Many offer IRRs of 20 to 40%
  - low risk investments
  - widely available -- result of 20 years R&D

Technology Offers Sensible Response

- Many available energy efficient technologies
  - short paybacks -- attractive rates of return
  - emissions reductions



A 4 year payback is about a 25% simple IRR, better than most other investment alternatives

Savings Potential by Sector and Representative Technologies

Residential Technologies	% Energy Savings*	IRR**	Payback (years)
Heating/Cooling, Total	30%	30%	3.5
Air Source/Heat Pump (12.5 SEER)	15%	25%	4
Duct Sealing***	15%	30%	3.5
Fluorescent Lamps & Fixtures	50%	40%	2.5
Efficient Refrigerator	40%	25%	4
Whole House	**30%**	**30%**	**3.5**

* Over standard, existing equipment.
** Based on incremental cost/savings of highly efficient equipment compared to typical equipment purchases
*** Availability of this newer technology is currently limited

Commercial Technologies	% Energy Savings	IRR	Payback (years)
Energy Efficient Lighting	45%	35%	3
ENERGY STAR Office Equipment	50%	no cost	-
Variable Speed Drive	50%	25-30%	3.5-4
Energy Efficient Boiler	25%	20-30%	3.5-5
Energy Efficient Chiller	35%	20-30%	3.5-5
Efficient Exit Signs	75%	70%	1.5
Average Building Wide Savings	**35%**	**25%**	**4**

Industrial Technologies	End-Use Energy Savings	IRR	Payback (years)
Industrial Boilers (Tune-ups and Hardware)	8%	100%	1
Advanced Efficiency Motor Systems	10%	40%	2.5
Compressed Air Systems (O&M and Hardware)	46%	160%	.5
Heat Recovery of Process and Waste Heat	5%*	60%	1.5
Cogeneration of Electricity and Steam	10%*	30%	3.5
Average Facility-Wide Savings	10%*	70%	1.5

Estimates of Technology Investment Cost and Savings
(in billions of 1992 dollars from 1998-2010)

	Source	Investment	Energy Bill Savings	Energy Savings (Quads)	Carbon Savings (MMT)	
	U.S. Cumulative Investment (AEO97)	$17,240	n/a	n/a	n/a	
AEO96	Energy Innovations NGO study	$426	$1,006	15.6	414	
AEO97	AMIGA " labs study	$373	$677	n/a	459	
AEO97	OAP Sector Analysis	$511	$685	26.5	n/a	pushing the envelope → 100% close to penetration
AEO97	Markal-Macro Tech Case .75	$140	n/a	16.7	427	
	OAP One-Pager	$886	n/a	23.8	n/a	
AEO97	Lab Study	d.3 counted 403	730	12.3	385	

954

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OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

TRANSMISSION NUMBER: 202/395-5836
VERIFICATION NUMBER: 202/395-6827

ENVIRONMENT BRANCH
ROOM 8026
NEW EXECUTIVE OFFICE BLDG.

Fax # 156870

Name

To: Joe Aldy

From: Bob Tuccillo

Message: Joe - We need to start tomorrow's meeting at 2:30 instead of 2:45 because of a conflict. Attached are Skip Laitner's numbers

Number of Pages to Follow: 7

Date: 8/12/97

Time: 3:00 pm

Technology Costs and Savings

Skip Laitner, EPA/OAP

Pre-Decisional Working Document

Do Not Quote or Cite

August 12, 1997

OPTIONAL FORM 99 (7-90)
FAX TRANSMITTAL # of pages ▸ 7

To Bob Tuccillo		From Skip	
Dept./Agency OMB		Phone # 233-9833	
Fax # 395-5836		Fax #	

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

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- Paying energy bills is a "drag" on economic growth

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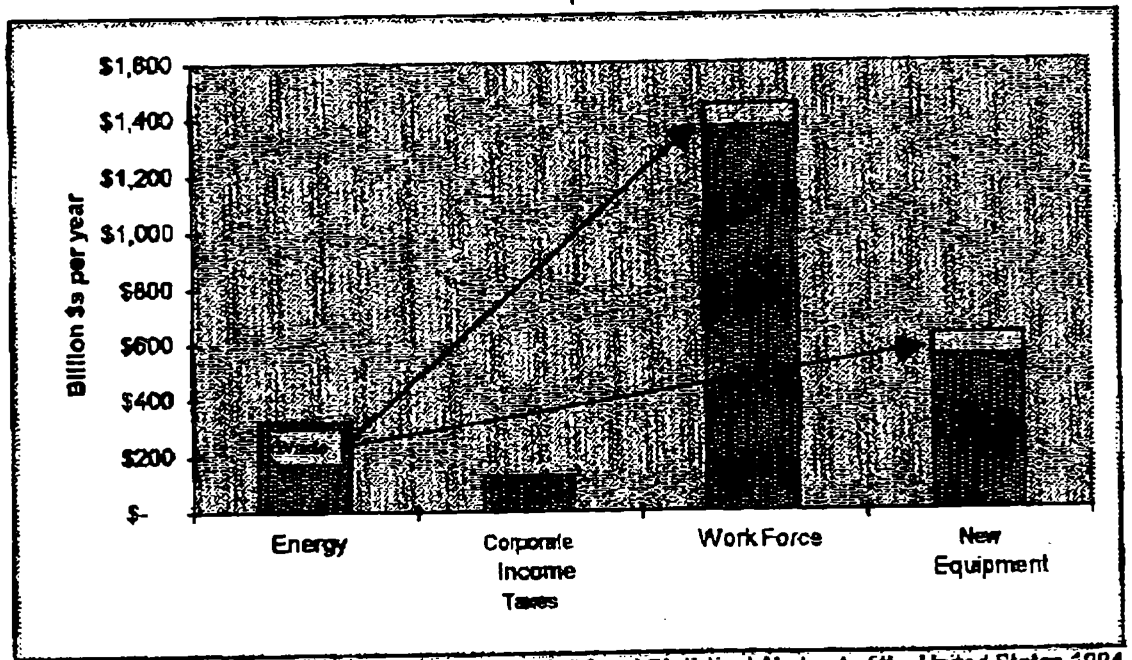

Source: AEO, 1994 and Statistical Abstract of the United States, 1994

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Technology Offers Sensible Response

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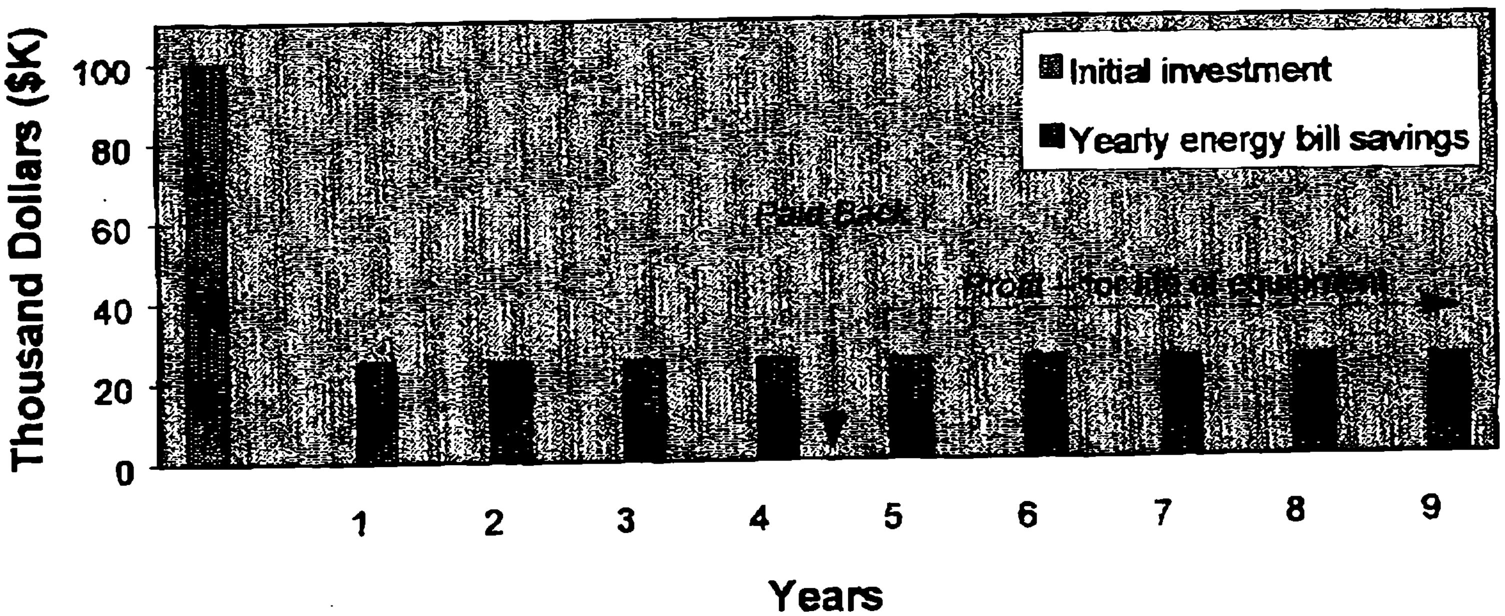

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[illegible]	[illegible]	[illegible]	[illegible]

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[illegible]	[illegible]	[illegible]	[illegible]

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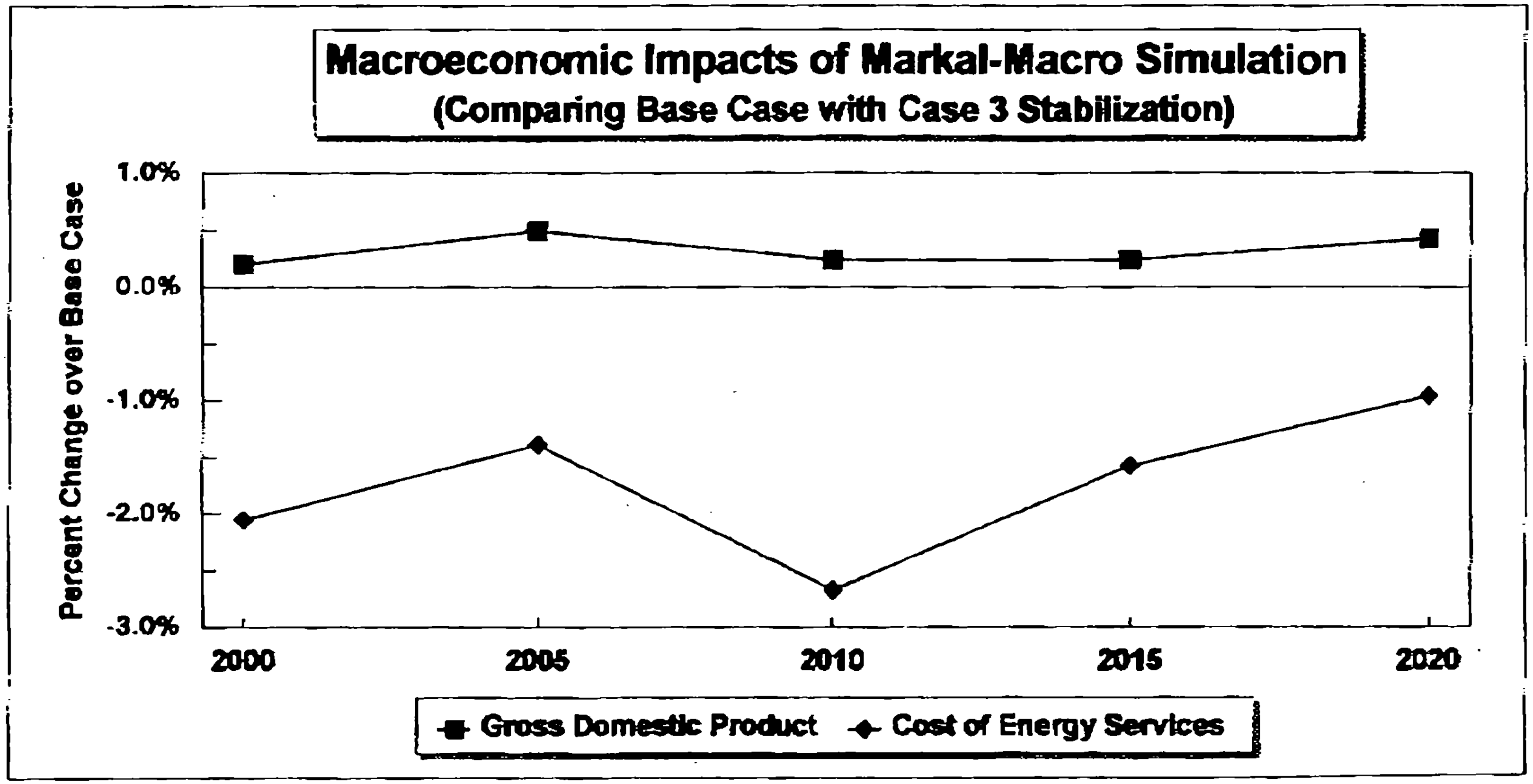
Lab Study				


Macroeconomic Impacts of Markal-Macro Simulation
(Comparing Base Case with Case 3 Stabilization)
Percent Change over Base Case
1.0%
0.0%
-1.0%
-2.0%
-3.0%
2000
2005
2010
2015
2020
Gross Domestic Product
Cost of Energy Services

Costs Eric Petersen

High efficiency / low carbon case, labs study

Climate Technology Strategy Cost Summary
($Billion)

	Buildings	Industry	Transport
Discounted total energy savings	270	125	335
Discounted total investment costs	123	62	218
NPV of benefits	147	64	117
Estimated gross payback period	9	11	8
Estimated project payback period	4	6	6
Estimated gross ROI	12%	10%	~~13%~~ ?
Estimated project ROI	25%	17%	18%

time period 1998 - 2010
discount rate 7%

lab study should be viewed as 12 yrs of effort
not a ~~forecast~~, scenarios
preliminary attempt
Skip is doing similar attempt w/ Markal, Amiga

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VERIFICATION NUMBER: 202/395-6827

ENVIRONMENT BRANCH
ROOM 8026
NEW EXECUTIVE OFFICE BLDG.

Fax # X56870

Name

To: Joe Aldy

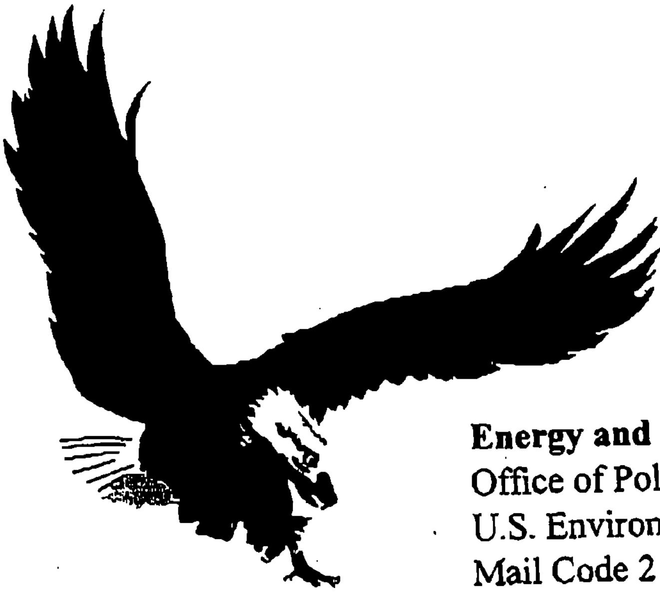
From: Bob Tuccillo

Message: DOE labs study cost summary I mentioned to you

Number of Pages to Follow: 1

Date: 8/6/97

Time: 6:05pm



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Energy and Transportation Sectors Division
Office of Policy, Planning and Evaluation
U.S. Environmental Protection Agency
Mail Code 2126
401 M Street, SW
Washington, DC 20460

Telephone (202) 260-5490
Fax (202) 260-0512

TO: Joe Aldi

Voice:

Fax

FROM: Jim Turner

Voice: (202) 260-2784

Number of pages to follow: 4

Comments: 7/18 "2-page" electric power piece
+
NEMS/DRI electric prices/revenues

Other factors include some early coal-coal switching as more efficient coal plants replace less efficient ones, and assumed limits on the rate of capital turnover. As a result, estimates of delivered (weighted average) electricity price impacts vary: +25% in DRI, +40% in NEMS. If a simple $50/ton carbon value is applied, as in the Interlab study, delivered prices may only rise by 15-20%.

Total costs of GHG policy in the utility sector will be in the $5-15 billion/year range, compared to 2010 baseline (incremental) production costs of about $70-75 billion per year. Of this, about half is due to capital investment and half to increased fuel and other operating costs. The bottom line financial outlook is uncertain because of changes in the electric power industry itself. Changes in production costs have not reduced profits under regulated ratemaking. The effects of such changes in a competitive market depend on the structure of the market and the distribution of costs among competing producers. State and federal policy towards new entrants, cleaner suppliers, or pollution credits are also important (as noted below).

Current Federal Programs and Funding

Although the technology and know-how to reduce GHG emissions exists today, several related challenges must be met in order to reduce costs and integrate climate policy with increased competition and more stringent air quality standards. Federal research and development, partnership programs, and policy decisions can all contribute to success.

The success of energy research and development can be measured by the performance of currently available power plants. Natural gas combined cycle systems have a combination of decreasing cost and increasing performance that has changed the industry. Renewable energy cost and performance goals have also been met, but the decline in fossil fuel prices has moved the goalposts. More aggressive goals are now in place for the 2005 time frame. Achieving these goals will require ongoing support for R&D and pilot plant deployment cost-sharing. Less mature or broadly applicable technologies, including solar photovoltaic and fuel cell systems, are vulnerable to R&D shortfalls in the near to mid term. R&D on power delivery systems, including transmission efficiency, is also a needed investment. Programs to market these technologies for export will improve their viability in the US through experience and expanded production capacity.

A carbon constraint will be introduced at the same time as a competitive restructuring of the industry and the implementation of the NAAQS. The combination of open power markets and market-based air regulation (i.e. a set of cap-and-trade systems for SO_2, NO_X and CO_2) will likely make climate-related policy incentives work faster and more effectively. At a minimum, there will be interactions between these changes which will alter the emissions profile of the sector.

For air regulations, early analysis using IPM and NEMS indicates that although new ozone and particulate matter rules will have a limited effect on CO_2 emissions (a reduction of approximately 5% from 2010 baselines), GHG limits could induce significant reductions in the criteria pollutants, on the order of 5-10% for SO_2 and 25-35% for NO_X.

Initial work on competitive power markets indicates that the ongoing restructuring of the power industry may have important effects. GHG emissions may increase in the near term (by perhaps 5-7% in the first ten years), due to increased sales by the cheapest coal units and higher demand. But competition may prove helpful in the long run if new technologies can readily enter markets, and if market-based incentives are a part of climate policy. One great unknown is the potential demand for cleaner power on the part of consumers, who will have new information and choices.

Combining market-based environmental policy, consumer choice, and new technologies may offer greater efficiency and enable the power sector to provide electricity that is both cleaner and higher-value. The technologies and physical changes needed for large-scale GHG emissions reductions appear to be reasonably achievable, although the costs of reductions are less certain. Industry restructuring, air regulations, and climate policy will all influence the evolution of this sector.

Baseline (AEO97) coal capacity is forecast to increase from 315 GW in 1995 to about 330 GW in 2015 (including 40 GW of new plant and 25 GW of retirements) with virtually no coal-gas switching in existing plants. GHG policy is likely to result in less new coal capacity, more retirements, and some fuel switching at existing units. By 2015, coal *capacity* will fall to 275 GW, a drop of 55 GW or 15%. About 10-20 GW of coal-gas conversions are forecast. Coal *use* (both in the electric sector and nationally) will decline by 25-60% if a stabilization target is met. Fuel use is affected more than installed capacity, because of resulting changes in dispatch. Competitive responses by coal producers and coal-fired generators can be anticipated, but most models already assume rapid gains in mining productivity and additional gains in coal plant efficiency. Economic options for life extension and repowering are also considered.

Stabilization will result in very large increases in gas combined-cycle generation. In some cases, natural gas becomes the dominant fuel in the power sector, tripling from base case levels to around 40% of all power produced. Natural gas use is affected by several sectors and competing fuels and is very sensitive to assumptions. IAT models project increased net gas demand in the electric power sector of 15-50%, but this could be offset by declines in other sectors (some models indicate net declines in US natural gas demand under a GHG stabilization policy). Most models show a small increase (about 5%) in overall US gas demand for a limited period. If electricity demand is reduced through efficiency, however, all of these fuel impacts could be considerably lessened.

Nuclear power could be affected by climate policy, but the trends in the nuclear industry are dominated by other regulatory and market factors. Economic options for nuclear plant life extension have been examined, and the possibility for large amounts of economic early retirements is taken into account in some models. Five to ten plants, with a capacity of 7.2 GW, are economically retired prior to 2010 in the DRI model, for example. Some of these plants may be kept on-line if the economics of the power markets change. Nuclear life extensions in the NEMS model are assumed, not economically selected, but some lefe extension could be an economic option under a climate policy.

As part of a GHG emissions reduction strategy, generation from non-hydro renewables will increase. Some models indicate that wind and biomass may become cost-effective options as more emissions reductions are called for. For example, MARKAL-MACRO and DRI both indicate a 35% increase in non-hydro renewable use in 2010 under GHG stabilization, raising their share of total generation by about 1%. Models could understate the potential of renewables because they do not consider 'green power' demand from consumers, niche markets or dispersed power (small scale production scattered throughout the system).

Further electricity supply options include increasing the efficiency of existing fossil plants, and improving other parts of the power system (mainly the transmission grid) to minimize losses. Impacts on the industry are sensitive to demand responses. Demand reductions of up to 15% of US electric use in 2010 (600 billion kWh) have been studied. When end-use demand is lowered, fewer new high-efficiency natural gas power plants are built and less gas and renewable power is used. Coal use is relatively less affected. Overall costs in the utility sector are lower, with total costs affected much more than the marginal (permit) cost. Electricity sector total costs may be as much as 50% lower under high demand reduction cases, even though permit prices are only 15% lower.

Costs

Physical responses are generally similar between models, but the estimated costs of reducing emissions vary. The recent Interlab study, along with other engineering cost studies, point to very large emissions reductions available for around $50/ton C. However, the modeled costs of reducing emissions are quite different, ranging up to $150/ton or more in some IAT analyses. These differences largely result from assumptions about capital replacement decisions and cost allocation. For example, current ratemaking practice often requires 'front-loading' of capital payments for new plants, but this may change with increased competition in favor of 'levelized' or constant capital recovery. Another reason for differences in cost estimates is the response of fuel prices to the climate policy. As coal use begins to decline, coal prices may fall, requiring larger incentives to achieve further emissions reductions. Similarly, natural gas prices may rise if net US consumption increases. These fuel price dynamics are important drivers of overall policy cost.

Electric Power

Key Findings

- Emissions from this sector, which were 481 MT in 1990, are forecast to increase from 506 MT in 1995 to 626 MT in 2010. Potential reductions from this sector (250MT or more) will make up a substantial portion (25-50% or more) of the total needed to stabilize national emissions.

- Increased use of natural gas and demand-side efficiency are the main means of reducing emissions through the 2010 period. Demand reductions from end-use sectors such as buildings may account for as much as half (90-120 MT) of total emission reductions. Natural gas use could increase in this sector by 15-50% but net US gas demand may not increase. Renewable power can be a significant factor in the longer term. Coal use will decline by 25-60%, to levels comparable to current use. According to the IAT, average electricity prices will rise by about 25-40%. Capital investment costs of $3-5 billion/year compare with baseline forecasts of $10 billion/year, but fuel and operating costs will also increase by a similar amount. Costs could be higher if demand reductions are not realized.

- No major technology breakthroughs are needed to achieve GHG emissions goals. Incremental improvements in combined-cycle turbines, renewable energy (particularly wind turbines and biomass fuel and gasification systems), and transmission systems will lower the cost of emissions reductions. Demand reductions through end-use technology development and adoption will also lower costs.

- Competitive trends, air pollutant regulation and climate policy will all influence the development of this sector.

Background

Electric power generation accounts for over 30% of US primary energy use. Electric power generation continues to grow in tandem with economic growth, unlike most other forms of energy consumption. Electric power sales of roughly $200 billion represented 3% of US GDP in 1995. Despite advances in the efficiency of fuel use, US electric power supply maintains an historic reliance on coal and (increasingly) natural gas, leading to an upward GHG emissions trend that is expected to continue in the absence of climate policies.

Coal is projected to continue supplying more than half of the Nation's electric power through 2010. Coal consumption, of which 90% is in the electric sector, will reach 1 trillion tons in 1997, and by 2010 is expected to reach 1.1 trillion tons. Natural gas supplies 15% of US power, near its historic peak share, and is growing most rapidly today. Nuclear power, currently 20% of the US power supply -- an historic high -- is projected to decline as plants age and face increased competition.

Most renewable power is currently hydroelectric, supplying 9% of US electricity. The potential for hydro expansion is limited. Non-hydro renewables currently account for about 2.7% of the US power supply. Some renewable technologies, such as wind and geothermal, are rapidly becoming economic and could grow quite rapidly between 2000-2010. Co-firing of biomass with coal at existing power plants also has a significant potential for reducing emissions by 2010. To be commercially viable, the least-cost renewable technologies, which are currently priced around $0.05/kWh, need to reach below $0.03-0.035/kWh (in the absence of high fossil fuel prices). Wind power may reach this goal by 2005.

CO2 Reduction Potential and Scenarios

This sector will be a key contributor to any GHG emissions reduction strategy. The IAT results show this sector reducing emissions by 20-33%. Because there are no direct emissions control technologies, achieving reductions relies on reducing demand or changing fuels. The rate of turnover in the capital stock becomes an important factor in determining both the means and the cost of GHG emissions control in the electric power sector.

The dominant emission reduction option is to use natural gas in place of coal, either through co-firing or repowering in existing coal units, or through increased use of new high-efficiency gas plants.

Delivered Electricity Prices and Revenue in 2010: NEMS and EPA/DRI, 1.25 Cases

NEMS		res	ind	com	total	weighted avg $/Mbtu	weighted avg $/kWh	Revenue $Billions
	$/Mbtu	23.31	13.31	21.35				
Base	bkWh	1306	1266	1146	3718	19.30	0.066	244.85
	$/Mbtu	31.71	18.67	29.88				
Stabilizati	bkWh	1262	1220	1031	3513	26.64	0.091	319.37
DRI		**res**	**ind**	**com**	**total**			
	$/Mbtu	20.25	11.69	16.84				
Base	bkWh	1179	1343	1205	3727	16.06	0.055	204.27
	$/Mbtu	24.91	16.8	21.12				
Stabilizati	bkWh	1025	1015	1080	3120	20.96	0.072	223.13

1995 avg $/kWh=0.069
1995 revenue=$207.7b

293.08 kWh/mBtu

7/15/97 draft 2

Outline of Technology Paper for Cabinet Meeting
(Approximately 14 pages)

Purpose: To identify what technology can do to ameliorate the climate change problem, to evaluate the reasonableness of the types and rates of technological progress needed to achieve GCC goals, and to identify public and private actions needed.

1. Overview — Summary of broad implications of GCC policy for technology, R&D (3 pages)
   - summarize patterns of technology strategies needed (identifying sectors where appropriate) -- accelerated capital stock turnover, increased market penetration, R&D successes, technology management and operating practices
   - relative contributions and costs for each type of technology strategy
   - incentives or other federal actions required to support each one

2. Key sectors — profile of emissions, energy use, and potential reductions resulting from technological innovation, by major sectors of the economy: utilities, transportation, buildings, industry (1 page)

3. Electric Power (2 pages)
   (standard for each sector below: profile emissions and technology trends, then types, rates and costs of technological change with reference to capital stock turnover implied for given reference scenario, as well as additional medium- and long-term opportunities possible, with implications for R&D and other federal actions)

4. Transportation — autos & light trucks (1 page)

5. Commercial transportation — freight, aircraft & rail (1 page)

6. Commercial & residential buildings (1 page)

7. Key industrial sectors (4 pages)
   - aluminum
   - petroleum refining
   - glass
   - steel
   - chemicals
   - pulp & paper
   - cement
   - high-growth industries (include potential "winners")

8. Renewable energy supplies (1 page)

BACKGROUND DOCUMENTS AVAILABLE

A. Technology Sector Summary Papers (6)

B. Sectors paper

C. DOE Technology Summary

D. DOE Labs Study Executive Summary

7/10/97

STANDARD FORMAT
Sectoral Emissions Reduction Potential Papers

Key Findings

In bullet format, 1990, 1995 and 2010 emissions, potential reductions, key technology changes needed to produce that (up to 4), scale of additional reduction potential available in medium or long term (if any), costs and payback (where appropriate).

Background

Current pattern and trend of energy use, key issues re. capital stock turnover, etc.
structural barriers in industry

CO2 Reduction Potential and Scenarios

Detail major sources of emissions reduction implied by the IAT economic analysis, with specific description of technological advances and market penetration by 2010 (and 2020 if long term most relevant), focusing on types of decisions that need to be influenced (eg, capital stock replacement, new equipment and facilities selection, etc).
acknowledge non-climate envl benefits
be more explicit about source of emission reduction (IAT, bottom-up)

Costs

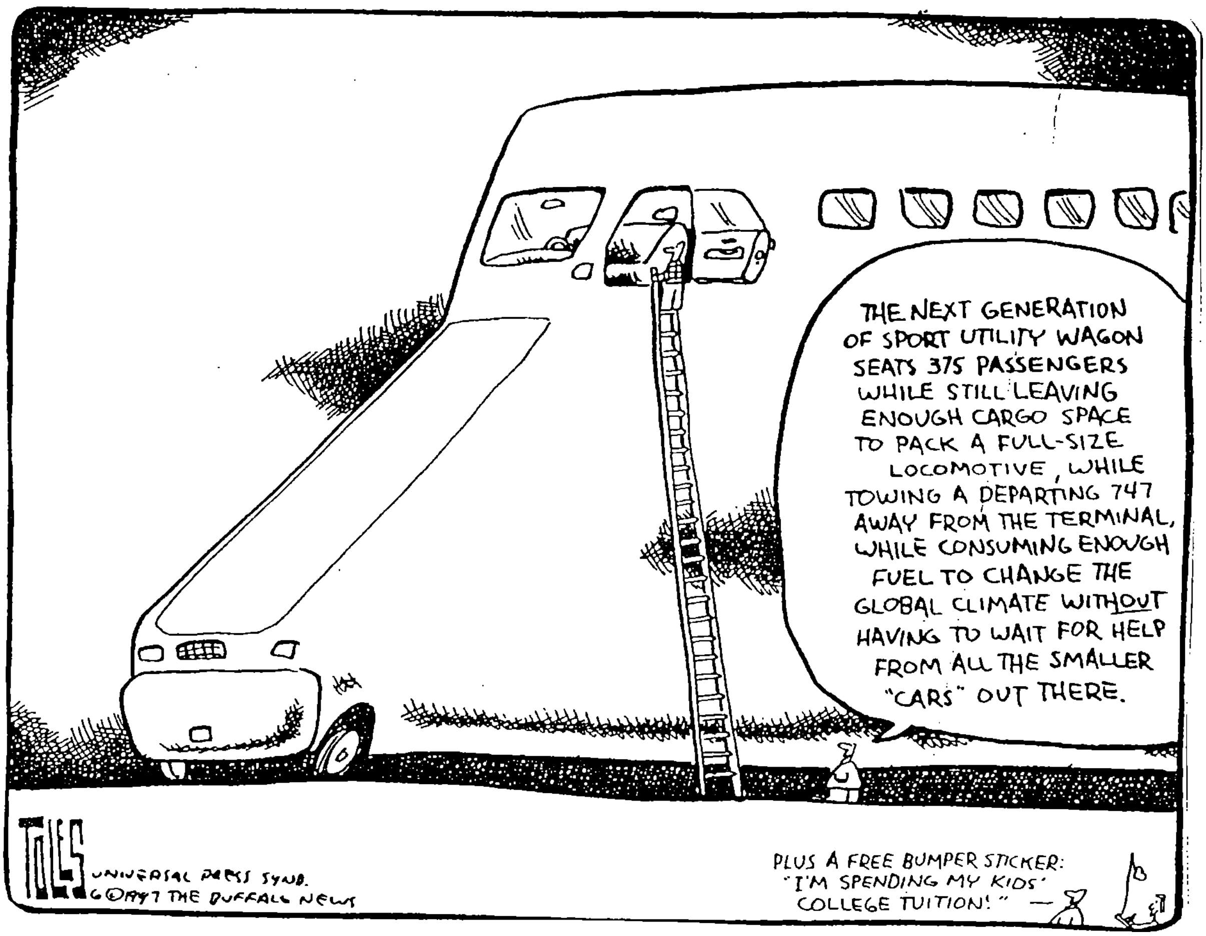
Start with estimated annual costs, but also note capital investment required and rate of return or payback, where appropriate.

Current Federal Programs and Funding

Include R&D, public/private initiatives, pilot programs, etc.

evolutionary tech v. revolutionary tech

new section (after costs)
long-term opportunities


THE NEXT GENERATION OF SPORT UTILITY WAGON SEATS 375 PASSENGERS WHILE STILL LEAVING ENOUGH CARGO SPACE TO PACK A FULL-SIZE LOCOMOTIVE, WHILE TOWING A DEPARTING 747 AWAY FROM THE TERMINAL, WHILE CONSUMING ENOUGH FUEL TO CHANGE THE GLOBAL CLIMATE WITHOUT HAVING TO WAIT FOR HELP FROM ALL THE SMALLER "CARS" OUT THERE.
PLUS A FREE BUMPER STICKER: "I'M SPENDING MY KIDS' COLLEGE TUITION!"
TOLES
UNIVERSAL PRESS SYND. ©1997 THE BUFFALO NEWS

DISCUSSION PAPER

THE ROLE OF TECHNOLOGICAL CHANGE TO ADDRESS GLOBAL CLIMATE CHANGE

July 30, 1997 Draft

*PREDECISIONAL DRAFT ** DO NOT QUOTE OR CITE***

DISCUSSION PAPER ON THE ROLE OF TECHNOLOGICAL CHANGE TO ADDRESS GLOBAL CLIMATE CHANGE

"In order to reduce greenhouse gases and grow the economy, we must invest more in the technologies of the future. I am directing my Cabinet to work to develop them. Government, universities, business and labor must work together. All these efforts must be sustained over years, indeed, over decades."

President Clinton
Address to the United Nations
June 26, 1997

Context for this paper:

- The U.S. position on global climate change has consistently been that any action program should be centered on a market-based approach. Given the proper market signals, the private sector will find the most efficient means to make changes in technologies, business practices, and patterns of energy use to reduce greenhouse gas emissions.

- A properly-designed, capped domestic emissions trading system would provide strong market signals to that end

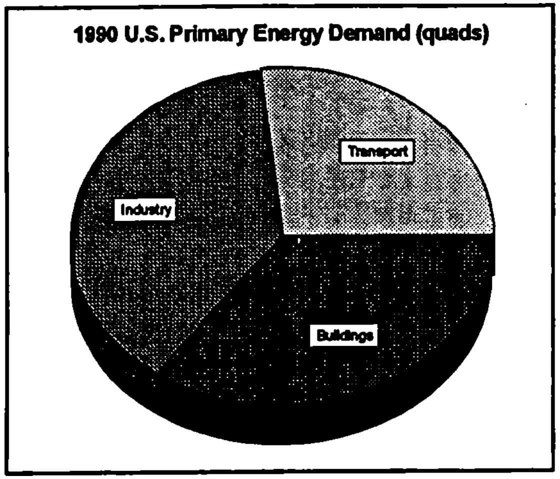
- There are also a variety of other technology supporting actions that the federal government could undertake to supplement such an emissions trading system to stimulate R&D and market development in specific areas, where market barriers exist or where changes might be restrained for various reasons.

- This paper first provides a perspective on the degree of change in energy usage and key technologies that would be needed in key sectors of the economy in order to begin reducing greenhouse gas emissions from energy use.

- Then, the paper identifies a menu of policy options, for discussion and further evaluation, from which specific elements could be selected to support a technology strategy to both reduce greenhouse gases and continue to grow the economy. This paper provides an initial identification of the options without providing a thorough evaluation of feasibility, impacts, or costs.

- Additional detailed papers are available from the Department of Energy and others on these technological opportunities.

PROFILE OF U.S. CARBON EMISSIONS IN THE ECONOMY

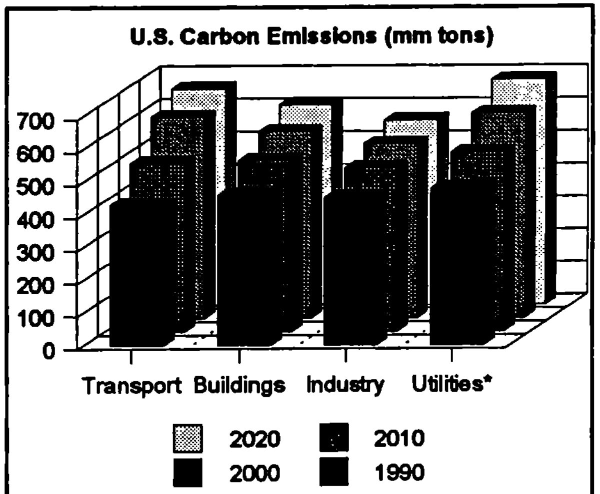


Energy Profiles

- Three sectors account for approximately one-third of U.S. primary energy demand — transportation, commercial and residential buildings, and industry
- The electric utility sector supplies about one-third of this demand, virtually all in the buildings and industrial sectors, and consumes fuels to generate that power. In the buildings sector, two-thirds of the energy usage is from electricity, and in industry the share is just over 10%
- Growth in U.S. energy consumption changed dramatically after the 1973 energy crisis, but is projected to continue growing steadily in the absence of new policies:
  — the 1960s +52%
  — the 1970s +14%
  — the 1980s +11%
  — the 1990s +12% (already +9% by 1997)
  — the 2000-2010 decade +12%
  — in total, 2010 will be 26% above 1990

Carbon Emissions Trends — 1990 - 2020

- The profile in U.S. carbon emissions parallels the pattern of energy demand — the three sectors, transportation, buildings, and industry, each account for approximately equal shares
- Electric utility emissions are double-counted in the sector in which the electricity is used and can only be lowered by reducing electricity demand, by switching to lower carbon content fuels or by carbon sequestration
- Growth projections for emissions parallel the pattern of energy growth. DOE's Energy Information Administration (EIA) projections show:
  — Total emissions up 28%, or 377 million tons, from 1990 to 2010
  — Transportation up 43%, or 184 million tons
  — Buildings up 24%, or 111 million tons
  — Industry up 18%, or 82 million tons
  — Utilities, included in the other sectors, up 30%, or 146 million tons



* Utilities emissions also included in final use sector

LONG-TERM TECHNOLOGY STRATEGY

In the long-term, over several decades, reductions in carbon emissions will require two fundamental changes, (1) shifts to low-carbon and zero carbon forms of energy, and (2) significant improvements in the efficiency of our energy usage. Appropriate technologies ae the only way to achieve these goals without forcing consumers to give up the services and lifestyles they want. A technology strategy, in combination with appropriate pricing policies, can achieve both goals and provide a strong worldwide position for the U.S. as a technology leader and exporter by advancing improvements such as the following:

Transportation	Buildings	Industry	Electric Utilities
o Hydrogen fuels o Fuel cell vehicles o Electric vehicles o Biofuels o Full PNGV 80 mpg vehicles	o Fuel cells o Control systems o Materials and structures o Efficient "plug load" o Lighting and equipment o Renewable energy	o High efficiency motors o Advanced processes o Materials recycling o Combined heat and power o Bioproducts/biofuels	o Renewable energy systems — solar, wind, biomass o Distributed power o Advanced gas generation o Superconducting cables, transformers and generators

Long-term Market and Economic Uncertainties
- Electricity deregulation, international competitiveness, increased concern over other emissions and waste reduction
- Lifestyle trend changes (eg, telecommuting, consumer preferences for large vehicles)
- Commercial transport shifts in modes, speed, and the role of short- and long-range transportation of goods and people

Cost Issues
- Currently, the federal government spends only 1% of its R&D budget, or $600 million/year on long-term energy technologies
- To achieve these major advances will require significant public and private investment
- In the long run, it is uncertain whether such technological changes will produce net costs or savings to the U.S. economy

Policy Issues
- Federal and private R&D funding
- Public/private partnerships
- Financing programs
- Information and education
- Federal procurement
- Regulations

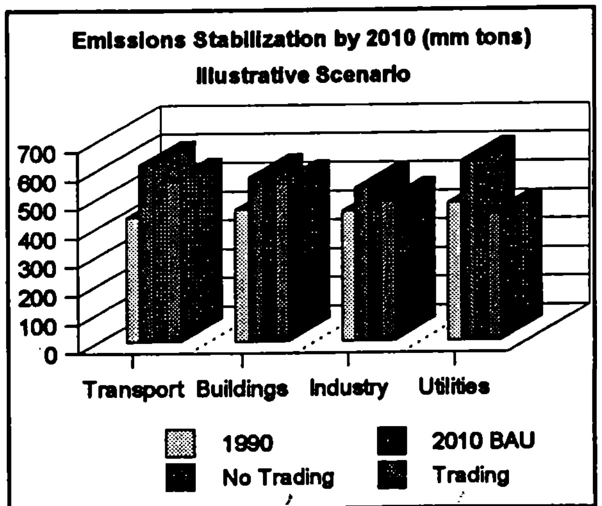
IN THE MEDIUM-TERM, TECHNOLOGY AND EMISSIONS TRADING PROVIDE A BRIDGING STRATEGY

In the medium-term, deployment of currently available, under-utilized technology, or nearly available technology, can serve a "bridging" function to reduce emissions sufficiently to allow time for the long-term R&D developments and the commercialization of various new technologies to reach significant levels.

Emissions trading and joint implementation are critical to a technology strategy in providing timing flexibility to deploy efficient technologies at rates close to normal capital stock turnover cycles, and to provide a "safety valve" if the required rates of technological change cannot be achieved fast enough. Both of these steps will help keep costs significantly lower than they otherwise would be.

The DOE "Labs Study", the IAT computer modeling, and other studies suggest ambitious rates of change in energy consumption, fuels mix, and technology would be needed to reduce U.S. carbon emissions significantly. For example, the implications of the most commonly evaluated scenario, reducing U.S. carbon emissions to 1990 levels by 2010, would lead to the following:

- Overall, emissions growth of 28%, or 377 million tons, would have to be avoided or offset
- If reductions were limited to the U.S., unless large-scale fuel-switching occurred, energy growth would probably have to drop to half its present rate, to about 10 to 12% over the 20-year period, and it's already about 9% above 1990 levels in 1997
- With emissions trading and joint implementation, the models suggest that up to 40% of the 2010 emissions reduction might be achieved abroad, at U.S. expense, to buy time for a more orderly technological transition here
- The key in the latter case would be to encourage, through pricing and other means, the utilization of the most efficient or low-carbon technologies when capital stock is being installed or replaced on its regular cycle



these imply intl
note that

Transportation

- In the absence of international emissions trading, growth in energy usage by 2010 would have to drop to about half its projected growth rate of 30% to 40%, down to 15% to 20%
- On-road fuel economy for all cars and trucks (new and existing) would have to reach 25 mpg by 2010, from its present level of 20 mpg
- Through PNGV, government is partnering with automakers and expects to develop new automotive technology that can triple the fuel efficiency of a

MEDIUM-TERM............continued

typical family sedan while meeting stringent emissions and safety standards and maintaining affordability, performance and utility. Production prototypes are expected by 2004

- One pathway to achieve an on-road fuel economy of 25 mpg would require about 30% of new light duty vehicles to meet the PNGV goal by 2010. Alternatively, all new cars and light trucks could incorporate 30% of the improvements represented by the PNGV goal by the 2010 model year....for 45 mpg new automobiles
- Currently projected higher costs of PNGV improvements would pay for themselves in fuel savings within 4 to 5 years
- With international emissions trading, the pace of improvements could be slower, but would likely still need to show significant improvement in fuel economy over present vehicles

Commercial and Residential Buildings

- Without emissions trading, growth in energy usage in buildings would have to be cut in half, to a rate of about 10% by 2010
- Technologies needed to achieve these savings largely exist today. No major breakthroughs are needed. Over the next decade, most buildings could be cost-effectively improved to use 30% less energy while delivering the same comfort.
- To achieve the needed efficiency savings by 2010, approximately 35% of the equipment that normally would be installed or replaced in buildings by then needs to be cost effective, high efficiency equipment
- Technology deployment programs such as EPA's and DOE's Energy Star labeling, Rebuild America, and Green Lights programs, are currently working to inform consumers and businesses of efficiency and cost savings opportunities

Industry

- Without emissions trading, energy growth would have to be almost flat at 1990 levels, instead of increasing about 20% by 2010
- Increased use of heat recovery, cogeneration, and more efficient motors offer the greatest generic opportunities, with other specific technologies also available in individual industrial sectors, such as those detailed in DOE's "Industries for the Future" cooperative program with seven major energy-intensive industries

- With emissions trading, modest emissions and energy growth of around 7% by 2010 could be possible
- Industrial energy efficiency has improved since 1972, now requiring just 67% as much energy per unit of output

Electric Utilities

- Without international emissions trading, utilities would likely have to make absolute reductions on the order of 30% in carbon emissions below 1990 levels, in order to offset the increases above with even substantial reductions in energy growth rates in buildings and industry, while at the same time supplying more electricity to customers
- Renewable energy sources would increase by 25%
- Combined cycle natural gas plants today can generate electricity while emitting about 2/3 less carbon than many existing coal plants. Natural gas would roughly double its 1990 usage in the industry
- Coal usage would have to drop to about one-third to one-half the 1990 level, while natural gas use would increase from 50% to three times its 1990 level → appear inconsistent
- With emissions trading, the coal-to-gas shift could be less severe, but electricity demand would also rise faster. Overall, emissions would still probably have to be about 10% below 1990 levels in 2010
- Shifts in the utility sector would offer other substantial air quality benefits. For example, fuel shifts and increased use of advanced technologies could reduce Nox emissions by over 1/3.

Costs

- How much these changes would cost the U.S. economy is uncertain. In some recent experiences, such as with the Montreal Protocol on ozone depletion and the sulfur dioxide emissions trading system under the Clean Air Act, actual experience has turned out to be substantially less costly than expected because market incentives were used
- The interagency economic modeling analysis indicates that the economic incentives needed to reduce emissions to 1990 levels by 2010 would be in the range of $100 per ton if all of the reductions were made domestically, about $50 per ton with international emissions trading among developed countries, and as low as $20 per ton if both international trading and joint implementation were available
- DOE's "Labs Study" identified those technological changes that were estimated to be cost effective at an emission allowance price of approximately $50 per ton → needs to note that they achieved 1990 in 2010 @ $50/ton

- The true, net cost of such emissions reductions would depend significantly on how the revenues from any emission allowance sales were recycled into the economy, and upon the degree of cost savings experienced due to reduced energy costs. The DOE "Lab Study" projected that the majority of costs would be offset by energy savings, with net costs as low as $10b annually in 2010

Policy Issues

- A commitment to cap carbon emissions would provide an immediate incentive to invest in energy efficiency, but because of market imperfections, some additional measures could be needed to stimulate R&D, commercialize new technologies, and purchase and use advanced technologies as capital stock turns over in the economy

This assumes the net cost of energy efficiency [illegible] is ≤ 0.

DOE'S 'Labs Study'

"SCENARIOS OF U.S. CARBON REDUCTIONS
The Potential Impact of Energy-Efficient and Low-Carbon Technologies"

THE REPORT'S CONCLUSION

Technology can lower the net cost of stabilizing carbon emissions at 1990 levels in the medium term (i.e., 2010) to less than $10 billion a year or less (0.1% of GDP). International trading or flexibility in meeting a stabilization target, considered by other studies, could reduce costs by another 50% or more. The study assumes penetration of technologies from expanding Administration initiatives, such as the PNGV, natural gas technologies, the Climate Change Action Plan and renewable energy such as wind and biomass.

BACKGROUND

Five DOE national laboratories, led by Oak Ridge and Lawrence Berkeley National Laboratories, have conducted a comprehensive, extensively peer-reviewed, 1 year "bottom-up" analysis of the role technology can play in stabilizing U.S. carbon emissions. It is the most authoritative and documented study of this subject since the National Academy of Sciences report and the Office of Technology Assessment Report in 1991. The study documents in detail how four key sectors of the economy-buildings, transportation, industry, and electric utilities-could respond to a climate treaty if launched in the year 2000 with a goal of stabilizing emissions in 2010 and a U.S. cap and trade system is phased in with gradually rising permit prices. The National Laboratories study examined what effect an aggressive program of research, development, and development of clean technologies could have if combined with alternative marginal permit prices of $25/ton and $50/ton of carbon (the average permit price is much lower).

RESULTS

The study concludes that energy efficiency and low-carbon technologies have a very large potential to cost-effectively reduce U.S. carbon emissions while meeting the full energy needs of U.S. businesses and families. Many consumers and businesses will save money.

Under moderate technology and market assumptions, energy efficiency technologies alone can reduce emissions in 2010 by 120 MMT (of the 380 MMT needed to stabilize at 1990 levels). This level of carbon reduction is estimated to be possible at little or no net cost - that is, the energy bill savings far exceed the investments required to achieve the carbon savings. Under more aggressive assumptions motivated in part by a $25/ton carbon permit price, a combination of energy efficiency, low-carbon technologies and relatively inexpensive coal power plant conversions to natural gas can reduce 2010 emissions by a total of 225 MMT. Under a $50/ton carbon permit price, technology investments reduce 2010 emissions by a total of 380 MMT. The analysis also suggests that substantial additional savings are available if permit prices were to begin to rise above the $50/ton level.

The annual investment costs of reductions of this magnitude are estimated to be $50 to $80 billion per year, but result in substantial energy bill savings. The resulting net costs are on the order of -$25 to +$10 billion per year in 2010.

METHODOLOGY

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

TOTAL BENEFITS EXCEED TOTAL COSTS

In the long term, these climate change mitigation actions will provide additional benefits not fully considered in the study - reductions in criteria air pollutants (i.e., ozone and fine particles), decreased dependence on foreign oil, greater industrial productivity, and U.S. leadership in technologies are likely to be a major source of international trade and jobs in the next century. This report provides details on the technologies that can potentially achieve the energy usage and carbon emissions reductions necessary if the U.S. commits to a scenario like the one outlined in the sections above, which would return U.S. carbon emissions to 1990 levels by 2010.

POLICY OPTIONS FOR A U.S. TECHNOLOGY STRATEGY

GOALS

To develop a set of policy options that can help establish the appropriate price signals in the economy, and then provide a set of supplemental actions that will help overcome market barriers and otherwise facilitate an efficient response in the private sector:

- encouraging manufacturers, builders, etc. to produce high efficiency equipment, systems, materials, etc.
- stimulating consumers and purchasers to accelerate their acquisition and use of those technologies
- encouraging the development of financial, service, and other infrastructure to support those technologies

A MENU OF POLICY OPTIONS

- **Prices in the economy**
  — Valuing carbon emissions rights, through a "cap and trade" system, which should be more efficient and less costly than individual subsidies and incentives
  — Investment tax credits, special depreciation treatment, differential fuel taxes (such as the ethanol tax credit), or other financial incentives through the tax system
  — Feebates, or complementary product fees and rebates depending upon product energy efficiency

- **Financing**
  — Enhance availability of financing through partnerships and innovative instruments with financial organizations
  — Incorporate incentives into federal loan, loan guarantee, and grant programs to promote high efficiency technologies

- **Federal R&D policy**
  — National public/private initiatives in key technologies, modeled after the Partnership for a New Generation of Vehicles, eg:
    - in DOE's 7 "Industries of the Future" programs for Pulp and Paper, Chemicals, Petroleum Refining, Glass, Aluminum, Iron and Steel, and Metal Casting
    - in DOE's "Buildings for the 21st Century" program for residential and commercial buildings

  — Increased federal funding for R&D, pilot projects and demonstrations leading to commercialization and/or wider availability of new technologies — current federal funding is just over $600 million annually
  — "Bonus Emissions Credits" under a cap and trade system to reward development and deployment of advanced technologies
  — Incentives for utility sector technology R&D incorporated into utility industry restructuring at the Federal and State levels

Continued.........................

POLICY OPTIONS...........continued

- **Market transformation**
  — Market aggregation, for local governments and companies to coordinate purchases for greater influence
  — Business-government partnerships to provide information, demonstrations, and technical assistance
  — Field verification of advanced technologies

- **Federal leadership through procurement**
  — Federal agencies "lead by example" by adopting aggressive policies to implement energy savings and renewable energy technologies at federal facilities, and to acquire and use more efficient and alternative-fuel vehicles in federal fleets
  — Broaden the participation in Federal Energy Savings Performance Contracts which DOE is implementing to leverage private sector financing through third party energy services companies to reduce the federal government's $8 billion annual energy bill
  — Executive Orders to provide clear direction and management flexibility for greenhouse gas emission reductions within agency plans and programs
  — Green Power Purchasing, by which agencies can negotiate contracts to supply a fraction of their electricity from renewable energy sources

- **Regulation and standards**
  — Appliance efficiency standards, negotiated with the industry and public, such as the recent refrigerator standards
  — Building energy efficiency codes, implemented at the local, state, and federal levels, as appropriate
  — Expedited environmental permitting for highly efficient or low carbon technologies
  — Coordinated implementation of National Ambient Air Quality Standards with climate change policies
  — Restructuring of the electric utility industry in a way that facilitates investment in new and renewable technologies

- **Information and education**
  — Voluntary or mandatory energy performance labels to internalize the asset value of energy efficiency, such as efficiency labels on appliances, vehicles, computers, equipment, and commercial and residential heating and air conditioning systems
  — Federally-supported multi-media materials development for use in schools and the mass media

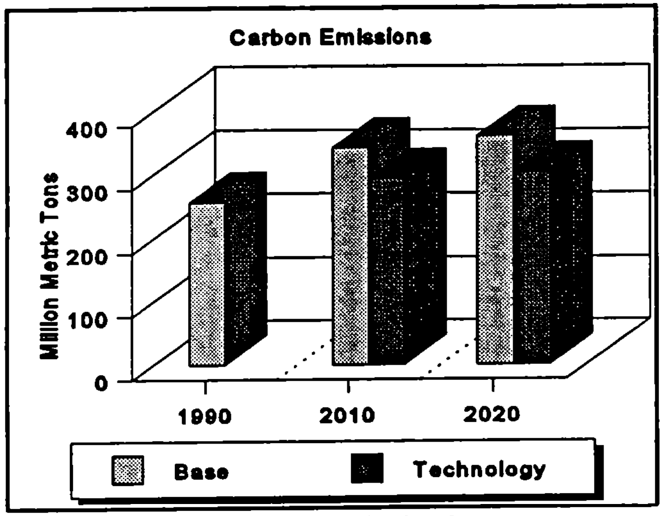
- **International market development**
  — Special focus on bilateral trade agreements, export assistance, and financial assistance in support of U.S.-produced advanced technologies for energy efficiency, renewable energy supplies, etc.

BACKGROUND ON KEY SECTORS

The material on these pages provides brief, thumbnail sketches of six key sectors of the economy, listed below. For each, the information profiles the sector's current energy and carbon emissions profile and trends, the types and extent of technological improvement needed under the scenario in which U.S. emissions are returned to 1990 levels by the year 2010. These descriptions assume no emissions trading or joint implementation, in order to provide a benchmark for further examination.

1. **Autos and Light Trucks**
2. **Freight, Aircraft and Rail**
3. **Residential and Commercial Buildings**
4. **Electric Utilities**
5. **Renewable Energy**
6. **Industrial Emissions**

Autos and Light Trucks



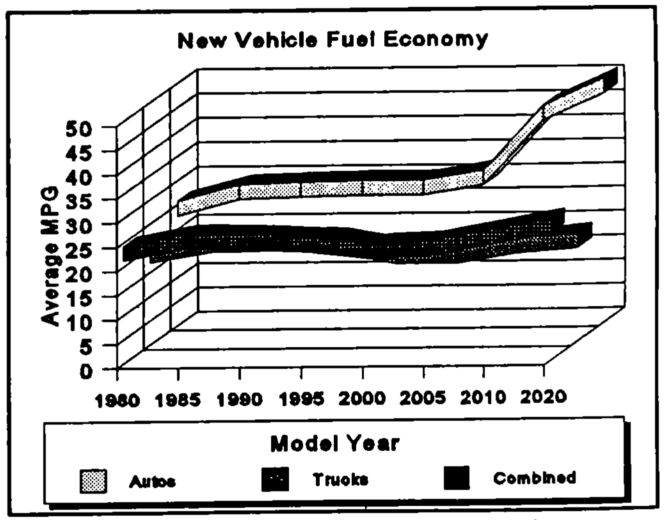
Source: Markal-Macro 1.25 Stabilization Case

Ship? [illegible] 1.75!

Since we only explain 5 Labs study, this may not [illegible]

Key Trends — 1990-2010

- The transportation sector generates one-third of all energy-related carbon emissions in the United States. Moreover, this is the fastest growing end-use sector. Cars and light trucks (light duty vehicles) alone account for 58 percent of the total transportation emissions.
- Average fuel economy for new automobiles has been regulated at a minimum 27.5 mpg since 1985. It is projected to grow to 31 mpg in 2010. New minivans, sports utility vehicles, and other "light trucks" now get 21 mpg and are projected to get 23 mpg in 2010.
- Light trucks were 20 percent of the personal vehicle market in 1974, 44 percent in 1996, and are projected to be 50 percent by 2010. Assuming no change in this trend, this will result in a declining overall fuel economy for all light duty vehicles.
- Vehicle miles traveled have been growing 2-3 percent per year for the past 30 years and are expected to grow 1.4 to 2 percent or more per year through 2010. Improved fuel economy will help maintain desired levels of vehicle miles traveled.



Source: DOE Labs; Markal-Macro 1.25 Stabilization Case

Needed Technological Improvements

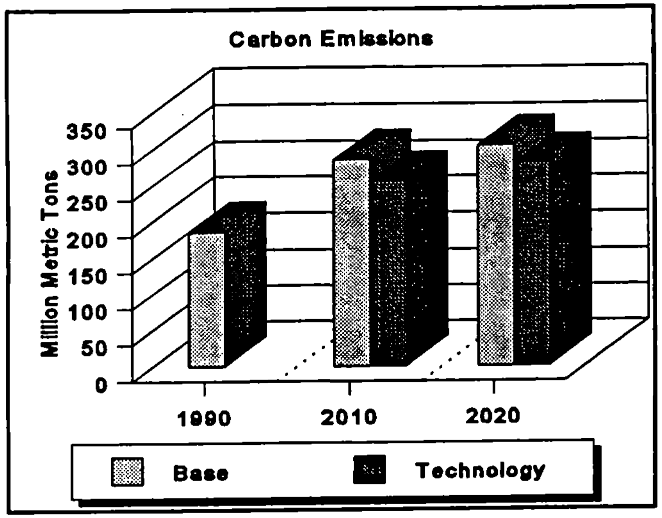
- By 2010, about 30 percent of new light duty vehicles would have to meet the Partnership for a New Generation of Vehicles (PNGV) goal of a tripled fuel economy (e.g., 80 mpg for automobiles) to help reduce overall carbon emissions to 1990 levels. On the other hand, all new cars and light trucks would have to embody 30 percent of the improvement represented by the PNGV goal (e.g., 45 mpg for automobiles).
- On-Road fuel economy for all cars and trucks (including both new and existing vehicles) would need to reach 25 mpg by 2010 and 31 mpg by 2020 compared to 20 mpg in 1995.
- Key technologies needed are vehicle weight reduction through advanced materials and

design, hybrid/electric drivetrains, and improved aerodynamics.

Costs
- If PNGV goals are met, the more efficient light duty vehicles will have no increased cost for consumers.
- At currently anticipated technology costs, new autos in 2010 would have an incremental price of $800-1,200. At gasoline prices forecasted for the year 2010, these higher costs would pay for themselves in fuel savings within 3.5-5.3 years.
- PNGV is currently funded at $263 million (Federal share).

Policy Challenges
- Achieve successful demonstration production prototype of PNGV vehicle by 2004.
- Ensure that PNGV technologies fully penetrate all markets for all new light-duty vehicles by 2010 and continue through the period 2020.
- Devise new commercialization strategies, including new approaches to fuel economy standards and market incentives (e.g., Green Machine Challenge, financing packages, bonus emission credits).

Freight, Aircraft and Rail



Source: DOE Labs Study, 1997

Key Trends: 1990-2010

- Freight, aircraft and rail together accounted for 185 million tons of carbon dioxide emissions in 1990, nearly 40 percent of all emissions from transportation.
- All modes of freight transport have improved their energy efficiency. However, increased freight tonnage and shifts toward more energy-intensive modes have meant a 60 percent increase in the amount of energy used to haul freight since 1972-1995, although about three times as much freight was transported.
- Opportunities to reduce carbon emissions from freight are expected to come mainly from trucking and air transport.

Needed Technological Improvements

- Key technologies to reduce energy intensity in truck freight in the next 10-15 years include vehicle weight reduction through materials substitution (which could allow for heavier loads and thus fewer trucks, improved tires, electronic engine and transmission controls). Larger reductions are possible beyond 2010 if hydrogen-powered, fuel cell powertrains are developed and commercialized for truck transport. Also, a more aggressive technology scenario might include advanced diesel engines, rapid penetration of diesel trucks that are 25 percent more efficient than current diesel engines.
- NASA programs have helped to reduce energy intensity in air transport for over 20 years. NASA's high performance turbine engine technology program aims to achieve a 40 percent increase in fuel efficiency by 2003, and such engines could conceivably be on commercial aircraft within 15 years.

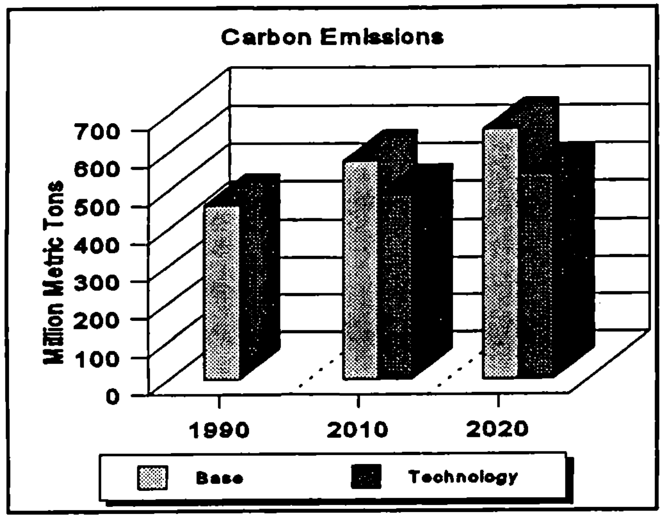
Costs

- The DOE Labs Study estimates that annual costs needed to achieve emissions reductions in 2010 in freight transportation range from $20-25 billion, and could save $27-40 billion annually in fuel costs.

Policy Challenges

- Technology R&D is key to reducing energy intensity in trucks in the medium and long term. Hybrid powertrains could likely be significantly advanced with increased R&D funding.
- To achieve a high efficiency/low carbon technology scenario, R&D programs might need to be increased substantially.

Residential and Commercial Buildings



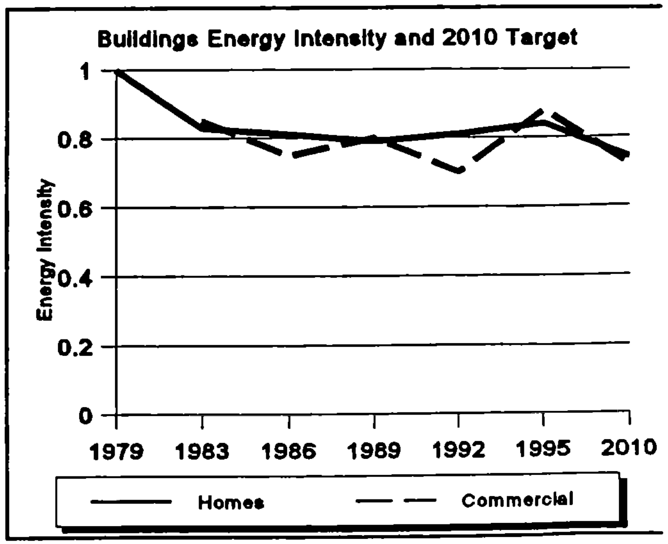
Source: EIA, Markal-Macro, DOE Labs Study, 1997

Key Trends - 1990-2010

- 35% of U.S. carbon emissions are from energy use in buildings, with homes emitting 19% and commercial buildings emitting 16%.
- Energy intensity in buildings has declined substantially since the late 1970s. Primary energy intensity in commercial buildings declined by 22% between 1979 and 1992, while residential primary energy intensity dropped by 15% since 1978.
- Buildings have become increasingly electrified - driven by rapid growth in office equipment, small appliances and other devices collectively know as "plug loads". From 1978 to 1992, commercial electricity consumption grew by 37%, while residential electricity grew by 36%.
- Due to continuing electricity growth, the EIA forecasts that future commercial energy intensity will decline by only 0.2% per year, and residential intensity by 0.5% per year. However, numerous studies identify substantial additional potential for cost-effectively reducing buildings energy consumption and greenhouse gas emissions.

Needed Technological Improvements

- Technologies needed to achieve the emissions reductions above largely exist today.
- The large potential emissions reductions are not being achieved in current markets because of a number of market barriers that impede the diffusion of energy-efficient technologies - such as lack of reliable product information; higher up-front costs; split incentives between efficiency purchasers and beneficiaries; conflicting building codes; and lack of market expertise in efficiency design, construction and financing.
- To achieve the efficiency savings in 2010, the equipment that naturally turns over in about 35% of buildings is replaced with the most cost-effective technologies by 2010; these savings assume normal retirement of equipment at the end of its useful life.
- Energy efficiency improvements needed are 12% for residential buildings and 18% for commercial buildings by 2010 vs. no sustained improvement from 1980 to 1995.



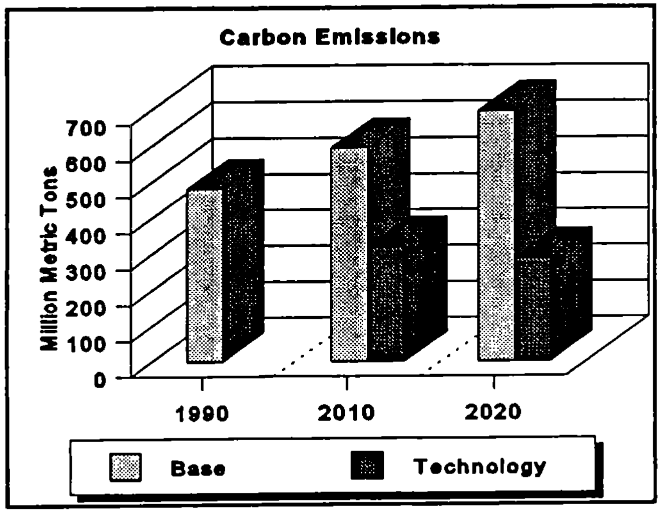
Source: EIA, DOE Labs Study, 1997

- Integrated renewable technologies in buildings can cut heating and cooling loads while directing cutting emissions.

Costs
- The DOE Labs Study estimates investments to achieve these 2010 savings are $7-$14 billion per year and result in 2010 energy bill savings of $18-33 billion - a net savings of $10-19 billion and a 20% return on investment.
- DOE estimates costs of Federal programs to accelerate the use of energy efficient technologies in buildings are $300 million per year.

Policy Challenges
- Federal, state and local policies that accelerate technology deployment and energy efficient building design, construction and operation.
- Partnerships with states, local government and industry to improve efficiency of existing buildings and remove market barriers.
- Research and development of a portfolio of advanced buildings technologies.

Electric Power



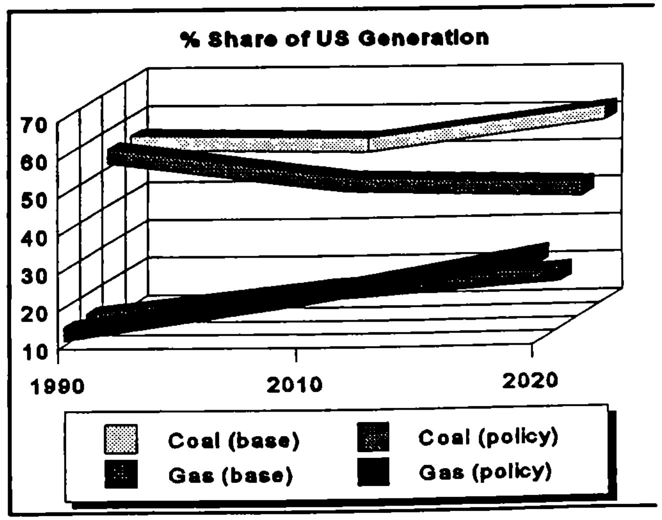
Source: Markal-Macro 1.25 Stabilization Case

Key Trends -- 1990-2010

- 36% of US carbon emissions are in the electric utility sector, primarily from burning of coal and natural gas.
- Coal and natural gas together are projected to increase from 63% of energy inputs to 70% by 2010, increasing the carbon intensity of this sector.
- Demand for electricity is projected to rise by 20 percent per decade compared to 30% from 1980 by 1990.
- Renewable power (other than hydroelectricity) is projected to rise from 1.5% of generation currently to 1.8% in 2010.

Needed Technological Improvements

- No breakthroughs are projected in generation technology. Continued improvements will be possible from combined cycle turbines, gasification for biomass fuels, wind turbines and system improvements (such as transmission efficiency).
- First, end use electricity demand growth must slow -- efficient technologies can reduce demand to 23% above 1990 levels by 2010, vs. a business as usual forecast of over 40% growth.
- Second, those reductions must primarily reduce coal-fired generation.
- Third, remaining coal-fired generation must be reduced in favor of natural gas, through gas co-firing, conversions to gas, and increased use of combined cycle gas turbines.
- Beyond 2010, nuclear plant life extensions may be an economically viable option.
- Renewables such as solar, wind, geothermal and biomass must be promoted for the long term, and must be accelerated to make a larger contribution.

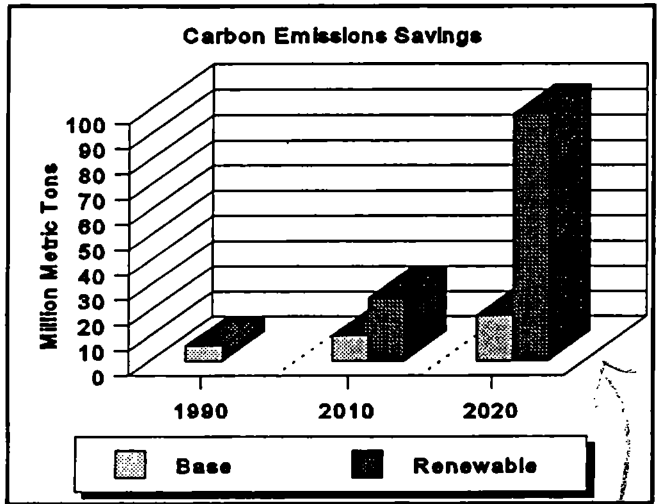


Source: DRI 1.25 Stabilization Case

Costs
- Cost estimates for the needed changes in the utility industry are under development at this time.

Policy Challenges
- Aggressive R&D and marketing for energy efficiency sectors is essential.
- Integrate climate policy with competitive trends and air quality regulation.
- Incentives for shifting power to lower-emitting fuels -- pricing, emissions trading credits, promotion, regulation, and financing.
- Incentives to develop emissions sequestration alternatives such as the capture and combustion of methane from landfills for power generation.

Renewable Energy



Source: DOE Labs Study, 1997

Is this consistent w/ electric power

Key Trends - 1990-2010

- Today, roughly 12% of the country's electricity generating capacity is from renewable energy - with 85% of this from hydropower. Newer renewable technologies - including wind, biomass, photovoltaics, solar thermal and geothermal - are increasingly economic and have large potential.
- Costs have dropped dramatically -photovoltaic cells have dropped from \$0.90/kilowatt-hour in 1980 to under \$0.20/kWh today, while wind power has dropped from \$0.25/kWh to \$0.05/kWh.
- Cost reductions will continue because of R&D advances and as manufacturing process improvements and production rates decrease costs.
- Cost performance improvements have resulted in several technologies being competitive in selected markets today and others will be competitive in broader markets in the near future.
- Several major international companies such as Royal/Dutch Shell, expect these technologies to be dominant global energy sources and are substantially investing in their development.

Needed Technological Improvements

- The contribution of renewable electric technologies to emissions reductions could be substantially higher than projected in the base case.
- Costs and performance of these technologies continue to improve, but additional advances in wind, biomass, photovoltaics, geothermal, solar thermal and transportation biofuels are needed - such as: wind turbine design for moderate wind speeds, photovoltaics conversion efficiency improvements, geothermal drilling technology and resource verification, large-scale celluosic biomass fuels production, and biomass combustion and integrating renewable technologies into building designs.
- Non-hydro renewable energy generation capacity could grow from 9 gigawatts (GW) today to 21-24 GW in 2010 and 77-108 GW by 2020.

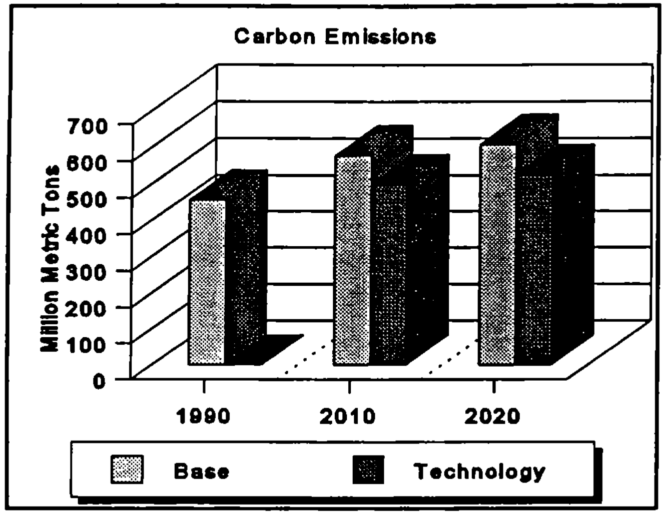
Costs

- According to the DOE Labs Study, the incremental capital investment in renewable power systems needed to achieve the above results is $2-3 billion in 2010 and $15-25 in 2020 - although fuel cost savings in 2020 will result in net incremental costs that are low or negligible.
- As estimated by DOE, the incremental production cost of renewable electricity is estimated to be $2-3 billion/yr in 2010 and negligible in 2020 as multiple renewable technologies are widely competitive with gas technologies.

Policy Challenges

- Expand technology R&D to lower costs and increase performance.
- Conduct cost-shared technology diffusion with industry to increase utility system experience and increase U.S. renewable energy production capacity.
- Conduct R&D on key support systems such as power storage, power conversion systems, controls and superconducting power equipment.
- Encourage use of U.S. renewable technologies abroad to tap the huge global market for renewable energy.

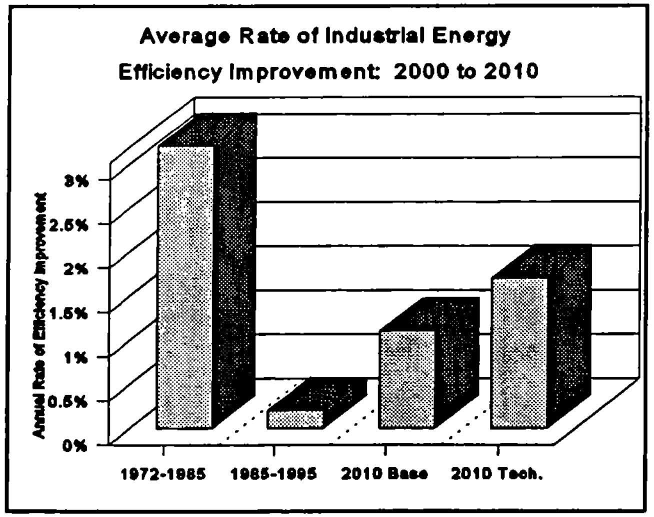
Industrial Emissions



Source: Markal-Macro Technology Investment Case

Key Trends -- 1990-2010

- Based upon EIA data for 1995, the industrial sector uses 37 percent of the nation's energy, or 34 out of a total 91 quads. Carbon emissions are now at about 33 percent or total emissions in the United States, or 464 of 1424 million metric tons (MMT). The industrial sector is second only to transportation in the growth of carbon emissions.
- Electricity accounts for 34 percent of the total industrial carbon emissions.



Source: Markal-Macro Technology Investment Case

Needed Technological Improvements

- With normal rates of capital stock turnover, the industrial energy intensity is expected to decline at a rate of 1.2 percent in base case forecast for the period 1997-2015. Historically, energy intensity has decreased by an average of 1.8 percent annually from 1972 to 1995. During this period, average energy intensity declined by 3 percent between 1972 and 1985, and then remained relatively unchanged from 1985 to 1995.
- The industry sector is also responsible for most of the non-energy related emissions of carbon dioxide (21 MMT) and other greenhouse gases (219 MMT of carbon equivalent). Although industrial emissions of these gases are far smaller than energy-related carbon emissions by weight, they have global warming potentials (GWP) that range from 21 for methane to 23,900 for sulfur hexafloride (SF6).

- The industrial sector has the potential to reduce energy use by 10-15 percent over 2010 baseline forecasts through cost effective investments in energy efficient technologies, and in some cases, low carbon technologies.
- The use of heat recovery and combined heat and power (i.e., cogeneration) systems such as the Advanced Turbine System, can reduce industrial carbon emissions by up to 35 MMT/year in 2010 with electricity costs that are 10 percent lower than current systems.
- Motor systems account for 70 percent of industrial electricity use (about 120 MMT). Better designed energy-efficient motor systems could reduce electricity use by up to 40 percent. Better maintenance of compressed air systems can also save 40 percent of the energy used in such systems.
- In addition, there are important longer term opportunities to reduce the carbon intensity of industrial operations through changes in the fuel mix, and by using lower-carbon fuels.

Costs
- There are readily-available but underutilized technologies with two to four-year paybacks that can reduce industrial energy use by 10 percent or more. As referenced above, these technologies include more efficient motor systems, air compressors, and process efficiency improvements.
- DOE estimates that the cumulative investment necessary to reduce industrial carbon emissions to 1990 levels by 2010 is on the order of $47 to $58 billion in the period 1998-2010. On an annual basis, this is about 3-4 percent of the total investments made by the manufacturing sector in 1995. By 2010, annual energy savings are estimated at $8-10 billion (with all values in 1995 dollars) -- approximately a 17% to 20% return on investment.
- Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing may actually improve the competitive position of many industries.

Policy Challenges
- Policies to encourage the more rapid diffusion of existing technologies include: (1) incentives to accelerate the investment in new capital stock and equipment; (2) increased RD&D to facilitate the development of improved technologies as well as the development of a new generation of industrial technologies; (3) incentives to increase the use of recycled feedstocks; (4) expediting the use of combined heat and power systems through improved environmental permitting and by incorporating provisions into the ongoing utility restructuring that facilitate the sale of excess power by industrial plants; and finally (5) a life cycle approach to environmental permitting and regulations.

y	s	n
~~||||~~ ||||	||	~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |||
9	2	43

no Δ in policy options discussion

54

Response to OMB

pound on costs estimate

need for price on C

need 1 consistent methodology for all sectors

I don't understand the co[st] and benefit numbers, given that on balance controlling GG Emissions will cost the economy.

DISCUSSION PAPER

(1) The Type of ~~A~~ **TECHNOLOGY** ical change that could be ~~**APPROACH**~~ elicited from Price changes.

TO ADDRESSING GLOBAL CLIMATE CHANGE

(2) Where will the improvements in energy efficiency come from?

(3) How can Technology help reduce Greenhouse Gas emissions?

July 28, 1998 Draft

The [illegible] to energy-efficient technology will not be costless

new title ~~**DISCUSSION PAPER ON A TECHNOLOGY APPROACH TO ADDRESSING GLOBAL CLIMATE CHANGE**~~

"In order to reduce greenhouse gases and grow the economy, we must invest more in the technologies of the future. I am directing my Cabinet to work to develop them. Government, universities, business and labor must work together. All these efforts must be sustained over years, indeed, over decades."

President Clinton
Address to the United Nations
June 26, 1997

10
Price 20
50
100

Context for this paper:

- The U.S. position on global climate change has consistently been that any action program should be centered on a market-based approach. Given the proper market signals, the private sector will find the most efficient means to actually make changes in technologies, business practices, and patterns of energy use to reduce greenhouse gas emissions.

- A properly-designed, capped emissions trading system ~~could~~ would provide strong market signals to that end

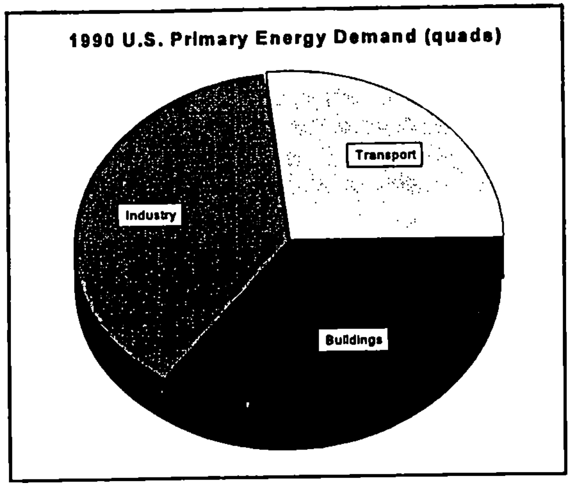
- ~~There are also a~~ A variety of other technology supporting actions that the federal government could undertake to supplement such an emissions trading system to stimulate R&D and market development in specific areas, where market barriers exist or where changes might be restrained for various reasons. ? are these cost-effective?

- This paper first provides a perspective on the degree of technological change that would be needed in key sectors of the economy ~~in order~~ to begin reducing greenhouse gas emissions from energy use, its primary source.

- Then, the paper identifies the menu of policy options, from which a federal strategy can be developed to support technology development to achieve the dual goals of reducing greenhouse gases and continuing to grow the economy.

- Additional detailed papers are available from the Department of Energy and others on the technological opportunities.

PROFILE OF U.S. CARBON EMISSIONS BY INDUSTRIAL SECTOR

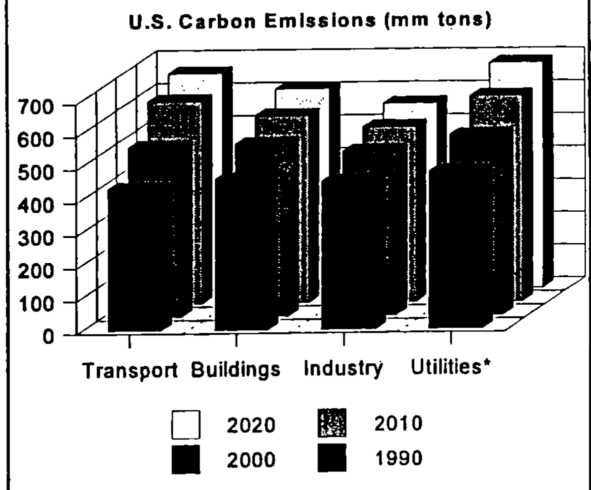


Energy Profiles

- Three sectors ~~each~~ account for approximately one-third of U.S. primary energy demand — transportation, commercial and residential buildings, and industry
- The electric utility sector supplies about one-third of this demand, virtually all in the buildings and industrial sectors, and consumes fuels to generate that power. In the buildings sector, two-thirds of the energy usage is from electricity, and in industry the share is just over 10%
- Growth in U.S. energy consumption changed dramatically after the 1973 energy crisis, but is projected to continue steadily in the absence of new policies:
  — the 1960s +52%
  — the 1970s +14%
  — the 1980s +11%
  — the 1990s +12% (already +9% by 1997)
  — the 2000-2010 decade +12%
  — in total, 2010 will be 26% above 1990

Carbon Emissions Trends — 1990 - 2020

- The profile in U.S. carbon emissions parallels the pattern of energy demand — the three sectors, transportation, buildings, and industry, each account for approximately equal shares
- Electric utility emissions ~~in the chart at the right are double-counted in the end-use sector in which the electricity is used — and~~ can only be reduced by either reducing end-use electricity demand or by switching to lower carbon content fuels
- Growth projections also parallel the pattern of energy growth. DOE's Energy Information Administration (EIA) projections show:
  — Total emissions up 28%, or 377 million tons, from 1990 to 2010
  — Transportation up 43%, or 184 million tons
  — Buildings up 24%, or 111 million tons
  — Industry up 18%, or 82 million tons
  — Utilities, included in the other sectors, up 30%, or 146 million tons



* Utilities emissions also included in final use sector

LONG-TERM TECHNOLOGY STRATEGY

The table below shows the major areas where we may have make a technological response to a change in incentives

In the long-term, over several decades, reductions in carbon emissions will require two fundamental changes, (1) shifts in the basic forms of energy used, and (2) significant improvements in the efficiency of our energy usage. ~~A technology strategy can achieve both and provide a strong competitive position for the U.S. by advancing improvements such as the following.~~ some Δ in new version

Transportation	Buildings	Industry	Electric Utilities
o Biofuels o Hydrogen fuels o Electric vehicles o Hybrid vehicles o Full PNGV 80 mpg vehicles	o Fuel cells o Efficient systems — heating, cooling, lighting, windows o Intelligent mgmt systems o Efficient "plug load" — computers, equipment, etc.	o High efficiency motors o Process changes o Recycling to reduce primary production	o Renewable energy systems — solar, wind, biomass o Distributed power o Improvements in power generation & transmission o Dispatching & load sharing

Long-term Market and Economic Uncertainties

- Electricity deregulation, international competitiveness
- Lifestyle trend changes (eg, telecommuting, consumer preferences for large vehicles)
- Commercial transport shifts in modes, speed, and the role of short- and long-range transportation of goods and people

Cost Issues

- Currently, the federal government spends only ....% of its energy R&D budget, or $....... annually on long-term technologies.
- T~~here are no estimates of the amount of~~ public and private investment ~~that will be needed~~ to achieve these major advances will require significant
- In the long run, it is uncertain whether ~~there will be an incremental cost or savings from~~ such technological changes will produce net cost or savings
-

Policy Issues

- Federal and private R&D funding
- Role of public/private partnerships
- Incentives.........funding, prices, emissions trading allocations, partnerships, public relations, published performance data, required performance standards, other

economy

respond

MEDIUM-TERM, TECHNOLOGY AND EMISSIONS TRADING PROVIDE A BRIDGING STRATEGY

measurable w/ help the economy respond to the price signals - X

In the medium-term, technology can ~~serve a "bridging" function to allow time for the long-term R&D developments and the commercialization of various technologies to reach significant levels~~.

to lower costs by X

Emissions trading and joint implementation ~~are~~ critical ~~to a technology strategy in~~ providing timing flexibility to deploy efficient technologies at rates close to normal capital stock turnover cycles, and to provide a "safety valve" if the required rates of technological change cannot be achieved fast enough.

~~Technology Implications~~

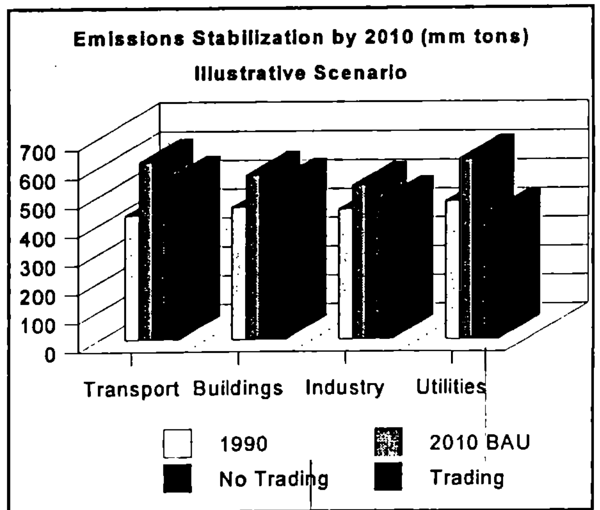
For example, the DOE "Labs Study" and the IAT computer modeling suggest ambitious rates of technological change would be needed to return U.S. carbon emissions to 1990 levels by 2010:

- Overall, emissions growth of 28%, or 377 million tons, would have to be avoided or offset
- If ~~done all in~~ the U.S., energy growth would probably have to drop to half its present rate, to about 10 to 12% over the 20-year period, and it's already about 9% above 1990 levels in 1997
- With emissions trading and joint implementation, the models suggest that up to 40% of the 2010 emissions reduction might be achieved abroad, at U.S. expense, to buy time for a more orderly technological transition here

reducing are limited to

Transportation

- Without trading, growth in energy usage would have to drop to about half its business as usual rate of 30% to 40%, down to 15% to 20%
- Unless consumer preferences for large cars and increased driving change, 30% of PNGV improvements would have to be integrated into new cars and light trucks by 2010...for 45 mpg new automobiles
- With trading, the pace of improvements could be slower, but would likely still lead to ....



Commercial and Residential Buildings

- Without trading, growth in energy usage would have to be cut in half, to a rate of about 10% by 2010, vs. BAU projections of about 20% to 25%
- High efficiency equipment would be needed on one-third of new installations and normal replacement cycles of building systems and equipment, compared to current rates of ....

Continued.....................

MEDIUM-TERM............continued

Industry

- Without emissions trading, energy growth would have to be almost flat at 1990 levels, instead of increasing about 20% by 2010
- Increased use of heat recovery, cogeneration, and more efficient motors offer the greatest generic opportunities~~, with other specific technologies also available in individual industrial sectors, such as those detailed in DOE's "Technologies for the Future" cooperative program with seven major energy-intensive industries~~
- With emissions trading, modest emissions and energy growth of around 7% by 2010 could be possible
- Industrial energy efficiency has improved since 1972, now requiring just 67% as much energy ~~per~~ unit of output

Int.

Electric Utilities

What does this mean,

- Without emissions trading, utilities would likely have to make ~~absolute~~ reductions on the order of 30% in carbon emissions below 1990 levels in order to offset the increases in other sectors above, while at the same time supplying more electricity to customers
- Coal usage would have to drop to about half the 1990 level, while natural gas use would roughly triple its 1990 ~~usage in the industry.~~
- With emissions trading, the coal-to-gas shift could be less severe, but electricity demand would also rise faster. ~~Overall, emissions would still probably have to be about 10% below 1990 levels in 2010~~

is uncertain (because market-incentives were used.

Costs

- ~~There is great uncertainty about just~~ how much these changes would cost the U.S. economy. In some recent experiences, such as with the Montreal Protocol on ozone depletion and the sulfur dioxide emissions trading system under the Clean Air Act, actual experience has turned out to be substantially less costly than expected
- Preliminary estimates for the scenario above, returning emissions to 1990 levels by 2010, in the absence of int- emissions trading and joint implementation, are that it could result in annual costs of $ .... billion, including amortization of approximately $.............. of investment Δ same
- With international emissions trading and joint implementation, that cost could fall to $.......... annually

Policy Issues

- Incentives are needed to stimulate R&D, commercialization of new technologies, and the purchase and use of advanced technologies as capital stock turns over in the economy

DOE'S 'Labs Study'

"U.S. CARBON REDUCTIONS BY 2010 AND BEYOND
The Potential Impact of Energy-Efficient and Low-Carbon Technologies"

b2p like economy respond to higher energy prices

This report provides details on the technologies that can ~~potentially achieve the energy usage and~~ carbon emissions reductions necessary ~~if the U.S. commits to a scenario like the one outlined in the sections above, which would return~~ U.S. carbon emissions to ~~1990 levels by 2010.~~

that will be required to reduce

(This page to be supplied by DOE)

study assumes

* ZERO implementation costs

Reframe in terms of introductory page?

POLICY OPTIONS FOR A U.S. TECHNOLOGY STRATEGY

GOALS

For the long-term, provide basic R&D and other support for the fundamental technological advances needed in the economy

For the short- and medium-term, provide incentives and support to:

- encourage manufacturers, builders, etc. to produce high efficiency equipment, systems, materials, etc.
- stimulate consumers and purchasers to accelerate their acquisition and use of those technologies
- encourage the development of financial, service, and other infrastructure to support those technologies

x **POLICY OPTIONS**

- **Prices in the economy**
  — Valuing carbon emissions rights, through a "cap and trade" system
  — Investment tax credits, special depreciation treatment, differential fuel taxes (such as the ethanol tax credit), or other financial incentives through the tax system
  — Feebates, or complementary product fees and rebates depending upon product energy efficiency

- **Financing**
  — Financial community partnerships with insurance, financial, utility and others to support advanced technologies
  — Incorporate incentives into federal loan, loan guarantee, and grant programs to promote high efficiency technologies

- **Federal R&D policy**
  — National public/private initiatives in key technologies, modeled after the Partnership for a New Generation of Vehicles, eg:
    - in DOE's 7 "Technologies for the Future" programs for Pulp and Paper, Chemicals, Petroleum Refining, Glass, Aluminum, Iron and Steel, and Metal Casting
    - in residential and commercial buildings

  — Increased federal funding for R&D, pilot projects and demonstrations leading to commercialization and/or wider availability of new technologies — current federal funding is $............. annually

- **Market transformation**
  — Market aggregation, for local governments and companies to coordinate purchases for greater influence
  — State and local partnerships with the federal government to provide information, demonstrations, and technical assistance
  — Field verification of advanced technologies

POLICY OPTIONS..........continued

- **Federal leadership through procurement**
  — Federal agencies "lead by example" by adopting aggressive policies to implement energy savings technologies at new and existing federal facilities, and to acquire and use more efficient and alternative-fuel vehicles in federal fleets
  — Broaden the participation in Federal Energy Savings Performance Contracts which DOE is implementing to leverage private sector financing through third party energy services companies to reduce the federal government's $8 billion annual energy bill
  — Executive Orders to provide clear direction and management flexibility for greenhouse gas emission reductions within agency plans and programs
  — Green Power Purchasing, by which agencies can negotiate contracts to supply a fraction of their electricity from renewable energy sources

- **Regulation and standards**
  — Appliance efficiency standards, negotiated with the industry and public, such as the recent refrigerator standards
  — Building energy efficiency codes, implemented at the state and local level
  — Expedited environmental permitting for highly efficient or low carbon technologies
  — Coordinated implementation of National Ambient Air Quality Standards with climate change policies
  — Restructuring of the electric utility industry in a way that facilitates investment in new technologies

- **Information and education**
  — Information disclosure requirements, such as efficiency labels on appliances, computers, equipment, and commercial and residential heating and air conditioning systems
  — Federally-supported multi-media materials development for use in schools and the mass media

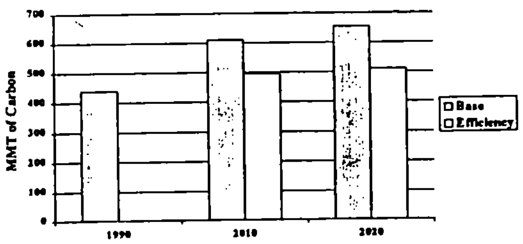
- **International market development**
  — Special focus on bilateral trade agreements, export assistance, and financial assistance in support of U.S.-produced advanced technologies for energy efficiency, renewable energy supplies, etc.

BACKGROUND ON KEY SECTORS

The material on these pages provides brief possible ~~thumbnail~~ sketches of six key sectors of the economy, ~~listed below~~. For each, the information profiles the sector's current energy and carbon emissions profile and trends, the types ~~and extent~~ of emissions technological improvement ~~needed under the scenario in which~~ U.S. that ~~could~~ might occur in response to price changes necessary to ~~emissions are~~ returned to 1990 levels by the year 2010. These descriptions assume no emissions trading or joint implementation, in order to provide a benchmark for further examination.

1. **Autos and Light Trucks**
2. **Freight, Aircraft and Rail**
3. **Residential and Commercial Buildings**
4. **Electric Utilities**
5. **Renewable Energy**
6. **Industrial Emissions**

Transportation Carbon Emissions



Source: Markal-Macro Technology Investment Case

Autos and Light Trucks

Key Trends — 1990-2010

- The transportation sector generates one-third of all energy-related carbon emissions in the United States. Moreover, this is the fastest growing end-use sector. Cars and light trucks (light duty vehicles) alone account for 58 percent of the total transportation emissions.
- Average fuel economy for new automobiles has been regulated at a minimum 27.5 mpg since 1985. It is projected to grow to 31 mpg in 2010. New minivans, sports utility vehicles, and other "light trucks" now get 21 mpg and are projected to get 23 mpg in 2010.
- ~~Light trucks were 20 percent of the personal vehicle market in 1974, 44 percent in 1996, and are projected to be 50 percent by 2010. Assuming no change in this trend, this will result in a declining overall fuel economy for all light duty vehicles.~~ X
- Vehicle miles traveled have been growing 2-3 percent per year for the past 30 years and are expected to grow 1.4 to 2 percent or more per year through 2010. Improved fuel economy will help maintain desired levels of vehicle miles traveled.

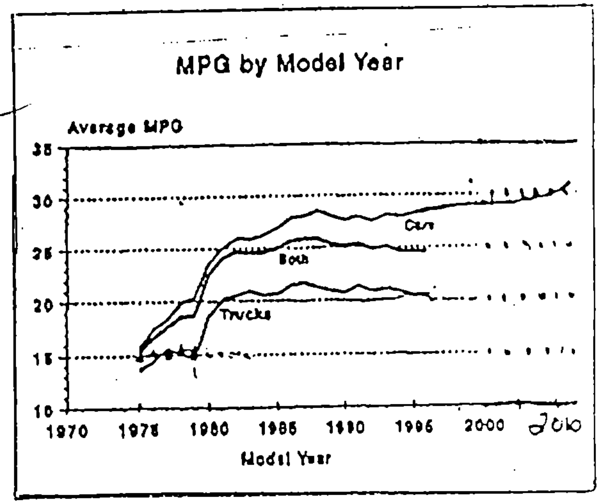
Alternatively X

Needed Technological Improvements

- By 2010, about 30 percent of new light duty vehicles would have to meet the Partnership for a New Generation of Vehicles (PNGV) goal of a tripled fuel economy (e.g., 80 mpg for automobiles) to help reduce overall carbon emissions to 1990 levels. ~~On the other hand~~, all new cars and light trucks would have to embody 30 percent of the improvement represented by the PNGV goal ~~(e.g., 45 mpg for automobiles)~~. X
- On-Road fuel economy for all cars and trucks (including both new and existing vehicles) would need to reach 25 mpg by 2010 and 31 mpg by 2020.
- Key technologies needed are vehicle weight reduction through advanced materials and design, hybrid/electric drivetrains, and improved aerodynamics.

Costs These two points look contradictory

- X If PNGV goals are met, the more efficient light duty vehicles will have no increased cost for consumers.
- At ~~currently~~ anticipated technology costs, new autos in 2010 would have an incremental price of $800-1,200. At gasolines prices forecasted for the year 2010, these higher costs would pay for themselves in fuel savings within 3.5-5.3 years.



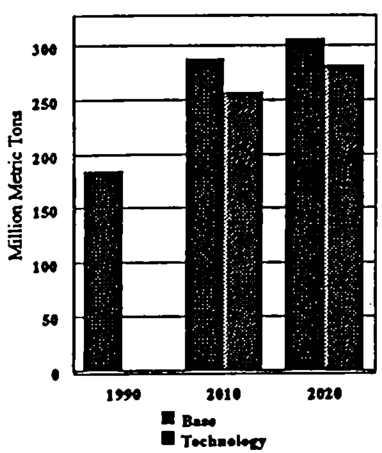
Policy Challenges

- Ensure that PNGV technologies fully penetrate ~~all markets for all~~ X the new light-duty vehicles X market by 2010 and continue through the period 2020.
- Devise new commercialization strategies, including new approaches to fuel economy standards and market incentives (e.g., Green Machine Challenge, financing packages, bonus emission credits).

X These don't mean much to the average reader

Freight, Aircraft and Rail

Carbon Emissions



Key Trends: 1990-2010

- Freight, aircraft and rail ~~together~~ accounted for 1~~85 million tons of carbon dioxide emissions in~~ 1990, nearly 40 percent of all emissions from transportation.
- All modes of freight transport have improved their energy efficiency. ~~However, increased freight tonnage and shifts toward more energy-intensive modes have meant a 60 percent increase in the amount of energy used to haul freight since 1972-1995, although about three times as much freight was transported.~~ too much detail
- Opportunities to reduce carbon emissions from freight are expected to come mainly from trucking and air transport.

Needed Technological Improvements

- Key technologies to reduce energy intensity in truck freight in the next 10-15 years include vehicle weight reduction through materials substitution, improved tires, electronic engine and transmission controls. Larger reductions are possible beyond 2010 if hydrogen-powered, fuel cell powertrains are developed and commercialized for truck transport. Also, a more aggressive technology scenario might include rapid penetration of diesel trucks that are 20 percent more efficient that current diesel engines.
- NASA programs have helped to reduce energy intensity in air transport for over 20 years. NASA's high performance turbine engine technology program aims to achieve a 40 percent increase in fuel efficiency by 2003, and such engines could conceivably be on commercial aircraft within 15 years.

additional investment — defined how? ?

over what period

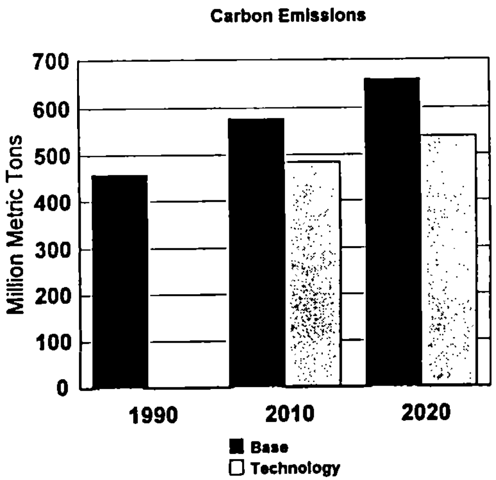
Costs

- DOE estimates that annual costs needed to achieve emissions reduction in transportation range from $25-40 billion, and could save $35-40 billion annually in fuel costs. add
- PNGV is funded at $____________, and to ~~succeed in~~ achiev~~ing~~e the ~~kinds of~~ emissions reduction sketched above, might need two to ten times this funding. moved to cars, lt trucks

Policy Options

- PNGV is key to reducing energy intensity in truck the medium and long term. Hybrid powertrains could likely be significantly advanced with increased R&D funding.
- To achieve a high efficiency/low carbon technology scenario, R&D programs might need to be increased 2 to 10 times.

Residential and Commercial Buildings

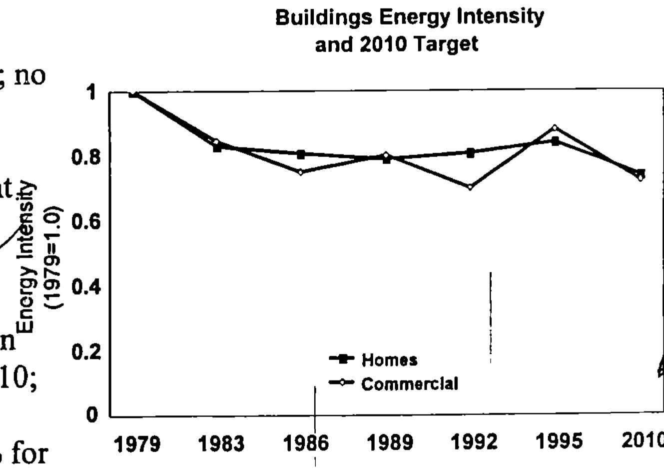


Key Trends - 1990-2010

- 35% of U.S. carbon emissions are attributable to energy use in buildings~~, with~~ homes e~~mitting~~ 19% and commercial ~~buildings emitting~~ 16%).
- Energy intensity ~~in buildings has declined substantially since the late 1970s. Primary energy intensity~~ in commercial buildings declined by 22% between 1979 and 1992, ~~while~~ and residential ~~primary~~ energy intensity dropped by 15%~~, since 1978.~~
- Buildings have become increasingly electrified - driven by rapid growth in office equipment, small appliances and other devices~~, collectively know as "plug loads".~~ From 1978 to 1992, commercial electricity consumption grew by 37%, while residential electricity grew by 36%.
- Due to continuing electricity growth, the EIA forecasts that future commercial energy intensity will decline by only 0.2% per year, and residential intensity by 0.5% per year. However, numerous studies identify substantial ~~additional~~ potential for cost-effectively reducing ~~buildings energy consumption and~~ greenhouse gas emissions.

Needed Technological Improvements

- Technologies needed to achieve the emissions reductions above largely exist today; no major technological breakthroughs are needed.
- The large potential emissions reductions are not being achieved in current markets because of a number of market barriers that impede the diffusion of energy-efficient technologies - such as lack of reliable product information; higher up-front costs; split incentives between efficiency purchasers and beneficiaries; conflicting building codes; and lack of market expertise in efficiency design and construction.
- To achieve the efficiency savings in 2010, the equipment that naturally turns over in about 35% of buildings is replaced with the most cost-effective technologies by 2010; these savings assume normal retirement of equipment at the end of its useful life.
- Energy efficiency improvements needed are 12% for residential buildings and 18% for commercial buildings by 2010.



Source: EIA, ORNL/LBNL 1997

• Raising the price of energy will bring these new technologies into play X

Costs

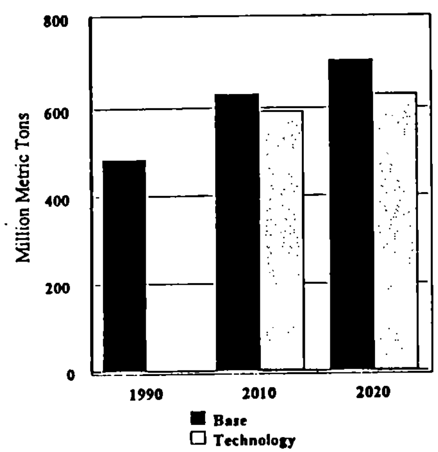
- Investments to achieve these 2010 savings are $7-$14 billion per year and result in 2010 energy bill savings of $18-33 billion - a net savings of $10-19 billion and a 20% return on investment.
- Costs of Federal programs to accelerate the use of energy efficient technologies in buildings are $300 million per year; achieving the above savings will require a rough doubling of budgets.

Policy Challenges

- Federal, state and local policies that accelerate technology deployment and energy efficient building design, construction and operation.
- Partnerships with states, local government and industry to improve efficiency of existing buildings and remove market barriers.
- Research and development of a portfolio of advanced buildings technologies.

Electric Power

Carbon Emissions



Source: EPA, DRI 1.25 Base Case

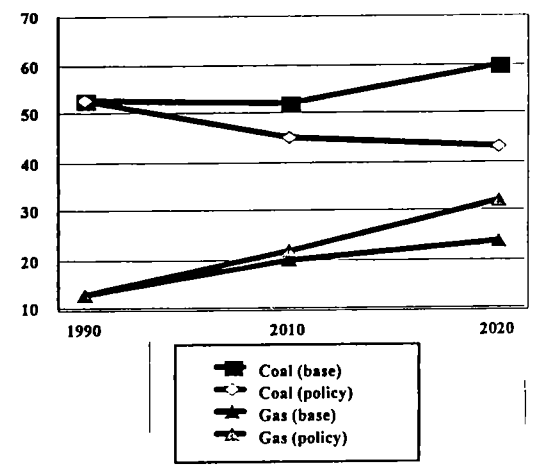
Key Trends -- 1990-2010

- 36% of US carbon emissions are in the electric utility sector, ~~primarily~~ from burning of coal and ~~natural~~ gas. X
- Coal and natural gas together are projected to increase from 63% of energy inputs to 70% by 2010, increasing the carbon intensity of this sector.
- Demand for electricity is projected to rise by 20 percent per decade compared to 30% from 1980 by 1990.
- Renewable power (other than hydroelectricity) is projected to rise from 1.5% of generation currently to 1.8% in 2010. X

Needed Technological Improvements

- No breakthroughs are projected in generation technology. Incremental improvements will be possible from combined cycle turbines, gasification for biomass fuels, wind turbines and system improvements (such as transmission efficiency).
- First, end use electricity demand growth must slow--efficient technologies can cut U.S. electricity growth from 30% down to 15% above 1990 levels by 2010.
- Second, those reductions must primarily reduce coal-fired generation.
- Third, remaining coal-fired generation must be reduced in favor of natural gas, through gas co-firing, conversions to gas, and increased use of combined cycle gas turbines.
- Beyond 2010, nuclear plant life extensions may be an economically viable option.
- Renewables such as solar, wind, and biomass must be promoted for the long term, but will not make significant contributions sooner.
- Overall, carbon emissions ....

% Share of US Generation



Costs

- Switching from coal to natural gas, renewables or demand-side efficiency will cost $50-120 per ton of carbon in 2010. Total capital investments will rise by $3-5 billion, or 30-50%. Fuel and operating costs will also rise by about $3-5 billion, or 5-10%.
- In total, utility annual costs could increase by $..... billion, or ....%, by 2010.

[• ?Overall, coal use would decline to roughly 1990 levels (plus or minus 10%) by 2010 in a US program without international trading -- with trading coal use could grow by 20-25% above 1990 levels.]

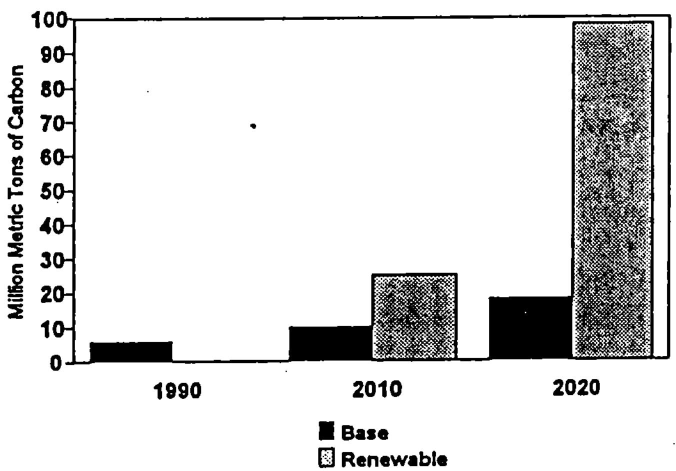
Policy Challenges

- Aggressive R&D and marketing for energy efficiency sectors is essential.
- Integrate climate policy with competitive trends and air quality regulation.
- Incentives for shifting power to lower-emitting fuels -- pricing, emissions trading credits, promotion, regulation, and financing.

Renewable Energy

will become more so when the price of energy increases. X

Carbon Emissions Savings



Key Trends - 1990-2010

- Today, roughly 12% of the country's electricity generating capacity is from renewable energy - with 85% of this from hydropower. Newer renewable technologies - including wind, biomass, photovoltaics, solar thermal and geothermal - are increasingly economic and ~~have large potential~~.
- Costs have dropped dramatically ~~-photovoltaic cells have dropped from $0.90/kilowatt-hour in 1980 to under $0.20/kWh today, while wind power has dropped from $0.25/kWh to $0.05/kWh~~. and X
- Cost reductions will continue because of R&D advances and ~~as~~ manufacturing efficiencies. X
- Cost performance improvements have resulted in ~~several~~ technologies being competitive in selected markets today ~~and others will be competitive in broader markets in the near future~~. X
- Several major international companies, such as Royal/Dutch Shell, expect these technologies to be dominant global energy sources and are substantially investing in their development.

Needed Technological Improvements

- The contribution of renewable electric technologies to emissions reductions could be substantially higher than projected in the base case. at the price of energy rises. x
- Costs and performance of these technologies continue to improve, but additional advances in wind, biomass, photovoltaics, geothermal, solar thermal and transportation biofuels are needed - such as: wind turbine blade design and materials, photovoltaics materials efficiencies, geothermal drilling technology and resource verification, large-scale celluosic biomass fuels production and manufacturing cost improvements.
- Non-hydro renewable energy generation capacity could grow from 9 gigawatts (GW) today to 21-24 GW in 2010 and 77-108 GW by 2020.

Costs

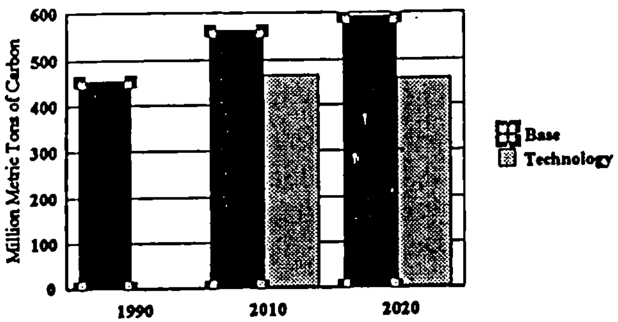
- The incremental capital investment in renewable power systems needed to achieve the above results is $2-3 billion in 2010 and $15-25 in 2020 - although fuel cost savings in 2020 will result in net incremental that are low or negligible.
- The incremental production cost of renewable electricity is estimated to be $2-3 billion/yr in 2010 and negligible in 2020 as multiple renewable technologies are widely competitive with gas technologies.

Policy Challenges

- Expand technology R&D to lower costs and increase performance.
- Conduct cost-shared technology diffusion with industry to increase utility system experience and increase U.S. renewable energy production capacity.
- Conduct R&D on key support systems such as power storage, controls and superconducting materials.
- Encourage use of U.S. renewable technologies abroad to tap the huge global market for renewable energy.

Industrial Emissions and Economic Impacts

Carbon Emissions



Source: Markal-Macro Technology Investment Case

Key Trends -- 1990-2010

- The industrial sector now uses 37 percent of the nation's energy, or 34.4 out of a total 93.6 quads. Carbon emissions are now at about 32 percent or total emissions in the United States, or 471 of 1467 million metric tons (MMT).
- Within the industrial sector, electricity accounts for 10% of the total energy consumed and about 37% carbon emissions.
- With normal rates of capital stock turnover, the industrial energy intensity is expected to decline at a rate of 1.2 percent in base case forecast for the period 1997-2015. Historically, energy intensity has decreased by an average of 1.8 percent annually from 1972 to 1995.
- The industry sector is also responsible for most of the non-energy related emissions of carbon dioxide (21 MMT) and other greenhouse gases (219 MMT of carbon equivalent). Although industrial emissions of these gases are far smaller that energy-related carbon emissions by weight, they have global warming potentials (GWP) that range from 21 for methane to 23,900 for sulfur hexafloride (SF6).

Why given change in price

?

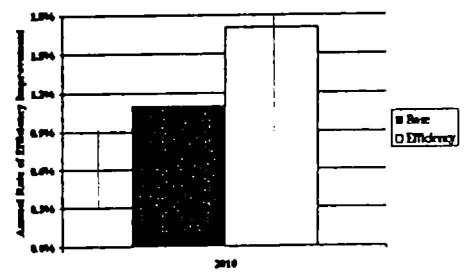
could ?

?

Needed Technological Improvements and Opportunities--Cross-cutting

- ~~The industrial sector~~ the potential to reduce energy use by up to 10% in carbon emissions by nearly 17% over 2010 baseline forecast through cost effective investments in energy efficient technolgies and low carbon technologies.
  how?
- The use of heat recovery and combined heat and power (i.e., cogeneration) systems such as the Advanced Turbine System can reduce industrial carbon emissions by up to 35 Mmt/year in 2010 with electricity costs that are 10 percent lower than current systems. Why aren't they used then
- Motor systems account for 70 percent of industrial electricity use (about 120 MMT). Better designed energy-efficient motor systems could reduce electricity use by up to 40 percent. Better maintenance of compressed air systems can also save 40 percent of the energy used in such systems.
- In addition, there are important longer term opportunities to reduce the carbon intensity of industrial operations through changes in the fuel mix, and by using lower-carbon fuels.

Average Rate of Industrial Energy Efficiency Improvement: 2000 to 2010



Source: Markal-Macro Technology Investment Case overall? what does this mean?

Costs

- ~~There are readily-available but underutilized technologies with two and three-year paybacks that can reduce industrial energy use by 10 percent or more.~~ X
- The annual investment necessary to stabilize overall carbon emissions to 1990 levels (15 percent) is on the order of $5 billion per year (about 4 percent of the investments made by the manufacturing sector in 1995). ~~The energy cost savings in 2010 are $8 billion/year.~~
- Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features may actually improve the competitive position of many industries.

Policy Challenges

- Policies to encourage the more rapid diffusion of existing technologies include: (1) incentives to accelerate the investment in new capital stock and equipment; (2) increased RD&D to facilitate the development of improved technologies as well as the development of a new generation of industrial technologies; (3) incentives to increase the use of recycled feedstocks; and finally, (4) expediting the use of combined heat and power systems through improved environmental permitting and by incorporating provisions into the ongoing utility restructuring that facilitate the sale of excess power by industrial plants; and finally (5) a life cycle approach to environmental permitting and regulations. X

?

increase in prices

X

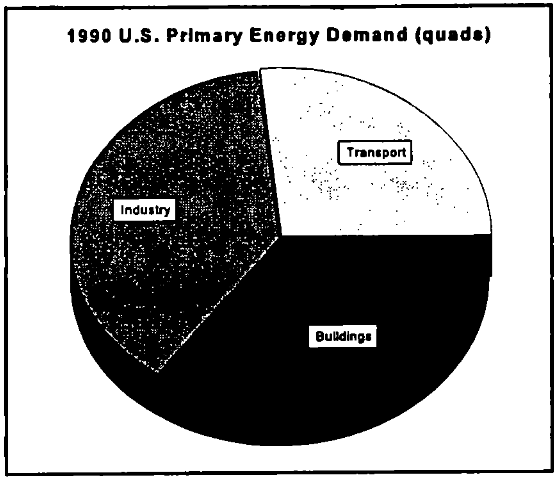
DISCUSSION PAPER

A TECHNOLOGY APPROACH

TO ADDRESSING GLOBAL CLIMATE CHANGE

July 28, 1998 Draft

PROFILE OF U.S. CARBON EMISSIONS BY INDUSTRIAL SECTOR

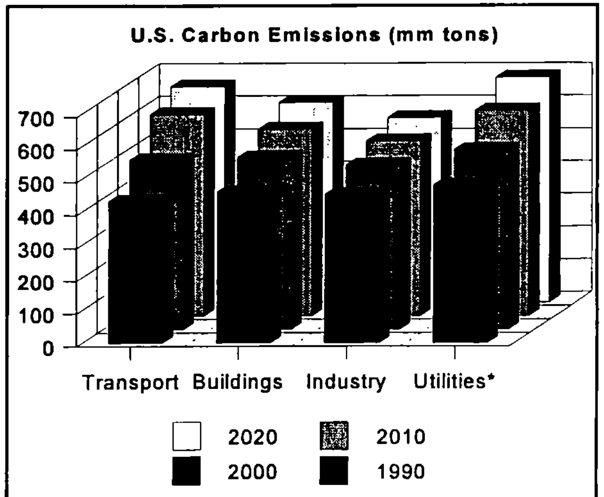


Energy Profiles

- Three sectors each account for approximately one-third of U.S. primary energy demand — transportation, commercial and residential buildings, and industry
- The electric utility sector supplies about one-third of this demand, virtually all in the buildings and industrial sectors, and consumes fuels to generate that power. In the buildings sector, two-thirds of the energy usage is from electricity, and in industry the share is just over 10%
- Growth in U.S. energy consumption changed dramatically after the 1973 energy crisis, but is projected to continue steadily in the absence of new policies:
  — the 1960s +52%
  — the 1970s +14%
  — the 1980s +11%
  — the 1990s +12% (already +9% by 1997)
  — the 2000-2010 decade +12%
  — in total, 2010 will be 26% above 1990

Carbon Emissions Trends — 1990 - 2020

- The profile in U.S. carbon emissions parallels the pattern of energy demand — the three sectors, transportation, buildings, and industry, each account for approximately equal shares
- Electric utility emissions in the chart at the right are double-counted in the end-use sector in which the electricity is used — and can only be reduced by either reducing end-use electricity demand or by switching to lower carbon content fuels
- Growth projections also parallel the pattern of energy growth. DOE's Energy Information Administration (EIA) projections show:
  — Total emissions up 28%, or 377 million tons, from 1990 to 2010
  — Transportation up 43%, or 184 million tons — this is DOE S Lab modification of AEO 97
  — Buildings up 24%, or 111 million tons
  — Industry up 18%, or 82 million tons
  — Utilities, included in the other sectors, up 30%, or 146 million tons



* Utilities emissions also included in final use sector

LONG-TERM TECHNOLOGY STRATEGY

need price signal

In the long-term, over several decades, reductions in carbon emissions will require two fundamental changes, (1) shifts in the basic forms of energy used, and (2) significant improvements in the efficiency of our energy usage. A technology strategy can achieve both and provide a strong competitive position for the U.S. by advancing improvements such as the following:

Transportation	Buildings	Industry	Electric Utilities
o Biofuels o Hydrogen fuels o Electric vehicles o Hybrid vehicles o Full PNGV 80 mpg vehicles	o Fuel cells o Efficient systems — heating, cooling, lighting, windows o Intelligent mgmt systems o Efficient "plug load" — computers, equipment, etc.	o High efficiency motors o Process changes o Recycling to reduce primary production	o Renewable energy systems — solar, wind, biomass o Distributed power o Improvements in power generation & transmission o Dispatching & load sharing

Long-term Market and Economic Uncertainties

- Electricity deregulation, international competitiveness
- Lifestyle trend changes (eg, telecommuting, consumer preferences for large vehicles)
- Commercial transport shifts in modes, speed, and the role of short- and long-range transportation of goods and people

What is private sector spending on long term tech.?

Cost Issues

- Currently, the federal government spends only ....% of its energy R&D budget, or $....... annually on long-term technologies
- There are no estimates of the amount of public and private investment that will be needed to achieve these major advances
- In the long run, it is uncertain whether there will be an incremental cost or savings from such technological changes

Policy Issues

- Federal and private R&D funding
- Role of public/private partnerships
- Incentives.........funding, prices, emissions trading allocations, partnerships, public relations, published performance data, required performance standards, other

MEDIUM-TERM, TECHNOLOGY AND EMISSIONS TRADING PROVIDE A BRIDGING STRATEGY

In the medium-term, technology can serve a "bridging" function to allow time for the long-term R&D developments and the commercialization of various technologies to reach significant levels.

Emissions trading and joint implementation are critical to a technology strategy in providing timing flexibility to deploy efficient technologies at rates close to normal capital stock turnover cycles, and to provide a "safety valve" if the required rates of technological change cannot be achieved fast enough.

380

Technology Implications

For example, the DOE "Labs Study" and the IAT computer modeling suggest ambitious rates of technological change would be needed to return U.S. carbon emissions to 1990 levels by 2010:

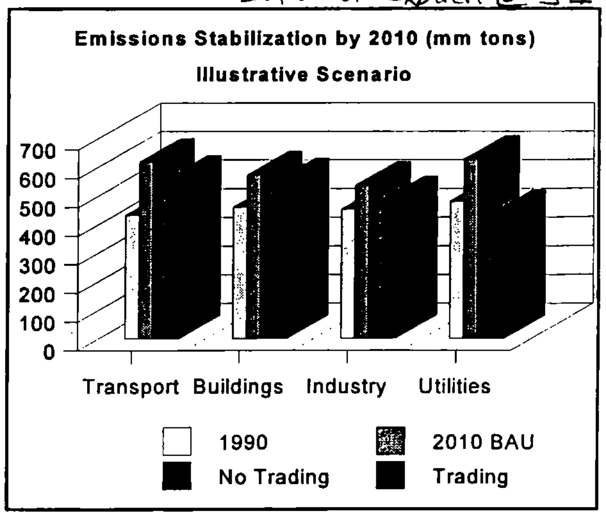
- Overall, emissions growth of 28%, or 377 million tons, would have to be avoided or offset
- If done all in the U.S., energy growth would probably have to drop to half its present rate, to about 10 to 12% over the 20-year period, and it's already about 9% above 1990 levels in 1997
- With emissions trading and joint implementation, the models suggest that up to 40% of the 2010 emissions reduction might be achieved abroad, at U.S. expense, to buy time for a more orderly technological transition here

domestic or intl + domestic?

40% of 380 ⇒ 152
IAT, p. 20, intl trading – US purchases 72 in 2010
IAT not explicit @ JI

Transportation

- Without trading, growth in energy usage would have to drop to about half its business as usual rate of 30% to 40%, down to 15% to 20%
- Unless consumer preferences for large cars and increased driving change, 30% of PNGV improvements would have to be integrated into new cars and light trucks by 2010...for 45 mpg new automobiles → costless?
- ? With trading, the pace of improvements could be slower, but would likely still lead to ....



need more contrast

are all reductions coming from electricity

Commercial and Residential Buildings

- Without trading, growth in energy usage would have to be cut in half, to a rate of about 10% by 2010, vs. BAU projections of about 20% to 25%
- High efficiency equipment would be needed on one-third of new installations and normal replacement cycles of building systems and equipment, compared to current rates of ....

Continued.....................

MEDIUM-TERM............continued

Industry

- Without emissions trading, energy growth would have to be almost flat at 1990 levels, instead of increasing about 20% by 2010
- Increased use of heat recovery, cogeneration, and more efficient motors offer the greatest generic opportunities, with other specific technologies also available in individual industrial sectors, such as those detailed in DOE's "Technologies for the Future" cooperative program with seven major energy-intensive industries
- With emissions trading, modest emissions and energy growth of around 7% by 2010 could be possible
- Industrial energy efficiency has improved since 1972, now requiring just 67% as much energy per unit of output

Electric Utilities

- Without emissions trading, utilities would likely have to make absolute reductions on the order of 30% in carbon emissions below 1990 levels in order to offset the increases in other sectors above, while at the same time supplying more electricity to customers → none of the IAT models predict this
- Coal usage would have to drop to about half the 1990 level, while natural gas would roughly triple its 1990 usage in the industry
- With emissions trading, the coal-to-gas shift could be less severe, but electricity demand would also rise faster. Overall, emissions would still probably have to be about 10% below 1990 levels in 2010

<u>Costs</u>

- There is great uncertainty about just how much these changes would cost the U.S. economy. In some recent experiences, such as with the Montreal Protocol on ozone depletion and the sulfur dioxide emissions trading system under the Clean Air Act, actual experience has turned out to be substantially less costly than expected
- Preliminary estimates for the scenario above, returning emissions to 1990 levels by 2010, in the absence of emissions trading and joint implementation, are that it could result in annual costs of $ .... billion, including amortization of approximately $.............. of investment
- With international emissions trading and joint implementation, that cost could fall to $.......... annually

<u>Policy Issues</u>

- Incentives are needed to stimulate R&D, commercialization of new technologies, and the purchase and use of advanced technologies as capital stock turns over in the economy

  costs of these programs

DOE'S 'Labs Study'

**"U.S. CARBON REDUCTIONS BY 2010 AND BEYOND
The Potential Impact of Energy-Efficient and Low-Carbon Technologies"**

This report provides details on the technologies that can potentially achieve the energy usage and carbon emissions reductions necessary if the U.S. commits to a scenario like the one outlined in the sections above, which would return U.S. carbon emissions to 1990 levels by 2010.

(This page to be supplied by DOE)

Key assumptions:

1. "The model runs for each of the 3 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. 1.2
2. enhanced public sector programs for both scenarios
3. "announcement effect" for hi case
4. "The transportation analysis postulates a set of technology breakthroughs" (p. 6.7) To achieve a high efficiency/low carbon scenario,
5. "We note, however, that we have confined our analysis to technology costs, and have not assessed policies or programs to achieve market acceptance." p. xvi
6. "... energy efficiency measures which, based on the data presented in this report, are on balance cost-effective. Ignoring the implementation costs, this means that the cost of reducing C emissions are negative overall." p. xvi

POLICY OPTIONS FOR A U.S. TECHNOLOGY STRATEGY

GOALS

For the long-term, provide basic R&D and other support for the fundamental technological advances needed in the economy

For the short- and medium-term, provide incentives and support to:

- encourage manufacturers, builders, etc. to produce high efficiency equipment, systems, materials, etc.
- stimulate consumers and purchasers to accelerate their acquisition and use of those technologies
- encourage the development of financial, service, and other infrastructure to support those technologies

POLICY OPTIONS

- **Prices in the economy**
  — Valuing carbon emissions rights, through a "cap and trade" system
  — Investment tax credits, special depreciation treatment, differential fuel taxes (such as the ethanol tax credit), or other financial incentives through the tax system Read: subsidies
  — Feebates, or complementary product fees and rebates depending upon product energy efficiency

- **Financing**
  — Financial community partnerships with insurance, financial, utility and others to support advanced technologies
  — Incorporate incentives into federal loan, loan guarantee, and grant programs to promote high efficiency technologies

- **Federal R&D policy**
  — National public/private initiatives in key technologies, modeled after the Partnership for a New Generation of Vehicles, eg:
    - in DOE's 7 "Technologies for the Future" programs for Pulp and Paper, Chemicals, Petroleum Refining, Glass, Aluminum, Iron and Steel, and Metal Casting
    - in residential and commercial buildings

  — Increased federal funding for R&D, pilot projects and demonstrations leading to commercialization and/or wider availability of new technologies — current federal funding is $............. annually

- **Market transformation**
  — Market aggregation, for local governments and companies to coordinate purchases for greater influence
  — State and local partnerships with the federal government to provide information, demonstrations, and technical assistance
  — Field verification of advanced technologies

Continued..........................

POLICY OPTIONS...........continued

- **Federal leadership through procurement**
  — Federal agencies "lead by example" by adopting aggressive policies to implement energy savings technologies at new and existing federal facilities, and to acquire and use more efficient and alternative-fuel vehicles in federal fleets
  — Broaden the participation in Federal Energy Savings Performance Contracts which DOE is implementing to leverage private sector financing through third party energy services companies to reduce the federal government's $8 billion annual energy bill
  — Executive Orders to provide clear direction and management flexibility for greenhouse gas emission reductions within agency plans and programs
  — Green Power Purchasing, by which agencies can negotiate contracts to supply a fraction of their electricity from renewable energy sources

- **Regulation and standards**
  — Appliance efficiency standards, negotiated with the industry and public, such as the recent refrigerator standards
  — Building energy efficiency codes, implemented at the state and local level
  — Expedited environmental permitting for highly efficient or low carbon technologies
  — Coordinated implementation of National Ambient Air Quality Standards with climate change policies
  — Restructuring of the electric utility industry in a way that facilitates investment in new technologies

- **Information and education**
  — Information disclosure requirements, such as efficiency labels on appliances, computers, equipment, and commercial and residential heating and air conditioning systems
  — Federally-supported multi-media materials development for use in schools and the mass media

- **International market development**
  — Special focus on bilateral trade agreements, export assistance, and financial assistance in support of U.S.-produced advanced technologies for energy efficiency, renewable energy supplies, etc.

BACKGROUND ON KEY SECTORS

The material on these pages provides brief, thumbnail sketches of six key sectors of the economy, listed below. For each, the information profiles the sector's current energy and carbon emissions profile and trends, the types and extent of technological improvement needed under the scenario in which U.S. emissions are returned to 1990 levels by the year 2010. These descriptions assume no emissions trading or joint implementation, in order to provide a benchmark for further examination.

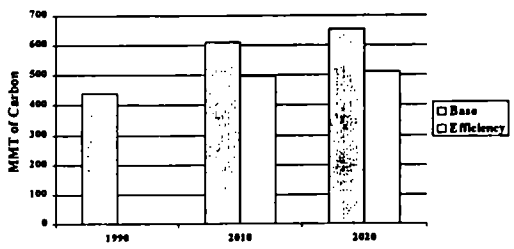
1. **Autos and Light Trucks**
2. **Freight, Aircraft and Rail**
3. **Residential and Commercial Buildings**
4. **Electric Utilities**
5. **Renewable Energy**
6. **Industrial Emissions**

this is entire trans sector, not autos & light trucks

this is AEO97 forecast — DOE 5 labs rejected this forecast & kept mpg constant

Autos and Light Trucks

Transportation Carbon Emissions



Source: Markal-Macro Technology Investment Case

which case is this? it gets more than DOE 5 lab hi case

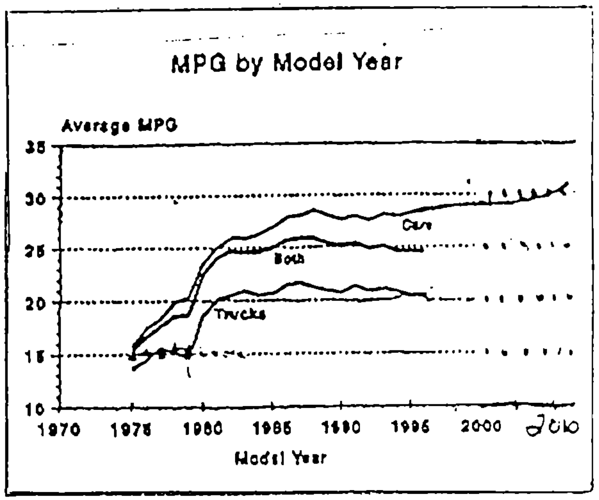
Key Trends — 1990-2010

- The transportation sector generates one-third of all energy-related carbon emissions in the United States. Moreover, this is the fastest growing end-use sector. Cars and light trucks (light duty vehicles) alone account for 58 percent of the total transportation emissions.
- Average fuel economy for new automobiles has been regulated at a minimum 27.5 mpg since 1985. It is projected to grow to 31 mpg in 2010. New minivans, sports utility vehicles, and other "light trucks" now get 21 mpg and are projected to get 23 mpg in 2010.
- Light trucks were 20 percent of the personal vehicle market in 1974, 44 percent in 1996, and are projected to be 50 percent by 2010. Assuming no change in this trend, this will result in a declining overall fuel economy for all light duty vehicles.
- Vehicle miles traveled have been growing 2-3 percent per year for the past 30 years and are expected to grow 1.4 to 2 percent or more per year through 2010. Improved fuel economy will help maintain desired levels of vehicle miles traveled. — no maintain C emissions given VMT

Sketchy chart given DOE disagreement

Needed Technological Improvements

- By 2010, about 30 percent of new light duty vehicles would have to meet the Partnership for a New Generation of Vehicles (PNGV) goal of a tripled fuel economy (e.g., 80 mpg for automobiles) to help reduce overall carbon emissions to 1990 levels. On the other hand, all new cars and light trucks would have to embody 30 percent of the improvement represented by the PNGV goal (e.g., 45 mpg for automobiles).
- On-Road fuel economy for all cars and trucks (including both new and existing vehicles) would need to reach 25 mpg by 2010 and 31 mpg by 2020.
- Key technologies needed are vehicle weight reduction through advanced materials and design, hybrid/electric drivetrains, and improved aerodynamics.



Costs

- If PNGV goals are met, the more efficient light duty vehicles will have no increased cost for consumers.

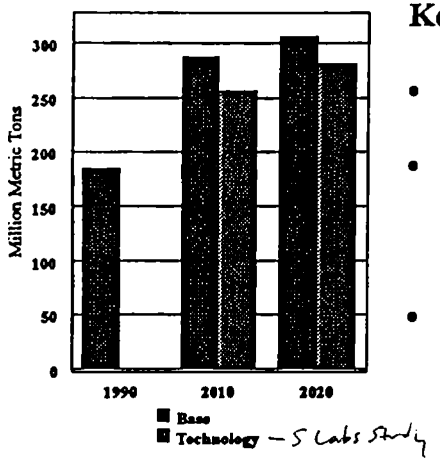
•At currently anticipated technology costs, new autos in 2010 would have an incremental price of $800-1,200. At gasolines prices forecasted for the year 2010, these higher costs would pay for themselves in fuel savings within 3.5-5.3 years.

Policy Challenges

- Ensure that PNGV technologies fully penetrate all markets for all new light-duty vehicles by 2010 and continue through the period 2020.
- Devise new commercialization strategies, including new approaches to fuel economy standards and market incentives (e.g., Green Machine Challenge, financing packages, bonus emission credits).

Freight, Aircraft and Rail

Carbon Emissions



Key Trends: 1990-2010

- Freight, aircraft and rail together accounted for 185 million tons of carbon dioxide emissions in 1990, nearly 40 percent of all emissions from transportation.
- All modes of freight transport have improved their energy efficiency. However, increased freight tonnage and shifts toward more energy-intensive modes have meant a 60 percent increase in the amount of energy used to haul freight ~~since~~ between 1972-1995, although about three times as much freight was transported.
- Opportunities to reduce carbon emissions from freight are expected to come mainly from trucking and air transport.

Needed Technological Improvements

- Key technologies to reduce energy intensity in truck freight in the next 10-15 years include vehicle weight reduction through materials substitution, improved tires, electronic engine and transmission controls. Larger reductions are possible beyond 2010 if hydrogen-powered, fuel cell powertrains are developed and commercialized for truck transport. Also, a more aggressive technology scenario might include rapid penetration of diesel trucks that are 20 percent more efficient that current diesel engines.
- NASA programs have helped to reduce energy intensity in air transport for over 20 years. NASA's high performance turbine engine technology program aims to achieve a 40 percent increase in fuel efficiency by 2003, and such engines could conceivably be on commercial aircraft within 15 years.

weak

Costs

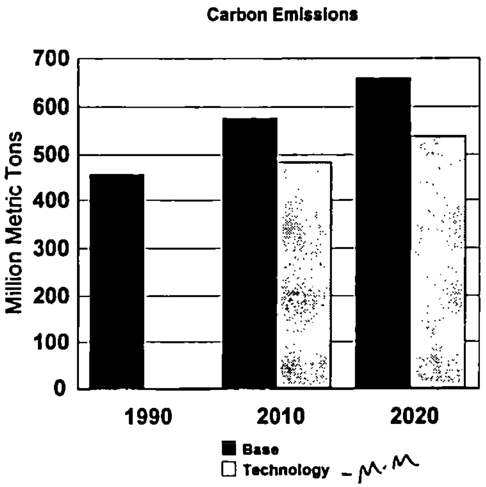
need details

- DOE estimates that annual costs needed to achieve emissions reduction in transportation range from $25-40 billion, and could save $35-40 billion annually in fuel costs.
- PNGV is funded at $______________, and to succeed in achieving the kinds of emissions reduction sketched above, might need two to ten times this funding.

Policy Options

- PNGV is key to reducing energy intensity in truck the medium and long term. Hybrid powertrains could likely be significantly advanced with increased R&D funding.
- To achieve a high efficiency/low carbon technology scenario, R&D programs might need to be increased 2 to 10 times.

Residential and Commercial Buildings

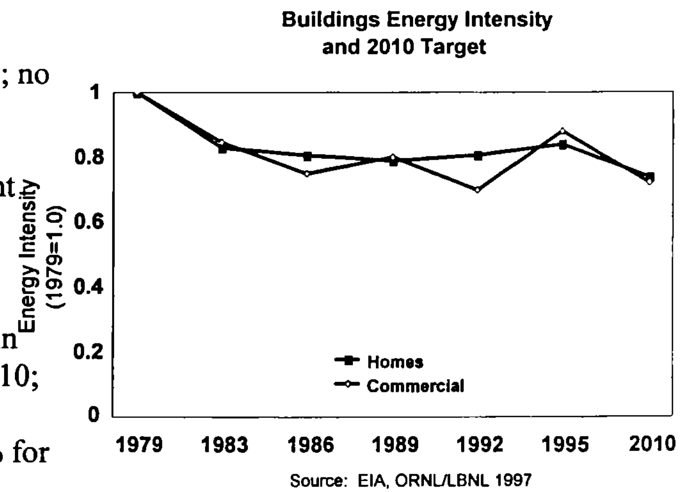


Key Trends - 1990-2010

- 35% of U.S. carbon emissions are attributable to energy use in buildings, with homes ~~emitting~~ responsible for 19% and commercial buildings ~~emitting~~ responsible for 16%. of emissions
- Energy intensity in buildings has declined substantially since the late 1970s. Primary energy intensity in commercial buildings declined by 22% between 1979 and 1992, while residential primary energy intensity dropped by 15% since 1978.
- Buildings have become increasingly electrified - driven by rapid growth in office equipment, small appliances and other devices collectively know as "plug loads". From 1978 to 1992, commercial electricity consumption grew by 37%, while residential electricity grew by 36%.
- Due to continuing electricity growth, the EIA forecasts that future commercial energy intensity will decline by only 0.2% per year, and residential intensity by 0.5% per year. However, numerous studies identify substantial additional potential for cost-effectively reducing buildings energy consumption and greenhouse gas emissions.

Needed Technological Improvements

- Technologies needed to achieve the emissions reductions above largely exist today; no major technological breakthroughs are needed.
- The large potential emissions reductions are not being achieved in current markets because of a number of market barriers that impede the diffusion of energy-efficient technologies - such as lack of reliable product information; higher up-front costs; split incentives between efficiency purchasers and beneficiaries; conflicting building codes; and lack of market expertise in efficiency design and construction.
- To achieve the efficiency savings in 2010, the equipment that naturally turns over in about 35% of buildings is replaced with the most cost-effective technologies by 2010; these savings assume normal retirement of equipment at the end of its useful life.
- Energy efficiency improvements needed are 12% for residential buildings and 18% for commercial buildings by 2010.



how are these calculated

Costs

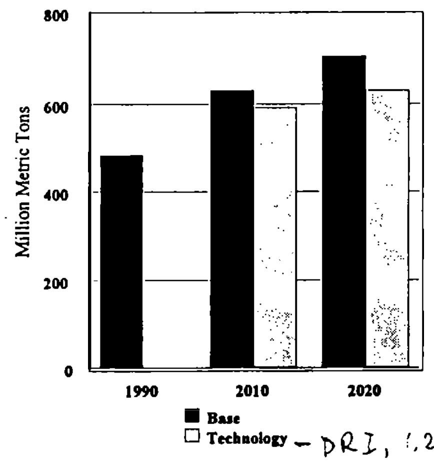
- Investments to achieve these 2010 savings are \$7-\$14 billion per year and result in 2010 energy bill savings of \$18-33 billion - a net savings of \$10-19 billion and a 20% return on investment.
- Costs of Federal programs to accelerate the use of energy efficient technologies in buildings are \$300 million per year; achieving the above savings will require a rough doubling of budgets.

Policy Challenges

- Federal, state and local policies that accelerate technology deployment and energy efficient building design, construction and operation.
- Partnerships with states, local government and industry to improve efficiency of existing buildings and remove market barriers.
- Research and development of a portfolio of advanced buildings technologies.

Electric Power

Carbon Emissions



— DRI, 1.25 w/o C policy

Source: EPA, DRI 1.25 Base Case

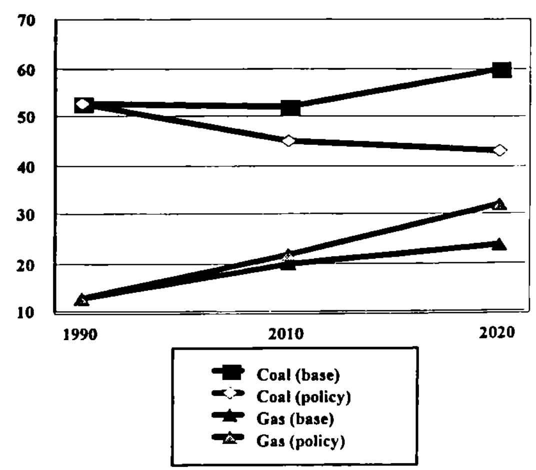
Key Trends -- 1990-2010

- 36% of US carbon emissions are in the electric utility sector, primarily from burning of coal and natural gas.
- Coal and natural gas together are projected to increase from 63% of energy inputs to 70% by 2010, increasing the carbon intensity of this sector.
- Demand for electricity is projected to rise by 20 percent per decade compared to 30% from 1980 by 1990.
- Renewable power (other than hydroelectricity) is projected to rise from 1.5% of generation currently to 1.8% in 2010.

Needed Technological Improvements

- No breakthroughs are projected in generation technology. Incremental improvements will be possible from combined cycle turbines, gasification for biomass fuels, wind turbines and system improvements (such as transmission efficiency).
- First, end use electricity demand growth must slow--efficient technologies can cut U.S. electricity growth from 30% down to 15% above 1990 levels by 2010.
- Second, those reductions must primarily reduce coal-fired generation.
- Third, remaining coal-fired generation must be reduced in favor of natural gas, through gas co-firing, conversions to gas, and increased use of combined cycle gas turbines.
- Beyond 2010, nuclear plant life extensions may be an economically viable option.
- Renewables such as solar, wind, and biomass must be promoted for the long term, but will not make significant contributions sooner.
- Overall, carbon emissions ....

% Share of US Generation



Costs

- Switching from coal to natural gas, renewables or demand-side efficiency will cost $50-120 per ton of carbon in 2010. Total capital investments will rise by $3-5 billion, or 30-50%. Fuel and operating costs will also rise by about $3-5 billion, or 5-10%.
- In total, utility annual costs could increase by $..... billion, or ....%, by 2010.

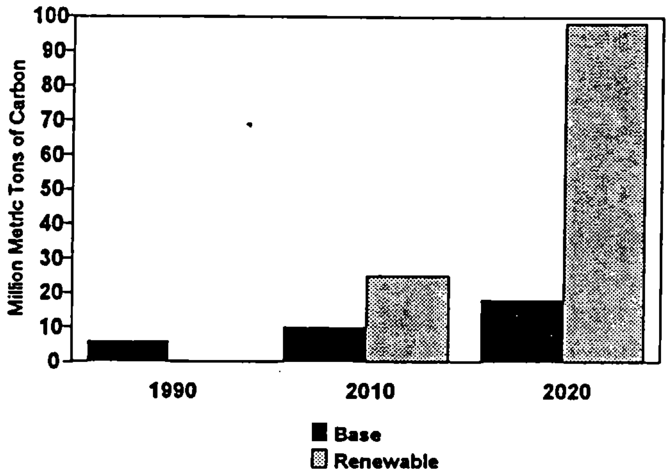
[• ?Overall, coal use would decline to roughly 1990 levels (plus or minus 10%) by 2010 in a US program without international trading -- with trading coal use could grow by 20-25% above 1990 levels.]

Policy Challenges

- Aggressive R&D and marketing for energy efficiency sectors is essential.
- Integrate climate policy with competitive trends and air quality regulation.
- Incentives for shifting power to lower-emitting fuels -- pricing, emissions trading credits, promotion, regulation, and financing.

Renewable Energy

Carbon Emissions Savings



Key Trends - 1990-2010

- Today, roughly 12% of the country's electricity generating capacity is from renewable energy - with 85% of this from hydropower. Newer renewable technologies - including wind, biomass, photovoltaics, solar thermal and geothermal - are increasingly economic and have large potential.
- Costs have dropped dramatically -photovoltaic cells have dropped from $0.90/kilowatt-hour in 1980 to under $0.20/kWh today, while wind power has dropped from $0.25/kWh to $0.05/kWh.
- Cost reductions will continue because of R&D advances and as manufacturing efficiencies.
- Cost performance improvements have resulted in several technologies being competitive in selected markets today and others will be competitive in broader markets in the near future.
- Several major international companies such as Royal/Dutch Shell, expect these technologies to be dominant global energy sources and are substantially investing in their development.

Needed Technological Improvements

- The contribution of renewable electric technologies to emissions reductions could be substantially higher than projected in the base case.
- Costs and performance of these technologies continue to improve, but additional advances in wind, biomass, photovoltaics, geothermal, solar thermal and transportation biofuels are needed - such as: wind turbine blade design and materials, photovoltaics materials efficiencies, geothermal drilling technology and resource verification, large-scale celluosic biomass fuels production and manufacturing cost improvements.
- Non-hydro renewable energy generation capacity could grow from 9 gigawatts (GW) today to 21-24 GW in 2010 and 77-108 GW by 2020.

→ electricity page indicates
renewables share grows
from 1.5 → 1.8
→ this is much larger than
that assuming the rest of
the energy/electricity sector
grows at a slow rate

Costs

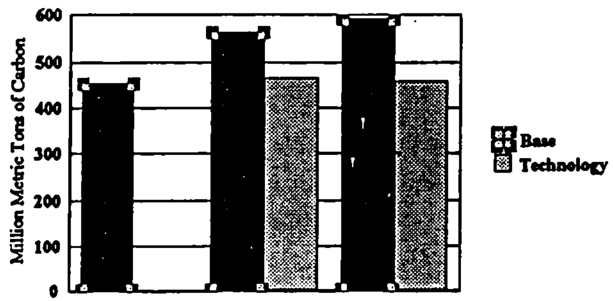
- The incremental capital investment in renewable power systems needed to achieve the above results is $2-3 billion in 2010 and $15-25 in 2020 - although fuel cost savings in 2020 will result in net incremental that are low or negligible.
- The incremental production cost of renewable electricity is estimated to be $2-3 billion/yr in 2010 and negligible in 2020 as multiple renewable technologies are widely competitive with gas technologies.

Policy Challenges

- Expand technology R&D to lower costs and increase performance.
- Conduct cost-shared technology diffusion with industry to increase utility system experience and increase U.S. renewable energy production capacity.
- Conduct R&D on key support systems such as power storage, controls and superconducting materials.
- Encourage use of U.S. renewable technologies abroad to tap the huge global market for renewable energy.

Industrial Emissions and Economic Impacts

Carbon Emissions



Source: Markal-Macro Technology Investment Case

or DOE 5 Labs

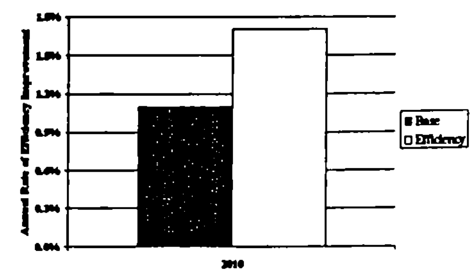
why give present? why not 1980

Key Trends -- 1990-2010

- The industrial sector now uses 37 percent of the nation's energy, or 34.4 out of a total 93.6 quads. Carbon emissions are now at about 32 percent or total emissions in the United States, or 471 of 1467 million metric tons (MMT).
- Within the industrial sector, electricity accounts for 10% of the total energy consumed and about 37% carbon emissions.
- With normal rates of capital stock turnover, the industrial energy intensity is expected to decline at a rate of 1.2 percent in base case forecast for the period 1997-2015. Historically, energy intensity has decreased by an average of 1.8 percent annually from 1972 to 1995.
- The industry sector is also responsible for most of the non-energy related emissions of carbon dioxide (21 MMT) and other greenhouse gases (219 MMT of carbon equivalent). Although industrial emissions of these gases are far smaller that energy-related carbon emissions by weight, they have global warming potentials (GWP) that range from 21 for methane to 23,900 for sulfur hexafloride (SF6). X

Needed Technological Improvements and Opportunities--Cross-cutting

Average Rate of Industrial Energy Efficiency Improvement: 2000 to 2010



Source: Markal-Macro Technology Investment Case

has

- The industrial sector the potential to reduce energy use by up to 10% in carbon emissions by nearly 17% over 2010 baseline forecast through cost effective investments in energy efficient technolgies and low carbon technologies.
- The use of heat recovery and combined heat and power (i.e., cogeneration) systems such as the Advanced Turbine System can reduce industrial carbon emissions by up to 35 Mmt/year in 2010 with electricity costs that are 10 percent lower than current systems.
- Motor systems account for 70 percent of industrial electricity use (about 120 MMT). Better designed energy-efficient motor systems could reduce electricity use by up to 40 percent. Better maintenance of compressed air systems can also save 40 percent of the energy used in such systems.
- In addition, there are important longer term opportunities to reduce the carbon intensity of industrial operations through changes in the fuel mix, and by using lower-carbon fuels.

Costs

- There are readily-available but underutilized technologies with two and three-year paybacks that can reduce industrial energy use by 10 percent or more.
- The annual investment necessary to stabilize overall carbon emissions to 1990 levels (15 percent) is on the order of $5 billion per year (about 4 percent of the investments made by the manufacturing sector in 1995). The energy cost savings in 2010 are $8 billion/year.
- Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features may actually improve the competitive position of many industries. — If they're win-win, why haven't they already been adopted?

Policy Challenges

- Policies to encourage the more rapid diffusion of existing technologies include: (1) incentives to accelerate the investment in new capital stock and equipment; (2) increased RD&D to facilitate the development of improved technologies as well as the development of a new generation of industrial technologies; (3) incentives to increase the use of recycled feedstocks; and finally, (4) expediting the use of combined heat and power systems through improved environmental permitting and by incorporating provisions into the ongoing utility restructuring that facilitate the sale of excess power by industrial plants; and finally (5) a life cycle approach to environmental permitting and regulations.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

TRANSMISSION NUMBER: 202/395-5836
VERIFICATION NUMBER: 202/395-6827

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	Name	Fax #
To:	See Distribution List	
From:	Bob Tuccillo	

Message: Technology Sector One-Pagers

Number of Pages to Follow: 11

Date: 7/22/97

Time: 4:20 pm

EXECUTIVE OFFICE OF THE PRESIDENT
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ROUTE SLIP

TO David Gardiner
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Lead Authors
Jason Shogren

Take necessary action ___
Approval or signature ___
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Prepare reply ___
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For your information ___
See remarks below ___

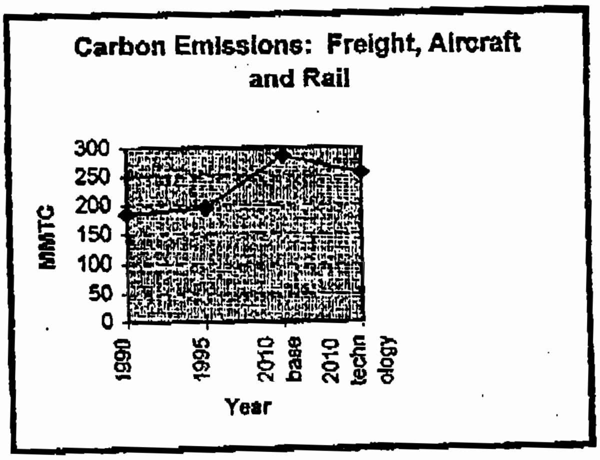
FROM Bob Tuccillo DATE 7/22/97

REMARKS **RE: Draft Technology Sector One-Pagers**

Attached are first drafts of the technology sector one-pagers. Please mark your comments on the drafts and fax them back to me at 395-5836. It would help if you can send me any comments by 3:00 pm tomorrow (7/23).

7121-

Freight, Aircraft and Rail



Key Trends: 1990-2010

- Freight, aircraft and rail together accounted for 185 million tons of carbon dioxide emissions in 1990, nearly 40 percent of all emissions from transportation.
- All modes of freight transport have improved their energy efficiency. However, increased freight tonnage and shifts toward more energy-intensive modes have meant very little change in the total amount of energy used to haul freight since 1972. In 1995, about three times as much freight was transported as in 1972.
- Opportunities to reduce carbon emissions from freight are expected to come mainly from trucking and air transport.

Needed Technological Improvements

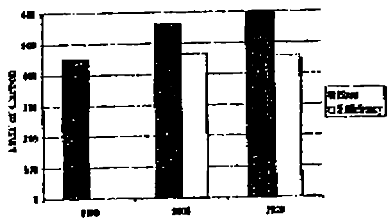
- Key technologies to reduce energy intensity in truck freight in the next 10-15 years include vehicle weight reduction through materials substitution, improved tires, electronic engine and transmission controls. More significant reductions are possible beyond 2010 if hydrogen-powered, fuel cell powertrains are developed and commercialized for truck transport.
- PNGV is a key to reducing energy intensity in truck transport in both the medium and long term. It is likely that hybrid powertrains could be significantly advanced if PNGV is continued and funding increased.
- NASA programs have helped to reduce energy intensity in air transport for over 20 years. Ongoing NASA and DOD programs are also working to improve fuel efficiency in aircraft engines and laminar (e.g. nonturbulent) flow of air over airframes. NASA's high performance turbine engine technology program aims to achieve a 40 percent increase in fuel efficiency by 2003, and such engines could conceivably be on commercial aircraft within 15 years.

Costs

- DOE estimates that annual costs needed to achieve emissions reduction in transportation range from $25-40 billion, and could save $35-40 billion annually in fuel costs.
- PNGV is funded at $____________, and to succeed in achieving the kinds of emissions reduction sketched above, might need two to ten times this funding.

Industrial Emissions and Economic Impacts

Industrial Carbon Emissions



Source: Multi-Metro Technology Investment Case

Key Trends – 1990-2010

- The industrial sector now uses 37 percent of the nation's energy, or 34.4 out of a total 93.6 quads. Carbon emissions are now at about 32 percent of total emissions in the United States, or 471 of 1467 million metric tons (MMT).
- With normal rates of capital stock turnover, the industrial energy intensity is expected to decline at a rate of 1.2 percent in base case forecast for the period 1997-2015.
- The industry sector is also responsible for most of the non-energy related emissions of carbon dioxide (21 MMT) and other greenhouse gases (219 MMT of carbon equivalent). Although industrial emissions of these gases are far smaller that energy-related carbon emissions by weight, they have global warming potentials (GWP) that range from 21 for methane to 23,900 for sulfur hexafloride (SF6).
- The industrial sector has the potential to reduce energy use and carbon emissions by 10-15 percent over 2010 baseline forecasts through cost-effective investments in energy efficient technologies, and in some cases, low-carbon technologies.

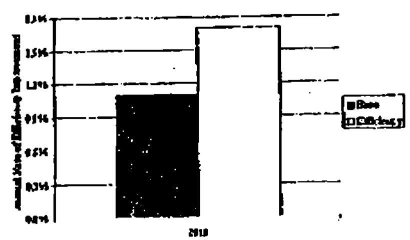
Needed Technological Improvements and Opportunities--Cross-cutting

- The use of heat recovery and combined heat and power (i.e., cogeneration) systems, for example, can save 10 percent of energy use with an internal rate of return of 30-60 percent.
- Better maintenance of compressed air systems can save 40 percent of the energy used in such systems. More energy-efficient motor systems can also provide a significant source of electricity savings.
- In addition, there are important longer term opportunities to reduce the carbon intensity of industrial operations through changes in the fuel mix, and by using lower-carbon fuels.

Costs

- There are readily-available but underutilized technologies with two and three-year paybacks that can reduce industrial energy use by 10 percent or more.
- The annual investment necessary to stabilize overall carbon emissions to 1990 levels by 2010 is on the order of $2.3 to $3.8 billion per year through 2010. This is about 2-3 percent of the investments made by the manufacturing sector in 1995.
- Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features. Since these new technologies tend to lower the overall cost of doing business, investments in energy efficient technologies may actually improve the competitive position of many industries.

Average Rate of Industrial Energy Efficiency Improvement: 2000 to 2010



Source: Multi-Metro Technology Investment Case

Policy Challenges

- Policies to encourage the more rapid diffusion of existing technologies include: (1) incentives to accelerate the investment in new capital stock and equipment; (2) increased RD&D to facilitate the development of improved technologies as well as the development of a new generation of industrial technologies; (3) incentives to increase the use of recycled feedstocks; and finally, (4) expediting the use of combined heat and power systems through improved environmental permitting and by incorporating provisions into the ongoing utility restructuring that facilitate the sale of excess power by industrial plants.

7121

Introduction to Industry Sector-Specific Section

Broadly speaking the industrial sector includes farming and ranching, agricultural services, fisheries, forestry, mining, construction and manufacturing. While many policy analysts think of "industry" as a homogenous set of economic activities, it embraces an incredibly diverse set of processes ranging from the growing and processing of food products to the production of paper, plastic resins, cars and computers. The process and energy requirements as well as other greenhouse gas emissions of each of the individual industries that are within the industrial sector are as different as the products that they produce. In each section following we have tried to parallel the structure of the other sections: first there is one section on sector emissions and key trends, then there are two to four sections on technological improvements that could reduce emissions, finally, there is a section on sector-specific policy challenges.

Petroleum Refining Industry

In energy use, petroleum refining is first at 5.9 Quads (including feedstocks). Thus, it produces the most energy-related carbon emissions. The industry has also been responsible for emissions of methane (GWP = 21) from gas flaring but has worked to reduce these emissions. Since 1985 energy efficiency increases have been offset by increased energy use due to environmental regulations, lower crude quality, and the demand for more complex fuels and "white products" (e.g. appliances). The 1997 EIA outlook, which takes these factors into account, projects that the energy usage in the industry can be expected to increase by 0.3%/yr.

- *Fluid Catalytic Cracking (FCC):* Cracking is the process that transforms crude oil into gasoline and other products. FCC is currently the most energy efficient and widely used of the cracking processes. It currently produces approximately 40% of gasoline and should continue to be a key process for meeting increased demand for "white products". Improved computer simulations of cracking kinetics should result in an improved commercial technology by 2008. FCC product yields are expected to increase from 2-6% per barrel of crude. Introduction of improved catalysts and other process modifications would occur somewhat later. FCC improvements could eventually lead carbon reductions of up to 8 MMT.
- *Fouling Mitigation in Heat Exchangers:* The overall energy efficiency of refineries is heavily dependent on the feed/effluent heat exchangers that recover thermal energy from high temperature processes. Foulant buildup impedes heat transfer, and the lost energy must be compensated by burning additional gas or liquid fuels in furnaces. Nearly 7% of the total energy consumed in refining and more than $2 billion in losses each year due to heat exchanger fouling. It is estimated that the energy penalty due to fouling can be reduced by a factor of two with an accelerated deployment of mitigation technologies. In the near term (3-7 years), fouling could be reduced by an accelerated program of: (1) retrofitting various mitigation technologies onto the existing heat exchangers; (2)more rigorous maintenance procedures, (e.g., increased frequency of heat exchanger cleaning); (3) extending laboratory experimental data to field operating conditions to enable heat exchanger operation below threshold fouling conditions; and (4) use of optimally designed physical devices such as enhanced tubes and tube inserts in conjunction with chemical additives. These measures could reduce carbon emissions by 0.5 MMT by 2010.
- *Advanced Distillation Control* Distillation in the refining and chemical industries consumes 3% of the total U.S. energy use, (2.4 Quads). To meet product purity specifications, distillation columns are often over-refluxed using energy. Thus, industry many times uses 30% to 50% more energy than necessary to produce its products. Recent research that provides detailed information on optimization of distillation control techniques gives these industries the information needed to run distillation columns more energy efficiently, reducing energy consumption by an average of 15%.
- *Oxy-Fuel Systems:* More than 60% of the energy used in refineries is obtained from burning gaseous fuels in refinery heaters. For higher temperature processes such as steam reforming, the application of advanced oxy-fuel combustion systems such as dilute oxygen combustion can result in net fuel savings of 25%. These gains can be enhanced further by converting natural gas to hydrogen and carbon monoxide, making use of waste heat generated by the dilute oxygen combustion system.

Chemicals

In energy use, chemicals is a close second in energy use at 5.5 Quads. Thus, chemicals is also second in energy-related Carbon emissions. The chemicals industry is also responsible for the relatively small emissions of other greenhouse gases such as methane (GWP=21), nitrous oxide (GWP=310) and engineered chemicals such as halocarbons (GWP's 1000's-10,000's). The industry's goals, published in February 1997, include improving efficiency in the use of raw materials., the reuse of recycled materials, and the generation and use of energy.

- *Incremental Efficiency Improvements:* A recent study has shown, that in the chemicals industry, straightforward capital-energy tradeoffs (e.g. using large pipes and heat exchangers) could result in a 37% drop in process energy use with a penalty of less than 1.5% of total productions costs. This study only examined energy related costs. Another recent study showed that productivity savings are often far larger than the energy savings. For example, the average total annual savings from efficiency projects from 1982 to 1993 from the Louisiana Division of Dow Chemicals were 3.2 times the energy savings.
- *Process Integration Techniques:* One example of such a technique is the "pinch" technique. This saves energy in heat exchanger networks because the "pinch" point is where the best match between available and needed heat is found. It allows the heat exchange system to be optimally sized for greatest cost effectiveness. Refinements to the technique have resulted in typical savings of 50% in new plants and retrofit paybacks of six months.
- *Biotechnologies:* Many chemicals firms are investing heavily in biotechnologies and within the next decade, expect to commercialize products. Low carbon biotechnologies include: engineered plant systems to allow crops to fix their own nitrogen from the air (avoiding N20 emissions associated with fertilizer manufacture), agricultural "petroleum plants" that grow chemicals industry feedstocks and intermediate products such as polymers.

Forest Products:

Forest products third highest in energy use at 3.3 Quads. The industry is about 57% energy self sufficient, due to the use of wood residues, i.e. hog fuel and bark, pulping wastes, i.e., black liquor, and cogenerated electricity. Industry goal's include increasing energy self-generation (with eventual self-sufficiency) and increased recovery of waste paper. More than forty percent of the paper used in the United States is now recovered for reuse as raw material in paper manufacturing and other processes. The industry is working on technologies to increase this to 50%.

- *Biomass and Black Liquor Gasification with Combined Heat and Power:* The forest products industry is looking for a cost-effective, proven, combined-cycle gasification technology as quickly as practical to provide an alternative to replacing an aging fleet of both recovery furnaces and conventional power boilers. Competitive development of combined-cycle, gasification technologies (for both black liquor and biomass feedstocks) is well underway, with successful pilot demonstrations already being reported. The technology generates less steam but 2-3 times more electricity. The 5-lab study estimates by 2010 the potential for this technology is 5 MMT.
- *Impulse Drying:* Impulse drying reduces the huge energy requirements of evaporative drying by removing more water in the pressing section and reducing the amount of water which must be evaporated. The total energy savings for full implementation of this technology could be approx. 0.25 quad/yr. Impulse drying methods allow papermaking machines to run at higher speeds, therefore increasing production rates. This technology also reduces energy use by one-third, reduces the emission of carbon dioxide, reduces production costs by five dollars per ton of paper, improves paper strength by 25 percent, and increases productivity by as much as 80 percent.
- *Polyoxometalate Bleaching:* This is a biotechnology based on the action of wood rotting fungi that could be commercial by 2020. It removes lignin from paper pulp to produce a desirable soft white fiber. The impetus for developing this technology was the need for a nonchlorine

bleaching process. However, like most process innovations in this industry, it has an important energy efficiency benefit--compared to chlorine-based systems the new process promises to reduce electrical energy consumption of pulp bleaching by 50%.

Steel

At 1.8 Quads, the steel industry is the fourth largest energy consuming industry in the U.S. The industry is also responsible for process Carbon emissions associated with coke production. The steel industry's carbon-related goals include a 1995 pledge to increase production of steel from scrap to 70%.

- *Near Net Shape Casting:* This technology is an example of rapid penetration of an innovative energy efficient technology in a capital and energy intensive industry. It is the direct casting of the metal into (or near to) the final shape, e.g. strips or sections, replacing the present energy- and capital intensive processes of continuous slab casting, slab reheating, and hot rolling. It uses 25% less energy than the current best practice conventional technology. The first commercial application, thin slab casting, was introduced in 1989 and now accounts for 1/4 of all U.S. thin slab production capacity. Using this technique, sheet steel can be produced at a cost of $250/ton compared to conventional technology costs of $350/ton.
- *Smelt Reduction:* This technology eliminates the production of coke and reduces the ore preparation needed by integrating three steel processes into one. Coke making and ore preparation are responsible for the largest part of emissions in primary steelmaking. This technology reduces energy consumption by 20-30% and capital costs by 25-50% compared to conventional blast furnace technology. The first commercial applications of this technology are operating in Europe.
- *Scrap Preheating* Energy consumption in minimills that produce steel with an electric arc furnace (EAF) can be reduced by preheating scrap to approximately 400 C with EAF offgases. Compared to conventional technologies, energy savings of 13.5% are estimated and reduced electrode consumption of 29%. Preheating also reduces furnace tap-to-tap time by up to 25% resulting in increased productivity.

Aluminum

Among the industries considered, the aluminum (primary plus secondary) industry is fifth in energy consumption (1 Quad). Energy-related carbon emissions from primary aluminum, (which uses large amounts of inexpensive hydropower) are 6 MMT. The industry has pledged to reduce primary aluminum energy use 15% in the near term (before 2010). The primary aluminum industry is also responsible for approximately 4 MMT in perfluorocarbon (PFC) emissions. It is involved in a voluntary partnership with EPA to reduce these emissions by 50%. This industry also emits about 1.5 MMT of process carbon dioxide due to anode consumption. The industry has also pledged to eliminate these emissions in the 2020 time frame. Finally, secondary production of aluminum uses only 4-5% of the energy of primary aluminum production. The industry has set a target of achieving 80% wrought recycling of autos by 2004.

- *Improving Aluminum Cell Efficiency:* The current U.S. composite baseline energy intensity for aluminum smelting is estimated at 15.2 kWh/kg of aluminum. Enhanced potline controls, better anode rod connections, improved cathode block materials, and increases in anode size have been used to increase efficiency. Further reduction are anticipated using dimensionally stable cells and to optimize materials use for internal control of cells, and to use signal analysis to analyze cell voltages in potlines. Together these could achieve 13 kWh/kg in the near term.
- *Advanced Aluminum Cell:* An advanced wettable cathode could improve energy efficiency by 15-20% and could be commercial by 2005. A carbonless inert anode that would eliminate process carbon emissions could be commercial by 2010. Together, these technologies, along with process control improvements, would eliminate PFC emissions. The 5-lab study estimates carbon reductions due to this technology of up to 4 MMT by 2010.

- *Aluminum: Recycling Technologies:* Remelting aluminum scrap requires only a small fraction of the energy required to smelt aluminum from alumina. In 1995, aluminum from scrap provided about 1/3 of U.S. consumption. While some of the barriers to higher recycling rates are institutional (e.g., perceived value of recycling beverage containers), technological barriers also exist for some products like aluminum in cars. These include problems with scrap sorting, separation, cleaning, and pre-treatment, which inhibit the increased use of different types of scrap and also contribute to problems with metal quality. Byproduct recycling (e.g., salt cake and spent potlining) is also inhibited by a lack of knowledge of byproduct characteristics.

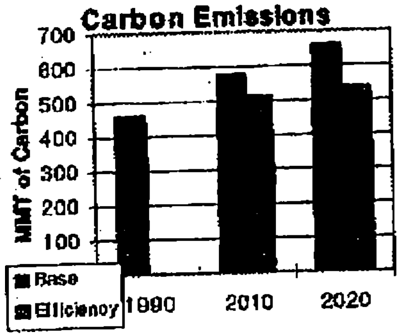
Cement

While the cement industry uses less energy (0.3 Quads) than the other industries in this section, it is by far the most energy-intensive at 169 TBtu per dollar of output--more than 14 times the manufacturing industry average of 12 TBtu/$. It is responsible for about 25 MMT of carbon dioxide emission annually with 10 MMT due to process carbon emitted during the calcination of limestone in the cement kiln.

- *Intergrinding Flyash and Steel Slag with Cement:* European experience has shown that up to 20% of limestone, utility flyash or steel slag can be ground into cement clinker with equivalent or superior performance. The 5-lab study estimates that this technology could reduce energy and process carbon emissions of the cement industry by up to 2 MMT.
- *Cement Particle Size Classifier* Cement grinding is also energy- and electricity-intensive. This technology controls the size of cement particles and reduces grinding requirement by separating the fine particles. Fewer particles must be reground, reducing grinding energy consumption by 20%. Currently more than 50 of these units are operating in the United States resulting in carbon reductions of 0.1 MMT.

16

Residential and Commercial Buildings



Source: EIA, Markal Model, ORNL/LBNL 1997

Key Trends - 1990-2010

- 35% of U.S. carbon emissions are from energy use in buildings, with homes emitting 19% and commercial buildings emitting 16%.
- Energy intensity in buildings has declined substantially since the late 1970s. Primary energy intensity in commercial buildings declined by 22% between 1979 and 1992, while residential primary energy intensity dropped by 15% since 1978.
- Buildings have become increasingly electrified - driven by rapid growth in office equipment, small appliances and other devices collectively know as "plug loads". From 1978 to 1992, commercial electricity consumption grew by 37%, while residential electricity grew by 36%.
- Due to continuing electricity growth, the EIA forecasts that future commercial energy intensity will decline by only 0.2% per year, and residential intensity by 0.5% per year. However, numerous studies identify substantial additional potential for cost-effectively reducing buildings energy consumption and greenhouse gas emissions.

Needed Technological Improvements

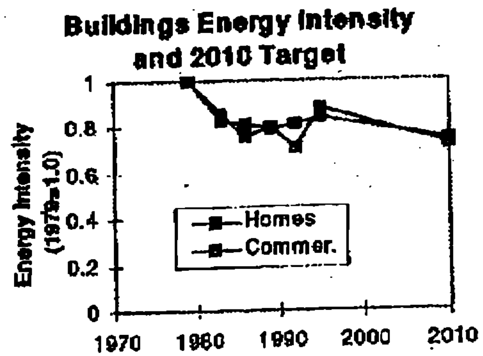
- Technologies needed to achieve the emissions reductions above largely exist today; no major technological breakthroughs are needed.
- The large potential emissions reductions are not being achieved in current markets because of a number of market barriers that impede the diffusion of energy-efficient technologies - such as lack of reliable product information; higher up-front costs; split incentives between efficiency purchasers and beneficiaries; conflicting building codes; and lack of market expertise in efficiency design and construction.
- To achieve the efficiency savings in 2010, the equipment that naturally turns over in about 65% of buildings is replaced with the most cost-effective technologies by 2010; these savings assume normal retirement of equipment at the end of its useful life.
- Energy efficiency improvements needed are 12% for residential buildings and 18% for commercial buildings by 2010.

Costs

- Investments to achieve these 2010 savings are $7-$14 billion per year and result in 2010 energy bill savings of $18-33 billion - a net savings of $10-19 billion and a 20% return on investment.
- Costs of Federal programs to accelerate the use of energy efficient technologies in buildings are $300 million per year; achieving the above savings will require a rough doubling of budgets.

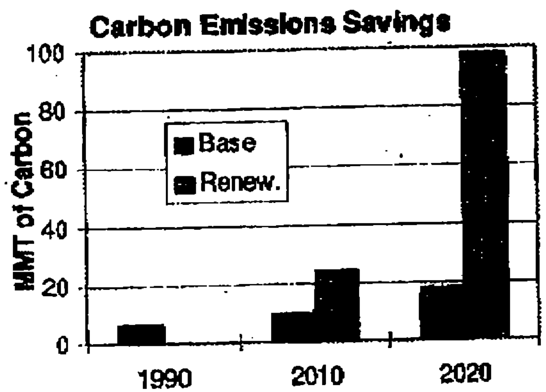
Policy Challenges

- Federal, state and local policies that accelerate technology deployment and energy efficient building design, construction and operation.
- Partnerships with states, local government and industry to improve efficiency of existing buildings and remove market barriers.
- Research and development of a portfolio of advanced buildings technologies.



Source: EIA, ORNL/LBNL 1997

Renewable Energy



Key Trends - 1990-2010

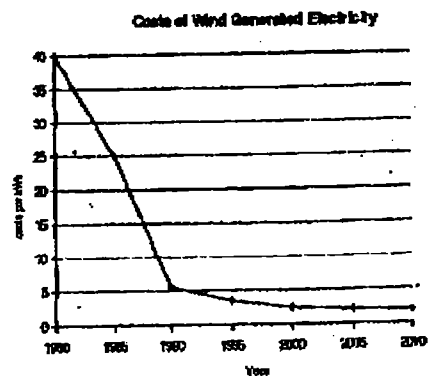
- Today, roughly 12% of the country's electricity generating capacity is from renewable energy - with 85% of this from hydropower. Newer renewable technologies - including wind, biomass, photovoltaics, solar thermal and geothermal - are increasingly economic and have large potential.
- Costs have dropped dramatically -photovoltaic cells have dropped from $0.90/kilowatt-hour in 1980 to under $0.20/kWh today, while wind power has dropped from $0.25/kWh to $0.05/kWh.
- Cost reductions will continue because of R&D advances and as manufacturing efficiencies.
- Cost performance improvements have resulted in several technologies being competitive in selected markets today and others will be competitive in broader markets in the near future.
- Several major international companies such as Royal/Dutch Shell, expect these technologies to be dominant global energy sources and are substantially investing in their development.

Needed Technological Improvements

- The contribution of renewable energy technologies to emissions reductions could be substantially higher than projected in the base case.
- Costs and performance of these technologies continue to improve, but additional advances in wind, biomass, photovoltaics, geothermal, solar thermal and transportation biofules are needed in several areas. Improvements include wind turbine blade design and materials, photovoltaics materials efficiencies, geothermal drilling technology and resource verification and large-scale celluosic biomass fuels production.
- Improvements in manufacturing costs are needed that will result from both R&D and higher production levels
- Additional utility company experience with these technologies and their integration into power systems is needed.

Costs

- Total capital investment in renewable power systems needed to achieve the above results is $15 billion in 2010 and $30 in 2020.
- The incremental costs of renewables investment is very low relative to inexpensive gas technologies in 2010 and likely negligible in 2020 as multiple renewable technologies are competitive in broad markets.

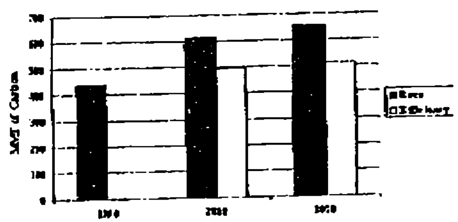


Policy Challenges

- Expand technology R&D to lower costs and increase performance.
- Conduct cost-shared technology diffusion with industry to increase utility system experience and increase U.S. renewable energy production capacity.
- Conduct R&D on key support systems such as power storage, controls and superconducting materials.
- Encourage use of U.S. renewable technologies abroad to tap the huge global market for renewable energy.

Autos and Light Trucks

Transportation Carbon Emissions



Source: Markal-Macro Technology Investment Case

Key Trends — 1990-2010

- The transportation sector generates one-third of all energy-related carbon emissions in the United States. Moreover, this is the fastest growing end-use sector. Cars and light trucks (light duty vehicles) alone account for 58 percent of the total transportation emissions, or 19 percent of total energy-related emissions.
- Average fuel economy for new automobiles has been regulated at a minimum 27.5 mpg since 1985. It is projected to grow to 31 mpg in 2010. New minivans, sports utility vehicles, and other "light trucks" now get 21 mpg and are projected to get 23 mpg in 2010.
- Light trucks were 20 percent of the personal vehicle market in 1974, 44 percent in 1996, and are projected to be 50 percent by 2010. Assuming no change in this trend, this will result in a declining overall fuel economy for all light duty vehicles.
- Vehicle miles traveled have been growing 2-3 percent per year for the past 30 years and are expected to grow 2 percent or more per year through 2010. Improved fuel economy will help maintain desired levels of vehicle miles traveled.

Needed Technological Improvements

- By 2010, about 30 percent of new light duty vehicles would have to meet the Partnership for a New Generation of Vehicles (PNGV) goal of a tripled fuel economy (e.g., 80 mpg for automobiles) to help reduce overall carbon emissions to 1990 levels. On the other hand, all new cars and light trucks would have to embody 30 percent of the improvement represented by the PNGV goal (e.g., 45 mpg for automobiles).
- On-Road fuel economy for all cars and trucks (including both new and existing vehicles) would need to reach 25 mpg by 2010 and 31 mpg by 2020.
- Key technologies needed are vehicle weight reduction through advanced materials and design, hybrid/electric drivetrains, and improved aerodynamics.

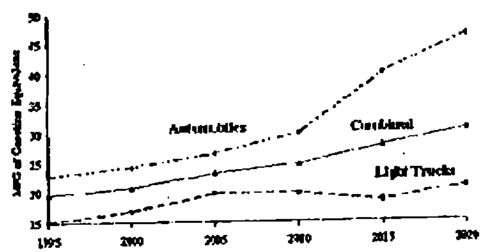
Costs

- If PNGV goals are met, the more efficient light duty vehicles will have no increased cost for consumers.
- At currently anticipated technology costs, new autos in 2010 would have an $800-1,200 higher price tag. At gasolines prices forecasted for the year 2010, these higher costs would pay for themselves in fuel savings within 3.5-5.3 years.

Policy Challenges

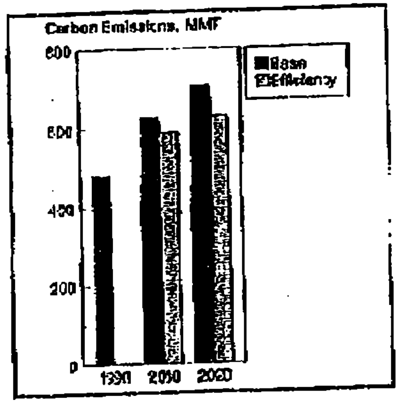
- Ensure that PNGV technologies fully penetrate all markets for all new light-duty vehicles by 2010 and continue through the period 2020.
- Devise new commercialization strategies, including new approaches to fuel economy standards and market incentives (e.g., EnergyStar car, financing packages, bonus emission credits).

LDV On-Road Fuel Economy (Total Fleet)



Source: Markal-Macro Technology Investment Case

Electric Power



Source: EPA, DRI 1.25 Base Case

Key Trends -- 1990-2010

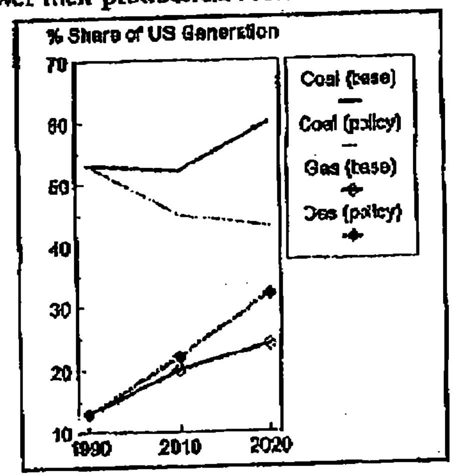
- 36% of US carbon emissions are in the electric utility sector, primarily from burning of coal and natural gas.
- Coal and natural gas together are projected to increase from 63% of energy inputs to 70% by 2010, increasing the carbon intensity of this sector.
- Demand for electricity is projected to rise at about 1.7 %/year over this period.
- Renewable power (other than hydroelectricity) is projected to rise from 1.5% of generation currently to 1.8% in 2010.

Needed Technological Improvements

- No breakthroughs are required in technology for power generation. Incremental improvements in key supply technologies will lower costs of meeting GHG emissions goals.
- Key supply technologies are combined cycle turbines, gasification for biomass fuels, wind turbines and system improvements (such as transmission efficiency, small distributed power sources, etc.).
- Commercial deployment of low-emitting technologies (including export markets) will lower their production costs.

Costs

- Switching from coal to natural gas, renewables or demand-side efficiency will cost $50-150 per ton C in 2010. Total capital investments will rise by $3-5 billion, or 30-50%. Fuel and operating costs will also rise by about $3-5 billion, or 5-10%.
- Public and private R&D will be largely unaffected, although shifts towards low-emitting technologies may occur.



Policy Challenges

- Aggressive R&D and marketing for energy efficiency and new generation technologies.
- Integrate climate policy with competitive trends and air quality regulation.
- Incentives for commercialization -- pricing, emissions trading credits, promotion, regulation, and financing.

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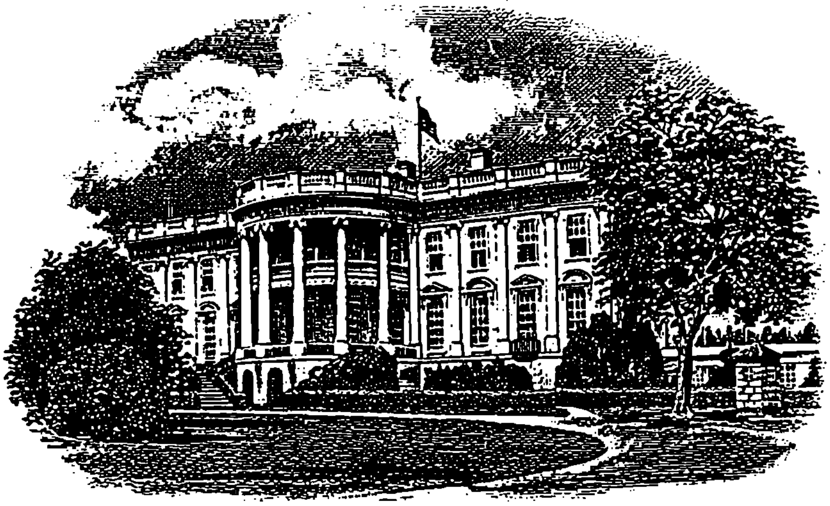
Office of Management and Budget



Natural Resources, Energy and Science

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Number of pages (including cover sheet) ________

Date: 7/15/97

To: HENRY KELLY / MARK MAZUR / DAVID SANDALOW / STEVE SEIDEL / JASON SHOGREN

Phone: ________ ________ ***Fax:*** ________

From: ***Alecia Ward, Confidential Assistant to the Associate Director***

Comments: Revised Papers for the 2PM GCC mtg tomorrow 7/16/97 Rm 324.

Phone: (202) 395-4561 Fax: (202) 395-4639

Transportation: Light Duty Vehicles and Carbon Emissions

Key Findings

- Based upon data from AEO97, the transportation sector used 24.4 quads of energy in 1995, about 27 percent of the nation's total energy requirements. Because of its almost total dependence on petroleum fuels (accounting for 97 percent of total energy use), the transportation sector was responsible for 33 percent of the overall U.S. greenhouse gas emissions. By 2010 transportation energy use will grow to 31.4 quads, a 29 percent growth over 1995 levels. In energy terms, this is the fastest growing end-use sector, significantly above the 19 percent growth of the economy as a whole. Carbon emissions will follow a similar pattern, increasing from 465 to 598 MMT in the years 1995-2010. Emissions in 1990 were 432 MMT.

- Light duty vehicles, including automobiles and light trucks, accounted for 58 percent of the nation's total transportation energy requirements in 1995. In contrast, freight trucks used only 22 percent of the transportation energy in 1995. The remaining 19 percent of the transportation share was used by air, rail and marine travel, pipeline fuels and lubricants. The share of light duty vehicles will fall to 55 percent by 2010.

- The transportation sector as a whole has the potential to reduce energy use and carbon emissions by 15-20 percent over 2010 baseline forecasts through cost-effective investments in energy efficient technologies, and in some cases, low-carbon technologies. This will not be enough to reduce carbon emissions to 1990 levels, but the savings can be achieved without significantly affecting either comfort, safety or travel.

- The anticipated 2010 energy and carbon savings could be achieved in the case of automobiles, for example, if new car sales in that year achieve one-third of the fuel economy gains represented by the PNGV goal of 80 MPG (i.e., moving from a fuel economy of 28 to 45 MPG).

- Assuming that PNGV cost goals are not met, and that the price of new vehicles in 2010 reflect current estimates of new technology costs, a 45 MPG car will cost between $800 and $1,200 more than a 28 MPG car (in 1995 dollars). Assuming 13,600 vehicle miles traveled for new vehicles and a gasoline price of $1.23 in 2010 (also in 1995 dollars), this implies a roughly 3.5 to 5.3 year simple payback for a car that has an expected 14-year lifetime.

Background

By 2010 transportation energy use will grow to 31.4 quads, a 29 percent growth over 1995 levels. In energy terms, this is the fastest growing end-use sector, significantly above the 19 percent growth of the economy as a whole. Carbon emissions will follow a similar pattern, increasing from 465 to 598 MMT in the years 1995-2010. Emissions in 1990 were 432 MMT. In the case of light duty vehicles, the growth in energy consumption is driven by increases in the vehicle miles traveled (VMT), and the significant growth of light trucks (including vans, sport cars and recreational vehicles) which have a substantially smaller fuel economy. The sales of light trucks have grown from a 20 percent market share in 1975 to a 44-percent market share in 1996. Whereas new cars are rated at 28 MPG, light trucks enter the market with a rating of only 20.5 MPG.

CO_2 *Reduction Potential and Scenarios*

Despite the significant growth in energy use by light duty vehicles, the technology exists to increase the average fuel economy of new vehicles by 40 percent or more in the year 2010 — without the need for reduced travel or increases in the cost of travel. This is true in both the movement of people and freight. This success would be achieved in the case of automobiles, for example, if new car sales achieve one-third of the fuel economy gains represented by the Partnership for a New Generation Vehicle (PNGV) goal of 80 MPG.

Major technologies for near-term light duty vehicle improvements include, for example, material substitution, reduced aerodynamic drag, improved automatic transmissions, reduced engine friction, variable valve timing, and advanced tire designs. Many of these technologies have already emerged in the market, lacking only appropriate policy signals to accelerate their diffusion, or to redirect their use toward fuel economy instead of improving other vehicle attributes. Honda, as one example, employs a system of variable valve timing that is used to boost power and improve fuel economy. General Motors has one vehicle that has already achieved a low aerodynamic drag. On the other hand, lean-burn engines which increase engine thermal efficiency are a low-risk technology that should be readily available by 2010.

barriers + policy

Work developed for the "Car Talk" advisory committee[1] resulted in estimated reductions of both energy use and carbon emissions (measured in million metric tons of carbon, or mmMTCe) through a variety of both technology and policy options. Summarized in the table below, and generally covering the period 2005 through 2025, the options include improved land-use planning, higher fuel prices, fuel economy standards and feebates, the PNGV vehicle, and the use of low life-cycle carbon fuels.

Modeling a different set of technology assumptions showed a significantly different set of results. DRI focused on largely behavioral response to reduce transportation energy consumption, while Markal-Macro had a larger technology bent. The table on the following page highlights these differences for automobiles. (Note: the reference to CCAP is the so-called Case Two scenario which moved toward but did not necessarily hit a rate of decline in E/GDP of 1.25 percent. This compares to an assumed 1.00 percent decline in the base case. The Case two scenario includes both the full set of CCAP programs as well as "announcement effect." Case three, the Technology Case formerly described as the 1.75 Case, assumes a higher level of investment potential for cost-effective energy efficient/low-carbon technologies.)

In case two (with stabilization), DRI forecasts a 9 percent reduction in VMT with an 8 percent increase in MPG for new automobiles. DRI's case three (with stabilization) forecasts a 5 percent VMT reduction with a 10 percent increase in new car MPG. MM shows a seven percent drop in VMT for the CCAP scenario. This rebounds, however, to nearly base case levels with better assumptions about improved levels of technology. Although new cars in MM enter the market in 2010 with a high EPA-rated fuel economy (again, with about one-third of the improvements of the PNGV goal), the entire fleet of automobiles show an on-road MPG of only 30 MPG because of the

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1. The "Car-Talk" committee is the *Policy Dialogue Advisory Committee to Assist the President in the Development of Measures to Significantly Reduce Greenhouse Gas Emissions from Personal Motor Vehicles* formed in 1993 to see whether a consensus set of policies could be developed to return personal transport GHG emissions to 1990 levels by 2005, 2015 and 2025. The committee failed to agree on such policies, but substantial analytic results were developed by a team of government analysts working with several expert committee members.

What does this mean?

time needed for fleet turnover. Hence, it is the on-road change in fleet fuel economy — moving from 24.2 to 30 MPG — that drives much of the transportation energy and carbon savings.

Costs

In the Markal-Macro assumptions, a new vehicle at 45 MPG would cost an estimated $1,200 above new cars in the base case. This assumes the PNGV cost goals are not met by the year 2010. The newly released *Energy Innovations* study suggests an added cost of about $800 dollars (in 1995 dollars). However, owners of the new vehicles would save about $225 per year,in avoided gasoline costs (also in 1995 dollars, assuming an average driving range of 13,600 miles per vehicle and a cost of gasoline of $1.23 per gallon). Simple payback for this technology improvement would range, therefore, from 3.5 to 5.3 years. In comparison, the average life of a new car would be about 14 years.

Car-Talk Summary Table of Policy Options[2]
(mmMTCe)

Policy Measure	Policy Type	2025 Annual Emission Reduction
Land Use and Transit Policy Package	Less VMT	25
Fuel Price Increases ($0.50/gal.)	Less VMT	120
Parking Tax ($2.00 nationwide)	Less VMT	25
Road Pricing	Less VMT	25
Fuel Economy Standards, "Feebates"	More Fuel Efficiency	90
PNGV	More Fuel Efficiency	60-200
Bio-Ethanol Subsidy	Low Emission Fuels	100
GHG Savings Needed to Return Personal Transport Emissions to 1990 Levels by 2020-2025		200-260

Key Automobile Indicators in 2010

	DRI			Markal-Macro		
	Base	CCAP	Technology	Base	CCAP	Technology
VMT	1526	1403	1450	1619	1509	1597
MPG New Car (EPA)	29.2	31.4	32	30.7	43.4	44.7
MPG Car Fleet (EPA)	24.7	26.5	30.6	29.3	32.7	35.7
MPG Car Fleet (On-Road)	23.3	24.5	26.9	24.4	27.3	30
LDV (MMT)				342	293	259

2. Emission reductions may not be added since the impact of implementing multiple policies may be significantly less than is implied by adding up the individual estimates. However, the motor vehicle GHG model used to develop most of these estimates can be used to forecast the effect of multiple policies.

The Problem of Allocating Carbon Savings

Comparing the savings from MM Case 3 using three different accounting methodologies └ 1.75 case

Methodology One:

All electric DSM and Fuel Switching options are allocated to the electric utility sector

	Fuels (MMT)	Electric (MMT)	Total (MMT)
Bldgs	36	0	36
Industry	36	0	36
Trans	116	0	116
Utilities	0	239	239
Total	188	239	427

Methodology Two: lab study approach

All electric DSM savings allocated to end-use sectors while change to low carbon fuels on utility side of meter allocated to the electric utility sector

more support for 2

do final D Ds first, then fuel switching

similar to MM accting framework

	Fuels (MMT)	Electric (MMT)	Total (MMT)
Bldgs	36	112	148
Industry	36	58	94
Trans	116	0	116
Utilities	0	69	69
Total	188	239	427

X **Methodology Three:**

All savings allocated to end-use sectors

	Fuels (MMT)	Electric (MMT)	Total (MMT)
Bldgs	36	151	187
Industry	36	88	124
Trans	116	0	116
Utilities	0	0	0
Total	188	239	427

Eric Petersen - #s don't add up w/ their M-M runs

Key Industrial Indicators for 2010 and 2020

Indicator	Markal-Macro							DRI						
	1995	2010			2020			1995	2010			2020		
		Base Case	Case 2	Case 3	Base Case	Case 2	Case 3		Base Case	Case 2	Case 3	Base Case	Case 2	Case 3
Output (1995=1.000)	1.000	1.408	1.400	1.412	1.544	1.531	1.551	1.000						
Energy (Quads)	19.6	22.8	19.3	20.2	24.3	19	20.1	22.8	25	21.9	22.3	26.4	21.9	22.4
Emissions (MMT)	466	563	421	465	592	407	456	472	521	436	445	542	419	422
10-Year Rate of Annual Efficiency Improvement	n/a	1.1%	2.6%	1.7%	0.8%	1.5%	1.4%	n/a	1.5%	2.6%	2.7%	0.9%	1.5%	1.4%

Note: Because of differences in accounting between the MM and DRI models, and because the energy totals do not include chemical feedstocks, the energy and carbon savings are somewhat understated. The overall magnitudes are in the right direction, however.

Freight, Aircraft and Rail
Emissions Projections and Potential for Reduction

Julie Fox Gorte, U.S. EPA

Try to make this section fit on 1st pg

Key Findings

Current and Projected Emissions from Commercial Transport 1990-2010 and Beyond

	1990	1995	2010 base[1]	2010 with advanced technology[2]
Total Emissions, MMTC	185[3]	195	276-295	244-266
Freight Truck Emissions	60	63	92-130	54-116
Aircraft Emissions	64	68	90-110	75-130
Rail Emissions	9	9	10	7
Other Emissions (marine, pipeline, other)	51	55	64	63

- Total carbon emissions from the transportation sector in 1995 were nearly 470 MMT. The freight, aircraft and rail sectors accounted for over 130 MMT of carbon emissions, or 28 percent of all transport emissions.
- All modes of freight transport, including trucks, rail, pipeline, shipping, and air, have improved their energy efficiency. However, intermodal shifts to more energy-intensive trucking and air transport has meant very little change in the amount of energy used to haul freight from 1972 to 1995. Because of increasing efficiency, however, three times as much freight was hauled in 1995, for about the same amount of energy, as in 1972.
- Energy use and carbon emissions from non-personal vehicles may surpass energy use and emissions from automobiles shortly after the millenium.
- Opportunities to reduce carbon emissions or energy use in commercial transport before 2010 will likely come mainly from trucking and air transport. Analysis of possibilities in a study by 5 DOE laboratories estimated that roughly 20-45MMT could be saved by new technologies, increased use of cellulosic ethanol fuel, and improved traffic flows. About 10 MMT in reduced emissions come from trucking, 10-15 come

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[1] This range expresses forecasts of both Markal Macro and the 5-lab study. Sector figures may not add to totals due to rounding and to the fact that the range bounds four different projections, two in Markal Macro and two in the labs study.

[2] This range expresses forecasts of both Markal Macro and the 5-lab study. Sector figures may not add to totals due to rounding and to the fact that the range bounds four different projections, two in Markal Macro and two in the labs study.

[3] 1990 emissions numbers are estimates. True figures will be in the next draft.

from air transport, and 7-10 from rail.[4]

- Significant reductions in emissions from commercial vehicle transport are possible beyond 2010 with an aggressive R&D program and coordinated public sector efforts to diffuse very low emission or zero emission technologies like fuel cell/fuel cell hybrid powertrains in rail and truck freight transport. In aircraft, significant improvements in energy use and carbon emissions are possible beyond 2010 with designs that promote laminar (e.g. non-turbulent) flow of air over the airframe, and continued work on energy efficient propulsion in subsonic jet engines.
- Achieving these savings in emissions by 2010 will require a more aggressive program of research and development in conventional powertrains and propulsion. The DOE five-lab study stipulates that carbon emissions reduction at the low end of the ranges in the last column of the table above are likely, so long as the government institutes appropriate policies and research efforts are intensified. They do *not* depend on fundamental technical breakthroughs, and do not require stepped up capital turnover.

barriers
policy

- Substantially greater opportunities to reduce emissions in commercial transport are apparent by 2015 than in 2010, primarily because most commercial transport capital is long-lasting. By 2015, the DOE labs study estimates that it would be possible to reduce emissions to 1997 levels (about 5 percent above 1990 levels) in its most optimistic scenario, which requires some luck in achieving technical progress as well as the appropriate policy environment and increased support for research and development on the order of two to ten times current levels [add numbers].
- DOE estimates that the annual costs to achieve emissions reductions are $25-20 billion, and would save $35-40 billion annually in energy costs. On balance, this level of investment could either break even or save up to $10 billion.
- [Bullet on current technology programs: put in the investment in PNGV and USABC and applicable NASA aeronautics programs. Add comparison numbers on industry R&D in motor vehicles and commercial subsonic aircraft.]

Background

The transportation sector, which includes both personal transportation (cars and light trucks, rail and air) and freight (heavy trucks, rail, aircraft, pipeline, and ships) accounts for almost 11 percent of U.S. GDP. The freight sector accounts for about a third of that.

Total emissions from freight and aircraft wereabout 185 MMT, with heavy trucks and aircraft each accounting for about one-third of the total. Aircraft emissions account for all aviation, including freight, passengers, and military, with the lion's share of aviation carbon emissions coming from passenger travel. Air freight was estimated at 1% of all air transport in 1989, and while it is the fastest-growing mode of non-local freight transport, it probably only accounts for a few percent of all freight transport in 1997. The share of emissions due to freight alone is unavailable, as many commercial flights carry both passengers and freight.

The U.S. economy moves more ton-miles of freight every year, on every mode. All modes of non-local freight transportation increased between 1970 and 1994. Air freight increased the most (434%), followed by trucks (210%), rail (57%), pipeline (41%), and water (37%). Water, rail, and trucks are each responsible for about 25% of freight movement, measured in ton-miles.

Truck use for freight has increased dramatically in the last 15 years. In recent years, however, trucking loads have grown heavier; between 1982 and 1992, mileage traveled by trucks with operating weights above 80,000 lbs. increased193%, and 120% for trucks below 33,000 lbs. The average length of haul increased from 224 miles in 1994 to 817 miles in 1994.

All modes have consistently improved their energy efficiency. Improvements have come from both technology and operational efficiencies. Between 1984 and 1994, heavy truck energy use per vehicle mile decreased 0.4% per year, and 1.6% annually per ton-mile. In rail, energy use per car-mile dropped 0.9% per year,

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[4]These figures still do not match adequately with numbers in the table above. DOE and EPA are working to understand the differences in numbers from the labs study and Markal Macro, and develop crosswalks.

and 2.7% annually per ton-mile.

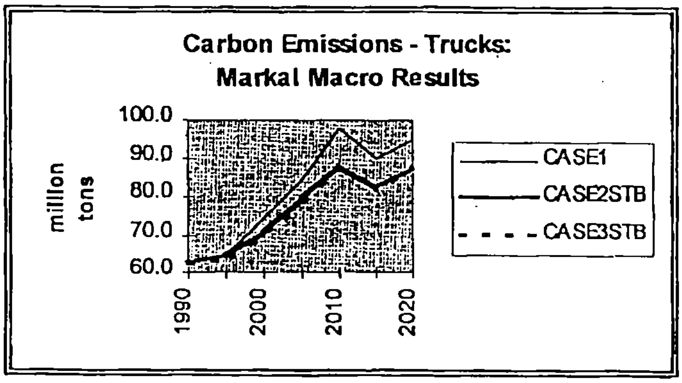
Between increasing efficiency and the shift to more energy-intensive modes (trucks and air), the net energy effect is about a wash: if energy intensities of 1972 still prevailed, 1994's energy bill for freight movement would be treble [check this] the actual number.

Improvements in fuel efficiency improvement have slowed in personal vehicles, but continue in other modes of transport. In freight, the weight and cost of fuel carried has a direct effect on the amount of freight that can be carried, so there are incentives to improve fuel efficiency even when fossil fuel prices are low. Nevertheless, commercial transport is substantially more energy intensive per mile than light duty vehicles; truck fuel efficiencies range from about 5.5 mpg to over 7-8 mpg for heavy- and medium-weight trucks, while automobiles average nearly 22 mpg. With freight transport growing faster than personal transport [check this], energy use and emissions from freight and commercial travel could outstrip energy use and emissions from personal vehicles by shortly after the turn of the century, according to Argonne National Laboratory.

Confirm w/ other transportation paper

Trucks and aircraft are expected to continue as the fastest-growing forms of non-personal transport, and will account for the greatest increases in emissions. The airline industry, since deregulation, operates close to maximum efficiency, and opportunities to use alternative fuels in aircraft are limited for the foreseeable future. Therefore most of the opportunities to reduce emissions from aircraft are in development and deployment of more fuel-efficient engine and airframe technology.

Reducing emissions from surface freight, on the other hand, is possible through both technological improvement and progress in reducing inefficient use of trucks (e.g. continued reduction in empty backhauls, more efficient routing, intrastate warehousing) and shifting from trucks to rail.



Model Results and Potential for Reducing Emissions

SGM does not include technological advances that affect emissions, or energy consumption, in the freight sector. DRI assumes modest advances in truck fuel efficiency—from 5.0 to 5.2 mpg in heavy trucks[5] by 2020, with no improvement by 2010. DRI also assumes that fuel efficiency of medium trucks[6] will increase from 6.5 mpg between 2010 and 2020, but no increase between now and 2010 [check].

Markal Macro includes several advanced technologies to improve the energy and carbon efficiency of freight, most of them fairly conservative projections of current trends. All three cases (base, stabilization with a rate of improvement in the energy/GDP ratio of 1.25%/year, and stabilization with E/GDP improvement of 1.75%/year) bring in more fuel-efficient diesels, with faster rates of introduction in the 1.25 and 1.75 cases. In addition, both advanced technology cases phase out existing gasoline trucks, and penetration of trucks LPGfuel. The 1.75 case shows very rapid penetration of diesel trucks that are 20% more efficient than current diesel trucks, starting in 2010 and accounting for well over 95% of vehicle miles traveled by 2020. Fuel efficiency of heavy trucks increases to 6.9 mpg in the 1.25 case and 7.3 mpg in the 1.75 case of Markal Macro. Carbon emissions in 2010 are forecast to be nearly 98 MMT in the base case, 88 MMT in the 1.25 case and 18 MMT in the 1.75 case (see figure above).

Emissions from rail, freight, air freight and pipelines were specified exogenously for the IAT, since none has more than a marginal impact on energy use and carbon emissions as a whole. The forecast shows emissions

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[5]Heavy trucks are those greater than 33,000 lb.

[6]Medium trucks are those between 10,000 lb. And 33,000 lb.

from rail freight at 10.5 MMT in the base case, and 9.7 and 9.8 MMT, respectively, in the 1.25 and 1.75 cases. Emissions from shipping are reduced from 8.5 MMT currently to about 7.6-7 for all cases in 2010.

Overall, the IAT model runs could be described as technologically conservative in the freight area. Foreseeable technologies could make more significant reductions in emissions, particularly with more aggressive efforts to develop and diffuse the technologies. Programs to develop transportation technologies such as PNGV and NASA programs on energy efficiency and aerodynamics could probably bring these new technologies to proof of concept or demonstration before 2010, and several, particularly in truck componentry and efficiency, could be well established in the market. Energy experts at DOE's multiprogram laboratories point out, however, that current levels of funding for PNGV are probably inadequate to achieve the program's technical goals.

Technology Options: Trucks. There are many opportunities to improve energy efficiency and carbon dioxide emissions in freight. Improved aerodynamic design that reduces drag, advanced engines (the Turbocompound Diesel Engine and the Advanced LE-55 Heat Engine), vehicle weight reduction through materials substitution, improved tires, and electronic engine and transmission controls can achieve fuel economy improvements ranging from 2 to over 20 percent in heavy trucks, as can advances in computational methods (hardware and software) aimed at understanding turbulence both for aerodynamics and within fuel chambers. The lab study assumed that these new technologies could be cose effective at a fuel equivalent price of $8/million Btu, less than the $9/MMBtu assumed in the base case. Moreover, the lab study assumed that all energy-efficient truck technologies could achieve 99 percent of their maximum market penetration (which, for most technologies, is less than 100 percent) in 20 years, compared with a base-case value of 99 years for a few of the technologies (e.g., the advanced heat engine).

Rail. The fuel efficiency of rail transport has increased at a healthy clip--nearly 3 percent per year--for 25 years, far higher than the 1%-per-year improvement assumed in energy modeling [and likely the IAT, since base case was based on NEMS--check this]. Improved operational efficiency accounts for the great preponderance of this improvement; one estimate is that 85% of the increase in energy efficiency of rail transport is attributable to improved scheduling and operations management. However, we have not yet wrung all the energy efficiency these changes are capable of making from the system, so it is likely that rail's energy efficiency will continue to improve at rates closer to those of the last two decades for a while. Other advanced technologies that could reduce energy use in rail include flywheels, to store the energy given up when trains go downgrade for use in propulsion; oxygen enrichment in locomotive engines; and alternative fuels, including natural gas.

Technology Options: Aircraft. In aircraft, energy efficiency is a perennial concern primarily because reducing the weight of fuel is one way of reducing aerodynamic drag, a central and constant concern of aircraft and engine designers. NASA programs aimed at achieving greater fuel efficiency in engines were both technically and economically successful in the 1980s, improving the efficiency of existing engines as well as producing new, more efficient jet engine cores and components. NASA and industry (principally GE and Pratt and Whitney) also produced advanced turbofan and unducted fan engines that achieve significant gains in energy efficiency, but have not been commercialized primarily because falling fossil fuel prices reduced the payoff to greater efficiency in the late 1980s. These engines, however, are still available and could be incorporated into aircraft designs with less expense and development expense than clean-sheet designs would entail should they become more attractive options in the future.

Ongoing NASA/DOD/industry work on energy efficiency continues, under the Integrated High Performance Turbine Engine Technology program, aimed at achieving a 40 percent improvement in energy efficiency by 2003. It is well to note, however, that even if this ambitious technical goal is met, it will be many years before engines that incorporate the new turbine technology are incorporated into engines, and still more before they appear on aircraft, making significant penetration of the aircraft engine market by these technologies unlikely before 2010. However, NASA's earlier engine efficiency projects of the 1970s and 1980s are still yielding benefits in commercial engine technology, including the GE-90, the most energy-efficient engine of its type [check the bypass ratio of GE-90].

Intermodal Switching. Intermodal shifting, or switching from truck to rail haul or air transport, has been underway for some time. Intermodal transportation of freight, or using both trucks and rail or aircraft, cuts emissions by relying on more energy-efficient modes (rail and air) rather than trucks for part of the trip. The Department of Transportation estimates in its 1996 annual transportation statistics report that intermodal freight hauls meant 1.5 million fewer large trucks on the highways. A simulation done in Markal Macro shows that diverting 10 percent of truck ton-miles of freight to rail could save 4.3 to 4.7 MMT of carbon. Whether such a shift would be operationally feasible is unknown. Markal Macro includes no cross-elasticities to optimize intermodal shifts, and while DRI does, no shifts occurred in IAT runs of DRI's energy model.

Long Term Opportunities

Trucks. More revolutionary technological advances, including the use of fuel cells in powertrains, are possible with an aggressive program to develop fuel cells for motor vehicles, along with the storage devices (batteries and ultracapacitors), fuel storage, and infrastructures supporting increased use of hydrogen fuel. With such a program, it might be possible to introduce hybrid fuel cell/electric powertrains into trucks before 2010, though significant market penetration is very unlikely by then.

Rail. Fuel cell/electric powertrains may be somewhat more likely to happen in locomotives than trucks, though significant market penetration of fuel cells in rail before 2010 is doubtful. The cost of fuel cell power is still prohibitive in rail, but with further development and expansion in the use of fuel cells for other applications (light duty motor vehicles and terrestrial power generation, e.g.) the economics may become more favorable. While widespread use of fuel cells for any kind of transport poses some significant infrastructural, maintenance, and technical problems, there has been significant progress in fuel cell and other hybrid powertrain technology over the past several years, with significant contributions from PNGV, and NASA and DOD programs. With increased spending on hybrid powertrain development and the appropriate incentives to develop infrastructure and support for operation and maintenance, fuel cell applications may be possible, though at no significant scale, by 2010.

Air. NASA research on computational fluid dynamics and numerical simulation is also showing promise for modifying the skins of aircraft to include tiny, micron-thin riblets that could decrease turbulence, and thereby, drag, by 5 or 6 percent, increasing fuel efficiency and airlines' profit margins. It is quite likely that some of these improvements could show up on commercial aircraft before 2010, although full market penetration will take decades due to lengthy capital life.

Costs and Benefits

Is the $10b value a NPV ?

DOE estimates that the annual costs to achieve emissions reductions in transportation (including personal vehicles) are $25-20 billion, and would save $35-40 billion annually in energy costs. On balance, this level of investment could either break even or save up to $10 billion. Another caveat of the DOE lab study is that, to achieve the emissions targets in either the efficiency or efficiency/low carbon scenarios, R&D programs would have to be increased by 2 to 10 times [add investment number].

In the models, costs of faster introduction of new technology were handled by proxies. Most of the models were made to hold multifactor productivity constant, so that investments in energy efficiency are compensated for by reductions in the productivity of labor and capital. These cannot be assigned to specific sectors [or...can they? Check.].

[Add section on theco-control effects of these reductions in GHG to criteria air pollutants. Controlling CO2 emissions by improving energy efficiency gives a much bigger co-control benefit than the NAAQS does for carbon dioxide...]

Current Federal Programs and Funding

[Add section briefly describing PNGV, USABC, other DOE programs in fuel cells and transport, and relevant NASA aeronautics programs and their funding.]

Technical success in research and development does not assure adoption or diffusion of new technology. Successful completion of the technical program of PNGV and NASA's engine and laminar flow programs must also be followed by investment in commercial development and marketing by industry in order to achieve market penetration. Moreover, capital in the freight sector tends to be turned over quite slowly; with maintenance and overhauls, trucks can last a couple of decades and locomotives and aircraft even longer. Incentives to hasten capital turnover, such as accelerated depreciation programs or investment tax credits, would also help to achieve stabilization. Finally, improving energy and carbon efficiency can also pay off in terms of improved

barriers + policy

competitiveness of efficient engines and powertrains on international markets.

The Carbon Reduction Potential in the U.S. Buildings Sector

July 14, 1997 Draft

Key Findings

Substantial reductions in greenhouse gas emissions are possible in residential and commercial buildings through greater use of cost-effective energy efficiency technologies that not only cut energy use, but also save consumers and businesses money.

- Estimated potential carbon emissions savings in the residential sector are 13-40 million metric tons (MMT) in 2010 and 30-70 in 2020.
- Commercial sector potential emissions savings are 13-40 MMT in 2010 and 30-70 in 2020.
- Realizing these potential savings is dependent upon the effectiveness of policies in removing key market barriers to energy efficiency investments in buildings.
- These emissions savings are estimated to require investments of \$7-\$14 billion per year and result in annual energy bill savings in 2010 of \$18-33 billion - for a net savings in 2010 of \$10-19 billion.

11?

Background

Energy is used in buildings to provide a variety of services such as space heating and cooling, lighting and refrigeration and to power a broad array of appliances and equipment. U.S. buildings energy consumption accounts for nearly one third of total primary energy consumption and related greenhouse gas emissions. The 1996 bill for these energy services was over \$200 billion.

Energy intensity in buildings has declined substantially over the past twenty years. Primary energy use (including losses from electricity generation) per square foot of commercial space declined by 22% between 1979 and 1992, while residential primary energy use per square foot dropped by 15% since 1978. However, during this time, buildings became increasingly electrified - driven by major growth in office equipment, small appliances and other devices collectively know as "plug loads". Commercial electricity consumption grew by 37%, while residential electricity grew by 36%. Driven by small appliances and home electronics, household electricity intensity *increased* 9% over that period. Largely because of expected continued electricity growth, the latest EIA business-as-usual forecast projects that commercial energy intensity in the future will decline by only 0.2% per year, and residential energy intensity by 0.5% per year. However, numerous studies (National Academy of Sciences, 1991; Office of Technology Assessment, 1991; and Energy Modeling Forum 12, 1994) have indicated that a substantial potential remains for cost-effectively reducing U.S. energy consumption and greenhouse gas emissions - particularly in buildings.

Despite the large opportunity, there is clear evidence that many of the potential reductions are not being realized in the current market system because of a number of institutional, organizational, and other barriers that impede the diffusion of energy-efficient technologies. These barriers include lack of appropriate and reliable product information; up-front costs of identifying efficiency opportunities in a particular building, split incentives between efficiency purchasers and those receiving benefits; extremely short payback requirements by some decision makers; local building codes that discourage efficiency measures; lack of expertise for design, installation and operations; and few low cost sources of capital. However, in the last few years changes in building codes and the emergence of the energy services industry have begun to ameliorate several of these barriers. barriers

CO2 Reduction Potential and Scenarios

Analysis results of the IAT indicate that large reductions in future greenhouse gas emissions could be realized through the use of more energy-efficient technologies at a net reduction in the total cost of energy services in residential and commercial buildings. The table below shows the baseline EIA projections of primary energy consumption in a future without a global climate treaty, any market signals to reduce carbon emissions or substantial technological advances in these areas.

	1995	2010	2020 [1]
Residential total (quads)	10.5	11.9	13.8
Commercial total (quads)	7.1	8.1	8.9
Buildings total (quads)	17.6	20.0	22.7

[1] IAT Base Case

The potential energy use reductions indicated by the IAT analysis are shown below. These results assume a binding international climate treaty leading to increased emphasis on U.S. carbon emissions reduction as well as federal and State policies to accelerate the use of existing cost-effective energy efficient buildings technologies.

barriers + policy

	Markal Model		DRI Model		Labs Study
	2010	2020	2010	2020	2010
Residential total (quads)	1.2-2.5	3.4	1.4-1.5	1.6-2.1	0.5-1.1
Commercial total (quads)	1.1-1.2	1.4	1.0-1.2	1.6-1.7	0.6-1.1
Buildings total (quads)	2.3-3.7	4.8	2.4-2.7	3.2-3.8	1.1-2.2

The IAT number translate into carbon savings of 26-33 MMT in 2010 and 35-44 MMT in 2020. A complementary bottom-up analysis is contained in the forthcoming study by five national laboratories, Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies. This study, which is a much more detailed sectoral analysis, indicates a lower overall energy savings potential, but a significantly higher electricity savings potential. As a result, estimated potential carbon emissions savings are 25-50 MMT. The major sources of reductions include residential miscellaneous uses, commercial other uses (such as office equipment), lighting and space conditioning.

The IAT analysis results are rather difficult to place in context because of the top-down method of analysis. The National Laboratories study, however, is quite clear on what is required, as it is based on a technology-by technology and end-use by end-use analysis. In order to achieve the lower end of the range, the equipment that naturally turns over in about 35% of buildings is replaced with the most cost-effective technologies by 2010. The high end of the range assumes the equipment that naturally turns over in 65% of buildings is replaced with the most cost-effective technologies by 2010. Building shells are also renovated, but the average commercial shell is assumed to last 50 years and the average house 100 years, so shell retrofits are a minor contributor. Efficiency gains could be higher, but would require lower technology capital costs and more rapid shell renovations than those assumed in the analysis. It is very important to note that the estimated savings do not require premature retirement of capital stocks - equipment is only replaced at the end of its useful life.

The key opportunities for efficiency gains in residential buildings include miscellaneous electrical appliances such as electronic equipment and small appliances, lighting, water heating, space heating, air conditioning and refrigeration. Primary energy savings in the top three areas - miscellaneous electrical appliances, lighting and space conditioning - are estimated to be 1.9, 0.5 and 0.4 quads, respectively. Overall, these results require the average energy efficiency of residential equipment in the affected buildings to improve by 12% over the next 13 years. An efficient home in 2010 will feature lighting 50% more efficient than the average today, major appliances that are 15-30% more efficient, heating and cooling 10-15% improved, miscellaneous small devices that are 33% more efficient and a building envelop that is 4-14% more efficient. All these improvements are based on currently available technologies.

The opportunities for efficiency improvements in commercial buildings include miscellaneous electrical and natural gas uses (such as telecommunications equipment, medical equipment, pumps, light product assembly and many other activities not easily categorized), lighting, space heating and air conditioning. Primary energy savings in the top three areas - miscellaneous uses, lighting and air conditioning - are estimated to be 1.2, 0.8 and 0.4 quads, respectively. These results require the overall energy efficiency of commercial equipment in the affected buildings to improve by 18% over the next 13 years. A commercial building in 2010 will feature heating and cooling systems 25-50% more efficient than the average today, lighting 25% more efficient, office equipment and miscellaneous plug loads 33% more efficient, and management control systems that result in less energy use through better systems integration. As in residential, all these improvements are based on currently available technologies. how?

The potential for energy efficiency gains in residential and commercial buildings is not limited by technology but rather by market barriers that impede the rapid market penetration of these cost-effective measures. The probability of realizing the potential savings estimated thus is largely dependent upon the effectiveness of policies in removing the barriers to these investments. barriers + policy

Costs

The investments required to achieve the savings in the National Laboratories study are estimated to have a annualized cost of $7-$14 billion and result in annual energy bill savings in 2010 of $18-33 billion - for a net savings in 2010 of $10-19 billion. The average return on investment is about 20%.

Current Federal Programs and Funding

Realizing the potential savings above requires a proactive set of federal, state and local policies that accelerate technology deployment, energy efficient building design and construction and energy efficient building operations. This is critical because most of the carbon savings by 2010 will result not from new technologies, but rather from increased market uptake of existing and near-term technologies. Maintaining carbon emissions stabilization or cutting emissions further will also require continued technology improvement. Federal agencies, State governments and many local organizations already conduct some programs to move the buildings sector toward a lower carbon future. However, the challenge in implementing such policies is considerable since the industry is so fragmented - there are hundreds of thousands of builders, designers and suppliers. Federal programs at the Department of Energy and the Environmental Protection Agency seek to reduce buildings energy use through diverse means.

- DOE and EPA work with state and local partnerships to improve efficiency of existing buildings through information, demonstrations, technical assistance (e.g., Green Lights, Rebuild America, Energy Star).
- EPA and DOE facilitate the manufacture and purchase of high-efficiency equipment and appliances.
- DOE and EPA work with insurance industry, the financial community, utilities and other market intermediaries to remove barriers to investments in energy efficiency.
- DOE conducts research and development of a portfolio of advanced buildings technologies - such as fuel cells in buildings, reflective surfaces and materials, and advanced windows.
- DOE works with State and local partners to improve efficiency of low income housing.

The total current budget for these programs is about $300 million per year - of which $150 million per year is for low income weatherization and State grants. The Administration has requested additional funding for these efforts.

Electric Power

Key Findings

- Emissions from this sector, which were 481 MT in 1990, are forecast to increase from 506 MT in 1995 to 626 MT in 2010. Potential reductions from this sector (230MT+) will make up a substantial portion (25-50% or more) of the total needed to stabilize national emissions.

- Increased use of natural gas, demand-side efficiency and renewable power are the main means of reducing emissions. Natural gas use could increase in this sector by 15-50% depending on the relative economics of these options. Renewable power will increase by about one-third above baseline levels. Coal use will decline by 25-60%. According to the IAT, average electricity prices will rise by about 25%. Capital investment costs of $3-5 billion/year compare with baseline forecasts of $10 billion/year, but fuel and operating costs will also increase by a similar amount.

- No major technology breakthroughs are needed to achieve GHG emissions goals. Incremental improvements in combined-cycle turbines, renewable energy (particularly wind turbines and biomass fuel and gasification systems), and transmission systems will lower the cost of emissions reductions. Demand reductions through end-use technology development and adoption will also lower costs.

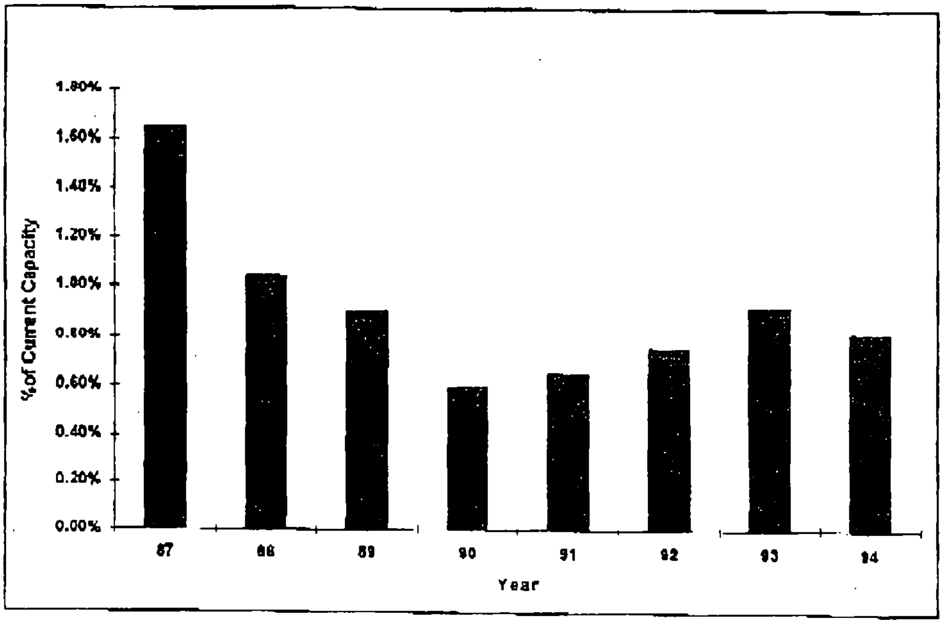
- Competitive trends and air pollutant regulation will need to be integrated with climate policy.

Background

Electric power meets just over 30% of US energy demand. Electric power generation continues to grow in tandem with economic growth, unlike most other forms of energy consumption. Electric power sales of roughly $200 billion represented 3% of US GDP in 1995. Despite advances in the efficiency of fuel use, US electric power supply maintains an historic reliance on coal and (increasingly) natural gas, leading to an upward GHG emissions trend that is expected to continue in the absence of climate policies.

The critical role of capital turnover is demonstrated by the near-absence of power plant retirements in the 1990s (See Figure 1 below). Access to new markets, regulatory uncertainty and regional conditions have all contributed to the slowdown of plant replacement, with planned 10-year retirement rates falling below 1% in 1989 and holding at low levels through the 1990s. This implies a 1,000-year period to turn the entire stock over once, an extraordinary (and presumably temporary) situation.

Fig. 1: 10-Year Plant Retirement Forecasts, 1989-1994



Coal will continue supplying more than half of the Nation's electric power through 2010. Coal consumption, of which 90% is in the electric sector, will reach 1 trillion tons in 1997, and by 2010 is expected to reach 1.1 trillion tons. Natural gas supplies 15% of US power, near its historic peak share, and is growing most rapidly today. Nuclear power, currently 20% of the US power supply -- an historic high -- will decline as plants age and face increased competition.

Most renewable power is currently hydroelectric, supplying 9% of US electricity. The potential for hydro expansion is limited. Non-hydro renewables currently account for about 2.7% of the US power supply. Some renewable technologies, such as wind and geothermal, are rapidly becoming economic and could grow quite rapidly between 2000-2010. Co-firing of biomass with coal at existing power plants also has a large potential for reducing emissions by 2010. To be commercially viable, costs of renewable technologies, which are declining from current levels of around $0.05/kWh, need to reach below $0.03-0.035/kWh (in the absence of high fossil fuel prices). Wind power may reach this goal by 2005.

CO2 Reduction Potential and Scenarios

This sector will be a key contributor to any GHG emissions reduction strategy. The IAT results show this sector reducing emissions by 20-33%. Because there are no direct emissions control technologies, achieving reductions relies on reducing demand or changing fuels. The rate of turnover in the capital stock becomes an important factor in determining both the means and the cost of GHG emissions control in the electric power sector.

The dominant emission reduction option is to use natural gas in place of coal, either through co-firing or repowering in existing coal units, or through increased use of new high-efficiency gas plants. Baseline (AEO97) coal capacity is forecast to increase from 315 GW in 1995 to about 330 GW in 2015 (including 40 GW of new plant and 25 GW of retirements) with virtually no coal-gas switching in existing plants. GHG policy will lead to less new coal capacity, more retirements, and some fuel switching at existing units. By 2015, coal *capacity* will fall to 275 GW, a drop of 55 GW or 15%. About 10-20 GW of coal-gas conversions are forecast, consistent with the Interlab study. Coal *use* (both in the electric sector and nationally) will decline by 25-60% if a stabilization target is met. Fuel use is affected more than installed capacity, because of resulting changes in dispatch. Competitive responses by coal producers and coal-fired generators can be anticipated, but most models already assume rapid gains in mining productivity and additional gains in coal plant efficiency. Economic options for life extension and repowering are also considered.

Stabilization will result in very large increases in gas combined-cycle generation. In some cases, natural gas becomes the dominant fuel in the power sector, tripling from base case levels to around 40% of all power produced. Natural gas use is affected by several sectors and competing fuels and is very sensitive to assumptions. IAT models project increased net gas demand in the electric power sector of 15-50%, but this could be offset by declines in other sectors (some models indicate net declines in US natural gas demand under a GHG stabilization policy). Most models show a small increase (about 5%) for a limited period. If electricity demand is reduced through efficiency, however, all of these fuel impacts could be considerably lessened.

Nuclear power tends to be unaffected by climate policy because the trends in the nuclear industry are dominated by other regulatory and market factors. No economic options for nuclear plant life extension have been demonstrated, and the possibility for large amounts of economic early retirements is taken into account in some models. Five to ten plants, with a capacity of 7.2 GW, are economically retired prior to 2010 in the DRI model, for example. Nuclear life extensions in the NEMS model are assumed and are not economically selected.

As part of a GHG emissions reduction strategy, generation from non-hydro renewables will increase. Some models indicate that wind and biomass may become cost-effective options as more emissions reductions are called for. For example, MARKAL-MACRO and DRI both indicate a 35% increase in non-hydro renewable use in 2010 under GHG stabilization. Models may understate the potential of renewables because they do not consider 'green power' demand from consumers, niche markets or dispersed power (small scale production scattered throughout the system).

Further electricity supply options include increasing the efficiency of existing fossil plants, and improving other parts of the power system (mainly the transmission grid) to minimize losses. Impacts on the industry are sensitive to demand responses. Demand reductions of up to 15% of US electric use in 2010 (600 billion kWh) have been studied. When end-use demand is lowered, fewer new high-efficiency natural gas power plants are built and less gas and renewable power is used. Coal use is relatively less affected. Overall costs in the utility sector are lower, with total costs affected much more than the marginal (permit) cost. Electricity sector total costs may be as much as 50% lower under high demand reduction cases, even though permit prices are only 15% lower. Combining end-use efficiencies with new supply technologies yields the lowest cost estimates for achieving substantial emissions reductions in the power sector.

Costs

Physical responses are generally similar between models, but the estimated costs of reducing emissions vary. The cost of replacing power from an existing coal plant with a new natural gas plant may appear similar between models (see box), given assumptions for fuel and equipment costs in 2010. The recent Interlab study, along with other engineering cost studies, point to very large emissions reductions available for around $50/ton C.

However, the modeled costs of reducing emissions are quite different, ranging up to $100/ton or more in some analyses. These differences largely result from assumptions about capital replacement decisions and cost allocation. For example, current ratemaking practice often requires 'front-loading' of capital payments for new plants, but this may change with increased competition in favor of 'levelized' or constant capital recovery. Another reason for differences in cost estimates is the response of fuel prices to the climate policy. As coal use begins to decline, coal prices may fall, requiring larger incentives to achieve further emissions reductions. Similarly, natural gas prices may rise if net US consumption increases. These fuel price dynamics are important drivers of overall policy cost.

Other factors include some early coal-coal switching as more efficient coal plants replace less efficient ones, and assumed limits on the rate of capital turnover. As a result, estimates of delivered (weighted average) electricity price impacts vary: +25% in DRI, +40% in NEMS. If a simple $50/ton carbon value is applied, as in the Interlab study, delivered prices may only rise by 15-20%.

Fuel switching cost analysis, costs in cents per kWh
Assumes baseloaded units at 70% capacity factor, capital recovered over 30 years (levelized)

Year=2010			
Non-fuel costs (capital plus O+M)			
	DRI	NEMS	IPM
Old coal	0.55	0.76	0.55
New gas	0.5	0.74	0.5
Fuel costs—without C tax (2010 baseline)			
	DRI	NEMS	IPM
Coal	0.89	1.14	0.72
Nat. gas	1.61	1.62	1.39
Total production costs--without C tax			
	DRI	NEMS	IPM
Old coal	1.44	1.9	1.27
New gas	2.11	2.36	1.89
Split	0.67	0.46	0.62
$/ton C	**54**	**31**	**50**

Total costs of GHG policy in the utility sector will be in the $5-15 billion/year range, compared to 2010 baseline (incremental) production costs of about $70-75 billion per year. Of this, about half is due to capital investment and half to increased fuel and other operating costs. Increased capital expenditures of $3-6 billion/year compare to 2010 baseline levels of around $10 billion per year, while baseline fuel and operating costs are about $65 billion per year. The bottom line financial outlook is uncertain because of changes in the electric power industry itself. Changes in production costs have not reduced profits under regulated ratemaking. The effects of such changes in a competitive market depend on the structure of the market and the distribution of costs among competing producers. Some renewable technologies, for example, have very low variable costs because they do not buy fuel. Such plants, once built, can actually reduce market prices, depending on the bidding or dispatch rules. State and federal policy towards new entrants, cleaner suppliers, or pollution credits are also important (as noted below).

Current Federal Programs and Funding

Although the technology and know-how to reduce GHG emissions exists today, several related challenges must be met in order to reduce costs and integrate climate policy with increased competition and more stringent air quality standards. Federal research and development, partnership programs, and policy decisions can all contribute to success.

The success of energy research and development can be measured by the performance of currently available power plants. Natural gas combined cycle systems have a combination of decreasing cost and increasing performance that has changed the industry. Renewable energy cost and performance goals have also been met, but the decline in fossil fuel prices has moved the goalposts. More aggressive goals are now in place for the 2005 time frame. Achieving these goals will require ongoing support for R&D and pilot plant deployment cost-sharing. Less mature or broadly applicable technologies, including solar photovoltaic and fuel cell systems, are vulnerable to R&D shortfalls in the near to mid term. R&D on power delivery systems, including transmission efficiency, is also a needed investment. Programs to market these technologies for export will improve their viability in the US through experience and expanded production capacity.

A carbon constraint will be introduced at the same time as a competitive restructuring of the industry and the implementation of the NAAQS. The combination of open power markets and market-based air regulation (i.e. a set of cap-and-trade systems for SO_2, NOX and CO_2) will likely make climate-related policy incentives work faster and more effectively. At a minimum, there will be interactions between these changes which will alter the emissions profile of the sector.

For air regulations, early analysis using IPM and NEMS indicates that although new ozone and particulate matter rules will have a limited effect on CO_2 emissions (a reduction of approximately 5% from 2010 baselines), GHG limits could induce significant reductions in the criteria pollutants, on the order of 5-10% for SO_2 and 25-35% for NOX.

Initial work on competitive power markets indicates that the ongoing restructuring of the power industry may have important effects. GHG emissions may increase in the near term (by perhaps 5-7% in the first ten years), due to increased sales by the cheapest coal units and higher demand. But competition may prove helpful in the long run if new technologies can readily enter markets, and if market-based incentives are a part of climate policy. One great unknown is the potential demand for cleaner power on the part of consumers, who will have new information and choices.

Combining market-based environmental policy, consumer choice, and new technologies may offer greater efficiency and enable the power sector to provide electricity that is both cleaner and higher-value. The technologies and physical changes needed for large-scale GHG emissions reductions appear to be reasonably achievable, although the costs of reductions are less certain. Industry restructuring, air regulations, and climate policy can work together, if closely integrated to achieve the best fit.

Industrial Emissions and Economic Impacts

Key Findings

- Based upon data from AEO97, the industrial sector used 33.8 quads of energy in 1995, about 37 percent of the nation's total energy requirements. This includes both process energy and chemical feedstocks. The sector was responsible for 33 percent of the overall U.S. greenhouse gas emissions in 1995. By 2010 industrial energy use will grow to 39.7 quads, a 17 percent growth over 1995 levels. In energy terms, this is the second fastest growing end-use sector, just below the 19 percent growth in energy consumption for the economy as a whole. Carbon emissions will follow a similar pattern, increasing from 464 to 549 MMT in the years 1995-2010. Emissions in 1990 were 452 MMT.

- The industrial sector has the potential to reduce energy use and carbon emissions by 10-15 percent over 2010 baseline forecasts through cost-effective investments in energy efficient technologies, and in some cases, low-carbon technologies.

- The annual investment necessary to achieve this level of carbon reduction is on the order of $2.3 to $3.8 billion per year through 2010. This is about 2-3 percent of the investments made by the manufacturing sector in 1995. Such investments should have only a small impact on the rate of capital stock turnover compared to a base case — accelerating the depreciation rate, for example, from a 30-year to a 29-year average life of equipment and structures. For the energy-intensive industries such as petroleum refining and chemicals, capital stock turnover will have to increase at a quicker rate than for industry as a whole.

- Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features. Since these new technologies tend to lower the overall cost of doing business, investments in energy efficient technologies may actually improve the competitive position of many industries.

- These energy savings and reduction in carbon emissions are unlikely to happen without policy measures driving the improvement in the industrial capital stock. barriers + policy

Background

The industrial sector has made important strides in reducing overall energy intensity over the past 25 years. However, there are still readily-available but underutilized technologies with two and three-year paybacks that can reduce industrial energy use by 10 percent or more. The use of heat recovery and combined heat and power (i.e., cogeneration) systems, for example, can save 10 percent of energy use with an internal rate of return of 30-60 percent. Better maintenance of compressed air systems can save 40 percent of the energy used in such systems. And more energy-efficient motor systems can also provide a significant source of electricity savings.

Broadly speaking the industrial sector includes farming and ranching, agricultural services, fisheries, forestry, mining, construction and manufacturing. While many policy analysts think of "industry" as a homogenous set of economic activities, it embraces an incredibly diverse set of processes ranging from the growing and processing of food products to the production of paper, plastic resins, cars and computers. The process and energy requirements of each of the individual industries that are within the industrial sector are as different as the products that they produce. While many products have similar uses, the processes involved in making them may be vastly different. For example, plastic drink bottles, glass drink bottles, and aluminum cans all are similar products; however, they share almost no processes in common. For this reason, it is important to develop climate policies which reflect these important differences among the industrial sectors.

Based upon data from the Energy Information Administration, the industrial sector uses 37 percent of the nation's energy in 1995, or 33.8 out of a total 90.9 quads. Carbon emissions were at 32 percent or total emissions in the United States, or 464 of 1424 MMT. With normal rates of capital stock turnover, the industrial energy intensity is expected to decline at a rate of 1.2 percent in base case forecast for the period 1995-2015 (*Annual Energy Outlook 1997*). Industrial carbon emissions are expected to climb to 549 MMT by 2010.

Savings Potential

The DOE National Lab study (*U.S. Carbon Reductions by 2010 and Beyond, 1997*) suggests that by 2010, the technology exists such that overall energy consumption can be reduced by 2.0 to 3.8 quads over the baseline forecasts. The level of energy savings are roughly the same for both electricity and fossil fuels. Carbon savings of a high efficiency/low carbon scenario are on the order of 125 MMT when electricity savings are credited to the industrial sector. A new study published by a consortium of non-governmental organizations suggests an overall energy savings potential of 3.75 quads of energy and 136 MMT of carbon in the year 2010 (*Energy Innovations*, 1997). Most analysts agree that in the period 2010, this is a reasonable level of savings — given available technology and reasonable rates of capital stock turnover. By 2030, however, the *Energy Innovations* study suggests carbon emissions can be lowered by as much as 41 percent below 1990 levels (again with electricity savings credited to the industrial sector based upon kilowatt-hours sales).

The table on the following page summarizes key indicators for the industrial sector for the years 2010 and 2020. The Markal-Macro simulation for 2010 suggests a potential carbon savings of 17 percent compared to baseline projections. The DRI model suggests a similar level of savings, estimated to be 15 percent of the base case forecast in 2010. Savings of this magnitude suggests that industry may be able to stabilize close to its 1990 levels of carbon emissions by 2010 without reducing industrial output.

Costs

In the Lab study a combination of energy efficiency investments and low-carbon are used to reduce carbon emissions. The incremental investment costs are estimated to be $11.60 to $13.88 per mmBtu. Based upon the AEO97 energy costs for the year 2010, this reflects a payback period of 1-4 years. According to the Lab study, the cumulative investment requirements are between $23.2 and $47.2 billions of 1995 dollars in the period 1998 through 2010. If the cumulative investment is averaged out over the 13 years of analysis, this is about 2-3 percent of the investments made by the manufacturing sector in 1995. The energy-intensive industries will have to invest at a higher rate. On the other hand, according to the Lab study, more energy savings can be obtained in the faster growing and less energy-intensive light manufacturing sectors.

Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features. A technology that reduces product loss or increases process throughput, for example, will often reduce labor and other material costs as well as energy costs (See, for example, the variety of papers contained in the proceedings from the *1997 ACEEE Summer Study on Energy Efficiency in Industry*). These additional co-benefits are generally not reflected in the results of either the MM or the DRI models. Hence, the benefits to the industrial sector may be somewhat understated. Stated differently, the competitive position of many industrial sectors may actually be strengthened — depending upon the type and flexibility of the climate policies that are actually implemented. These energy savings and reduction in carbon emissions are unlikely to happen at this level, however, without additional policy measures to drive the needed improvements in the industrial capital stock.

yes policy

if it's a win-win then why the need for policy

Sector Impacts Papers

Industrial Sector

1) Win-win claim: The author argues that "since these new technolgies tend to lower the overall cost of doing business, investments in energy efficicent technologies may actually improve the competitive position of many industries." Then why haven't they already adopted these technolgies?

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

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

Electric Power Sector (also see comments on renewable energy sector discussion)

1) Changing the rate of investment: This raises the capital issue discussed in the industrial paper. Coal plants are, for the most part, fully depreciated. Therefore, the costs of coal-based electricity result from variable cost factors only. Switching to new forms of power requires significant capital investments. Will the US subsidize solar and wind like it did hydro?

Renewable Energy Sector

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

2) Wind and solar power vary spatially: It would be interesting to know where wind power and solar power are most cost-effective. Some regions can definitely support one or the other better than other regions. However, is this an issue with deregulation of the utility industry?

Compare future renewable prices w/ future coal prices

3) Factors that accelerate use of renewable energy: The author identifies four factors. Actually, the first two factors are the same: consumer choice and price premium for "green" energy. The third factor is that states may require utilities to pass some renewable energy portfolio standards -- such standards eliminate the likelihood of a green energy premium, since consumers could not differentiate between utilities if they all provide green energy. The fourth factor is that lower renewable energy costs will spur more investments, especially relative to rising fossil fuel costs. The key there is that renewable costs have to be close to fossil fuel costs for any significant investments beyond what we experience today (and with expectations of rising fossil fuel costs).

Buildings Sector

1) Barriers to adoption: The author notes that there "is clear evidence that many of the potential reductions are not being realized in the current market system because of a number of institutional, organizational, and other barriers that work against the diffusion of energy-efficicent technologies." The list of barriers include: insufficient information, lack of expertise for design, lack of low cost sources of capital, and inability for efficiency purchasers to fully capture rents. IF the government should try to lower market barriers, should it target these issues?

2) Cost savings of technologies: The author notes that an array of technologies (unspecified) can have an annualized cost of $14-$24 billion/year with an annual energy bill savings of $33 billion. I would like to see this broken down by each technology (some may be big winners and others could be losers). Also, I would like to know the cost assumptions in estimating energy bills (since the modeling efforts presume significant increases in electricity prices).

Electric Power Sector: M-M + DRI indicate a 35% increase in non-hydro renewable use in 2010 under GHG stabilization (p. 3)

Renewable Energy:	1995	2010
EIA	9	14
M-M	9	31-33
DRI	9	?

is hydro making up the difference?
are different assumptions made about natural gas?

Eric Peterson
586-5389
fax 586-2176

The Carbon Reduction Potential in the U.S. Buildings Sector

July 8, 1997 Draft

Summary

Substantial reductions in greenhouse gas emissions are possible in residential and commercial buildings through greater use of cost-effective energy efficiency technologies that not only cut energy use, but also save consumers and businesses money. Estimated potential carbon emissions savings in the residential sector are 13-40 million metric tonnes (MMT) in 2010 and 30-70 in 2020. In the commercial sector, potential emissions savings are 13-40 million metric tonnes (MMT) in 2010 and 30-70 in 2020.

Background

Energy is used in buildings to provide a variety of services such as space heating and cooling, lighting and refrigeration and to power a broad array of appliances and equipment. U.S. buildings energy consumption accounts for nearly one third of total primary energy consumption and related greenhouse gas emissions. The 1996 bill for these energy services was over $200 billion.

Energy intensity in buildings has declined substantially over the past twenty years. Energy use per square foot of commercial space declined by about 30% between 1979 and 1992, while residential energy use per square foot has dropped by 18% since 1978. Despite these past gains, the latest EIA business-as-usual forecasts project that commercial energy use in the future will decline by only 0.2% per year, and residential energy use by 0.5% per year. However, numerous studies (National Academy of Sciences, 1991 and Office of Technology Assessment, 1991, EMF-12, 1994) have indicated that a substantial potential remains for cost-effectively reducing U.S. energy consumption and greenhouse gas emissions - particularly in buildings.

Despite the large opportunity, there is clear evidence that many of the potential reductions are not being realized in the current market system because of a number of institutional, organizational, and other barriers that work against the diffusion of energy-efficient technologies. These barriers include lack of appropriate and reliable product information; split incentives between efficiency purchasers and those receiving benefits; lack of expertise for design, installation and operations; and low cost sources of capital.

Potential

Analysis results indicate that large reductions in future greenhouse gas emissions could be realized through the use of more energy-efficient technologies at a net reduction in the total cost of energy services in residential and commercial buildings. The table below shows the baseline EIA projections of primary energy consumption in a future without a global climate treaty, any market signals to reduce carbon emissions or substantial technological advances in these areas.

	1995	2010	2020[1]
Residential total (quads)	10.5	11.9	13.8
Commercial total (quads)	7.1	8.1	8.9
Buildings total (quads)	17.6	20.0	22.7

[1] Markal/Macro Base Case

The potential energy use reductions indicated by the IAT analysis are shown below. These results assume a binding international climate treaty leading to increased emphasis on U.S. carbon emissions reduction as well as federal and State policies to accelerate the use of existing cost-effective energy efficient buildings technologies.

	Markal		DRI		Labs Study
	2010	2020	2010	2020	2010
Residential total (quads)	1.2-2.5	3.4	1.4-1.5	1.6-2.1	0.5-1.1
Commercial total (quads)	1.1-1.2	1.4	1.0-1.2	1.6-1.7	0.6-1.1
Buildings total (quads)	2.3-3.7	4.8	2.4-2.7	3.2-3.8	1.1-2.2

The IAT number translate into carbon savings of 26-33 MMT in 2010 and 35-44 MMT in 2020. A complementary bottom-up analysis is contained in the forthcoming study by five national laboratories, U.S. Carbon Reductions by 2010 and Beyond: The Potential of Energy Efficient and Low-Carbon Technologies. This study, which is a much more detailed sectoral analysis, indicates a lower overall energy savings potential, but a significantly higher electricity savings potential. As a result, estimated potential carbon emissions savings are 25-50 MMT. The major sources of reductions include residential miscellaneous uses, commercial other uses (such as office equipment), lighting and space conditioning. These investments are estimated to have a annualized cost of $14-$24 billion, but result in annual energy bill savings of $33 billion.

While the IAT and the national laboratories study differ on the precise size of the potential for these three markets, they do agree that they are substantial. This suggests a need for additional technology development and deployment in these areas as part of a national climate strategy.

Implications

The IAT analysis results are rather difficult to place in context because of the top-down method of analysis. The National Laboratories study, however, is quite clear on what is required, as it is based on a technology-by technology and end-use by end-use analysis. In order to achieve the lower end of the range, about 35% of buildings in 2010 need to be using existing cost-effective buildings technologies. The high end of the range requires 65% of buildings in 2010 to use such technologies. Efficiency gains could be higher, but would require lower technology capital costs than those assumed in the analysis. This range does not require premature retirement of capital stocks - only normal retirements of various equipment and currently expected renovation timing.

The key opportunities for efficiency gains in the residential sector include miscellaneous electrical appliances such as electronic equipment and small appliances, lighting, water heating, space heating, air conditioning and refrigeration. End-use energy savings in the top three areas are estimated to be 0.7, 0.2 and 0.3 quads, respectively. Overall, these results require the average energy efficiency of residential equipment in the affected buildings to improve by 12% over the next 13 years. The specific rates of improvement vary substantially among end uses - from 50% in lighting to 30% for miscellaneous electrical appliances to 12% for air conditioning to 10% for electric space heating. Building shells are assumed to become 4-14% more efficient. All these improvements are based on currently available technologies.

The opportunities for efficiency improvements in the commercial sector include miscellaneous electrical and natural gas uses (such as telecommunications equipment, medical equipment, pumps, light product assembly and many other activities not easily categorized), lighting, space heating and air conditioning. End-use energy savings in the top three areas are estimated to be 0.4, 0.4 and 0.3 quads, respectively. These results require the overall energy efficiency of commercial equipment in the affected buildings to improve by 18% over the next 13 years. The specific rates of improvement vary substantially among end uses - from 30% for miscellaneous electrical appliances to 25% for air conditioning to 20% for lighting to 20% for gas space heating. As in residential, all these improvements are based on currently available technologies. Thus these estimates appear plausible relative to the performance improvements, stock turnover and infrastructural investments they imply.

The potential for energy efficiency gains in residential and commercial buildings is not limited by technology but rather by market barriers that impede the rapid market penetration of these cost-effective measures. The probability of realizing the potential savings estimated thus is largely dependent upon the effectiveness of policies in removing the barriers to these investments.

Actions
Realizing the potential savings above will require a proactive set of federal, state and local policies that accelerate technology deployment, energy efficient building design and construction and energy efficient building operations. This is critical because most of the carbon savings estimated above will result not from new technologies, but rather from increased market uptake of existing and near-term technologies. Maintaining carbon emissions stabilization or cutting emissions further will also require continued technology improvement. Federal agencies, State governments and many local organizations already conduct programs to move the buildings sector toward a lower carbon future. However, the challenge in implementing such policies is considerable since the industry is so fragmented - there are hundreds of thousands of builders, designers, suppliers and others. Some of the federal actions that will need to continue or begin include:

- working with state and local partnerships to improve efficiency of existing buildings through information, demonstrations, technical assistance (e.g., Rebuild America, Energy Star);
- facilitating the manufacture and purchase of high-efficiency equipment and appliances;
- working with the insurance companies, financial industries, utilities and other market intermediaries to remove barriers to investments in energy efficiency;
- Accelerated development of a portfolio of advanced buildings technologies - such as fuel cells in buildings, reflective surfaces and materials, and advanced windows.

Skip
233-9833

Transportation: Light Duty Vehicles and Carbon Emissions

Key Findings

- Based upon data from AEO97, the transportation sector will use about 25.4 quads of energy in 1997, about 27 percent of the nation's total energy requirements. Because of its almost total dependence on petroleum fuels (accounting for 97 percent of total energy use), the transportation sector is responsible for 34 percent of the overall U.S. greenhouse gas emissions.

- Light duty vehicles, including automobiles and light trucks, will account for about 58 percent of the nation's total transportation energy requirements in 1997. In contrast, freight trucks will use only 16 percent of the transportation energy in 1997. The remaining 25 percent of the transportation share will be used by air, rail and marine travel, pipeline fuels and lubricants.

- The transportation sector has the potential to reduce energy use and carbon emissions by 15-20 percent over 2010 baseline forecasts through cost-effective investments in energy efficient technologies, and in some cases, low-carbon technologies. The savings can be achieved without significantly affecting either comfort, safety or travel.

- The anticipated 2010 energy and carbon savings could be achieved in the case of automobiles, for example, if new car sales in that year achieve one-third of the fuel economy represented by the PNGV goal of 80 MPG.

- Assuming that PNGV cost goals are not met, and that the price of new vehicles in 2010 reflect current estimates of new technology costs, a 45 MPG car will cost between $800 and $1,200 more than a 28 MPG car (in 1995 dollars). Assuming 13,600 vehicle miles traveled for new vehicles and a gasoline price of $1.23 in 2010 (also in 1995 dollars), this implies a roughly 3.5 to 5.3 year simple payback for a car that has an expected 14-year lifetime.

Background

After a roughly 15-year period (1975-1990) of energy efficiency improvements in the nation's vehicle fleet, energy use in the transportation sector now appears to be growing at nearly the same rate as the gross domestic product (GDP). In the case of light duty vehicles, the growth in energy consumption is driven by increases in the vehicle miles traveled (VMT), and the significant growth of light trucks (including vans, sport cars and recreational vehicles) which have a substantially smaller fuel economy. The sales of light trucks have grown from a 20 percent market share in 1975 to a 40-percent market share in 1994. Whereas new cars are rated at 28 MPG, light trucks enter the market with a rating of only 20.5 MPG.

Savings Potential

Despite the significant growth in energy use by light duty vehicles, the technology exists to increase the average fuel economy of the nation's transportation fleet by 40 percent or more in the year 2010 — without the need for reduced travel or increases in the cost of travel. This is true in both the movement of people and freight. This success would be achieved in the case of automobiles, for example, if new car sales achieve one-third of the fuel economy represented by the Partnership for a New Generation Vehicle (PNGV) goal of 80 MPG.

Major technologies for near-term light duty vehicle improvements include, for example, material substitution, reduced aerodynamic drag, improved automatic transmissions, reduced engine friction, variable valve timing, and advanced tire designs. Many of these technologies have already emerged in the market, lacking only appropriate policy signals to accelerate their diffusion, or to redirect their use toward fuel economy instead of improving other vehicle attributes. Honda, as one example, employs a system of variable valve timing that is used to boost power and improve fuel economy. General Motors has one vehicle that has already achieved a low aerodynamic drag. On the other hand, lean-burn engines which increase engine thermal efficiency are a low-risk technology that should be readily available by 2010.

argues for policy to eliminate barriers

Work developed for the "Car Talk" advisory committee[1] resulted in estimated reductions of both energy use and carbon emissions (measured in million metric tons of carbon, or mmMTCe) through a variety of both technology and policy options. Summarized in the table below, and generally covering the period 2005 through 2025, the options include improved land-use planning, higher fuel prices, fuel economy standards and feebates, the PNGV vehicle, and the use of low life-cycle carbon fuels.

Modeling a different set of technology assumptions showed a significantly different set of results. DRI focused on largely behavioral response to reduce transportation energy consumption, while Markal-Macro had a larger technology bent. The table on the following page highlights these differences. (Note: the reference to CCAP is the so-called Case Two scenario which moved toward but did not necessarily hit a rate of decline in E/GDP of 1.25 percent. This compares to an assumed 1.00 percent decline in the base case. The Case two scenario includes both the full set of CCAP programs as well as "announcement effect." Case three, the Technology Case formerly described as the 1.75 Case, assumes a higher level of investment potential for cost-effective energy efficient/low-carbon technologies.)

In case two (with stabilization), DRI forecasts a 9 percent reduction in VMT with an 8 percent increase in MPG for new automobiles. DRI's case three (with stabilization) forecasts a 5 percent VMT reduction with a 10 percent increase in new car MPG. MM shows a seven percent drop in VMT for the CCAP scenario. This rebounds, however, to nearly base case levels with better assumptions about improved levels of technology. Although new cars in MM enter the market in 2010 with a high EPA-rated fuel economy (again, with about one-third of the improvements of the PNGV goal), the entire fleet of automobiles show an on-road MPG of only 30 MPG because of the time needed for fleet turnover. Hence, it is the on-road change in fleet fuel economy — moving from 24.2 to 30 MPG — that drives much of the transportation energy and carbon savings.

In the Markal-Macro assumptions, a new vehicle at 45 MPG would cost an estimated $1,200 above new cars in the base case. The newly releases *Energy Innovations* study suggests an added cost of about $800 dollars (in 1995 dollars). However, owners of the new vehicles would save about $225 per year in avoided gasoline costs (also in 1995 dollars, assuming an average driving range of

1. The "Car-Talk" committee is the *Policy Dialogue Advisory Committee to Assist the President in the Development of Measures to Significantly Reduce Greenhouse Gas Emissions from Personal Motor Vehicles* formed in 1993 to see whether a consensus set of policies could be developed to return personal transport GHG emissions to 1990 levels by 2005, 2015 and 2025. The committee failed to agree on such policies, but substantial analytic results were developed by a team of government analysts working with several expert committee members.

13,600 miles per vehicle and a cost of gasoline of $1.23 per gallon). Simple payback for this technology improvement would range, therefore, from 3.5 to 5.3 years. In comparison, the average life of a new car would be about 14 years.

Car-Talk Summary Table of Policy Options[2]
(mmMTCe)

Policy Measure	Policy Type	2025 Annual Emission Reduction
Land Use and Transit Policy Package	Less VMT	25
Fuel Price Increases ($0.50/gal.)	Less VMT	120
Parking Tax ($2.00 nationwide)	Less VMT	25
Road Pricing	Less VMT	25
Fuel Economy Standards, "Feebates"	More Fuel Efficiency	90
PNGV	More Fuel Efficiency	60-200
Bio-Ethanol Subsidy	Low Emission Fuels	100
GHG Savings Needed to Return Personal Transport Emissions to 1990 Levels by 2020-2025		200-260

Key Automobile Indicators in 2010

	DRI			Markal-Macro		
	Base	CCAP	Technology	Base	CCAP	Technology
VMT	1526	1403	1450	1619	1509	1597
MPG New Car (EPA)	29.2	31.4	32	30.7	43.4	44.7
MPG Car Fleet (EPA)	24.7	26.5	30.6	29.3	32.7	35.7
MPG Car Fleet (On-Road)	23.3	24.5	26.9	24.4	27.3	30

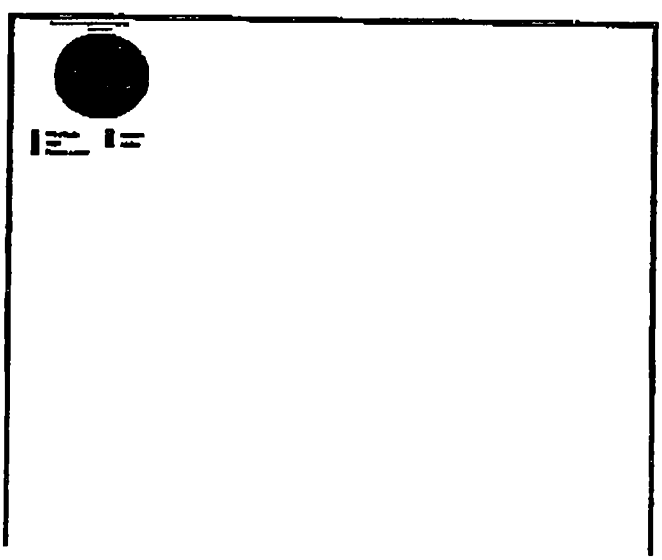
2. Emission reductions may not be added since the impact of implementing multiple policies may be significantly less than is implied by adding up the individual estimates. However, the motor vehicle GHG model used to develop most of these estimates can be used to forecast the effect of multiple policies.

260-2724

Freight, Aircraft and Rail
Emissions Projections and Potential for Reduction

Key Points

- Total carbon emissions from the transportation sector in 1995 were nearly 470 MMT. The freight, aircraft and rail sectors accounted for nearly 200 MMT of carbon emissions, or 42 percent of all transport emissions.
- All modes of freight transport, including trucks, rail, pipeline, shipping, and air, have improved their energy efficiency. However, intermodal shifts to more energy-intensive trucking and air transport has meant very little change in the amount of energy used to haul a ton of freight from 1972 to 1995.
- Energy use and carbon emissions from non-personal vehicles is likely to surpass energy use and emissions from automobiles shortly after the millenium.
- Opportunities to reduce carbon emissions or energy use in commercial vehicle transport before 2010 will likely come mainly from trucking and air transport. Analysis of possibilities in a study by 5 DOE laboratories estimated that roughly 20-45MMT could be saved by new technologies, increased use of cellulosic ethanol fuel, and improved traffic flows. About 10 MMT in reduced emissions come from trucking, 10-15 come from air transport, and 7-10 from rail. Beyond 2010, further significant reductions are possible through improved aerodynamics (laminar flow) and more efficient propulsion in aircraft, and in rail and trucking, major improvements could be made if hybrid/fuel cell powertrain technology can begin to capture more than a trivial share of the market.
- To achieve the savings in emissions by 2010 will require a more aggressive program of research and development in conventional powertrains and propulsion, as well as policies to encourage the use of new technologies and/or capital turnover. The same is true, but at significantly greater scales, of very low emission or zero emission technologies like fuel cell/fuel cell hybrid powertrains in rail and truck, and advanced laminar flow technologies in aircraft.



Background

The transportation sector, which includes both personal transportation (cars and light trucks, rail and air) and freight (heavy trucks, rail, aircraft, pipeline, and ships) accounts for almost 11 percent of U.S. GDP. The freight sector accounts for about a third of that.

Total emissions from freight and aircraft were just over 200 MMT, with heavy trucks and aircraft each accounting for about one-third of the total. Aircraft emissions account for all aviation, including freight, passengers, and military, with the lion's share of aviation carbon emissions coming from passenger travel. Air freight was estimated at 1% of all air transport in 1989, and while it is the fastest-growing mode of non-local freight transport, it probably only accounts for a few percent of all freight transport in 1997. The share of emissions due to freight alone is unavailable, as many commercial flights carry both passengers and freight.

The U.S. economy moves more ton-miles of freight every year, on every mode. All modes of non-local freight transportation increased between 1970 and 1994. Air freight increased the most (434%), followed by trucks (210%), rail (57%), pipeline (41%), and water (37%). Water, rail, and trucks are each responsible for about 25% of freight movement, measured in ton-miles.

Truck use for freight has increased dramatically in the last 15 years. Historically, rail has had an advantage in hauling heavier frieght. In recent years, however, trucking loads have grown heavier; between 1982 and 1992, mileage traveled by trucks with operating weights above 80,000 lbs. increased193%, and 120% for trucks below 33,000 lbs. The average length of haul increased from 224 miles in ~~1994~~ to 817 miles in 1994.

All modes have consistently improved their energy efficiency. Improvements have come from both technology and operational efficiencies. Between 1984 and 1994, heavy truck energy use per vehicle mile decreased 0.4% per year, and 1.6% annually per ton-mile. In rail, energy use per car-mile dropped 0.9% per year, and 2.7% annually per ton-mile.

Between increasing efficiency and the shift to more energy-intensive modes (trucks and air), the net energy effect is about a wash: if energy intensities of 1972 still prevailed, 1994 freight movements would have required about as much energy as was actually used in 1994 to haul more than three times the amount of freight.

Trends

According to Argonne National Laboratory, total energy use by non-personal vehicles is expected to surpass that of personal vehicles before 2005. Improvements in fuel efficiency improvement have slowed in personal vehicles, but continue in other modes of transport. In freight, the weight and cost of fuel carried has a direct effect on the amount of freight that can be carried, so there are incentives to improve fuel efficiency even when fossil fuel prices are low.

Trucks and aircraft are expected to continue as the fastest-growing forms of non personal transport, and will account for the greatest increases in emissions. The airline industry, since deregulation, operates close to maximum efficiency, and opportunities to use alternative fuels in aircraft are limited. Therefore most of the opportunities to reduce emissions from aircraft are in development and deployment of more fuel-efficient engine and airframe technology.

Reducing emissions from surface freight, on the other hand, is possible through both technological improvement and progress in reducing inefficient use of trucks (e.g. continued reduction in empty backhauls, more efficient routing, intrastate warehousing) and shifting from trucks to rail.

Results and Potential for Reducing Emissions

Neither DRI nor SGM include technological advances that affect emissions, or energy consumption, in the freight sector. DRI, in fact, assumes constant MPG for all heavy trucks through 2010, at just over 5 mpg, less than the average for heavy trucks now (approximately 6.8 mpg on-road).

Markal Macro includes several advanced technologies to improve the energy and carbon efficiency of freight. All three cases (base, stabilization with a rate of improvement in the use of energy as a share of GDP of 1.25%/year, and stabilization with an annual rate of improvement of 1.75 percent) bring in more fuel-efficient diesels, with faster rates of introduction in the 1.25 and 1.75 cases. In addition, both advanced technology cases phase out existing gasoline trucks, and penetration of trucks LPGfuel. The 1.75 case shows very rapid penetration of diesel trucks that are 20% more efficient than current diesel trucks, starting in 2010 and accounting for well over 95% of vehicle miles traveled by 2020. Fuel efficiency of heavy trucks increases to 6.9 mpg in the 1.25 case and 7.3 mpg in the 1.75 case of Markal Macro. Carbon emissions in 2010 are forecast to be nearly 98 MMT in the base case, 88 MMT in the 1.25 case and 18 MMT in the 1.75 case (see figure above).

Emissions from rail, freight, air freight and pipelines were specified exogenously for the IAT, since none has more than a marginal impact on energy use and carbon emissions as a whole. The forecast shows emissions from rail freight at 10.5 MMT in the base case, and 9.7 and 9.8 MMT, respectively, in the 1.25 and 1.75 cases. Emissions from shipping are reduced from 8.5 MMT currently to about 7.6-7 for all cases in 2010.

Technology Options: Trucks. There are many opportunities to improve energy efficiency and carbon dioxide emissions in freight. Improved aerodynamic design, advanced diesel engines, vehicle weight reduction through materials substitution, improved tires, and electronic engine and transmission controls can achieve fuel economy improvements ranging from 2 to over 20 percent in heavy trucks, as can advances in computational methods (hardware and software) aimed at understanding turbulence both for aerodynamics and within fuel chambers. More revolutionary technological advances, including the use of fuel cells in powertrains, are possible with an aggressive program to develop fuel cells for motor vehicles, along with the storage devices (batteries and ultracapacitors), fuel storage, and infrastructures supporting increased use of hydrogen fuel. With such a program, it might be possible to introduce hybrid fuel cell/electric powertrains into trucks before 2010, though significant market penetration is very unlikely by then.

Rail. Fuel cell/electric powertrains may be somewhat more likely to happen in locomotives than trucks, though significant market penetration of fuel cells in rail before 2010 is doubtful. The cost of fuel cell power is still prohibitive in rail, but with further development and expansion in the use of fuel cells for other applications (light duty motor vehicles and terrestrial power generation, e.g.) the economics may become more favorable. While widespread use of fuel cells for any kind of transport poses some significant infrastructural, maintenance, and technical problems, there has been significant progress in fuel cell and other hybrid powertrain technology over the past several years, with significant contributions from PNGV and NASA and DOD programs. With increased spending on hybrid powertrain development and the appropriate incentives to develop infrastructure and support for operation and maintenance, fuel cell applications may be possible, though at no significant scale, by 2010.

Technology Options: Aircraft. In aircraft, energy efficiency is a perennial concern primarily because reducing the weight of fuel is one way of reducing aerodynamic drag, a central and constant concern of aircraft and engine designers. NASA programs aimed at achieving greater fuel efficiency in engines were both technically and economically successful in the 1980s, improving the efficiency of existing engines as well as producing new, more efficient jet engine cores and components. NASA and industry (principally GE and Pratt and Whitney) also produced advanced turbofan and unducted fan engines that achieve significant gains in energy efficiency, but have not been commercialized primarily because falling fossil fuel prices reduced the payoff to greater efficiency in the late 1980s; these engines, however, are still available and could be incorporated into aircraft designs with less expense and development expense than clean-sheet designs would entail should they become more attractive options in the future. Ongoing NASA/DOD/industry work on energy efficiency continues, under the Integrated High Performance Turbine Engine Technology program, aimed at achieving a 40 percent improvement in energy efficiency by 2003. NASA research on computational fluid dynamics and numerical simulation is also showing promise for modifying the skins of aircraft to include tiny, micron-thin riblets that could decrease turbulence, and thereby, drag, by 5 or 6 percent, increasing fuel efficiency and airlines' profit margins. It is quite likely that some of these improvements could show up on commercial aircraft before 2010, although full market penetration will take decades due to lengthy capital life.

Intermodal Switching. Intermodal shifting, or switching from truck to rail haul or air transport, has been underway for some time. Intermodal transportation of freight, or using both trucks and rail or aircraft, cuts emissions by relying on more energy-efficient modes (rail and air) rather than trucks for part of the trip. The Department of Transportation estimates in its 1996 annual transportation statistics report that intermodal freight hauls meant 1.5 million fewer large trucks on the highways. A simulation done in Markal Macro shows that diverting 10 percent of truck ton-miles of freight to rail could save 4.3 to 4.7 MMT of carbon. Whether such a shift would be operationally feasible is unknown. Markal Macro includes no cross-elasticities to optimize intermodal shifts, and while DRI does, no shifts occurred in IAT runs of DRI's energy model.

Action

Overall, the IAT model runs could be described as technologically conservative in the freight area. Foreseeable technologies could make more significant reductions in emissions, particularly with more aggressive efforts to develop and diffuse the technologies. Programs to develop transportation technologies such as PNGV and NASA programs on energy efficiency and aerodynamics could probably bring these new technologies to proof of concept or demonstration before 2010, and several, particularly in truck componentry and efficiency, could be well established in the market. Energy experts at DOE's multiprogram laboratories point out, however, that current levels of funding for PNGV are probably inadequate to achieve the program's technical goals.

Technical success in research and development does not assure adoption or diffusion of new technology. Successful completion of the technical program of PNGV and NASA's engine and laminar flow programs must also be followed by investment in commercial development and marketing by industry in order to achieve market penetration. Moreover, capital in the freight sector tends to be turned over quite slowly; with maintenance and overhauls, trucks can last a couple of decades and locomotives and aircraft even longer. Incentives to hasten capital turnover, such as accelerated depreciation programs or investment tax credits, would also help to achieve stabilization. Finally, improving energy and carbon efficiency can also pay off in terms of improved competitiveness of efficient engines and powertrains on international markets.

Market mechanisms can also reduce emissions while improving economic efficiency when prices are brought in line with true costs. Better pricing truck use of highways is justified considering that trucks probably do not pay their fair share for use of federally-funded highways, according to the Department of Transportation. Obliging trucks to pay a greater share of the cost of highway construction and maintenance would also be likely to increase incentives for intermodal switching, as would subsidizing rail transport or operating freight railroads.

laitner.skip@epamail.epa.gov Skip 233-9833
fax 233-9589

Industrial Emissions and Economic Impacts

Key Findings

- Based upon data from AEO97, the industrial sector now uses 37 percent of the nation's energy. It is responsible for 32 percent of the overall U.S. greenhouse gas emissions.
- The industrial sector has the potential to reduce energy use and carbon emissions by 10-15 percent over 2010 baseline forecasts through cost-effective investments in energy efficient technologies, and in some cases, low-carbon technologies.
- The annual investment necessary to achieve this level of carbon reduction is on the order of $2.3 to $3.8 billion per year through 2010. This is about 2-3 percent of the investments made by the manufacturing sector in 1995. Such investments should have only a small impact on the rate of capital stock turnover compared to a base case — accelerating the depreciation rate, for example, from a 30-year to a 29-year average life of equipment and structures.
- Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features. Since these new technologies tend to lower the overall cost of doing business, investments in energy efficient technologies may actually improve the competitive position of many industries. why haven't they been implemented then?
- These energy savings and reduction in carbon emissions are unlikely to happen without policy measures driving the improvement in the industrial capital stock.

Background

The industrial sector has made important strides in reducing overall energy intensity over the past 25 years. However, there are still readily-available but underutilized technologies with two and three-year paybacks that can reduce industrial energy use by 10 percent or more. The use of heat recovery and combined heat and power (i.e., cogeneration) systems, for example, can save 10 percent of energy use with an internal rate of return of 30-60 percent. Better maintenance of compressed air systems can save 40 percent of the energy used in such systems. And more energy-efficient motor systems can also provide a significant source of electricity savings.

Broadly speaking the industrial sector includes farming and ranching, agricultural services, fisheries, forestry, mining, construction and manufacturing. While many policy analysts think of "industry" as a homogenous set of economic activities, it embraces an incredibly diverse set of processes ranging from the growing and processing of food products to the production of paper, plastic resins, cars and computers. The process and energy requirements of each of the individual industries that are within the industrial sector are as different as the products that they produce. While many products have similar uses, the processes involved in making them may be vastly different. For example, plastic drink bottles, glass drink bottles, and aluminum cans all are similar products; however, they share almost no processes in common. For this reason, it is important to develop climate policies which reflect these important differences among the industrial sectors.

Based upon data from the Energy Information Administration, the industrial sector now uses 37 percent of the nation's energy, or 34.4 out of a total 93.6 quads. Carbon emissions are now at about 32 percent or total emissions in the United States, or 471 of 1467 MMT. With normal rates of capital stock turnover, the industrial energy intensity is expected to decline at a rate of 1.2 percent in base case forecast for the period 1997-2015 (*Annual Energy Outlook 1997*).

Savings Potential

The DOE National Lab study (*U.S. Carbon Reductions by 2010 and Beyond, 1997*) suggests that by 2010, the technology exists such that overall energy consumption can be reduced by 2.0 to 3.8 quads over the baseline forecasts. A combination of energy efficiency investments and low-carbon fuels can reduce carbon emissions by 22 to 73 MMT. Industry's share of further carbon reductions available in the electricity sector would increase overall carbon savings by perhaps another 40 to 50 MMT. The incremental investment costs are estimated to be $11.60 to $13.88 per mmBtu. Based upon the AEO97 energy costs for the year 2010, this reflects a payback period of 1-4 years. According to the Lab study, the cumulative investment requirements are between $23.2 and $47.2 billions of 1995 dollars in the period 1998 through 2010. The level of energy savings are roughly the same for both electricity and fossil fuels. A new study published by a consortium of non-governmental organizations suggests an overall energy savings potential of 3.75 quads of energy and 41 MMT of carbon in the year 2010 (*Energy Innovations*, 1997).

The table on the following page summarizes key indicators for the industrial sector for the years 2010 and 2020. The National Lab study suggests that by the year 2010 it is possible to reduce energy use by 5 to 10 percent over the base case forecast through cost-effective investments in energy efficient technologies. The Markal-Macro simulation for 2010 suggests a savings potential of 11 to 15 percent. The DRI model suggests a similar level of savings, estimated to be 11-12 percent of the base case forecast in 2010. These results are somewhat larger than either the National Lab study or the Energy Innovations analysis. Two reasons account for most of this difference. The first is that the Lab study results are reported in primary energy units while the Markal-Macro and DRI results are reported at the end-use. The second is that the consumption reported in the table for both models do not include petroleum or natural gas feedstocks.

Many of the most successful technologies have multiple benefits, including environmental- or productivity-enhancing features. A technology that reduces product loss or increases process throughput, for example, will often reduce labor and other material costs as well as energy costs. These additional co-benefits are generally not reflected in the results of either the MM or the DRI models. Hence, the benefits to the industrial sector may be somewhat understated. Stated differently, the competitive position of many industrial sectors may actually be strengthened — depending upon the type and flexibility of the climate policies that are actually implemented. These energy savings and reduction in carbon emissions are unlikely to happen at this level without additional policy measures to drive the needed improvements in the industrial capital stock.

Actions

Most analysts agree that there are significant opportunities to improve overall energy efficiency within the industrial sector. In addition, there are important opportunities to reduce the carbon intensity of industrial operations through changes in the fuel mix, and by using lower-carbon fuels. The latter includes biomass gasification, natural gas diesel and fuel cell technologies. The more efficient use of chemical feedstocks will also contribute to a reduction in carbon intensity.

Broadly speaking, there are four sets of policies to encourage the more rapid diffusion of existing technologies as well as the development of a new generation of process efficiencies and industrial energy supply technologies. These policies include: (1) incentives to accelerate the investment in new capital stock and equipment (with such incentives ranging from targeted financial support as investment tax credits to increased regulatory flexibility that allows industries to more fully optimize overall plant operations); (2) increased RD&D to facilitate the development of improved technologies as well as the development of a new generation of industrial technologies; (3) incentives to increase the use of recycled feedstocks; and finally, (4) expediting the use of combined heat and power systems through improved environmental permitting and by incorporating provisions into the ongoing utility restructuring that facilitate the sale of excess power by industrial plants.

Key Industrial Indicators for 2010 and 2020

Indicator	Markal-Macro							DRI						
	1995	2010			2020			1995	2010			2020		
		Base Case	Case 2	Case 3	Base Case	Case 2	Case 3		Base Case	Case 2	Case 3	Base Case	Case 2	Case 3
Output (1995=1.000)	1.000	1.408	1.400	1.412	1.544	1.531	1.551	1.000						
Energy (Quads)	19.6	22.8	19.3	20.2	24.3	19	20.1	22.8	25	21.9	22.3	26.4	21.9	22.4
Emissions (MMT)	466	563	421	465	592	407	456	472	521	436	445	542	419	422
10-Year Rate of Annual Efficiency Improvement	n/a	1.1%	2.6%	1.7%	0.8%	1.5%	1.4%	n/a	1.5%	2.6%	2.7%	0.9%	1.5%	1.4%

Jim Turner
260-2784
fax 260-0512

Electric Power

Key Findings:

- Potential reductions from this sector are very large (250MT+) and will make up a substantial portion (25-50% or more) of the total needed to stabilize national emissions.

- If the capital stock of this industry continues to turn over at the rates seen in the last decade, it will take 1000 years to retire the existing stock of power plants. Changing the rate of retirement of existing plant would facilitate the transition to a lower carbon intensive power sector.

- Coal use will certainly decline and delivered power prices will increase if carbon use is constrained. The decline in coal use (both in the electric sector and nationally) will be from 25-60% under stabilization. According to the IAT, prices will rise by about 25%.

- Natural gas, demand-side efficiency and renewable power are the main means of reducing emissions. These options would compete with each other in a carbon-constrained economy. The outcome of this competition is uncertain: gas use could increase in this sector by 15- 50% depending on the relative economics of these options.

- Non-hydro renewables currently account for about 2.7% of the US power supply; even at fairly rapid rates of growth, these technologies will not constitute a large share of generation for some time. To be commercially viable, costs of renewable technologies need to decline from current levels of around \$0.05/kWh to perhaps \$0.03-0.035/kWh (in the absence of high fossil fuel prices).

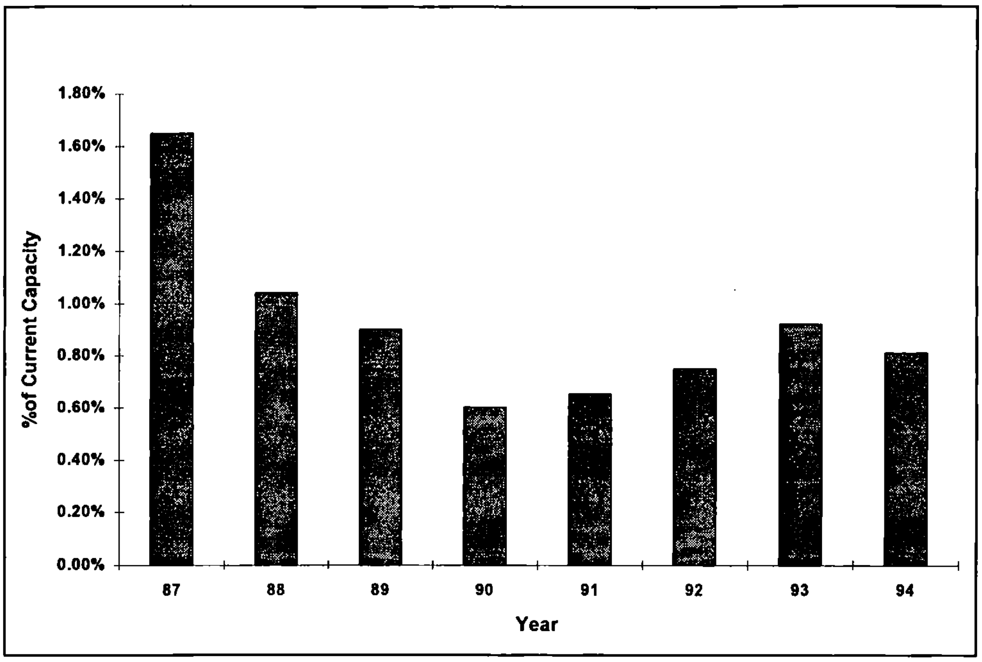
- Competitive trends and air pollutant regulation will need to be integrated with climate policy.

Background

Electric power meets just over 30% of US energy demand. Electric power generation continues to grow in tandem with economic growth, unlike most other forms of energy consumption. Electric power sales of roughly \$200 billion represented 3% of US GDP in 1995. Despite advances in the efficiency of fuel use, US electric power supply maintains an historic reliance on coal and (increasingly) natural gas, leading to an upward GHG emissions trend that is expected to continue in the absence of climate policies.

The critical role of capital turnover is demonstrated by the near-absence of power plant retirements in the 1990s (See Figure 1 below). Access to new markets, regulatory uncertainty and regional conditions have all contributed to the slowdown of plant replacement, with planned 10-year retirement rates falling below 1% in 1989 and holding at low levels through the 1990s. This implies a 1,000-year period to turn the entire stock over once, an extraordinary (and presumably temporary) situation. Changing this trend is a key job for climate policy.

Fig. 1: 10-Year Plant Retirement Forecasts, 1989-1994



Coal will continue supplying more than half of the Nation's electric power through 2010. Coal consumption, of which 90% is in the electric sector, will reach 1 trillion tons in 1997, and by 2010 is expected to reach 1.1 trillion tons. Natural gas supplies 15% of US power, near its historic peak share, and is growing most rapidly today. Nuclear power, currently 20% of the US power supply -- an historic high -- will decline as plants age and face increased competition.

Most renewable power is currently hydroelectric, supplying 9% of US electricity. The potential for hydro expansion is limited. Non-hydro renewables currently account for about 2.7% of the US power supply. Even at fairly rapid rates of growth, these technologies will not constitute a large share of generation for some time. To be commercially viable, costs of renewable technologies need to decline from current levels of around $0.05/kWh to perhaps $0.03-0.035/kWh (in the absence of high fossil fuel prices).

Model Results and Potential for Reducing Emissions

This sector will be a key contributor to any GHG emissions reduction strategy. The IAT results show this sector reducing emissions by 20-33%. Because there are no direct emissions control technologies, achieving reductions relies on reducing demand or changing fuels. The rate of turnover in the capital stock becomes an important factor in determining both the means and the cost of GHG emissions control in the electric power sector.

The dominant emission reduction option is to use natural gas in place of coal, either through co-firing or repowering in existing coal units, or through increased use of new high-efficiency gas plants. Baseline (AEO97) coal capacity is forecast to increase from 315 GW in 1995 to about 330 GW in 2015 (including 40 GW of new plant and 25 GW of retirements) with virtually no coal-gas switching in existing plants. GHG policy will lead to less new coal capacity, more retirements, and some fuel switching at existing units. By 2015, coal *capacity* will fall to 275 GW, a drop of 55 GW or 15%. About 10-20 GW of coal-gas conversions are forecast, consistent with the Interlab study. Coal *use* (both in the electric sector and nationally) will decline by 25-60% if a stabilization target is met. Fuel use is affected more than installed capacity, because of resulting changes in dispatch.

Stabilization will result in very large additions of gas combined-cycle capacity -- up to 150 GW. Natural gas use is affected by several sectors and competing fuels and is very sensitive to assumptions. IAT models project increased gas demand in the electric power sector of 15-50%, but this could be offset by declines in other sectors (some models indicate net declines in US natural gas demand under a GHG stabilization policy). Most models show a small increase (about 5%) for a limited period. If electricity demand is reduced through efficiency, however, all of these fuel impacts could be considerably lessened.

As part of a GHG emissions reduction strategy, generation from non-hydro renewables will increase. Some models indicate that wind and biomass may become cost-effective options as more emissions reductions are called for. For example, MARKAL-MACRO and DRI both indicate a 35% increase in non-hydro renewable use in 2010 under GHG stabilization. Models may understate the potential of renewables because they do not consider 'green power' demand from consumers, niche markets or dispersed power (small scale production scattered throughout the system).

Further electricity supply options include increasing the efficiency of existing fossil plants, and improving other parts of the power system (mainly the transmission grid) to minimize losses. Impacts on the industry are sensitive to demand responses. When end-use demand is lowered, fewer new high-efficiency natural gas power plants are built and less gas and renewable power is used. Coal use is relatively less affected. Overall costs in the utility sector are lower. Combining end-use efficiencies with new supply technologies yields the lowest cost estimates for achieving substantial emissions reductions in the power sector.

Physical responses are generally similar between models, but the estimated costs of reducing emissions vary. The cost of replacing power from an existing coal plant with a new natural gas plant may appear quite similar between models (see box), given assumptions for fuel and equipment costs in 2010. However, the modeled costs of reducing emissions are quite different. These differences mainly result from assumptions about capital replacement decisions and cost allocation. Other factors include some early coal-gas switching, and the potential natural gas price response. As a result, estimates of delivered (weighted average) electricity price impacts vary: +25% in DRI, +40% in NEMS.

Relationship to other trends

A carbon constraint will be introduced at the same time as a competitive restructuring of the industry and the implementation of the NAAQS. The combination of open power markets and market-based air regulation (i.e. a set of cap-and-trade systems for SO2, NOX and CO2) will likely make climate-related policy incentives work faster and more effectively. At a minimum, there will be interactions between these changes which will alter the emissions profile of the sector.

For air regulations, early analysis using IPM and NEMS indicates that although new ozone and particulate matter rules will have a limited effect on CO2 emissions (a reduction of approximately 5% from 2010 baselines), GHG limits could induce significant reductions in the criteria pollutants, on the order of 5-10% for SO2 and 25-35% for NOX.

Initial work on competitive power markets indicates that the ongoing restructuring of the power industry may have important effects. GHG emissions may increase in the near term (by perhaps 5-7% in the first ten years), due to increased sales by the cheapest coal units and higher demand. But competition may

Fuel switching cost analysis, costs in cents per kWh

Assumes baseloaded units at 70% capacity factor, capital recovered over 30 years (levelized)

Year=2010

Non-fuel costs (capital plus O+M)			
	DRI	**NEMS**	**IPM**
Old coal	0.55	0.76	0.55
New gas	0.5	0.74	0.5
Fuel costs—without C tax (2010 baseline)			
	DRI	**NEMS**	**IPM**
Coal	0.89	1.14	0.72
Nat. gas	1.61	1.62	1.39
Total production costs--without C tax			
	DRI	**NEMS**	**IPM**
Old coal	1.44	1.9	1.27
New gas	2.11	2.36	1.89
Split	0.67	0.46	0.62
$/ton C	**54**	**31**	**50**

prove helpful in the long run if new technologies can readily enter markets, and if market-based incentives are a part of climate policy. One great unknown is the potential demand for cleaner power on the part of consumers, who will have new information and choices.

Combining market-based environmental policy, consumer choice, and new technologies may offer greater efficiency and enable the power sector to provide electricity that is both cleaner and higher-value. The technologies and physical changes needed for large-scale GHG emissions reductions appear to be reasonably achievable, although the costs of reductions are less certain. Industry restructuring, air regulations, and climate policy can work together, if closely integrated to achieve the best fit.

Eric

The Role of Renewable Energy in a U.S. Climate Change Strategy

July 8, 1997 Draft

Summary

Renewable energy has substantial potential to reduce U.S. carbon emissions in the mid and long term. These technologies are significant options because they emit little or no carbon. While renewable energy technologies have typically been viewed by some as both costly and futuristic, rapid and steady declines in costs and improvements in performance have resulted in several of these technologies being competitive in selected markets today and the expectation that others will be competitive in broader markets in the near future. Estimated potential carbon savings from increased use of renewable electricity generation are 22-26 million metric tons (MMT) in 2010 and 50-85 in 2020.

Background

Renewable sources of energy are either continuously resupplied by the sun or they tap inexhaustible resources, such as geothermal energy. The use of modern renewable energy technologies to generate electricity either does not pollute or emits far less pollution than burning any fossil fuel. Most renewable energy technologies produce no greenhouse gas emissions at all during operation, and are responsible for only very small emissions during manufacture. Biomass fuels emit no net carbon on a life cycle basis--the amount of carbon released by biomass combustion is equal to the amount absorbed from the atmosphere during growth. Today, roughly 12% of the country's electricity generating capacity is based on renewable power systems. Over 85% of this generation is from hydropower - which has little potential for expansion. However, the remaining renewable technologies - including wind, biomass, photovoltaics, solar thermal and geothermal - are becoming increasingly economic and have large potential to expand and reduce greenhouse gas emissions in the mid to long term. Both wind and photovoltaics are experiencing a 20% cost reduction for every doubling of cumulative production. Photovoltaic cells, which convert sunlight into electricity, have dropped from 90 cents per kilowatt-hour in 1980 to under 20 cents today, while wind power has dropped from 25 cents per kWh to 5 cents. Cost reductions will continue to occur because of R&D advances such as thin film photovoltaics as well as manufacturing factors such as economies of scale and improvements in manufacturing processes that come with increased production. Several major international companies, most notably Royal/Dutch Shell, expect these technologies to be the dominant global source of energy by the middle of the next century and are beginning to make substantial investments in their development.

Two of these technologies - wind and biomass - could also play important roles by 2010. Wind is projected to have a levelized cost of energy of 2.6-3.2 cents per kilowatt-hour by 2005 - quite competitive even in a world without a climate treaty. Biomass has a large potential in two key markets: co-firing with coal and cogeneration of power and steam in industry. Incremental costs for co-firing for many sites are less than $200/kW - making it a low cost low-carbon option. Industrial biomass gasification and high efficiency cogeneration have a large potential for emissions reductions - especially in the forest products industry, which has abundant biomass feedstocks. Geothermal energy also could play a significant role by 2010. Geothermal energy has a large potential in two markets - building space conditioning through geothermal heat pumps and electricity generation.

Potential

Analysis results indicate that renewable electric technologies have a large potential for reducing carbon emissions. The table below shows the baseline EIA projections for renewable electricity generation capacity as well as the results of the Markal Macro and DRI models. The EIA baseline assumes a future without a global climate treaty, any market signals to reduce carbon emissions or substantial technological advances in renewables. The IAT results assume increased focus on U.S. carbon reduction and a continuation of the current trend of improvements in the performance and costs of renewable electric technologies.

Does this include hydro

Renewable Energy Generation Capacity (GW)	1995	2010	2020
EIA AEO97 Base Case	9	14	26
Markal Macro	9	31-33	70-120
DRI	9	?	?

Note: 2020 EIA baseline estimates are extrapolated from 2015 projections.

These numbers translate into carbon savings of 15-16 MMT in 2010 and 35-60 MMT in 2020 - assuming that renewable energy technologies displace efficient gas generation. However, the IAT models have limited representation of utility and industrial cogeneration markets, so biomass capacity is likely underestimated. The forthcoming study by five national laboratories, U.S. Carbon Reductions by 2010 and Beyond: The Potential of Energy Efficient and Low-Carbon Technologies, offers a more detailed analysis of biomass. That study suggests a substantially higher potential for biomass co-firing with coal and greater potential for biomass gasification and cogeneration in industry. These numbers translate into additional carbon savings beyond the IAT Markal results of 7-10 MMT in 2010 and 15-25 MMT in 2020.

Implications

The analysis suggests that the contribution of renewable electric technologies in 2010 could be substantially higher than projected in the base case. However, the contribution of these technologies in 2010 (excluding hydroelectricity) is still expected to be less than 5% of U.S. generation capacity. However, in considering renewables, it is important to realize that they are in the midst of a major, long term transition from "advanced technologies" with only a peripheral market role to mainstream technologies that will be technologies of choice in the energy marketplace early in the next century. This is critically important, because in the long term, zero-carbon energy supply technologies will likely be the most important component in a national greenhouse gas emissions reduction strategy. The use of these technologies is also rapidly expanding in developing countries - particularly those without national utility systems. Development of the U.S. renewable industries is vital to any U.S. desire to be a major exporter of environmental technologies in the 21st century.

The pace and timing of the transition of renewable energy is difficult to project because of uncertainties in the rate of R&D progress, the evolution of restructuring and energy policies and consumer interest in "green energy". Four factors will tend to accelerate the use of renewable energy. First, restructuring of the electricity industry will make available more choices to consumers allowing consumers to choose electricity based not only on cost, but a variety of other factors including environmental impact. Second, it has been demonstrated in many areas that consumers are willing to pay a premium for "green power" - indicating that environmental choices presented by industry could be quite popular with consumers. Third, some energy policies at the State level are evolving in a direction that directly support renewable energy. For example, several States have already passes renewable energy portfolio standards and several more are considering similar actions. Finally, continued decreases in renewable energy costs - especially in the face of potentially rising costs of fossil fuels - will motivate additional investments in these technologies.

1 + 2 are the same; if 3 => ↑ prices, then it will be the premium stated in 2

The renewable energy projections imply a substantially higher growth rate in investments in renewable electric technologies than projected in the business as usual base case. In the base case, the overall growth rate is 3.5% per year through 2010 and over 6% per year between 2010 and 2020. In the IAT technology investment case, renewable electricity capacity grows 10% per year through 2010 and 8-14% per year between 2010 and 2020. The Markal model suggests that wind and biomass co-firing with coal will account for most of the renewable energy increase. The 2020 wind power projections are consistent with use of about 10% of total U.S. wind resource, so the only potential major constraint is one of wind turbine manufacturing capacity. The growth rates would require a major expansion of a small U.S. industry -

although wind turbines could be imported as well. For biomass co-firing, a net of 2.5-3.5% of coal electricity production is co-fired with biomass in 2010 and 4-8% is co-fired in 2020. That would require a maximum of 2-3 million acres of woody and herbaceous energy crops in 2010 and 5-10 million acres in 2020 - largely on marginal farmland - although substantial use of agricultural and forestry wastes could reduce these requirements

In reality, It is more likely that a portfolio of technologies would account for the projected increases in renewable energy. Wind and co-firing of biomass with coal are the likely lowest cost options by 2010, but geothermal power could also make a sizable contribution. By 2020, it is expected that a diversified portfolio of technologies would be used - including wind, biomass, geothermal, photovoltaics and solar thermal. These technologies would all be cost competitive in many areas - allowing power generation companies to select technologies that make best use of local resources and best match their power demands.

Actions
While electricity from fossil fuels continue to become cleaner and cheaper, expanded R&D and deployment could make a number of renewable technologies beyond wind competitive on purely economic grounds in the next 10 to 20 years: photovoltaics, biomass gasification, solar thermal, and geothermal. In a greenhouse-gas constrained world, these zero-carbon emitting sources of power would be even more competitive. The following actions could accelerate the use of these technologies by 2010 and make a large difference beyond 2010.

- expanded technology research and development to continue to lower costs and increase performance;
- expanded cost-shared technology deployment efforts with industry to increase utility system experience and increase U.S. production renewable energy production capacity - lowering costs still further; and
- promotion of U.S. renewable energy technologies abroad to tap the huge market for renewables in the developing world - enabling U.S. producers to further lower costs.

Industries with Significant Non-Annex I Trade Shares (1996)

Rank	SECTOR	Non-Annex I Imports as a % of Total Consumption	SECTOR	Non-Annex I Exports as a % of Total US Output
1	RUBBER & PLASTICS FOOTWEAR	86.5%	MINING & OIL FIELD MACHINERY	56.1%
2	OTHER LEATHER GOODS	63.0%	TANKS & TANK COMPONENT	43.8%
3	LEATHER FOOTWEAR	62.6%	ELECTRON TUBES	43.2%
4	HOUSEHOLD AUDIO & VIDEO EQUIP.	57.1%	TURBINES & TURB. GENERATING SETS	33.3%
5	APPAREL FROM PURCHASED MATL	47.7%	SEMICONDUCTORS	30.3%
6	KTCHEN POTTERY PRODUCTS	42.0%	AIRCRAFT & MISSILE PARTS & EQUIP,NE	28.0%
7	JEWELRY & SILVERWARE	39.0%	MACHINE TOOLS, METAL FORMING	27.0%
8	TOYS & SPORTING GOODS	38.3%	COTTON	26.9%
9	CRUDE PETROLEUM	37.0%	MISC. ELECTRONIC COMPONENTS	25.4%
10	WATCHES & CLOCKS	33.7%	RADIO & TV BROADCASTING & COMM EQ	25.0%
11	SEMICONDUCTORS	33.1%	MISC GENERAL INDUS MACHINERY	23.2%
12	COMPUTER PERIPHERAL EQUIPMENT	31.9%	AIRCRAFT	22.7%
13	ELECTRONIC COMPUTERS	30.2%	CONSTRUCTION MACHINERY	21.4%
14	COMMERCIAL FISHING	27.3%	MAGNETIC & OPTICAL RECORDING MEDI	21.2%
15	MUSICAL INSTRS & PARTS	26.3%	MACHINE TOOLS, METAL CUTTING	21.1%
16	BLOWERS & FANS	23.5%	ELECTRICITY MEASURING INSTR	19.6%
17	MAGNETIC & OPTICAL RECORDING ME	22.6%	PUMPS & COMPRESSORS	17.7%
18	FRESH, FROZEN & CANNED SEAFOOD	22.0%	PRINTING TRADES MACHINERY	17.6%
19	CALCULATING & OTHER OFFICE MACH	21.8%	NONFER ROLLING & DRAWING,NEC	17.2%
20	MOTORCYCLES, BICYCLES & PTS	20.8%	HOUSEHOLD AUDIO & VIDEO EQUIP.	16.8%
21	ELECTRICAL EQUIP & SUPPLIES	20.1%	WATCHES & CLOCKS	16.3%
22	SMALL HOUSEHOLD APPLIANCES	20.1%	ELECTRONIC COMPUTERS	16.2%
23	MISC DURABLES & SEMIDURABLES	19.1%	KTCHEN POTTERY PRODUCTS	16.0%
24	OPHTHALMIC GOODS	17.4%	MOTORS & GENERATORS	15.9%
25	MISC. ELECTRONIC COMPONENTS	17.1%	OTHER SPECIAL INDUSTRY MACH.	15.8%

Dingell's ofc
225-4071
Dan Beedy

1994 p. 623
96 Stat Abs.
8991000 passenger cars
5703000 light duty trucks
14,694000

1997 est. 15.1m. – N.

15,000,000
1,200 — m.M est from Ship
18,000,000,000
$.186

present ratio
15m *.6*2000 DOES high eff
\+ 15m *.4*1650 DOES high eff
18b
~~18b~~ + 9.9b
27.9b

28,32,33

National Association of Business Economists (NABE Outlook and Policy survey, February, 1997)

NABE members expect total U.S. vehicle sales, including sales of medium and heavy trucks, to drop to 15.1 million in 1997 and remain at that level for 1998.

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