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Folder Title:
[Climate Change Issues] [Folder 1] [1]

| Stack: | Row: | Section: | Shelf: | Position: |
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Principles for Climate Change Policy

We should pursue policies that have integrity. It is important to have credible goals, for which the costs and benefits are prudently forecast.

It is more important to begin in a successful way than to get the parameters exactly right. Loose targets that are ratifiable and achievable are more important than tight targets that cannot be accomplished in the short run.

We must pursue strategies that have a reasonable prospect of ratification. Meeting the criteria of either the international or domestic communities alone is not sufficient.

To maintain the above principles, any solution must meet four criteria:

- Equitably proportioned reductions from a plausible future baseline (eg. 2010).
- It should involve fluctuations in energy prices that are within our historical range of experience.
- Developing countries must eliminate subsidies to carbon consumption
- Domestic credit for reductions abroad, through Joint Implementation projects, must depend on credibly demonstrated reductions in emissions from a plausible baseline.

395-5018
D ONG By 3:15

8/1

CLIMATE CHANGE POLICY ANALYSIS

(Lead authors indicated in parentheses)

1. Domestic Emissions Trading (Gardiner, Gruber)

Revised paper to be distributed Aug. 4. Includes analysis of auctions (FCC, other experiences) and administrative issues.

talk to Peter about meeting
need new stuff with phasing in

-WTO/MAI issues (Haverkamp)

Paper due Aug. 8

-Relationship to international trading (Simon)

Draft being circulated for comment.

Shogren Europe paper
only need WTC

2. International Emissions Trading and Joint Implementation (Doniger, Gruber)

Revised int'l emissions trading paper to be distributed Aug. 13. Will include additional analysis of institutional and compliance/monitoring issues.

-joint implementation/additionality (Doniger, Gruber), DOE

Paper due Aug. 13

-payment/trade account questions (Hunker, Shogren)

Paper due Aug. 13

-WTO/MAI issues (Haverkamp)

Paper due Aug. 8

Beebe round → Not appropriate discussion

3. Technology (Glauthier/Bierbaum)

Sectoral paper distributed. Paper setting forth major policy options to be developed in August. (First draft Aug. 13) President's Committee of Advisers on Science and Technology (PCAST) and DoE Labs preparing reports to the President for October 1 delivery.

4. Developing country commitments (Pomerance, Hunker)

Paper setting forth policy options due Aug. 13

-escape clause (Pomerance, Gruber)

Paper due Aug. 8

-competitiveness/trade issues (Orszag)

Paper drafted.

what should they commit to? would we live up to that
what is trigger? not in draft
com would be by world day

5. Federal undertakings (Goodman, Glauthier)

Paper setting forth major policy options due Aug. 22. (First draft Aug. 13).

lots of ways to do this = could be on debt country commitments
comp & loan &

overview

how it would work

**Climate Change Working Groups
Core Members
July 14, 1997**

I. Domestic emissions trading

1. EPA (Gardiner and Doniger)
2. Treasury (Wilcox and Gruber)
3. OMB (Minarik)
4. CEA (Shogren)

II. Developing country commitments

1. State (Pomerance)
2. AID (Hales)
3. Treasury (Geithner)
4. Commerce (Hunker)
5. WH Task Force (Forrister)

III. International emissions trading and joint implementation

1. State (Pomerance)
2. AID (Hales)
3. Justice (Simon)
4. CEA (Frankel)
5. OMB (Gotbaum)
6. DOE (Reicher)
7. Commerce (Hunker)
8. WH Task Force (Forrister)

IV. Technology programs

1. OMB (Glauthier)
2. DoE (Reicher and Romm)
3. OSTP (Henry Kelly and Rosina Bierbaum)
4. EPA (Gardiner and Doniger)
5. Treasury (Gillingham)
6. CEA (Frankel)
7. DoT (Kruesi)
8. USDA (Rawls)
9. Commerce (Hunker, Good)

V. Regulations and Standards

1. OMB (Glauthier)
2. EPA (Gardiner and Doniger)
3. DoE (Reicher and Romm)
4. Treasury (Gruber)

VI. Transition Assistance

1. Labor (Montgomery)
2. EPA (Gardiner)
3. NEC (Robyn)

CC: [unclear]

DW
[unclear]

OFFICE OF THE LEGAL ADVISER
UNITED STATES DEPARTMENT OF STATE



TELEFAX COVER SHEET

Mr. John Gruber - phone 622-0563 - fax 622-2633

TO: Col. Roy Salzman - phone (703) 604-1628 - fax (703) 607-3124

FROM: Mr. Robert K. Harris & Sue Biniatz
Telefax Number: (202) 736-7115
Telephone Number: (202) 647-1370

DATE: 8/5/97

SUBJECT: Climate Change: Clearance/Comments on Paper on Escape Clause

Number of Pages Including This Cover Page: 4

Message: In the interagency process on Climate Change, State is tasked with presenting a paper on August 8 on the issue of "escape clauses". Attached is a draft, for your clearance and/or comments. Please give us any thoughts by COB, Wednesday, August 6. Thanks.

DRAFT

Climate Change: "Escape Clause"

Issue

Whether, in the current negotiations on a follow-on protocol/other legal instrument, the United States should press for an "escape clause" whereby a Party would be discharged from its legal obligation to meet an emissions target if certain conditions existed.

Background

- o Concerns have been raised concerning a future scenario under which the United States would be legally bound to a particular emissions limitation/reduction target even if achievement of the target would cause harm to U.S. competitiveness or national security.
- o There appear to be a number of ways in which such a scenario could potentially be addressed, not all of which are mutually exclusive, e.g.,
 - Agreeing to a non-legally binding, rather than legally binding, target.
 - Agreeing to a binding target at a level that is not likely to result in the above scenario.
 - Agreeing to a binding target, with substantial flexibility in terms of implementation (through, for example, multi-year targets, emissions trading, legal "borrowing" of emissions allowances from future budget periods).
 - Ensuring that the agreement allows for withdrawal upon reasonably short notice. The Climate Change Convention requires three years' notice; an amendment to the Convention would be covered by this requirement. A protocol could vary the notice requirement, for example, by allowing withdrawal upon one year's notice.
 - Having the agreement provide for discharge of the legal obligation to meet a target upon certain conditions; unlike withdrawal, such a clause would allow a country to remain a Party to the agreement.

This paper focuses on the last approach.

DRAFT

-2-

Discussion

- o Apart from policy issues (see below), devising a clause providing for the discharge of the legal obligation to meet a target raises a number of legal questions:
 - What would the substantive condition(s) be that would trigger the discharge of obligation (for example, harm to national security)?
 - o Given the U.S. position that the agreement should dictate the target but not the policies/ measures to achieve it, how would one deal with the situation in which the target itself is not necessarily the cause of the condition, but the particular Party's chosen method(s) of implementation?
 - Who would decide whether the substantive condition(s) had been met, i.e., would it be self-judging (by the Party in question) or would it be the subject of a decision by other Parties to the agreement or a third party? If the latter, what kind of institution would decide?
 - What would the temporal aspects be: in the case of a multi-year target, when could a Party invoke the clause? in the case of more than one budget period, what would the Party's obligation be with respect to subsequent budget periods?
 - What would be the relationship between the international "escape" clause and the domestic legislation necessary to implement the target (e.g., how would the domestic regime reflect the international clause)?
- o Policy considerations in connection with a possible "escape" clause include, e.g.,
 - likely domestic reaction (Senate, industry, environmental NGOs);
 - likely international reaction;
 - likelihood of being able to negotiate such a clause;
 - likelihood of "escape" clauses being demanded by other countries (for example, by developing countries seeking to subject their environmental obligations to their need for economic development and/or the receipt of financial and technical assistance);
 - in the case of a clause excusing environmental performance based on harm to the economy, extent of its consistency with the U.S. conception of and worldwide goals regarding "sustainable development."

DRAFT

-3-

- o Examples of types of agreements that provide for non-performance of obligations under conditions related to national security/economic impacts include:
 - Investment: The typical Bilateral Investment Treaty provides that it does not preclude the application of measures necessary, inter alia, "for the protection of its own essential security interests."
 - Trade: Certain trade agreements provide for suspension of certain obligations (e.g., tariff concessions) in response to qualifying import surges. Further, in the GATT, for example, there is a clause providing that nothing in the agreement prevents a Party from "taking any action which it considers necessary for the protection of its essential security interests relating to [three defined areas, including the traffic in arms]...."
 - FCN: The model bilateral Friendship, Commerce, and Navigation Treaty provides that it does not preclude the application of measures necessary to protect a Party's "essential security interests." Note that the International Court of Justice, with respect to the U.S.-Nicaragua FCN Treaty, found that this clause was not self-judging.
 - Arms Control/Nonproliferation: - These agreements generally contain a withdrawal clause along the following lines: "Each Party shall in exercising its national sovereignty have the right to withdraw from the Treaty if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardized the supreme national interests of its country." A Party must give three months' notice, along with a statement of the extraordinary events. Note, however, that this type of "escape" clause does not provide a Party with an additional basis for non-performance; on the contrary, it is written as a limitation on a Party's ability to withdraw from the Treaty.
- o Note that the above examples appear to involve a Party's ability to take certain measures vis-a-vis another Party that would otherwise violate the agreement, rather than a total discharge of the agreement's core obligation vis-a-vis all other Parties. (The arms control provision does discharge the totality of obligations, but only in the context of withdrawal.)

Drafted:L/OES:SBiniiaz

Elaborate on the inputs call with GK

h.s. - members of ec. comm. & local the board -> presence

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To: Victoria Greenfield, State

From: Jeff Frankel

Re: Comments on Escape Clause papers

Overall, I think that the escape clause idea might turn out to be very important, notwithstanding that the U.S. has not yet brought it up in the international negotiations, unless I am mistaken.

First, comments on the paper "**Climate Change: "Escape Clause"**"

I think that the focus on the examples of "competitiveness and national security" in paragraph 2 of page 1, and also pages 2 and 3, is misplaced. Most importantly, concerns about "competitiveness" per se properly apply only to a small number of (energy-intensive) industries that may be adversely affected in international competition. This point came out clearly in an interagency paper reviewing the literature on competitiveness written and circulated by Peter Orszag, drawing on Janet Yellen's remarks at a Principals meeting on developing country participation. (The point is somewhat related to Paul Krugman's "Competitiveness: A Dangerous Obsession.") Rather than saying "competitiveness", I think what you want to say is "adverse effects on the economy." These are effects on the entire economy of higher energy prices (or, if a more inefficient means of implementation is chosen, the effects of regulation) that would be virtually as worrisome regardless which foreign countries participated and regardless whether international trade existed.

A less important point is that I am not sure why national security is mentioned so many times. The major implication of climate change policy for this area that I can think of is that reducing US use of fossil fuels would mean reducing dependence on Mideast oil, and would thereby *enhance* national security.

As I have mentioned to you by telephone, I also think it might be useful to consider adding some other escape clauses, in addition to the principal one triggered by unexpectedly severe adverse economic effects or energy price increases. My guess is that this paper is the place to enter these ideas (rather than the other paper, for example). Three possibilities:

- An escape clause that would be triggered in the future if continued **scientific research** determined that the dangers from GHG concentrations and climate change were much less than feared. (Presumably the treaty would be renegotiated in such a case anyway. But the arguments for putting this language in now are three: (1) to facilitate the change, should this come to pass, (2) so that we don't look foolish in the eyes of history if this should come to pass, and most importantly, (3) to help allay the fears of today's skeptics.
- An escape clause that would be triggered in the future if **developing country accession**

turned out to be less than we expect after Kyoto.

- An escape clause that would be triggered in other Annex I countries do not live up to their commitments.

Each of these might be important.

Comments on the paper *Climate Change: Permit Prices "Too High"*

I have seen Treasury's comments. I agree with all six of them, and would have liked to make most of the same points myself. So consider that two votes for their suggestions.

A note under their item 5: your words on the possibility of an international mandate for common policies and measures, while running against good economics if common "standards" is the sort of thing contemplated, would instead be consistent with good economics if the proposal by Treasury regarding a possible US implementation (measures to raise the price of carbon directly) were interpreted as the common policy/measure..

I approve the focus in the paper on "permit prices too high" even if, as Treasury suggests, you were to change the title. I think the triggering condition, permit prices above some level "+x%", needs to be clarified in the longest paragraph on page 4. Also, in the preceding bullet, I don't like the phrase "competitiveness /national security" for the reasons indicated toward the beginning of this memo.

August 22, 1997

Comments - Escape Clause Economic Analysis Paper
Office of Economic Policy, Treasury Department

1) It is important in this paper to draw a distinction between the symptoms (a high permit price) and the cause (fast economic growth, etc.). The paper bounces between these two concepts throughout. The paper should be retitled "Escape Clauses for Economic Circumstances".

Rewrite the opening paragraph as:

How to deal with the concern that Congress is unlikely to enact implementing legislation that binds the U.S. to a particular target without the possibility of exceeding that target in the event that it becomes extremely costly for the U.S. economy.

2) Retitle the third section "What is the problem" (Not "Is there a real problem"), since there is certainly a problem in theory, even if it is small in reality.

3) Rewrite the economics section as follows:

- The source of the problem is that restrictions on the amount of emissions can serve as a very costly brake on economic activity under particular circumstances, for example very rapid economic growth. This can lead to extreme costs, both economically and politically.
- This problem will manifest itself through the permit price: when the emissions cap binds strongly on economic activity, there will be very high demand for permits, and as a result a very high permit price.
- High permit prices could pose an economic problem to the extent that the higher prices of permits leads to inflation and/or chokes off growth.
- This scenario could arise for two types of reasons:
 - Faster than expected economic growth
 - Slower than expected progress in the technology of emissions reduction
- In the former case, it is important to draw the distinction between short run "economic overheating", which would raise the prices of permits temporarily, and longer run factors such as changes in aggregate productivity, which would permanently raise the demand for permits and their price; the latter case, slow technological progress, is clearly a permanent shift.
 - **Temporary rise in permit prices:** A temporary increase in the price of permits would increase the cost of compliance, relative to our projections. There is substantial variation in the growth rate of the U.S. economy in the recent past,

leading to these types of overheating concerns. For example, since 1960, the real growth rate in the U.S. has exceeded the average (3.2%) by more than 2 percentage points in 7 years.

- The increased costs of this scenario could be eased, although not necessarily erased, through several policy mechanisms:
 - multi-year budget periods
 - banking and borrowing
 - international trading
 - JI with credit
- **Permanent rise in permit prices:** A permanent increase in the price of permits could be a more important economic problem. International trading or JI with credit could relieve some of the pressure, but budgets, banking, and borrowing would be less helpful. To guard against this case, specific escape clause language may be required.

In addition, a permanent change might occur not only in the U.S. but worldwide. In this case, escape clause considerations might be extended not simply to the U.S., but to the entire global system of emissions permits; that is, there could be a cap on the international price of permits.

4) Under the borrowing section, it is important to draw a distinction between borrowing by individual firms, and aggregate borrowing by the U.S. This is an important distinction because the former raises a number of difficult issues with respect to bankruptcy, etc., while the latter simply provides an aggregate escape mechanism.

Also, with borrowing, there is an important issue of how to set the appropriate interest rate at which the parties must repay the "loan".

5) The section on policies and measures is somewhat confusing and should be ~~deleted~~. Any standard has the same problems as a cap on emissions - it becomes overly restrictive if the economy overheats.

This section should be replaced with a section on carbon taxation:

- Another option is for the U.S. to replace its emissions cap system with a carbon tax.
- The tax rate could be set so that, at anticipated energy consumption, we achieve the same level of GHG as under a cap-and-trade system
- But the advantage of a tax in this context is that it allows for a natural escape mechanism: by fixing the price of emissions, rather than the level, it allows for more emissions if there is an overheated economy or slow technological progress.

✓
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- At the same time, explicit tax approaches run into domestic political problems, as witnessed by the BTU tax experience.

✓ 6) Some changes to the section on escape clauses:

✓ a) The third bullet should be rewritten as:

- Such a provision would need to identify the substantive condition under which exceeding the target would not be a violation. This condition should be specified in terms of the price of a permit.
 - The appropriate price level should be chosen to not disproportionately constrain economic growth, e.g. the price level that would arise with economic growth rates that are 50% higher than expected.
 - The escape clause target price should be flexible, as future information about permit pricing may adjust the appropriate level at which escape is needed

✓ b) The fifth bullet should also point out some mechanisms:

- we could fix the price at some level - if it rises above \$x per ton, we will sell as many permits at \$x as are demanded.
- we might allow for a certain number of new permits to be “released” depending on the price: e.g. if the price rises to \$X, we increase the number of permits by 10%, if it rises to \$1.5*X, we increase the number of permits by 20%, etc.

✓ c) There is no need for the last bullet. In fact, economists should like this escape clause - it solves an important problem with a cap and trade system.

August 18, 1997

Comments - Escape Clause Economic Analysis
Office of Economic Policy, Treasury Department

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 - **Temporary rise in permit prices:** A temporary increase in the price of permits would increase the cost of compliance, relative to our projections. There is substantial variation in the growth rate of the U.S. economy in the recent past,

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4) Under the borrowing section, it is important to draw a distinction between borrowing by individual firms, and aggregate borrowing by the U.S. I know that the former is part of the U.S. position; is the latter? This is an important distinction because the former raises a number of difficult issues with respect to bankruptcy, etc., while the latter simply provides an aggregate escape mechanism.

Also, with borrowing, there is an important issue of how to set the appropriate interest rate at which the parties must repay the "loan".

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b) The fifth bullet should also point out some mechanisms:

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c) There is no need for the last bullet. In fact, economists should like this escape clause - **it solves an important problem with a cap and trade system.**

Escape clause for stringency ("overheating")
Questions that would need to be settled

- Treaty language specific (price of carbon) or vague (economic damage)?

One test date, two, or continuous?

Triggered by judgment of individual countries, or international body?

Remedy is sale of additional permits at pre-determined price by national govts. or by supranational authority?

Pre-determined price is best guess of economists, or claims of the optimists?

Other

Legal

- researchers change
- LDCs don't participate
- other Annex 1 don't abide

8/14/97

Escape clause for over-stringency ("overheating")

Questions that would need to be settled

Treaty language specific (price of carbon) or vague (economic damage)?

One test date, two, or continuous?

Triggered by judgment of individual countries, or international body?

Remedy is sale of additional permits at pre-determined price by national govts. or by supranational authority?

Pre-determined price is best guess of economists, or claims of the optimists?

Escape clause for developing-country non-participation.

Escape clause for evolution of scientific knowledge.

August 18, 1997

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Office of Economic Policy, Treasury Department

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b) The fifth bullet should also point out some mechanisms:

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c) There is no need for the last bullet. In fact, economists should like this escape clause - it solves an important problem with a cap and trade system.



Joseph E. Aldy
09/24/97 12:41:13 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:

Subject: EMF results

Jeff,

241. transfers from MY permit trading
|

From Battelle:

WG-1 550: 2035: \$181.4 billion for US
2050: \$169.8 billion for US

WRE 550: 2035: \$32.0 billion for US
2050: \$84.6 billion for US


I will check about the model -- I think these might be MiniCAM results, not SGM.

Joe



Joseph E. Aldy
09/29/97 10:10:12 AM

Record Type: Record

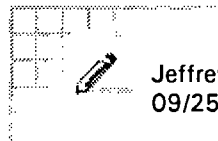
To: Jeffrey A. Frankel/CEA/EOP
cc: Adele C. Morris/CEA/EOP
bcc:
Subject: Re: EMF results 

Jeff,

The results below are from the MiniCAM model, which assesses the economics of climate change with the Edmonds-Reilly Model, not SGM. However, in addition to the fact that these results are outputs from a different model than the one used in the earlier memo, they also differ substantially in terms of the allocation of emissions to countries. Recall in the earlier memo that emissions rights to Annex I countries were based on 1990 emissions in the 1990 in 2010 case (and the variants thereof), or on our prescribed emissions path under the Peak in 2015 case. In 2050, the U.S. is then allocated 1340 MMTCE (1990 level). However, the EMF runs mentioned below use the Manne-Richels burden sharing rule. This implies that the U.S. only receives about 4% of global emissions rights in the year 2050. Thus, the U.S. has to buy a lot more in the WRE and WGI runs than the earlier SGM runs. If you want to talk about this more, feel free to let me know.


Joe

Jeffrey A. Frankel



Jeffrey A. Frankel
09/25/97 07:03:19 PM

Record Type: Record

To: Joseph E. Aldy/CEA/EOP
cc: Adele C. Morris/CEA/EOP
bcc:
Subject: Re: EMF results 

Joe,

These results on international transfers don't seem to match up with those in the 8/27 memo. Do you know why?

The targets are different, but I would expect those numbers to fall between WRE and WG1 here. Those numbers were from SGM; if these numbers are from another model, that could explain the difference.

JF

Joseph E. Aldy



Joseph E. Aldy
09/24/97 12:41:13 PM

Record Type: Record

To: Jeffrey A. Frankel/CEA/EOP

cc:

Subject: EMF results

Jeff,

From Battelle:

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2050: \$169.8 billion for US

WRE 550: 2035: \$32.0 billion for US
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I will check about the model -- I think these might be MiniCAM results, not SGM.

Joe

8/21/97 Draft

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

Dear Joe:

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

Sincerely,

Gillighan looked over the general comment on the 1st page and he is satisfied with it. He will try to review the specific comments and get back to me by the early morning. Do you have any comments/suggestions? Should the letter be under your name, or Jay's + mine?

Joe

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

General comment

The report, *Scenarios of U.S. Carbon Reductions*, presents a useful cataloging of the technological options that could play a key role in reducing greenhouse gas emissions. The report does not present the specific policies or the behavioral responses that will trigger the adoption or diffusion of these technologies. As such, the report does not present information in a form useful to policy making. The report as written, however, leaves the impression that these technologies are policy, which they are not. The report must be either redone to reflect how likely these technologies will be used given the behavioral responses to likely policies, or reframed to reflect what it is--a catalog of technologies to address global climate change. The latter path is more straightforward and could readily be accomplished. Among other changes, it is essential that DOE remove references to “net savings” from the report because this does not reflect the actual costs of implementing these policies.

Our specific comments follow.

Executive Summary

1) paragraph 3: The point regarding the opportunity to reduce emissions through “a vigorous national commitment” should be explicit that this commitment is implemented through federal policies. To state that 120 MMTCE can be reduced by “energy efficiency alone” implies that they are free. These reductions through energy efficiency are induced by aggressive policies, and the statement should reflect that. The subsequent discussion of reductions with carbon permits should also reflect that the level of reductions can occur only with both non-price policies (e.g., standards) and a carbon pricing policy (e.g., replace “assumptions” with “federal policies” in sentence 4).

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

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

Chapter 1

4) 1.1, paragraph 1: Sentence 3 should note that “the improved performance and increased penetration of efficient and low-carbon technologies” are program- and price-induced.

5) 1.1, section 1.1, purpose 1: The statement about a “vigorous national commitment” should be explicit that this means a commitment through government programs.

6) 1.4, Table 1.1: The study notes that it employs EIA’s Annual Energy Outlook 1997 projections for the business-as-usual case in 2010 with a modification to the transportation sector. However, the numbers in this chart do not match up with the numbers in the AEO97 reference case. In fact, they are much closer to the AEO97 low economic growth case (for industry and buildings). We assume that the labs study is using the reference case from AEO97 since it uses the reference case carbon emissions for 2010. If this is the case, then the following should be the sectoral breakdown of energy consumption (AEO97, pp. 97-99, and pp. 125-127):

| | |
|-----------------|---------------------------|
| Buildings: | 36.81 quads |
| Residential: | 20.83 quads |
| Commercial: | 15.98 quads |
| Industrial: | 39.69 quads |
| Transportation: | 31.39+ quads ¹ |
| Total: | 107.89+ quads |

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

7) 1.6, Table 1.2: The 2010 BAU carbon emissions for buildings and industry do not match the AEO97 reference case emissions for these sectors. AEO97 projects carbon emissions to be 576.1 MMTCE for buildings (residential: 321.4; commercial: 254.7) and industry to be 548.5 MMTCE in 2010. This implies that, with the adjusted transportation emissions, BAU should total 1740 MMTCE, not 1720.

8) 1.8, Table 1.3: The study states that it employs the Annual Energy Outlook business-as-usual (BAU) forecast for the buildings and industry sectors, with modifications that are “not greatly different from the EIA case” (p. 1.2) for the transportation sector.² The one modification stated in the study affects the fuel efficiency of the light duty vehicle fleet. While AEO97 assumes that fuel efficiency will increase in the future, the labs study assumes that fuel efficiency will remain

¹ The 1997 AEO projects transportation energy consumption to be 31.39 quads in 2010. With the labs study assumption regarding constant fuel efficiency, the projected energy consumed in this sector should increase. Although the text never explicitly states the extent of this increase, we inferred that it is 0.9 quads. However, since Andersen informed us that the increase would be 0.6 quads, we assessed both in a subsequent comment.

² The labs study also modified the electricity sector forecast, but that modification is not relevant to our discussion of the energy efficiency of the economy.

constant. This change should result in a slower rate of energy efficiency improvement in the economy under business as usual conditions.

The AEO97 BAU forecast assumes an improvement of energy efficiency of 0.9% per year through 2015 (annual E/GDP = -0.9%) (AEO97, p. 4). The study assumes energy efficiency improvement under BAU occurs at a rate of 0.77%. This difference appears to be somewhat significant. Inferring from the transportation chapter (table 5.1), this report states that energy use would increase 0.9 quads over the AEO97 reference case. CEA contacted Art Andersen at the Energy Information Administration to determine how much of an effect holding fuel efficiency constant would have on the E/GDP ratio.³ According to Andersen, constant fuel efficiency would “disappear in the rounding” in the E/GDP ratio. He stated that this assumption would result in energy use increasing by 0.6 quads in 2010 over the reference case. CEA recalculated the E/GDP ratio used in the AEO97 BAU to account for this extra energy use (assuming GDP remains the same across these cases), and found that annual E/GDP would decrease 0.86% under the constant fuel efficiency assumption (0.6 quads case). With the inference from the transportation chapter, the annual E/GDP rate would be -0.85% (0.9 quads case). The labs study BAU assumes fewer energy efficiency improvements than should be expected under these adjusted BAU scenarios.

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

Second, the carbon reductions calculated for the various scenarios in this study are based on this -0.77% E/GDP BAU. This implies that some of the carbon reductions claimed under the efficiency and high efficiency cases actually occur in the -0.86% BAU. This double-counting could be significant. The CEA-generated BAU (0.6 quads case) accounts for 17% of the E/GDP gains assumed in the efficiency case (see attached chart).⁴ The alternative CEA-generated BAU (0.9 quads case) accounts for 15% of the E/GDP gains assumed in the efficiency case. Assuming that E/GDP and carbon reductions are perfectly correlated (given that the efficiency case involves no fuel switching, this is reasonable), then the efficiency case over estimates emissions reductions by 18 to 20 MMTCE.

³ Art Andersen is the Director of the Energy Demand and Integration Division, EIA.

⁴ The AEO97 BAU would capture 25% of the efficiency gains in the efficiency scenario.

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

9) 1.11, Table 1.4: It would be valuable to understand the effect of non-price policies and permit prices on the carbon reductions. Could you break down the high efficiency cases into two categories: non-price policy induced and permit induced technology adoption?

10) 1.12, paragraph 1: The discussion on government programs costing 15% of investment costs should include references to the literature that have estimated this percentage. Does the literature describe the marginal costs for government programs, or does it just provide this average cost value? Consistent with the literature on technology adoption, the marginal costs should not be assumed to be the same for all units of adoption. In fact, it is likely that the marginal costs increase for higher rates of adoption.

11) 1.12, paragraph 1: The text in this paragraph notes that government costs in the best estimate case are 15% of total investment costs, while figure A-1.1 on p. A-1.2 indicates that the costs are 7% of investment costs for the end-use sectors and 1% for the electricity sector. Which costs are correct?

12) 1.12, paragraph 1: The text notes that “one could argue that... a social discount rate” of 3% or 7% should be used. Alternatively, one could argue that since these analyses assess private decisions on technology adoption, that private marginal rates of time preference should be used that reflect “current market behavior”. This analysis is not attempting to conduct a social benefit-cost analysis. Rather, it is attempting to model the private individual or firm’s benefits and costs associated with a technology adoption decision. Since this report projects technology adoption assuming a set of aggressive policies, the rates of time preference used by individuals and firms should be used in assessing the extent of adoption.

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

13) 1.12, paragraph 5: Again, until the complete costs of investment and accurate cost-savings can be estimated, the text on net benefits should be deleted.

14) 1.13, Table 1.5: The estimates of carbon reductions under the alternative view do not match with the carbon reductions in table A-1.2 on p. A-1.5. It seems implausible that discount rates could double and have no effects on any technology adoption decision in this report. Are the numbers in the appendix the right set? Is it true that every single energy efficient technology adoption decision is cost-effective under the “best estimate” discount rate and the “alternative view” discount rate? If these technologies are such big winners, then why aren’t people and firms already adopting them?

15) 1.14: Until the costs and cost-savings issues are adequately addressed, estimates of net savings should be omitted.

16) 1.15, paragraph 3: As stated in the executive summary comments, the text should not state “energy efficiency alone can take the nation 30 to 50% of the way to 1990 levels.” If energy efficiency could achieve these reductions “alone”, there would be no need for an invigorated federal policy effort. The role of policy should be explicitly stated.

Chapter 2

17) 2.6, transportation sector bullet: The text states that the transportation sector analysis uses a 5 year time horizon. However, the description of the best estimate and alternative view cost effectiveness calculations on p. A-1.10 indicate that a time horizon of 14 years was used. Further, the transportation chapter indicates that the cost effectiveness analyses were conducted using a 6% discount rate in combination with a decline in usage and depreciation to calculate fuel savings (p. 5.45). The footnote to table 5.9 implies that the analyses used a 14 year time horizon as well. The report should clarify these inconsistencies.

Chapters 3-7

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

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

Chapter 3

20) 3.3: In the context of fully incorporating the effects of climate policy on energy prices, the analyses on buildings technologies should be modified. Under the efficiency case, energy consumption declines. This scenario should be changed to reflect the downward effect on prices

resulting from this decreased energy consumption. The high efficiency scenario should reflect two counteracting effects on prices: the decline in energy consumption and the \$50/ton permit fee. The study ignores the former effect and insufficiently incorporates the latter effect. For example, in the buildings chapter, the penetration rate is assumed to be 65% instead of 60% of the maximum cost-effective technical potential in this scenario because of the \$50/ton permit price. However, the energy-cost savings calculations for buildings technologies assume the same energy price as in the business as usual scenario. Since the study assumes that exogenous, undefined policy influences drive the penetration rates, the penetration rate should be set at 60% and the energy cost-savings should be recalculated with the appropriate energy price. In addition, the assumed energy use for these technologies should be based on consumers' responses to the lower operating costs. For example, if running an air conditioner becomes less expensive with a new energy efficient technology, people will run the air conditioner more. This latter effect decreases the carbon reductions associated with each adoption decision.

21) 3.9 and Appendix C-1: The study uses the average cost of electricity to calculate the energy cost savings of these technologies. Many of the electricity-dependent technologies are cost effective based on the assumption of average, not marginal electricity prices. Since marginal prices may be much lower than average prices, especially in cases where households use less electricity, this may over estimate the extent of cost effective technologies. The analysis should be modified using marginal electricity prices.

22) 3.23, box: The text in the box is not clear on the inclusion of fuel cell technology in the high efficiency scenarios. The first paragraph states that fuel cells were not included in the main building sector scenarios. However, emissions reductions of 3 MMTCE from fuel cells are listed under buildings in Table 1.4 on p. 1.11. Further, the discussion on fuel cells in the text outside of this box implies that fuel cell technology will not be available until 2020 (since it falls in the section "Potential for Advanced Technologies in 2020"). If the study relies on ADL's analysis of fuel cell adoption, then the assumptions of ADL's assessment should be provided in an appendix. Two issues should be addressed here. First, if fuel cells are projected to be adopted under the high efficiency scenarios, then this discussion should be placed in the appropriate section of this chapter (not the 2020 section), and the inconsistencies in the text should be remedied. Second, if fuel cells are adopted, then a discussion of the carbon emissions accounting should be provided to ensure that the study does not double count emissions reductions from energy efficient technology adoption and from switching energy sources to fuel cells.

23) 3.29, summary bullet two: This states that the high efficiency scenario yields 91 MMTCE of carbon reductions from the BAU emissions level. However, Table 1.4 indicates that only 44 MMTCE of reductions occur under the \$25/ton permit price and only 62 MMTCE of reductions occur under the \$50/ton permit price. Which carbon reduction estimate is correct?

Chapter 4

24) 4.6, paragraph 4: The analysis assumes that the capital recovery factor falls by more than half. This appears to be an arbitrary reduction. Did industry behave as if it operated under a lower CRF during the 1970s oil shocks? There is no discussion of the economic behavior necessary to result in this outcome.

25) 4.6, paragraph 4: The high efficiency penetration rate is assumed to be double the rate used in the efficiency scenario, which is the undefined “normal” rate. It is impossible to determine how much of this doubling of penetration results from undefined, aggressive policy efforts and how much results from the permit price. It would be valuable to understand the relative impacts of both.

26) 4.13, paragraph 4: The text states that the high efficiency case causes an acceleration of capital retirement, but does not estimate these costs. Could you estimate the costs of early retirement? If not, can you provide some information on the extent of early retirement (e.g., percentage of capital retired early under this scenario)?

Chapter 5

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

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

29) 5.4, Table 5.1: Why do the energy consumption numbers for this sector in 1997 vary across scenarios? We understand that the start year for the scenario analyses is 1998 (e.g., refer to Table 4.8 on p. 4.12 that implies 1998 as the start year for assessing cumulative incremental investment).

30) 5.21, paragraph 2: Does the assumption about reducing technology costs reflect any empirical analysis on transportation technologies? For example, the 1970s oil shocks and fuel efficient imports spurred domestic fuel efficiency R&D. Does this analysis incorporate

information about accelerating technology development and lowering technology costs that may be available from this earlier period?

31) 5.23, paragraph 3: As we have noted before, it is difficult to modify consumers' preferences. Assuming that the demand for horsepower will decrease because consumers will become "more green" over the next decade appears tenuous. This statement is repeated on p. 5.32. Is there any evidence that concern about global warming has affected consumers' purchase decisions to date?

32) 5.25, paragraph 1: If the turbocompound diesel engine and the advanced LE-55 heat engine are not available in the reference case (which implies that the earliest these are available is 2016), then how are they made available by 2003? Is there any precedent for accelerating transportation technology from a time horizon of at least 18 years to a horizon of only 5 years?

33) 5.25, paragraph 1: The efficiency case assumes that advanced drag reduction in heavy trucks has become available this year, but this is excluded from the reference case. First, has this actually occurred? Second, if it has already occurred, then why is it excluded from BAU?

34) 5.25, paragraph 4: Again, the assumption of reducing a technology price appears arbitrary. What is the basis for assuming that the trigger price for heavy truck technologies will fall?

35) 5.25, paragraph 5: The efficiency analysis assumes penetration rates of 100% for several of the heavy truck technologies over a 20 year period. This seems incongruous with the assumptions in the other sector analyses that imply much lower penetration rates. 100% penetration of a technology within 20 years, that is not expected to be available 18 years from now in the BAU, appears to be an extreme and unsubstantiated assumption.

36) 5.32, paragraph 1: The analysis assumes that fuel cells, because their costs are unknown, will be cost effective. This is an entirely arbitrary assumption, especially for a technology that is not even projected to become available in the BAU scenario. There is absolutely no economic basis for this assumption. This assumption is all the more extraordinary given that this analysis does not (apparently) incorporate the impacts of a carbon permit on fuel prices.

37) 5.36, Table 5.7: If the scenarios over estimate fuel economy, as stated in the footnote, then the numbers should be revised to remedy this error.

38) 5.38, paragraph 2: The modification of assumed improvement of fuel efficiency by multiplying the expected improvement by 0.7 to reflect offsetting performance effects, appears arbitrary. Why wouldn't the fraction be much smaller? The introduction to this chapter indicates that almost all improvements in fuel efficiency are offset by performance effects. Why would only 30% of fuel efficiency improvements in the future be offset?

39) 5.45: The chapter is not explicit about its accounting of fuel efficiency improvements in light duty vehicles and the change in the fuel mix reflecting an increase in cellulosic ethanol and the

use of fuel cell technology. We cannot determine if carbon reductions are double counted, however, there is no discussion of how cellulosic ethanol and fuel cells are accounted for in the energy cost savings description on pp. 5.43-5.45. If the reductions from fuel efficiency and the reductions from cellulosic ethanol and fuel cells do not overlap, then this should be stated explicitly. Again, a more transparent presentation of the methodology would address the readers' uncertainty about this issue.

40) 5.45, Table 5.9: The cost effectiveness estimates assume a constant price of \$1.20 per gallon through the life of the vehicles. The gasoline price should be adjusted down to reflect the impact of decreased gasoline consumption due to fuel efficiency. Further, vehicle miles traveled should increase through time as cars become more fuel efficient, consistent with the trend to date, instead of held constant.

Chapter 7

41) 7.1, paragraph 2: If the report has eliminated the double counting in this sector evident in the June 10 draft, then the sentence that states that double counting is "a likely possibility" should be deleted. A reference to appendix G-2 should be inserted.

42) 7.2, paragraph 3: Again, if the double counting has been remedied by integrating the dispatching and repowering analyses, then the following sentence should be modified: "The analytical approach was static in that the cost of repowering was computed for each candidate power plant but the analysis did not optimize unit/plant production cost, dispatch, or system load."

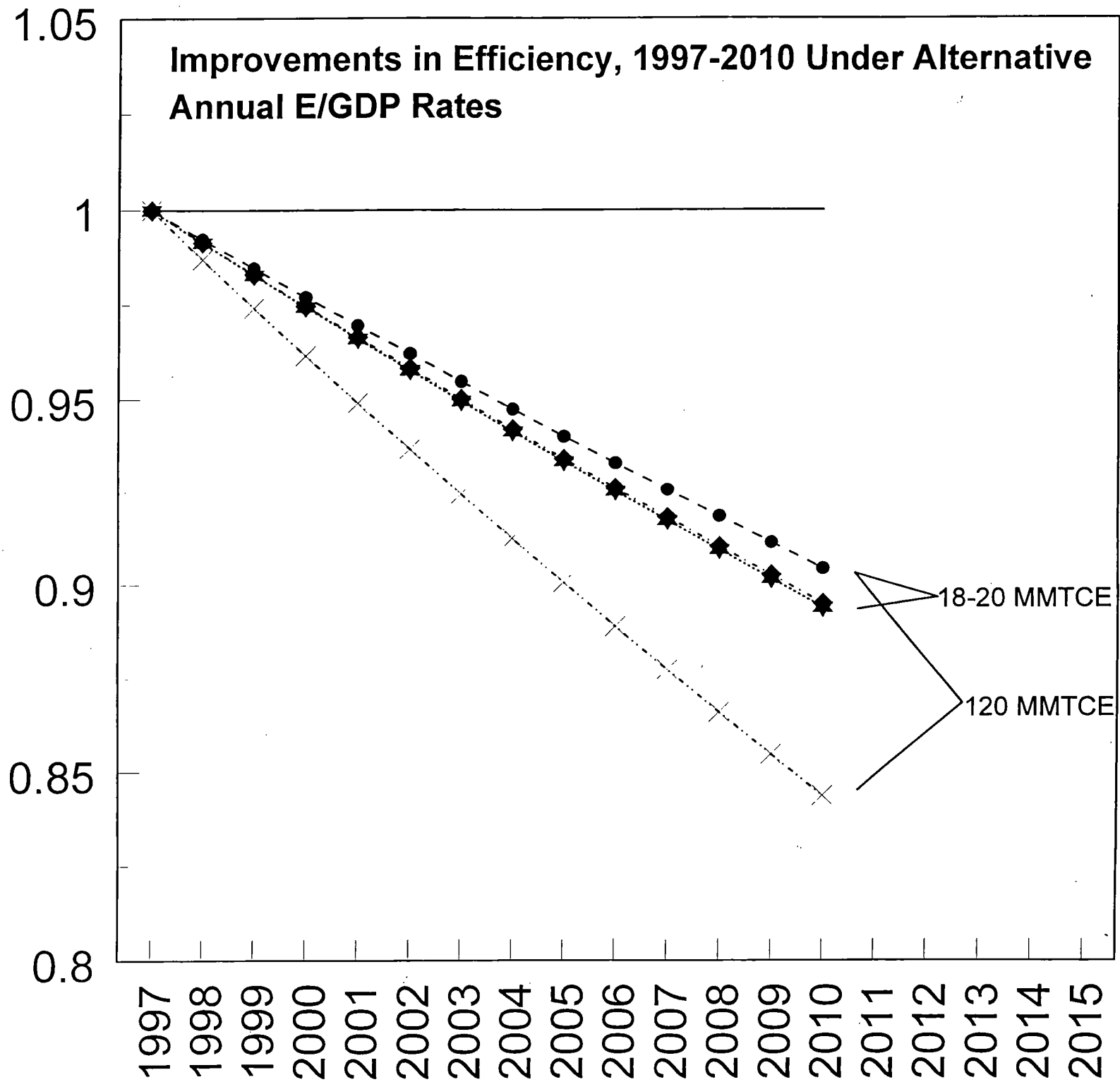
43) 7.6, paragraph 5: The reference to appendix G-2 is wrong. This reference implies that appendix G-2 provides a methodology for SO₂ and NO_x benefits. Nothing in the text of chapter 7 reads as if the double counting issue from the June 10 draft has been resolved.

Appendices

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

ranges from 1 (residential) to 12 years (commercial). The cost effectiveness estimates should be recalculated using specific end use lifetimes.

Improvements in Efficiency, 1997-2010 Under Alternative Annual E/GDP Rates



No Efficiency
 —
 BAU-CEA (0.6)
 ·····★····
 BAU-CEA (0.9)
 ·····◆····
 BAU-DOE5
 - - - ● - - -
 Efficiency Case
 ·····×····

All efficiency values are shown relative to a 1997 E/GDP ratio indexed to 1.

18-20 MMTCE
 120 MMTCE



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FOR IMMEDIATE RELEASE

September xx, 1997

**Clean Technology Can Achieve
Significant Greenhouse Gas Reductions**

Peer-Reviewed Energy Study: What's Good for Environment is Good for Economy

National investment in energy-efficiency and clean energy technologies can reduce U.S. emissions of global warming gases and produce energy savings that roughly equal or exceed the costs to implement them, Energy Department experts predict. A study conducted by five Department of Energy laboratories and peer-reviewed by industry and academic experts demonstrates that the United States could hold down the costs of meeting climate change goals through technological solutions such as advanced natural gas turbines, biomass and biofuels, and energy-saving appliances. Many consumers and businesses could actually save money through reduced energy use and lower overall energy bills.

"This analysis provides strong evidence that progress on climate change can be achieved without increasing the nation's energy bill. What's good for the environment also can be good for the economy," said Energy Secretary Federico Peña. "President Clinton's plan to make technology a cornerstone for reducing greenhouse gas emissions can achieve these results. From the Partnership for a New Generation of Vehicles that's creating the super-efficient car of the future to expanded use of renewable energy sources, the technology solution is already creating environmental benefits and savings in energy costs."

Current projections suggest that a carbon emissions reduction of 390 million metric tons (MMT) would be required to reduce U.S. emissions in 2010 to 1990 levels. The study models a scenario that combines a vigorous national technology program with a domestic system of carbon trading to achieve the reduction. The study concludes that such an approach could reduce emissions by up to 390 MMT. A new generation of technologies and international carbon emission trading could result in further reductions over the next quarter century.

This study estimated the potential costs of the reductions at \$50 to \$90 billion per year. Costs in the study include incremental investments to deploy clean energy or energy efficient technologies by consumers and industry as well as those associated with hypothetical increases in energy prices. In addition, Energy Department experts reviewed energy cost savings resulting from the use of these technologies; these estimated savings through 2010 total \$70 to \$90 billion year. This indicates that the clean energy investments could produce energy cost savings roughly equal to or greater than the costs of implementation, on a life-cycle basis.

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The "bottoms-up" approach in the study examines 200 specific technologies in four major sectors of the economy -- buildings, industry, transportation and electric utilities -- and analyzes the possible advances in each sector. For the buildings, industry and transportation sectors, the study analyzes the impacts of end-use energy-efficiency improvements and low-carbon technologies on carbon emissions. The utility sector analysis estimates the impacts of clean energy activities, such as increased use of natural gas and renewable energy. While no one measure can address the entire problem, technologies already in development could contribute substantially to the reductions. For example:

- **Transportation:** The Partnership for a New Generation of Vehicles is developing advanced automobiles that will be three times more fuel-efficient than today's vehicles but still safe and affordable. In the biofuels area, cellulosic ethanol, a promising biofuel made from agricultural and forestry wastes, produces no net carbon emissions; the Energy Department projects cutting the cost of ethanol to under 70 cents/gallon by 2010.
- **Buildings:** The study projects promising carbon reductions from energy-efficient appliances supported by the Energy Department, including a 1 kilowatt-hour/day refrigerator and advanced lighting. Advanced fuel cells powered by natural gas will produce electricity and provide heating at 80-percent efficiency, while lowering the current cost of power.
- **Utilities:** Wind turbines are expected to produce power at less than 3 cents/kilowatt-hour by 2010. Biomass co-firing with coal at some plants could produce significant emissions reductions.
- **Industry:** Advanced turbines are expected to achieve 80 percent system efficiency, producing electricity and steam in industrial plants at less than today's costs. Advanced motor systems and clean industrial technologies can cut emissions and costs while increasing productivity.

The Department of Energy's Oak Ridge and Lawrence Berkeley National Laboratories led the comprehensive one-year analysis, with contributions by the National Renewable Energy Laboratory and Pacific Northwest and Argonne National Laboratories. The findings, which were reviewed extensively by representatives from industry and academia, are consistent with those of two previous studies. Those studies, released by the National Academy of Sciences and Office of Technology Assessment in 1991, also concluded that technology could play a prominent role in reducing U.S. greenhouse gas emissions.

To request a summary or full copy of the study, titled *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficiency and Low-Carbon Technologies by 2010 and Beyond*, media can call the Department of Energy Press Office at 202/586-5806; others can call Public Inquiries at 202/586-5575.

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I. BUILDINGS

A. PATH

1. *Background*

This initiative would; develop a challenge goal through discussions with industry; build on existing initiatives - National Construction Goals, Buildings for the 21st Century, National Homeownership Strategy, and Energy Star Buildings, with added focus and coordination; map out a coordinated strategy based on an evaluation of the technology R&D process and needed resources in government and private sector; significantly reduce the economic, legal and regulatory barriers to systematic use of technological innovation; help implement regulatory streamlining models and procedures.

Included would be three pilots to initiative PATH. These might include (1) Colorado — using the Stapleton Airport Redevelopment as a major site for these homes, (2) Florida — the current insurance and housing crisis makes this a good starting place (3) Los Angeles — urban housing issues are a critical issue.

This is more than a climate change initiative as it includes disaster mitigation, occupation health and safety and home ownership. Final budget numbers and carbon estimates not yet available. Vice President has discussed his interest in this partnership independent of climate change issues.

2. *Actions*

A partnership designed to streamline federal, state, and local regulations and create markets for building designs that achieve major energy savings while reducing costs. Partners will seek expedited permitting and reciprocity from participating communities. Insurance companies will play a key role by encouraging construction quality.

- Large procurements for new housing units meeting ambitious performance specifications will be made in Colorado, Florida, and Los Angeles.

Federal agencies will participate by streamlining federal regulations, helping communities craft performance-based procurement instruments, helping review and certify structures claiming to meet performance specifications, forming research partnerships to develop pre-commercial components and design concepts (not costed here, see long-term section) and providing overall national leadership and an infrastructure for communication between participating communities

3. *Analysis of Impact*

This initiative has the potential of making housing affordable to 5 million families in the U.S. who don't own homes today and at the same time reduce carbon emissions. To help the industry grow, and to meet the policy goals we need to introduce new technologies and practices - but introducing new technologies has been a slow and difficult process. We have the opportunity to create a partnership between government and industry that will challenge the industry to create and apply advanced and innovative technologies and practices in the residential building marketplace.

The residential and commercial buildings sector produces over 30 million tons of waste and energy use in buildings account for more than one-third of air emissions.

B. RATINGS FOR EXISTING HOMES

1. *Background*

A new program under consideration would recognize homeowners for making comprehensive energy efficiency improvements by providing Energy Star certification to highly efficient existing homes. This certification will provide reliable information in the market place that will be useful to buyers and sellers of homes, enabling purchasers to identify energy-efficient homes and providing asset value to home energy efficiency improvements.

The energy used in a typical home causes more greenhouse gas pollution in a year than does an average car. These greenhouse gas emissions can be reduced by 1/3 in many homes while maintaining or improving home comfort. At the same time, homeowners can reduce their annual energy bills by 1/3, saving hundreds of dollars per year.

The Energy Star Homes program compliments the Energy Star New Homes program, which is working hand-in-hand with home builders to construct homes that exceed the Model Energy Code by 30%. Certified homes will receive an "Energy Star Home" plaque. DOE and EPA have joined forces with industry to provide consumers with energy-efficient, lower-pollution home products that are easily identified by the Energy Star label. In addition to launching an Energy Star Homes program, the President could "challenge" consumers to invest in energy efficiency, turning their homes into Energy Star Homes. This message would reinforce the national Energy Star campaign currently underway, and provide additional motivation to consumers to consider energy efficiency in their investment decisions.

Thousands of products currently carry the Energy Star label, including heating and cooling equipment, refrigerators, dishwashers, computers, and others. Measurement techniques have already been established by DOE through the proposed Home Energy Rating System guidelines, which are widely used in the homes industry. A Public Service Announcement campaign has been launched in August to facilitate the national Energy Star campaign. The print, television, and radio announcements draw the link between energy use and pollution and encourage Energy Star purchases. Initial roll-out has focused on the West Coast and has received significant media attention. The campaign will spread to target cities across the country in the coming months.

2. *Actions*

- Develop a national, voluntary rating system for existing homes which would be available to potential purchasers.
- Widely advertise the value and use of the rating system

3. *Analysis of Impact*

C. ENERGY STAR CUSTOMER SERVICE PROGRAM

1. *Background*

2. *Actions*

- Provide national leadership to encourage partnership with utilities, energy service companies, and others interested in offering improved service to their residential and commercial customers by helping them reduce their energy usage and energy bills. For commercial customers, including

schools, hospitals, and shopping malls, this could also include installing, financing, and maintaining on-site electricity generation systems that would reduce overall energy usage. Goals would include:

- increase the installation rate of high efficiency equipment for routine replacements of key building equipment and appliances

increase the market penetration rates of intelligent building management systems

3. Analysis of Impact

D. MILLION SOLAR ROOFS

1. Background

Government and industry to install 1 million buildings applications of photovoltaics, solar water heating and energy efficient design.

The chief competitors of the US industry, Germany and Japan, have already established national initiatives to enhance their native industries' market and lower system costs. Germany is expecting to spend over \$100 million on research and domestic PV rooftop programs and Japan plans to spend \$120 million to subsidize the purchase of 10,000 rooftop PV systems. Those countries have realized that to be a world-leader in PV requires a strong domestic market

2. Actions

The program would have a number of components, some related to other activities. The key to the program would be the partnership with communities, states and companies with the federal government providing information resources to help develop voluntary deployment programs. The program could also include potential government purchases of rooftop systems for government facilities (related to the proposed executive order in part 2); low cost financing options - a variety of federal loan programs (SBA, FEMA, FmHA, RUS, Fannie Mae among others) already in existence could be utilized to provide low cost financing - approximately 20 years at 5% below bank rates; promotion by the White House and DoE will be invaluable in this process.

3. Analysis of Impact

The US can achieve a critical mass for domestic sales without spending the type of money that Japan and Germany will be spending. The greenhouse gas impacts of the program are important. While rooftop solar systems will contribute only a little to reducing greenhouse gas emissions before 2010 (200,000 metric tons) the key to the program is that the technology and market will be strong and viable to accelerate after 2010 and be the cornerstone to maintaining a stabilized level of carbon emissions. Renewables will be critical after 2010 in keeping emissions stable through 2020 and beyond and this program will ensure that the domestic industry is ready to meet the challenge at a cost of \$10M per year.

A) ADVANCED BUILDING R&D

i) Background

ii) Actions

- lighting
- advanced appliances
- sensors and controls
- tools for integrated building design/analysis
- advanced appliances

iii) Analysis of Impact

E. NEW APPLIANCE STANDARDS

1. Background

DOE suggests that high priority be given to new standards for clothes washers, cooking products, distribution transformers, fluorescent lamp ballasts, residential water heaters and room air conditioners. Medium priority would be given to residential central air conditioners and heat pumps

2. Actions

- Enforce existing appliance standards and promote benefits
- Develop aggressive standards for: central air conditioning, ballasts, washing machines

3. Analysis of Impact

II. TRANSPORTATION

B) PNGV

i) Background

ii) Actions

- Increased funding in bottleneck technologies may be needed to increase the probability of meeting the 80mpg goal. These include:
 - ⇒ lithium ion batteries (key bottleneck is electric storage)
 - ⇒ low-cost electric power controls in small volume (see electric controls below)
 - innovative hydraulic storage and pump/motor hybrids low-cost composite materials

iii) Analysis of Impact

C) NEW TECH FOR AIR TRAVEL

i) Background

Current emissions of CO₂ from aircraft are 2.5% of the total global emissions from fossil fuel use. Over the past 30 years, aircraft have contributed about 1.5% of the industrial increase in atmospheric carbon dioxide. Current emissions of NO_x from aircraft are estimated to have an effect on climate that is comparable to CO₂.

Operational efficiencies that will be achieved through a global transition to advanced technology Communications, Navigation, Surveillance/Air Traffic Management include:

- Increased user-preferred routing
- Reduced horizontal aircraft separation
- More efficient climb/descent procedures
- More efficient approach procedures
- More efficient ground movement procedures

A joint research venture between NASA and industry pursuing innovative engine technologies that will lead to cleaner-burning and higher-efficiency engines can meet these challenges.

Today, over 11,000 airplanes are in commercial service worldwide. In the next two decades 12,000 new commercial airplanes will be necessary to both meet projected growth in air travel and replace the older aircraft. New technologies must be adopted to ensure that these airplanes meet the highest safety and environmental standards. There are technological solutions that will significantly reduce aircraft emissions that contribute to global climate change

ii) Actions

Continue planned funding for aeronautics and air traffic control in NASA, FAA, and DoD. Ensure effective coordination and that adequate priority is given to improved fuel efficiency.

iii) Analysis of Impact

NASA's test facilities and core expertise in materials, structures, aerodynamics, propulsion, analytical methods, and computational tools will be key elements in helping to revolutionize aircraft design and manufacturing. NASA's research efforts will focus on innovative design techniques and structural concepts to enable the U.S. aviation industry to significantly advance today's aircraft and engines. NASA's Advanced Subsonic Technology (AST) program seeks to reduce emissions of future aircraft by a factor of three within 10 years and by a factor of five within 20 years. The stretch goals are to reduce NO_x by 70 percent and improve fuel efficiency by at least 8-10 percent. Could achieve 10 mmtc savings.

Additional savings can be achieved by improved air traffic control efficiencies is a 12% reduction in the annual amount of fuel burned, leading to the following reductions in annual emissions (MLbs/yr):

- CO2 79.10
- NOx .37
- H2O 29.20
- HC .05

D) PNGV FOR HEAVY (>8500LB) TRUCKS

i) Background

The Partnership for a New Generation of Trucks (PNGT) would be a joint public/private automotive technology research program focused on the objective of increasing the fuel economy, and reducing carbon emissions, of heavy trucks.

This program would be modeled after the existing Partnership for a New Generation of Vehicles (PNGV) program. The preliminary fuel economy improvement goals would be 25 to 50 percent improvement for long haul trucks and 100 to 200 percent improvement (note that 200 percent is equivalent to the "3X" level of improvement in PNGV) for urban delivery vehicles. One could achieve 10-20 mmtc reduction post 2010 with a government investment of \$25-30M per year.

i) Actions

ii) The timetable would be to develop production prototype vehicles by 2005 that meet levels of fuel economy improvement given above while also maintaining other important attributes: 1) particulate and nitrogen oxides emission levels of 0.05 and 1.0 grams per horsepower-hour, respectively, 2) applicable safety standards, 3) total life-cycle cost no higher than baseline vehicles, and 4) engine performance at least as good as baseline vehicles. An important constraint would be that the fuel economy improvement must be achieved through improved technology rather than through the use of increasing gross vehicle weight loadings or decreasing empty backhauls

- 25 to 50 percent improvement in fuel economy for long haul trucks and 100 to 200 percent improvement for urban delivery vehicles.

⇒ *focus on improved diesels, hybrid drive-trains Analysis of Impact*

Heavy trucks, defined as trucks with gross vehicle weight ratings over 8500 pounds, account for about 16 percent of the carbon emissions from the transportation sector or about 5 percent of the total national carbon emissions (or about one-quarter of the carbon emissions from cars, pickup trucks, minivans, and sport utility vehicles). About 70 percent of the carbon emissions from heavy trucks are from long haul trucks (semi-tractor trailers). The diesel engines used in long haul trucks are the most efficient engines used in any vehicle application and are generally operated under steady-state, high-power conditions which are optimal for high fuel economy (for example, on an energy per ton-mile basis, a 7 mpg long haul truck is equivalent to a car that gets 140 mpg). Urban delivery vehicles account for most of the remaining 30 percent of carbon emissions from heavy

trucks. Urban delivery vehicles use both diesel and gasoline (with the recent trend being increasing use of diesel) and are generally operated under low-speed, stop-and-go conditions which offer greater opportunities for fuel economy improvement.

A. STIMULATE MARKETS FOR EFFICIENT VEHICLES

III. INDUSTRY

A. ACCELERATE COMBINED HEAT AND POWER

1. Background

Advanced turbines, utilizing natural gas or biofuels, when operated as part of a combined heat and power (C.P.) system at industrial facilities, can generate electricity while meeting thermal loads. Systems can achieve nearly doubling the energy efficiency over conventional electricity generation and separate process heating systems. Recent developments in combustion turbine technology present an opportunity for major improvements in competitiveness and reduction in emissions as well and represent a potential major new international market for U.S. industry. In addition to accelerating coordinated industry and government research, development and demonstrations, the amelioration of several market barriers or impediments would radically enhance the entry and expansion of these systems in the industrial market.

Air Quality Permitting barriers: To site a new C.P. facility or repower an existing industrial boiler can require an extensive and several year application process, driving up costs. A standardized and accelerated permitting process could be developed.

Utility Open Access barriers: Current and potential future utility regulations can impose burdens on independent facilities generating electricity in terms of cost of stand-by power, artificially high access fees and artificially low electricity purchase rates.

Equitable Financial Treatment: Depending upon the ownership of the C.P. facility, current depreciation schedules can impose higher rates than for comparable electric utility generation.

2. Actions

- establishment of expedited and standardized environmental permitting processes for advanced turbine-based industrial Combined Heat and Power systems;
- performance-based emissions standards as for utility generator emissions in the new EPA rules on SO_x and NO_x;
- credits for efficient C.P. systems that displace utility generation emissions in emissions permit applications;
- strong encouragement by the Federal Government that unencumbered, open access to the electricity distribution system by efficient C.P. and on-site generation be included in state and national utility restructuring legislation;
- common depreciation schedules for all on-site and utility-generation assets.
- ensure focus on near-term opportunities in forest product industries including paper processing's supply of "black liquor" and "hog fuels"

develop information, tools, best practices, and training.

3. *Analysis of Impact*

B. EXPAND INDUSTRIES OF THE FUTURE RESEARCH PARTNERSHIPS

1. *Background*

ii) *Actions*

- Biocatalysis and other methods for achieving high productivity chemical production and separations at low cost and with low emissions
- Use of biomass feedstocks as substitutes for petrochemical feedstocks

[Other long-term research projects from "industries of the future" roadmaps?]

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- Use of biomass feedstocks as substitutes for petrochemical feedstocks

[Other long-term research projects from "industries of the future" roadmaps?]

iii) *Analysis of Impact*

C.

D. INDUSTRIAL POWER

1. *Background*

The Motor Challenge program has had remarkable success in partnering with industry; moving the market to more efficient industrial motor-driven systems. Working off this success, and expanded partnership activities will seek greater participation in Motor Challenge. Expanded activities will provide information on best practices, and training to assist industries in managing, upgrading, and engineering their motor-driven, steam and compressed air system technology that is pervasive throughout manufacturing facilities.

The principal market barriers to be overcome are to: 1) move the market from a first cost to a life cycle cost focus, 2) fill the void of unbiased and reliable technical information and training; make it easily obtainable, and 3) overcome a lack of awareness of benefits available from a "system focus" and energy efficiency overall throughout all levels of manufacturing firms -from the CEO to the person on the shop floor. Expanded activities will promote a message that cost reduction and increased productivity can be achieved simultaneous to improving energy efficiency. That is, energy efficiency and improved productivity go hand and hand.

Implementation will pattern the steam system and compressed air system initiative program designs after the Motor Challenge partnership activities which are industry-driven, and relies heavily on market participants to deliver information and training to the industrial end-user customers (i.e., the existing Motor Challenge Allied Partner network).

2. *Actions*

- Enforce existing appliance standards and promote benefits

Develop aggressive standards for: central air conditioning, ballasts, washing machines

3. *Analysis of Impact*

Motor driven systems, steam systems and compressed air systems comprised over 60 percent of all industrial energy - over 300 MMT per year. Therefore, the near-term opportunity would be to mitigate about two to three times more carbon than the Motor Challenge program will accomplish, alone, almost 30-45 mmtc.

IV. CITIES

A. CLEAN CITIES

1. *Background*

10 regional pilot projects to overcome institutional and analytic barriers to better integration of transportation and land use planning as proposed in the President's budget.

STI is modeled after the success that has been achieved in Portland, Oregon. The Portland region avoided construction of a costly western by-pass by implementing policies that focused on in-fill development and developments near a new light rail system. Portland combined a program of aggressive public outreach with new methodologies that enabled planners to explore alternatives to highway construction. Portland has stabilized growth in per-capita VMT over the last 5 years.

Goals are to increase transportation efficiency, decrease VMT and congestion, maintain or improve regional mobility, promote brownfields redevelopment, and reduce environmental impacts of transportation. Funding for collaborative planning, public participation, modeling, pre-construction engineering, and project evaluation. \$30 million in DOT funding over 6 years; \$4.25 requested for FY98. Builds on EPA's existing CCAP program Transportation Partners and DOT's Sustainable Communities Initiative. Complements EPA's Urban Initiative, Brownfields Initiative and Sustainable Development Challenge Grants

The House Appropriations Committee has zeroed the line item for this initiative from DOT's budget. ISTEA-2 as proposed by Moynihan and Chafee authorizes a similar program for \$50 million annually over the next six years. This is substantially more than the administration's budget request.

2. *Actions*

- Support Urban Initiative, Brownfields Initiative and Sustainable Development Challenge Grants
- ten regional pilot projects to overcome institutional and analytic barriers to better integration of transportation and land use planning as proposed in the President's budget

Using a similar program, Portland stabilized growth in per-capita VMT over the last 5 years

3. *Analysis of Impact*

Extrapolating from the Portland experience to the nation, it is estimated that the \$30 million proposed for this initiative could support annual national air pollution reductions of approximately: 0.9% for HC; 1.4% for Nox; 0.9% for CO; and 1.2% for CO₂, or approximately 18 MMTC

B. NATIONAL LEADERSHIP FOR STATE TRANSPORTATION PROGRAMS

V. AGRICULTURE

A. BIOFUELS

1. *Background*

2. *Actions*

- Solicit bids for a large-scale facility for converting biomass to a liquid fuel (ethanol, ethanol, synthetic diesel

a) AND/OR

Restructure ISTEA proposal for extension of ethanol tax credit so that it will apply to all biomass-derived fuels on an equitable basis

3. *Analysis of Impact*

B. FARM-BILL FOR BIOMASS

1. *Background*

2. *Actions*

Review use of Conservation Reserve , Rural Economic Development, Flood Control and Drainage, riparian control, and other programs to encourage experiments with sustainable biomass crops

3. *Analysis of Impact*

E) NEW CROPS FOR BIOMASS

i) *Background*

ii) *Actions*

- Apply advanced genetic techniques to create drought/disease/pest-resistant biomass crops capable of being delivered for less than \$20/dry ton/ha
- Develop production/harvesting methods compatible with sound conservation/wildlife management plans
- Develop low-cost harvesting, drying, transport methods

- Apply advanced genetic techniques to create drought/disease/pest-resistant biomass crops capable of being delivered for less than \$20/dry ton/ha
- Develop production/harvesting methods compatible with sound conservation/wildlife management plans

(1) Develop low-cost harvesting, drying, transport methods

iii) Analysis of Impact

F) LOW INPUT AG.

i) Background

ii) Actions

Launch an ambitious program to achieve the yields of "green revolution" hybrid grains without use of nitrogen fertilizers. This means either fixing nitrogen in microorganisms associated with the plant root structure or developing nitrogen-fixing cyanobacteria capable of reproducing in the soil.

Launch an ambitious program to achieve the yields of "green revolution" hybrid grains without use of nitrogen fertilizers. This means either fixing nitrogen in microorganisms associated with the plant root structure or developing nitrogen-fixing cyanobacteria capable of reproducing in the soil.

iii) Analysis of Impact

VI. UTILITIES

A. PUBLIC BENEFITS CHARGE

1. Background

The Systems Benefit Charge, also known as the Universal System Benefits Charge, is a simple non-bypassable charge that appears on all customer electric bills. The charge is commonly thought of as based on a user's kWh consumption, but it can also be a flat fee, similar to the long-distance access charge that appears on all telephone bills. The System Benefits Charge is commonly proposed in restructuring proceedings as a means of raising a pool of funds to maintain investments in public programs such as R&D, support for low-income consumers, energy efficiency programs and investments, and in some cases, renewable energy technologies. This fund would be disbursed to states on a matching basis, if a state had one or more of the public purpose programs in place. This proposal is being considered in three Congressional bills (Jeffords, DeFazio and Markey), nine states and the Pacific Northwest, and the proposed legislation being discussed within the Administration. A potential model for this fund is the Telecommunication Act, which has a surcharge collection and disbursement to states on matching basis.

(i) Consumer Information Disclosure

Actions would be taken to provide consumers with information so they can participate in an educated fashion in the competitive deregulated electricity market to their full advantage. Information about prices should be provided so they understand the competitive advantage of one seller over another, and this should be provided consistently across state lines, as sellers will be able to sell across state lines. Also, consistent and accurate information should be provided on renewable technologies, as the interest in "green" electricity develops, as is expected, based on experience gained in retail pilot programs in the northeast and other regions. Two Congressional bills have

mandatory disclosure requirements (Markey and Jeffords). Ten states have disclosure requirements in their state restructuring legislation. It is also included in the DOE utility restructuring legislation being discussed within the Administration.

2. *Actions:*

- Submit legislation
- A fund similar to the Universal Service Fund for telecommunications would be established to cover poor and rural customers as well as to provide state resources to fund efficiency and renewable programs which would be eliminated under deregulation.

Federal service charge of a tenth of a cent per kWh (1 mill/kWh) would be collected and given to states which charge an additional tenth of a cent for state operations.

3. *Analysis of Impact:*

B. LOW CARBON ELECTRICITY

1. *Background*

Actions would be taken to provide consumers with information so they can participate in an educated fashion in the competitive deregulated electricity market to their full advantage. Information about prices should be provided so they understand the competitive advantage of one seller over another, and this should be provided consistently across state lines, as sellers will be able to sell across state lines. Also, consistent and accurate information should be provided on renewable technologies, as the interest in "green" electricity develops, as is expected, based on experience gained in retail pilot programs in the northeast and other regions. Two Congressional bills have mandatory disclosure requirements (Markey and Jeffords). Ten states have disclosure requirements in their state restructuring legislation. It is also included in the DOE utility restructuring legislation being discussed within the Administration.

(i) Renewable Portfolio Standards

A renewable portfolio standard would require either every generator or every retail power supplier to have a certain percentage of renewable energy credits in their resource mix, equal to some percentage of its total annual electricity sales. A retail seller can earn credits by owning renewable electric plants and generating credits, purchasing renewable electric power and receiving credits, purchasing credits from a renewables generator, or perhaps from a specialized REC market. A credit is earned for every MWh of renewable power. Such standards are being proposed in four Congressional bills (Bumpers, Jeffords, Schaefer, and Markey), in restructuring legislation in four states (Arizona, Maine, Nevada, and Vermont), and in restructuring legislation currently being discussed within the Administration. Percentage requirements for purchase would begin at very modest levels and gradually increase over a set time period, with most proposals going through 2010. The requirements on levels, which technologies and other issues would be set at the State level within broad Federal guidelines.

2. *Actions*

- As a part of utility restructuring, require either every generator or every retail power supplier to have a certain percentage of renewable energy credits in their resource mix, equal to some percentage of its total annual electricity sales. A retail seller can earn credits by owning

renewable electric plants and generating credits, purchasing renewable electric power and receiving credits, purchasing credits from a renewables generator, or perhaps from a specialized REC market.

(i) AND/OR

require that information be made available to facilitate state programs whereby customers could voluntarily indicate a willingness to pay a premium for electricity generated from low-pollution (low CO₂) generating facilities. Technical assistance (information infrastructure) could be provided for state green energy programs

3. *Analysis of Impact*

C. RENEWABLES PORTFOLIO STANDARD

D. ENCOURAGE GREEN PROCUREMENT

VII. CROSS-CUTTING AND BASIC RESEARCH

G) FUEL CELLS FOR CARS AND OTHER LIGHT-DUTY

i) Background

ii) Actions

- 20-40 \$/kW fuel cells capable of meeting the weight/volume/maintenance requirements of an automobile
 - low-cost/volume gasifiers for converting liquid fuels to hydrogen low-cost/efficient on-board hydrogen storage

iii) Analysis of Impact

H) FUEL CELLS FOR BUILDINGS, TRUCKS, AND OTHER HEAVY DUTY VEHICLES

i) Background

If successful, a new or retrofit building in 2010 using efficient technologies with electricity and hot water provided by an 80% to 90% efficient fuel cell could have no first-cost penalty with well under half the energy costs of a typical 1990 building and one-quarter the greenhouse gas emissions. The fuel cell is a unique technology that can revolutionize the way buildings acquire power, heating, cooling and hot water - with low emissions, low noise and high efficiency. This accelerated funding will result in prototype introduction of the PEM technology by 2004. This prototype introduction will be followed by cost-shared demonstrations in buildings that illustrate how installation of PEM fuel cells and energy efficient equipment can reduce buildings air emissions to extremely low levels.

ii) Actions

- 100-300 \$/kW fuel cells compatible with heavy vehicles (trucks, rail) and buildings (cogeneration units producing electricity and power).
 - low-cost/high-reliability reformers for converting natural gas emphasis on range of technologies: PEM, molten carbonate, solid oxide

iii) Analysis of Impact

I) BIOFUELS RESEARCH

J) BASIC ENERGY RESEARCH

K) SEQUESTRATION

i) Background

ii) Actions

- lightweight materials for vehicles and other applications
- advanced nuclear cycles [safe, proliferation-resistant, environmentally benign, cost-effective]
- bulk energy storage
- hydrogen production, storage, transportation, and use
- semiconductor research for advanced photovoltaics
 - inexpensive devices capable of switching large electric currents rapidly
 - molecular biology for bioprocessing, biofuels, and low-input agriculture

iii) Analysis of Impact

Climate Change Technology Options

The Options outlined below include both options which will accelerate deployment of technologies at or near commercial readiness as well as options for stimulating research which can achieve breakthroughs that will provide benefits in the long-term.

1. Buildings:

Buildings produce 35% of US CO₂ and consume over 2/3 of all US electricity. Energy use in buildings has increased 2.5%/year since 1986. The construction industry has not gone through the transformation that has reshaped most American manufacturing because of fragmented local regulation and no tradition of research or systems engineering. It appears possible to cut greenhouse emissions in buildings by a factor of 2 or more (and in some cases make buildings net energy producers) using methods that both improve building quality and lower cost. Leaders in the industry, its suppliers, the companies that insure and finance buildings, and state and local regulators are willing to join us in capturing the potential of making sharp reductions in building energy by improving products and production methods and streamlining regulation. Our strategy involves near-term actions to reinvent federal, state, and local regulations to create a near-term demand for the many technologies already available and a research partnership with builders and suppliers aimed at dramatically new building designs and appliances.

| | Actions | Federal Cost \$ millions (per year) | Savings (MMT) | |
|------|--|--|------------------|------|
| | | | 2010 | 2030 |
| PATH | <p>The Partnership for Advanced Technologies in Housing (PATH) aims to develop building designs and production methods which can lower costs while reducing greenhouse emissions by 50% and meet ambitious goals in wind and seismic resistance and other areas. The partnership includes builders, building suppliers (windows, appliances, etc.), insurance companies and federal/state/local officials. It will:</p> <ul style="list-style-type: none"> streamline federal, state, and local regulations and create markets for building designs that achieve major energy savings while reducing costs. Partners will seek expedited permitting and reciprocity from participating communities. Insurance companies will play a key role by encouraging construction quality. organize large, locally funded, procurements (tens of thousands of units) for new housing units meeting performance goals in partnership with states and cities (Colorado, Florida, and Los Angeles appear to be the most likely in the near term) | \$10 HUD \$10 NIST \$5 DOE | | |

| | | | | |
|--------------------------------------|---|--------------|-----|-------|
| | <ul style="list-style-type: none"> Federal agencies will participate by streamlining federal regulations, helping craft performance-based procurement instruments, helping review and certify structures, supporting forming research partnerships to develop pre-commercial components and design concepts (not costed here, see long-term section) and providing overall national leadership and communication infrastructure for participants. | | | |
| Home Energy Ratings | <ul style="list-style-type: none"> Widely advertise the value and use of a voluntary rating system for new and existing homes which would assist homebuyers make choices based on sound information about energy/environmental characteristics of the building | | | |
| Energy Star Customer Service Program | <ul style="list-style-type: none"> Provide national leadership to encourage partnership with utilities, energy service companies, and others interested in offering improved service to their residential and commercial customers by helping them reduce their energy usage and energy bills. For commercial customers, including schools, hospitals, and shopping malls, this could also include installing, financing, and maintaining on-site electricity generation systems that would reduce overall energy usage. Goals would include: <ul style="list-style-type: none"> increase the installation rate of high efficiency equipment for routine replacements of key building equipment and appliances increase the market penetration rates of intelligent building management systems | ? EPA/DOE | | |
| Million Solar Roofs | <ul style="list-style-type: none"> partnership combining businesses, federal, state, and local governments to develop and communicate approaches to voluntary deployment programs for photovoltaic and hot water systems on one million US rooftops by 2010. government purchases of rooftop systems for government facilities develop special programs for federal loan programs (SBA, FEMA, FmHA, RUS, Fannie Mae among others) already authorized to provide low-cost financing (20year loans 5% below bank rates are possible) promotion by federal agencies | \$10 DoE | 0.2 | 30-50 |
| Advanced Building R&D | <ul style="list-style-type: none"> Expand competitive, cost-shared research partnerships on integrated building design research using the Building America framework Expand research on advanced appliances, consumer electronics, lighting, sensors, controls, and tools for integrated building design/analysis | | | |
| New Appliance Standards | <ul style="list-style-type: none"> Continue developing appliance standards using existing authority for energy-intensive appliances. | | | |

2. Transportation

Cars, trucks, aircraft, and other transportation produces 33% of US CO₂ and has grown an average of 2.3% annually since 1986. Low fuel prices and constant increases in vehicle miles traveled make this the fastest growing source of US greenhouse gases. The average efficiency of new US cars and light trucks has been declining since 1985. All attempts to affect the industry through fuel taxes or fuel economy regulation face fierce opposition. Research may produce radically new technologies capable of delivering large gains in efficiency without increasing the cost of vehicles or travel. This program focuses entirely on research designed to reduce fuel consumption of cars, trucks, and aircraft by factors ranging from 50-200%.

| | Actions | Federal Cost \$ millions (per year) | Savings (MMT) | |
|--|---|--|------------------|------|
| | | | 2010 | 2030 |
| PNGV | <ul style="list-style-type: none"> • Increased funding in bottleneck technologies may be needed to increase the probability of meeting the 80mpg goal. These include: <ul style="list-style-type: none"> ⇒ lithium ion batteries (key bottleneck is electric storage) ⇒ low-cost electric power controls in small volume (see electric controls below) ⇒ innovative hydraulic storage and pump/motor hybrids ⇒ low-cost composite materials | 0-100 [above \$261M in FY97] | up to 70 | |
| New Tech for Air Travel | <ul style="list-style-type: none"> • Reduce energy consumption per passenger mile of air travel by []% • Next generation air-frames and high-bypass engines increase efficiency 10-15% • Use of advanced air-traffic control systems can reduce fuel requirements by []% by avoiding delays and permitting optimized routes | [100 in FY98 NASA budget] | 10 | |
| PNGV for Heavy (>8500lb) Trucks | <ul style="list-style-type: none"> • 25 to 50 percent improvement in fuel economy for long haul trucks and 100 to 200 percent improvement for urban delivery vehicles. • focus on improved diesels, hybrid drive-trains | 25-30 | 10-15 | |

| 3. Industry | | | | |
|--|--|-----------------------------|------------------|------|
| Industry produces 33% of US greenhouse gases — 78% of it in six industrial sectors: pulp and paper, chemicals, petroleum refining, glass, aluminum, iron and steel, and metal casting. Our strategy is to focus on accelerating the adoption of technologies which could have a major impact in a few areas where the payoff is high and regulatory or other barriers appear to be blocking adoption. Over the long-term, research partnerships can achieve efficiency gains with biotechnologies and other methods. | | | | |
| | Actions | Federal Cost \$ millions | Savings (MMT) | |
| | | (per year) | 2010 | 2030 |
| Accelerate Combined Heat and Power (use waste biomass or natural gas) | <ul style="list-style-type: none"> • establishment of expedited and standardized environmental permitting processes for advanced turbine-based industrial Combined Heat and Power systems; • performance-based emissions standards as for utility generator emissions in the new EPA rules on SO_x and NO_x; • credits for efficient C.P. systems that displace utility generation emissions in emissions permit applications; • strong encouragement by the Federal Government that unencumbered, open access to the electricity distribution system by efficient C.P. and on-site generation be included in state and national utility restructuring legislation; • common depreciation schedules for all on-site and utility-generation assets. • ensure focus on near-term opportunities in forest product industries including paper processing's supply of "black liquor" and "hog fuels" • develop information, tools, best practices, and training. | | 10-30 | |
| Expand Industries of the Future Research Partnerships | <ul style="list-style-type: none"> • Establish priorities in long-term research identified in the roadmaps already developed by industry groups and increase federal investment • Topics would include such things as biocatalysis and other methods for achieving high productivity chemical production and separations at low cost and with low emissions, inert anodes for aluminum production, and electromagnetic metal casting. | 30-50 DOE | | |
| Industrial Power | <ul style="list-style-type: none"> • Expand existing Motor Challenge Allied Partner network capture energy efficiency* opportunities employing market-ready industrial steam system and compressed air | \$10 DOE | 30-45 | |

| | | | | |
|--|---|--|--|--|
| | <p>system technology.</p> <ul style="list-style-type: none"> • Partnership will develop and communicate improved designs for efficient air and steam systems in addition to electric motor control • Provide training programs for industrial designers and expand programs in engineering schools. | | | |
|--|---|--|--|--|

| <p>4. Cities</p> | | | | |
|---|---|---|---------------|------|
| <p>The local transportation policies, urban design, and other urban policies have a profound influence on carbon production. [%] of vehicle miles driven occur in metropolitan regions. Portland Oregon demonstrated that a growing economy did not need to translate into growing amounts of travel and urban congestion given sensible programs in highway construction, parking policies, mass transit, and zoning. Using a similar program, Portland stabilized growth in per-capita VMT over the last 5 years. Some of the programs considered (building retrofits and increased use of non-auto transportation) could have impacts in the near term. Programs to encourage changes in urban structure that minimize travel needs are important but will have influence only over the long-term.</p> | | | | |
| | Actions | Federal Cost \$ millions | Savings (MMT) | |
| | | (per year) | 2010 | 2030 |
| Clean Cities | <ul style="list-style-type: none"> • Develop a partnership with the nation's mayors to strengthen and focus existing programs in DoT, EPA, and DoE to encourage efficient urban transportation planning and improve the energy efficiency of public buildings including schools and hospitals. • Support Urban Initiative, Sustainable Development Challenge Grants • Support regional pilot projects to overcome institutional and analytic barriers to better integration of transportation and land use planning | \$30 in NEXTEA \$? EPA ? DOE | 18 | |
| National Leadership for State Transport programs | <ul style="list-style-type: none"> • The administration's NEXTEA bill proposes a 25% increase (to \$1.3 billion annually) for the Congestion Mitigation and Air Quality Improvement Program . While states have authority to spend the funds in many areas, federal leadership could help focus programs on carbon emissions and provide information and analysis not available to many states. • Help states consider greenhouse emission goals as they develop plans for responding to the New National Ambient Air Quality standards.. | 325 . (increase included in NEXTEA budget) | | |

| 5. Agriculture | | | | |
|---|---|--|------------------|------|
| <p>Programs in agriculture aim to develop production methods that achieve large reductions in inputs of agricultural chemicals and create new economic opportunities for rural communities through crops that can produce an energy source which can be used with zero net contribution of greenhouse gases. The strategy relies on using authorities available in the farm bill to encourage early experiments in areas where niche-markets can be identified for biomass energy crops and a research program designed to achieve much larger markets in the future.</p> | | | | |
| | Actions | Federal Cost \$ millions (per year) | Savings (MMT) | |
| | | | 2010 | 2030 |
| Biofuels | <ul style="list-style-type: none"> Restructure ISTEA proposal for extension of ethanol tax credit so that it will apply to all biomass-derived fuels on an equitable basis <i>And/OR</i> Provide funding to share the cost of a large-scale facility for converting biomass to a liquid fuel (ethanol, ethanol, synthetic diesel) | | | |
| Farm-Bill for Biomass | <ul style="list-style-type: none"> Review use of Conservation Reserve , Rural Economic Development, Flood Control and Drainage, riparian control, and other programs to encourage experiments with sustainable biomass crops | 2 USDA | | |
| New Crops for Biomass | <ul style="list-style-type: none"> Apply advanced genetic techniques to create drought/disease/pest-resistant biomass crops capable of being delivered for less than \$20/dry ton/ha Develop production/harvesting methods compatible with sound conservation/wildlife management plans Develop low-cost harvesting, drying, transport methods | 20 USDA | | |
| Low Input Agriculture | <ul style="list-style-type: none"> Launch an ambitious program to achieve the yields of "green revolution" hybrid grains without use of pesticides or nitrogen fertilizers. (fixing nitrogen in microorganisms associated with the plant root structure, nitrogen-fixing cyanobacteria capable of reproducing in the soil, and other concepts) | | | |

6. Utilities

Electric utilities produce about a third of all US greenhouse gases 88% of which results from coal-fired power plants. Emissions have grown about 3.5% annually since 1990. Our strategy here focuses on using the opportunities presented as states and the federal government consider sweeping deregulation of electric generation. The goal is, at a minimum, to maintain incentives for efficiency and renewable energy that are at least as powerful as those available under existing regulation. Several options would increase incentives. In addition, we suggest options for accelerating development and adoption of renewable energy technologies such as wind which may be able to provide competitive power in some parts of the country.

| | Actions | Federal Cost \$ millions (per year) | Savings (MMT) | |
|------------------------------|---|--|------------------|------|
| | | | 2010 | 2030 |
| Public Benefits Charge | <ul style="list-style-type: none"> • A would be established to cover poor and rural customers as well as to provide state resources to fund efficiency and renewable programs which would be eliminated under deregulation. • Federal service charge of up to a tenth of a cent per kWh (1 mill/kWh) would be collected and given to states which charge an additional tenth of a cent for state operations. | \$1,000-3,000 (scoring?) | | |
| Renewable Portfolio Standard | <ul style="list-style-type: none"> • As a part of utility restructuring, require either every generator or every retail power supplier to have a certain percentage of renewable energy credits in their resource mix, equal to some percentage of its total annual electricity sales. A retail seller can earn credits by owning renewable electric plants and generating credits, purchasing renewable electric power and receiving credits, purchasing credits from a renewables generator, or perhaps from a specialized REC market. | | | |
| Encourage Green Procurement | <ul style="list-style-type: none"> • Help states experiment with methods for encouraging programs in which individual utility customers would be given the option of paying somewhat higher bills to cover the cost of purchasing low-carbon energy. • Require that information be made available to facilitate state programs whereby customers could voluntarily indicate a willingness to pay a premium for electricity generated from low-pollution (low CO₂) generating facilities. Technical assistance (information infrastructure) could be provided for state green energy programs | | | |

| | | | | |
|------------------------|--|--|--|--|
| Renewable Procurements | <ul style="list-style-type: none"> Help utilities and other potential buyers of renewable energy purchase equipment (possibly through purchasing consortium such as the "green carrot" procurements) that provides the lowest-cost to customers while creating a market that can encourage innovative technologies. This might, for example, permit a firm to develop a large wind field including construction of required transmission to connect the field to a suitable grid and possibly use of underground compressed air energy storage (CAES) to increase capacity factor and load-following characteristics of the and therefore the value of the power. | | | |
|------------------------|--|--|--|--|

7. Cross-Cutting and Basic Research

Stabilizing global greenhouse gas concentrations over the next few decades will require major changes in the way energy is produced and consumed. Achieving these goals requires investment in long-range, high-risk technologies which do not meet the investment objectives of private firms. The programs proposed here would provide federal investment for basic science and basic engineering in key areas. Most of the technologies supported here would benefit many different business sectors.

| | Actions | Federal Cost \$ millions | Savings (MMT) | |
|--|---|-----------------------------|------------------|------|
| | | (per year) | 2010 | 2030 |
| Fuel Cells for Cars and Other Light-Duty | <ul style="list-style-type: none"> 20-40 \$/kW fuel cells capable of meeting the weight/volume/maintenance requirements of an automobile low-cost/volume gasifiers for converting liquid fuels to hydrogen low-cost/efficient on-board hydrogen storage | | | |
| Heavy Duty Fuel Cells | <ul style="list-style-type: none"> 100-300 \$/kW fuel cells capable of providing cogeneration or onsite power for buildings and other applications (including coproduction of electricity and liquid fuels using biomass) and for use in heavy vehicles (trucks, buses, rail) low-cost/high-reliability reformers for converting natural gas to hydrogen balanced investment in PEM, molten carbonate, solid oxide | | | |
| Biofuels Research | <ul style="list-style-type: none"> next generation technology capable of producing liquid fuels for less than 75 cents/gallon gasoline equivalent including options for cogeneration systems yielding electricity. | | | |

| | | | | |
|-------------------------|---|--|--|--|
| Basic Energy Research | <ul style="list-style-type: none"> • lightweight materials for vehicles and other applications • advanced nuclear cycles [safe, proliferation-resistant, environmentally benign, cost-effective] • bulk energy storage • hydrogen production, storage, transportation, and use • semiconductor research for advanced photovoltaics • inexpensive devices capable of switching large electric currents rapidly • molecular biology for bioprocessing, biofuels, and low-input agriculture | | | |
| Sequestration of Carbon | <ul style="list-style-type: none"> • injection of CO₂ in aquifers and in other mechanisms • production of hydrogen at wellheads • advanced concepts | | | |

8. Federal Procurement Policy

| | |
|---------|---|
| Various | Options being prepared by a separate policy group |
|---------|---|

9. International

| | |
|------------------|--|
| Export Promotion | <p>Many energy technologies will have larger, earlier markets abroad than they do in the US. These international markets provide large export potential for US producers and could result in worldwide savings much higher than those shown in estimates which only indicate carbon savings in the US. Large export opportunities include:</p> <ul style="list-style-type: none"> • PNGV and other automobile technology • aircraft technology • photovoltaic and wind • high-technology components of biomass systems (turbines, gasifiers, harvesting equipment) • fuel cells • advanced industrial technologies • building controls and appliances |
|------------------|--|

A U.S. TECHNOLOGY STRATEGY FOR CLIMATE CHANGE MITIGATION

GOAL To join forces with the nation's leading corporate, university and other research centers to develop, demonstrate and encourage the market adoption of technologies in key sectors of the economy that will enable the U.S. to stop the growth of the country's greenhouse gas emissions in the future and, at some point, to return them to 1990 levels and lower, while maintaining or increasing overall economic performance and consumer satisfaction. In addition, to foster the development of these and related technologies for export to, or joint venture with, developing countries also working to minimize greenhouse gas emissions.

LONG-TERM TECHNOLOGIES

For the long-term, the strategy focuses on basic energy technologies, where breakthroughs are needed to provide radically different paradigms capable of providing high performance services with zero or very low emissions of greenhouse gases. An example of this type of program is the present "Partnership for a Next Generation of Vehicles" (PNGV) in which the auto manufacturers and the government are collaborating to develop a production prototype vehicle by 2004 that will achieve three times the fuel economy of a standard passenger car, 80 mpg, with the same performance and passenger amenities. The long-term technology strategy will phase up to a level of \$..... per year of federal funds. Because of the very long-term nature of this basic research, non-federal funding is expected to be limited. Examples of the research that are included in this area are:

- Small, light hydrogen fuel cells for automobiles and light-duty trucks, that can meet the weight, size, performance and maintenance requirements of these vehicles
- Biofuels research that can produce liquid fuels from agricultural products and waste materials at a price equivalent to 75 cents per gallon of gasoline or less
- Aircraft engines and design innovations that will reduce the combination of CO₂ and NO_x emissions (both greenhouse gases at high altitudes) by a factor of five
- Expanded "Industries for the Future" program to focus on topics jointly-identified with the industries, such as biological process for catalytic reactions and chemical separation to achieve.....
- Bulk energy storage, such as advanced batteries, that can
- Carbon sequestration, including injection of CO₂ into aquifers and other geological or oceanic formations

MEDIUM-TERM TECHNOLOGIES

For medium-term technologies, the strategy focuses on refining and proving technologies that have already been demonstrated in the laboratory, but may need critical incremental improvements, such as to achieve key threshold performance levels, and which need to be proven under real-world operating and use conditions. The strategy, when fully implemented, will reach a level of \$..... per year of federal funding, which should leverage an equal or greater level of private sector funding of these technologies. These projects should be cost-shared at least 50% by the private sector to ensure that they will respond to true market needs. Examples of the types of medium-term technologies that are included in the strategy are:

- Hydrogen fuel cells for buildings and heavy-duty transportation, that are able to operate for over 5,000 hours per year for 10 years or more with outputs of that can power a school, shopping center, or long-haul truck or train
- Advanced turbine systems for use in combined heat and power systems at industrial facilities, which can meet new air quality standards and achieve twice the energy efficiency levels of conventional electricity generation and separate process heating systems
- Biomass production and processing for electric powerplant use on a scale to support a commercial powerplant of 300 megawatts on a sustainable, long-term basis
- A PNGV program for heavy trucks, as a partnership between the truck engine manufacturers and the Defense Department which purchases commercial truck engines for its trucks and heavy combat equipment, to demonstrate a medium/heavy duty diesel engine that will achieve

NEAR-TERM TECHNOLOGIES

For near-term technologies, the strategy focuses on actions to encourage market adoption of improved technologies that have been proven in pilot tests to be superior technologically and economically, but are not being used widely by end users. The reasons for that may include market barriers, lack of information and demonstrations, and initial investment cost. The federal role will be one of supporting the private sector, consumer groups, and others in funding demonstrations, supplying consumer information, streamlining regulations, and encouraging the development of innovative financing programs. [?? tax credits, accelerated depreciation, emissions limits/allowances, financing, efficiency standards and regulations??] These incentives will be particularly focused on encouraging investment in more efficient technologies when capital equipment stock is replaced. This program will reach a level of \$..... when fully phased in, and should leverage a much larger amount of private sector funding, since these products are close to full market status. Examples in this area are:

- Solar power, where the “Million Solar Roofs Initiative” is a partnership with businesses and government to develop and

encourage voluntary programs to deploy one million solar photovoltaic and hot water systems on residential, business, and government rooftops by the year 2010

- New residential housing construction, where our new “Partnership for Advanced Technologies in Housing” (PATH) program is starting to work with builders, suppliers, insurance companies, and local regulators to develop and use building designs and production methods that can lower costs, improve safety, and also reduce greenhouse gas emissions by 50%
- A cities partnership with the nation’s mayors to stimulate the improvement of energy efficiency and reduction of energy costs and air pollution in major cities through the use of alternative fuel buses and other municipal vehicles, more efficient street and other lighting, and energy-saving investments in municipal buildings
- A Federal government initiative to use the government’s purchasing power and its 500,000 buildings and000 vehicles to demonstrate advanced energy efficient technologies while also saving money for the public. Since 1990, the Federal government has reduced its total energy usage by 18% and reduced its energy bill from over \$11 billion to just \$8 billion in 1995. This will also include actions in locations where large numbers of the public will experience them, such as the National Parks, which are visited by over 200 million people per year.

PRINCIPLES

- Partner with the private sector to the maximum extent feasible, including cost-sharing and joint agreement on plans and goals
- Include the nation’s universities and other research institutions along with the federal government’s research laboratories and centers
- Evaluate specific areas of research on their potential for both cost-effective and absolute levels of reduction in future greenhouse gas emissions, and for maintaining high levels of performance and user satisfaction
- Develop specific, peer-reviewed performance goals
- Maximize market-based approaches and minimize the government’s attempt to pick “winners” and “losers”, especially by focusing on target performance levels needed in various applications, rather than on specific technologies

EMISSIONS REDUCTIONS

This strategy is designed to provide both long-term and near-term benefits in reducing greenhouse gas emissions. The very long-term research initiatives are, of course, quite uncertain with respect to the technological performance they will achieve in emissions reduction. Their goals, however, are very ambitious and are aimed at the step function improvements that are needed to deal with the climate

change issue in the long run. The shorter-term elements of the strategy are, of course, also uncertain, but primarily as a result of uncertainty about customer and market acceptance of the technologies, rather than about their underlying technical capabilities.

Acknowledging those uncertainties, this technology strategy is estimated to achieve carbon dioxide reductions in about years reaching approximately to million tons per year from the projected levels under a business as usual set of technology assumptions.

In the longer term, by 2030 and beyond, this strategy should lead to advances that would reduce emissions on the order of to per year, and could potentially be much higher.

FUNDING

When fully phased in, the Climate Change Technology Strategy should be funded at an annual level of \$ per year from the federal government. That should leverage an additional amount of at least \$ in private sector funding for the development and demonstration of these technologies.

The full phasing in of this strategy will depend upon the availability of funds from the sale of emissions allowance auctions or other new sources of revenue. By reinvesting a portion of such revenues in this technology strategy, these funds are being put back into the economy in a manner that creates jobs, improves the competitive standing of U.S. industry, and will provide long-term benefits to the country.

In the meantime, to initiate the technology strategy, the Federal Government will seek an increase in funding from the Congress beginning in the next Budget, to be submitted in February.

MANAGEMENT

The Federal implementation of this technology strategy will be led by It will involve practically every Federal department and agency, and, of course, the whole system of national laboratories and research centers throughout the country. Every effort will be made to work closely with the Congress to enlist their advice and support for this important national initiative.

In order to ensure a high quality, independent oversight and review of the strategy over time, the President's Council on Science and Technology is being asked to establish a standing committee to provide an annual review of the program. As with other such PCAST committees, it is expected that this one will include

leaders from the private sector, universities, independent research centers, and public interest groups.

ISSUES

- Funding — the use of auction or other climate-related revenues for funding, and the concept of delaying the full phase in of the strategy in until such funds are available
- Funding levels and emissions reductions, including the allocation among long-, medium-, and near-term technologies
- Incentives — what are we willing to include, especially to stimulate the near-term adoption and use of these technologies: direct funding, information, streamlining regulations, financing or preferential financing in government programs, tax credits, accelerated depreciation, emissions trading, efficiency standards and regulations?
- Management — who will run it? Should we have a formal outside review group, like the PCAST committee described above?

Powering America for the 21st Century

As we prepare for the 21st century, one of the greatest challenges our nation faces is addressing the problem of global climate change without sacrificing our economic prosperity and quality of life. Scientific evidence is mounting that atmospheric concentrations of greenhouse gases--including carbon dioxide, methane, and nitrous oxide--have increased dramatically during the past fifty years, and that these increased concentrations are causing a change in global temperature and precipitation.

Greenhouse gas emissions are largely caused by the burning of fossil fuels --oil, coal and natural gas--which are used to supply three quarters of the world's energy needs, and eighty five percent of U.S. energy needs. Atmospheric greenhouse gas concentrations can be expected to increase even more dramatically during the next few decades given projected economic growth in the developed and developing world. The President's Council of Advisors on Science and Technology has warned, "There is considerable doubt whether the world . . . can continue to rely on these fossil fuels to this degree through the expected economic growth of the next few decades without encountering intolerably disruptive climatic change caused by the resulting greenhouse gas emissions."

To ensure our economic prosperity, food supply, environmental quality and quality of life, the U.S. must, over the next few decades, substantially reduce our reliance on fossil fuels, produce adequate and reliable supplies of affordable energy in environmentally sustainable ways, and find other solutions to the climate change problem. The key to meeting these challenges lies in America's technological strength and our tremendous innovative capacity.

Developing technologies to reduce concentrations of greenhouse gases and a new generation of energy technologies is perhaps the greatest technological challenge our nation has ever faced. It is even more difficult and important to our nation than President Kennedy's challenge, "to put a man on the moon in ten years," which spawned the Apollo program. Our nation invested more than \$111 billion (in 1997 dollars) over an eleven year period in our manned space program (representing 1.4 percent of *total* federal spending during this period). To solve the problem of climate change, we must make the same kind of bold, serious, sustained commitment to R&D that we made during the Apollo program.

The Clinton Administration proposes to increase our investment in energy and climate change R&D by \$6 billion annually, over a twenty year period, through the "Powering America for the 21st Century Program." The Powering America Program would establish a variety of innovative, cooperative R&D partnerships among all sectors of American industry, academia and the federal government, as well as among our international trading partners.

The program would focus on two critical aspects of the climate change problem. The first is meeting the U.S. projected energy needs in the 21st century with highly efficient energy technologies which produce no or low greenhouse gas emissions. The second is aggressively pursuing innovative techniques for reducing the atmospheric concentration of greenhouse gases.

The Powering America Program would operate as follows:

- The federal government would invest \$3 billion annually, leveraging a \$ 3 billion annual investment by U.S. industry, in a variety of government-university-industry partnerships to accelerate research, development and deployment of a new generation of energy technologies which 1) cause no or low greenhouse gas emissions, 2) are vastly more energy efficient than today's technologies, and 3) provide the same performance and cost effectiveness as today's technologies ("next generation energy technologies").
- This funding also would support studies and cost-shared R&D projects to reduce atmospheric concentrations of greenhouse gases, including exploring sequestration techniques, underground storage of greenhouse gases, and ecological solutions such as re-forestation and ocean management ("concentration reduction technologies").
- The federal government would invest an additional \$3 billion annually--over twenty years-- in R&D on next generation energy technologies and concentration reduction technologies in cooperation with our industrialized trading partners. This \$ 3 billion investment would leverage a \$___ billion annual investment by our international partners. This funding also would support joint implementation and deployment, where appropriate.
- All sectors of U.S. industry would be involved in this cooperative R&D effort, including the transportation sector (autos, light trucks, freight, aircraft and rail), residential and commercial buildings sector, electric power generators, and energy and waste intensive industries (including chemicals, steel, glass products and agriculture).
- Each industry sector would set voluntary targets for greenhouse gas emissions reductions by a date certain, and define the technological challenges that industry faces in order to meet its emissions targets. This will enable each industry sector to identify next generation energy technologies and concentration reduction technologies applicable to that industry, and to prepare an initial technology road map. That road map will be revised over time as the state of knowledge improves. In setting emissions reduction targets and technological goals, establishing a dialogue and cooperation across industry sectors would be emphasized. The development of multi-industry road maps would be encouraged.
- Funding decisions with respect to both domestic and international partnerships will be made, based on technical and business merit, by an Energy Advisory Board composed of senior level representatives from each of the participating industry sectors (with appropriate technical and business experience), leading academic experts on next generation energy technologies and concentration reduction technologies, the Secretaries of Energy and Commerce, and the President's Science Advisor.
- In addition to the \$6 billion in new funding, to ensure the coordination of federal climate change efforts, the government will consolidate all of its existing research and development activities relating to climate change, including monitoring and assessment, and research on next generation energy technologies and concentration reduction technologies, within a single federal laboratory within the Department of Energy system. All other current functions of the designated laboratory will be moved to other facilities, and the laboratory will be given the sole mission of research, development and deployment activities related to climate change. The research agenda of this laboratory will be determined by the Energy Advisory Board.
- The Energy Advisory Board will be directed to consider all relevant research areas, including clean power generation, renewables, energy efficiency, fission, advanced fossil fuel, sequestration and fusion technologies. Attached is a paper prepared in consultation NIST's industry advisory committee, outlining a few possible promising research areas.

Federal R&D Recommendations for Climate-Change Technologies

Summary

September 17, 1997

Based on our broad based outline of recommended research topics, we have focused, prioritized, and expanded the outline. The result is a summary of selected R&D recommendations for mitigating CO₂ and other harmful atmospheric emissions, and the development of a global modeling infrastructure, which is vital to our ability to objectively assess the climactic impacts of policy decisions.

A. Commercial & Residential Buildings

- **Blended Cements**

Background: Concrete is composed of about 10-15% cement, with the balance being crushed stone, sand, gravel, water, and other materials. Cement production is extremely energy intensive, resulting in about 1 ton of CO₂ emissions per ton of cement produced. In 1997, approximately 80 million tons of cement will be produced in the U. S., resulting in approximately 80 million tons of CO₂ emissions.

Recommendation: Replace a portion of the portland cement with waste byproducts such as flyash (from coal-fired utilities), granulated blast-furnace slag (from iron-ore production), or with limestone interground with clinker and gypsum. A 5% replacement of portland cement with flyash, slag, limestone or other mineral admixtures yields about a five million ton reduction in CO₂ emissions. Ten percent yields ten million tons, etc. Allowable percentages in Europe range up to 35%, although 5% is typical. Research is required to develop test methods and data which can become the technical basis for the improved specifications needed to assure adequate and reliable performance. The problem is complex because of the number of variables involved, and progress is likely to be slow unless a strong government-industry partnership can be established. R&D is needed to develop chemical and physical methods for evaluating raw materials and for use in quality control and assurance of the final product, and for assuring the adequacy of the many aspects of the performance of concretes made from the cements using different mixture proportions and different processing conditions.

Benefits: This is a relatively well understood process. Use of waste byproducts in cement, which would otherwise be landfilled benefits the environment, reduces CO₂ emissions, improves productivity of cement companies and increases their global competitiveness. Concrete producers would benefit from increased availability of cement, and end users of cement and concrete would benefit by reduced costs of construction materials.

Barriers: U. S. standards do not encourage use, or specifically prohibit use of extenders. Consensus standard-setting organizations are composed of some organizations that have a financial interest in preserving the use of unblended cements. Specification of construction materials in the U. S. is very fragmented, and there are currently no substantial incentives for customers or standard-setting organizations to change material specifications. It will be important to work to get new standards adopted and work with states and localities to implement the new standards.

- **Improved Energy Efficiency of Buildings, Appliances and Electrical Devices**

Background: Most of the energy for residences and commercial buildings is consumed by major electrical appliances, HVAC, and lighting systems that operate much below theoretically achievable limits.

Recommendations: Many scientists agree that a substantial increase in the efficiency of current appliances and lighting systems is not unreasonable, and could be achieved, not by incremental improvements, but by substantial redesign, use of new materials, and development of new technologies. For example, replacement of fluorescent or incandescent light fixtures by of solid-state devices for lighting could result in much brighter illumination, substantial efficiency improvements, and increased durability and longevity. Improved insulation and space-conditioning systems (*e. g.*, alternative refrigerants), as well as passive and active reflective coatings for buildings and structures would provide make substantial energy-saving gains and benefit by their ease of retrofit.

Benefits: Because residential and commercial buildings consume so much energy, even modest improvements would have enormous impacts on CO2 emissions.

B. Biotechnology/Forestry/Agriculture/Food Production

- **Biotechnology for Atmospheric CO2 Mitigation**

Background: Approximately 40% of all photosynthesis occurs in the seas. In this process, oceanic plants take up CO2 and with light energy from the sun, convert it into organic carbon and oxygen. The oceans contain 50 times as much CO2 as does the atmosphere, and it is estimated that primary production incorporates 35 gigatons of carbon into marine biomass annually. This abundant source of fuel for energy has not been tapped commercially because it is not competitive with soybean meal and other easily harvested, traditional sources of biomass, and also because, regardless of the source, biomass is not competitive with other types of fuels.

Recommendations: The federal government should continue to support research on the use of biotechnology to enhance biomass production and utility, as well as manipulate cellular metabolic pathways for optimized CO₂ consumption. The enzyme that captures CO₂ for photosynthesis, ribulose biphosphate carboxylase/oxygenase is relatively inefficient so it is important to determine its structure in order to redesign the enzyme to make it more efficient. Next, the chemical composition of biomass can be altered to make it more suitable for particular applications. For example, marine microalgae can be genetically engineered to boost their lipid content with the aim of providing an economic source of alternative fuels. It is vital to develop tools to elucidate the biogeochemical cycles that determine the fate of all life-supporting elements on Earth. Work must be conducted to understand and manipulate the molecular genetics and biology of esoteric metabolic pathways associated with the carbon, sulfur, phosphorous, iron and other biogeochemical cycles. For example, iron induced algae blooms in the open water off the Galapagos Islands demonstrated significant photosynthetic energy production with a concomitant increase in CO₂ elimination from the atmosphere. In another example, genetically-enhanced microorganisms represent a low-energy, high-conversion pathway of vegetable matter to ethanol. The results of genetic manipulation need not be restricted to marine applications, but would have substantial impact on terrestrial plants and trees as well.

Benefits: The oceans represent an immense and virtually untapped source of biomass-derived products, a substantial commercial opportunity, and an unoptimized sink of CO₂. A minute increase in the uptake of CO₂ by the oceans, whether due to increased harvesting of biomass materials or introduction of CO₂-loving algae would have tremendous commercial impact and exert tremendous leverage on mitigating terrestrial CO₂ levels. Further, applications to terrestrial plants and vegetation could increase sequestration of CO₂.

C. Energy Production

- **Solar Energy Production**

Background: Solar energy conversion makes more sense now than ever before. In the last few years, there have been dramatic improvements in the semiconductor and thin-film technologies which enable solar energy conversion, and very importantly, the new materials and manufacturing methods are increasingly efficient and inexpensive.

Recommendations: We propose a government-wide program to exploit the new developments in solar conversion to develop this technology as a truly viable alternative to fossil fuel. The program would involve research, technology development, and infrastructural support for industry.

Examples of work to be done include development and characterization of advanced materials such as photoconductive polymers, "buckyballs," and dye-sensitized semiconductor films, which have considerable potential to revolutionize the technology. Needed measurements for new developments include characterization of the key photophysical processes and failure mechanisms. Measurements and standards will be essential for a successful solar energy conversion industry, providing developers, suppliers, and users with a framework for assessing properties which must be specified. These include energy conversion efficiency, longevity, and the optical properties of materials and coatings. New and existing solar conversion technologies will benefit from recent advances in measurement methods, such as optical microscopy and imaging, light scattering, and ultrafast time-resolved laser spectroscopy, which can characterize the light-conversion process, map composition of photovoltaic films, and assess quality in manufacturing. Measurements of optical properties of materials, such as thin-film absorption and reflectance, as well as measurements of the spectral efficiencies of solar energy conversion devices will be essential for optimizing performance.

Benefits: Solar energy offers an inexhaustible power generation alternative that is clean, free of greenhouse gas emissions, is inexpensive and reliable in operation, and is readily accessible to all countries and economies throughout the world. Solar power generation is also amenable to rapid retrofit, and can be used by existing power distribution infrastructures.

- **Fusion Energy**

Background: The benefits of fusion energy production are well known (cleaner source of energy without the radioactive disposal problems of current fission systems, abundant supply of "fuel"). However, the fusion energy research community has been somewhat disjointed and projections for working systems keep getting delayed beyond the 25 year horizon, thus losing the attention of many policy makers.

Recommendations: We must demonstrate plasma ignition without significant degradation of critical plasma parameters, impurity control, fueling and ash removal, long pulse or steady state operation; we must find acceptable new materials for plasma facing components and first wall, develop hot blankets for breeding tritium, demonstrate reliability, high duty cycle and safety and so on. Many experts believe that the above problems can be addressed and solved in 2-4 tokamak systems, built partly in parallel, over the coming 15 to 25 years. In principle, we could have a demonstration power plant as early as the year 2015. This must be a goal of a world-wide fusion program - because of the enormous costs, no single country can afford or risk to go it alone. A fusion demonstration facility, generating electricity in an environmentally acceptable manner, should be built as rapidly as technically feasible, by the year 2015. This calls for an aggressive development of a number of parallel systems which solve the various problems of

physics, technology, safety, environmental acceptability etc. Some pruned version of ITER could be one of the required parallel systems needed for overall development.

Benefits: The benefits of fusion energy are well documented. A virtually limitless supply of fusion energy would revolutionize mankind in unimagined ways. Greenhouse gas emissions would drop precipitously, industrial and economic growth would explode world-wide, and direct benefits would be reaped by every person on the planet.

- **Fossil Fuel Decarbonization, Direct CO₂ Removal and Sequestration**

Background: Combustion of fossil fuels is the largest man-made source of CO₂ emissions. Fuel decarbonization, direct CO₂ removal and sequestration would allow continued use of fossil fuels and their infrastructure while releasing far less carbon dioxide to the atmosphere. Fuel decarbonization involves using a reformer or gasifier and shift reactors to produce a gaseous mixture of hydrogen and CO₂ from the fossil feedstock. The hydrogen is then separated and relatively pure CO₂, accounting for a large fraction of the carbon in the original feedstock, is obtained as a byproduct.

In direct CO₂ removal, industrial effluent streams which typically contain vast amounts of CO₂, would be "scrubbed", not only to remove the typical pollutants such as NO_x, SO_x, and HCl, but innovative technologies would remove the CO₂ as well, thus preventing its release into the environment altogether. In direct CO₂ sequestration, the collected CO₂ is sequestered in deep saline aquifers under the land or under the ocean floor, or in abandoned oil and gas wells. There is currently underground space available in the European Union and Norway alone, mostly in deep aquifers under the North Sea, to store about 280 billion tons of carbon (as CO₂). For comparison, world-wide emissions from fossil-fuel burning are about 6 billion tons annually.

Recommendation: Research into the scale-up of the fuel decarbonization process, direct CO₂ removal technologies, and the long term fate of CO₂ sequestration is needed. The fuel decarbonization technique is well known, although an economic means of large-scale hydrogen production, and an insufficient infrastructure for hydrogen distribution remain significant problems that must be addressed. In addition, hydrogen storage is problematic and new high-density or solid state storage technologies must be promoted and developed. Recent advances in hydrogen fuel cells must continue. For example, the proton-exchange membrane fuel cell runs at low temperatures, has a high power density, and is small enough for mobile applications, but can also be used for residential and commercial buildings. For direct CO₂ removal from stack gases, research is needed to develop innovative membranes and cryogenic processes to efficiently remove CO₂ with minimal energy requirements. Questions that must be answered in CO₂

sequestration include what effect CO₂ would have on sea life near the point of injection, how much CO₂ would become mixed with the ocean over time, what happens in the event of an earthquake and a sudden uncontrolled release of CO₂, and what effects it would have on life near the ocean bottom?

Benefits: If decarbonization were combined with the use of hydrogen fuel cells, direct CO₂ removal and carbon sequestration, the resulting energy regime would utilize fossil fuels efficiently, yet greatly reduce the amount of CO₂ emitted to the atmosphere. This would allow much of the world, which is primarily fossil-based, to continue using much of their fossil infrastructure while they are transitioning to a non-fossil or reduced-fossil mode of energy production.

D. Geoengineering

- **Repairing the Earth's Atmosphere**

Background: Global time scales for natural absorption, dissolution, destruction, or transformation of atmospheric pollutants and greenhouse gases is on the decadal and century level. Thus, even if the most draconian global reductions in pollutants and greenhouse gases are immediately implemented, substantive changes or improvements in the climate and eco-system will not be observed within the many people's lifetime, and certainly not within the political lifetime of many policy makers. However, if an active means of remediating or repairing the present atmospheric conditions can be developed, global changes can be substantially accelerated.

Recommendations: Active physical remediation of the upper atmosphere via directed energy beams (electromagnetic or particle beams) could have tremendous and rapid benefit. Although economic and safety issues would require careful study and creative design, it may in principle be possible to actively dissociate and remove greenhouse gases using energy beams directed into the atmosphere from land, air, or space borne sources. It may even be possible to redirect and utilize Strategic Defense Initiative technology for peaceful purposes in this way. It might also be possible to utilize the natural bombardment of the upper atmosphere which occurs during solar flares--when the sun hurls energetic particles toward the earth. Now that it is possible to predict somewhat in advance when these solar events occur, perhaps the atmosphere could be seeded with a sensitizing agent just prior to the solar event. The sensitizing agent would then react to bombardment by the solar flare to effect a desirable change in the greenhouse gas content of the upper atmosphere. The idea is analogous to that in medicine where the body is injected with a particular chemical prior to bombardment with energy beams for diagnostic or therapeutic purposes--only in this case the goal would be to "heal the earth" rather than a single patient.

Benefits: Directed energy beams can be tailored in wavelength and intensity to target the destruction, transformation, or generation of specific atmospheric species. Impacts would be substantial and much more rapid than natural global time scales. Used in tandem with ongoing emission reduction programs around the world, atmospheric remediation can provide the option of a slower phase-in of emission reduction targets. In addition, this represents an excellent defense conversion program where much of the technology developed for the Strategic Defense Initiative would have direct application here.

E. Environmental Assessment and Evaluation

- **Understanding the Global Climate System**

Background: The global climate system consists of exist extremely complex interactions and feedback among energy inputs (from space to/from the earth), energy transport and transformations, human and natural chemical cycles, regional and global circulation (atmosphere and oceans), model building, metrology, and global (current and paleo-) monitoring. The most vital thrusts of a large global climate program should look at the system as a whole, and to identify weak points in our understanding, modeling, data, monitoring, and metrological capabilities. An especially pernicious aspect is that extremely small and apparently insignificant imbalances (or model errors or data inadequacies) can have profound impacts on the accuracy of our forecasts.

Recommendations: There are four major thrust areas that must be addressed in order to advance our understanding of the global climate system and begin to develop confidence in our modeling capabilities: 1) *Energy inputs as a function of time and space*, which involves satellite and ground-based monitoring and model-based forecasting (retrospective and prospective) of geo- and solar-based energy input changes, 2) *Energy transformations and redistribution*, which requires that the life cycles of greenhouse and ozone-harming species be understood and monitored, 3) *Circulation and modeling*, typified by activities like the World Ocean Circulation Experiment where unique input functions of human-made chemicals (SF₆, CFCs) and isotope injections (Kr-85, C-14, H-3) have been critical to the success tracer monitoring in establishing global circulation patterns and the hydrological cycle, and 4) *Metrological Aspects* are at the core of our understanding and forecasting of global climate. Measurements of radiation and chemical and isotopic species are central input data for climate (and circulation) models, as well as being indicators of sometimes unsuspected climate change. What is missing, or under-represented, are sufficient interactions linking the *quantitative* needs of the modelers with the fundamental measurement capabilities, and availability and accuracy of physical and chemical parameters.

- **Measurement of Whole-Spectrum Radiation Load on Global Climate**

Background: Solar radiation is the primary source of the energy needed for the development and sustenance of terrestrial and aquatic life on Earth. Solar radiation from the far infrared to the deep ultraviolet impinges on the Earth's atmosphere, penetrates to different depths in the atmosphere, depending on the wavelength of the light, and ultimately induces innumerable forms of physical, chemical, and biological transformations. However, our knowledge of the amount of solar radiation throughout the electromagnetic spectrum and throughout the atmosphere is too fragmentary and of insufficient quality to account for the ultimate environmental effects of our most important environmental component.

Recommendations: By building on emerging optical technology in the long and short wavelength regions of the spectrum, an opportunity exists for a national effort to quantify the whole-spectrum radiation forcing needed to model and mitigate the effects of human activity on global climate change. An important aspect is to quantify the radiation dosage and absorption at all levels within the atmosphere, by terrestrial features, bodies of water.

Benefits: This information is vital for understanding the a key component of the global energy balance, as well as understanding how environmental contaminants are can be affected or transformed throughout the ecosystem.

F. International R&D

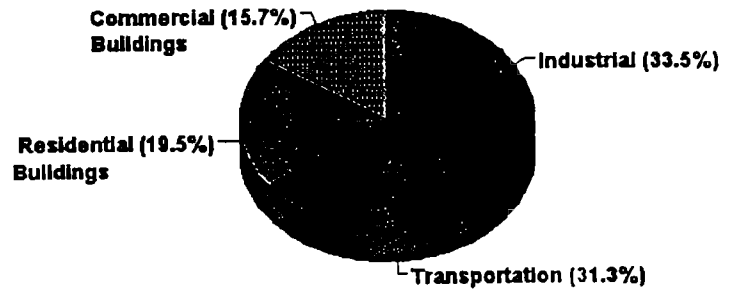
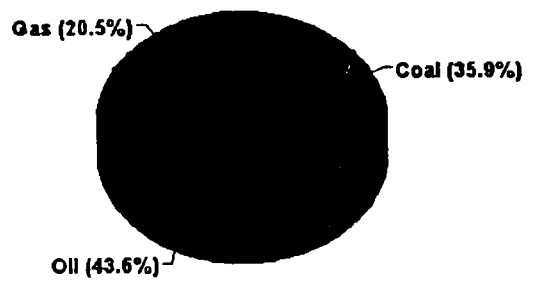
- **Fusion Energy Development**

Programs in many countries, especially some of the developing ones, have now started to mature and must establish linkages with each other and with mainstream activities like ITER etc. Considering the importance of fusion for developing nations, it should be possible to raise resources for a joint mature experiment which can then address an important set of questions for the mainstream fusion program. This can also be treated as an insurance so that at some point of time in the future, if the developed nations feel that they would prefer to wait, the developing nations can take off on their own and solve their energy problems themselves.

→ Residual
0.56mm

Sources of Greenhouse Gases

- ◆ CO₂ released by consumption of coal, oil, and gas is responsible for 85% of U.S. greenhouse gases
- ◆ U.S. greenhouse gas emissions are now 10% above 1990 levels and are projected to be 28% above 1990 levels by 2010 because of growing demand for energy. 1997 production was 1,480 Million Metric Tons (MMT)
- ◆ Transportation, Industry, and buildings are each responsible for about a third of US greenhouse gases. Residential buildings are responsible for slightly more than half of the total contribution buildings.
- ◆ Coal produces 72% more greenhouse gases than natural gas per unit of energy delivered; oil 22% more.
- ◆ Coal prices are expected to fall 2% by 2010 and gas prices 5%. Oil prices will be nearly constant.
- ◆ Oil remains the single largest source of CO₂ and 73% of oil is used in transportation. Coal burning produces 36% of CO₂ and 85% of coal is used to generate electricity.
- ◆ In these accounts, the CO₂ produced to generate electricity is charged to the sector using the electricity. Taken together, emissions of electric production sold to all sectors is 36% of U.S. CO₂ .

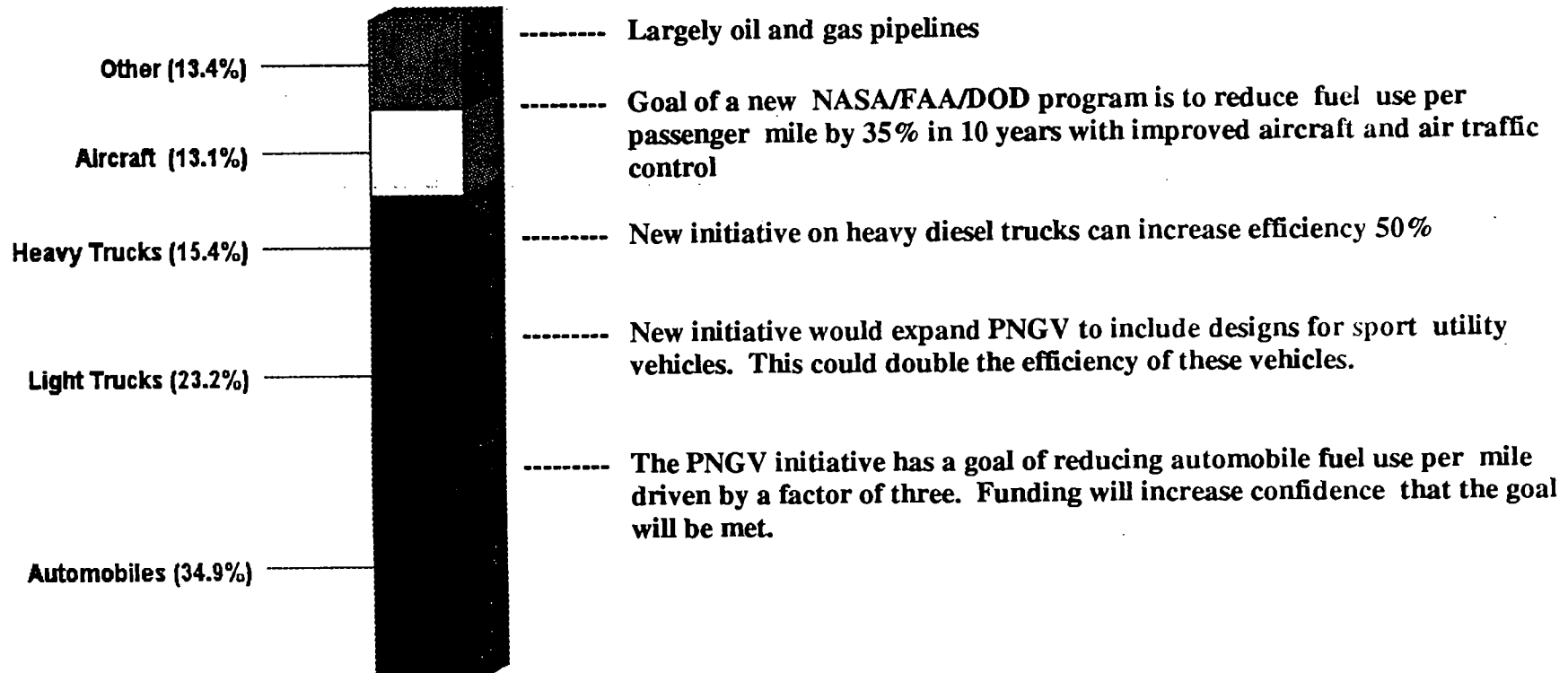


Transportation

- ◆ **Transportation contributes 31% of U.S. CO2 and output is growing 1.8% per year (10 million tons per year) – twice as fast as industry and buildings -- because vehicle miles traveled have been increasing by nearly 3%/year and because nearly half (44.5%) of all passenger vehicles sold are now sport-utility vehicles and other “light trucks” which get, on average, 25% fewer miles per gallon than automobiles.**
- ◆ **More than 98% of all transportation energy comes from petroleum**

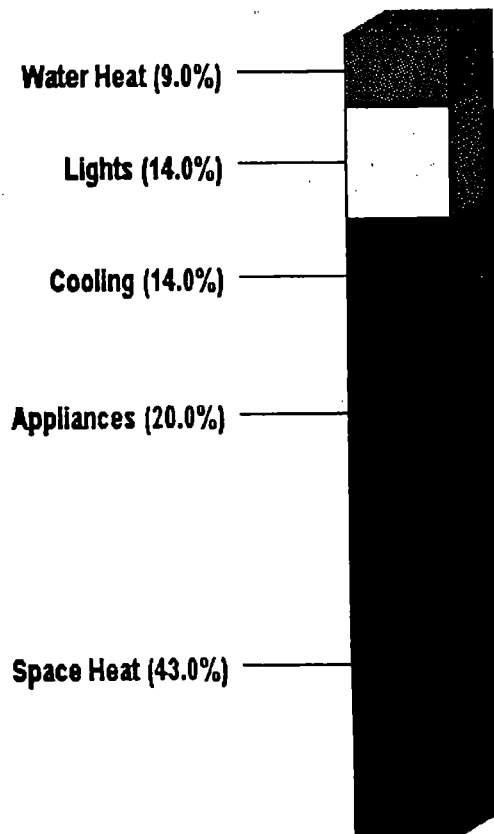
Percent of all U.S. CO2 Production

Options



Buildings

- ◆ Residential buildings produce 19% of U.S. CO₂ and emissions are expected to grow 1% annually (2.6 MMT/year). Energy demand is greatest for heating, electrical appliances (refrigerators, clothes dryers), and air conditioning.
- ◆ Commercial buildings produce 15% of U.S. CO₂ and emissions are expected to grow 1% annually (2.1 million metric tons per year). Energy demand is greatest for lighting, electric equipment (computers, fax machines, copiers), and air conditioning.



----- Best available appliance technology can increase efficiency 25-30%

----- Energy for residential lighting can be cut by 50% and commercial lighting by 25% using existing technology. Advances in bulbs, controls, and daylighting will lead to greater savings.

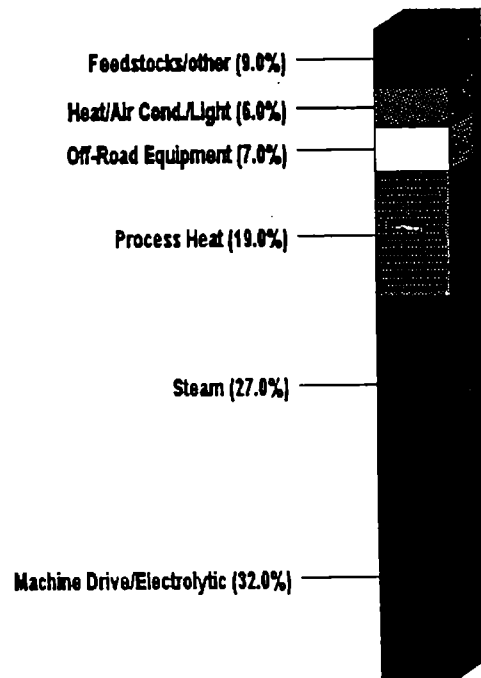
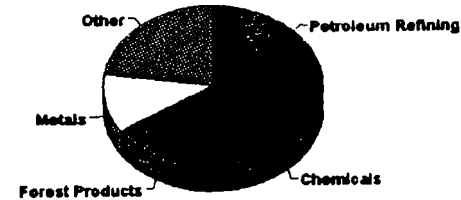
----- Existing technology can reduce commercial air conditioning and ventilation 48%. With improved building designs can lead to greater savings

----- Refrigerator and freezer efficiency can be increased 25-30% using available technology. Growing energy use in electronic equipment at home and in offices (TVs, computers, fax and copiers) need attention. Labeling is key

----- With improved building designs (such as PATH homes), new buildings can be much more efficient. In the future, fuel cells and gas turbines for buildings will be able to provide heat, hot-water, and electricity. Residential heating units can be made 10-25% more efficient and commercial heating 48%. Energy star labels are critical.

Industry

- ◆ Manufacturing industries produce a third of all CO₂ – an amount which is expected to 4 million metric tons per year.
- ◆ 80% of all industrial CO₂ comes from petroleum refining, Chemicals, Paper, lumber and other forest products, and metals (dominated by steelmaking).
- ◆ While overall growth of industries is expected to average 2.1% during the next 15 years, output from the energy intensive industries responsible for most of CO₂ production is expected to be 1.3%. Growth is much faster in information-intensive industries



- In the future, some biomass products could be substituted for oil/gas
- Savings much like those available for commercial buildings
- New diesel technology can be applied to many of these uses
- Steam and process heat dominate the energy use chemical manufacturing, paper production, and many other energy-intensive operations. Available industrial natural gas turbines produce electricity and process heat and produce 1/3 to 1/2 as much CO₂ as conventional systems. Regulatory changes are needed to encourage high-efficiency, new units. New chemical processing techniques and use of biomass instead of fossil fuel can lead to further gains.
- Motors, compressed air, and other machines providing mechanical power can be improved significantly using improved control strategies, more efficient designs and components.

MEMORANDUM

TO: Rosina Bierbaum

FROM: Jeff Frankel and Joe Aldy

DATE: 10/1/97

RE: Comments on *Sources of Greenhouse Gases*

We appreciate the opportunity to look over *Sources of Greenhouse Gases*. The document provides a very important service of specifying the sources of the nation's carbon dioxide emissions. In four pages, a substantial amount of useful information is provided in easy to understand figures and bullets. However, the document could be improved by addressing three issues: 1) remove the ambiguous "options" listed by the sectoral breakdowns of carbon dioxide emissions; 2) clarify and refine carbon dioxide emissions numbers; and 3) include sources of non-carbon dioxide greenhouse gas emissions.

- The list of "options" should be removed. In a document on sources of emissions, they appear to be out of place. Further, the document provides no context for the options -- are these options for consumers? producers? local and state governments? the federal government? They appear to be a list of goals without any specification of how they are to be achieved, the likelihood they will be achieved, the costs of attempting to achieve them, and the cost-effectiveness. Many resemble the unspecified visions in the DOE 5 Labs Study. Visions are not programs, and without specific and credible information on how these goals could be achieved, they can only serve to confuse the intended audience.
- Several of the references to carbon dioxide emissions and energy use need to be clarified. First, bullet two on the first page appears to represent the trend in greenhouse gas emissions, although the numbers represent energy-related carbon dioxide emissions. The statement about 1997 emissions is the projection for energy-related CO₂, not for greenhouse gas emissions. We do not have the projection for 1997 for all greenhouse gases, but given that in 1994, total U.S. GHG emissions summed to 1,672 MMTCE (EIA, U.S. Emissions of Greenhouse Gases, table ES2), it is difficult to imagine that 1997 emissions would be nearly 200 MMTCE below this. We know that the percentage increases above 1990 reflect EIA's Annual Energy Outlook 1997 projections for energy-related CO₂ emissions, but we do not know if the trend holds for the remaining ~15% of greenhouse gas emissions.

Second, the estimates of carbon emissions per unit energy in the fourth bullet do not conform with comparisons using the EIA's Emissions of Greenhouse Gases in the United States 1995 (table B1) carbon emissions coefficients for coal (electricity), gasoline (as an example of oil), and natural gas. Coal should have a slightly higher estimate of carbon emissions, while oil should have a much higher carbon emissions estimate (almost double of the estimate in the document).

Third, the projections regarding energy prices do not conform with EIA's Annual Energy Outlook 1997 estimates for 2010. Between 1995 and 2010, minemouth coal prices fall from \$18.83/short ton to \$16.92/short ton (greater than 2% decline), gasoline prices increase from \$1.148 to \$1.218 (instead of falling 5%), and world oil prices increase from \$17.26/barrel to \$20.41/barrel (not nearly constant).

- While the document identifies specific emissions of carbon dioxide, it virtually omits any discussion of non-carbon dioxide greenhouse gas emissions. A complete survey of the sources of all greenhouse gases could better inform policy makers.

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

Record Type: Record

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

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

Subject: Sources of Greenhouse Gases

TO: Jeff Frankel and Joe Aldy

From: Mark Bernstein, Rosina Bierbaum and Henry Kelly

Date: 10/2/97

RE: Comments on *Sources of Greenhouse Gases*

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

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

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

There seems to be some ^①misunderstanding on the use of some numbers, and the wording of bullets. We generally use carbon coefficients as follows: coal = 25; oil = 20 and gas = 14.5. To that end, the relative carbon impact of coal to gas is 25/14.5 or 72% as stated. The rest of that bullet was written improperly and should have said "and 22% more than oil"

On energy prices - we did take the numbers from AEO97 and in some cases we were looking at different numbers than you were - in particular we were looking at ^②delivered coal which declines by 11% (which we had wrong and have corrected), and delivered natural gas which declines at 5% ^③ even though wellhead prices increase, and finally the last part should have been gasoline prices which are pretty flat (growing at less than .1% per year according to EIA). ^④

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

- ① The EIA coefficients I used are more specific than what OSTP used. However, once they clarified the end of the bullet (so it reads as oil is compared to coal, not natural gas), the point is essentially correct.
- ② Delivered coal and mine-mouth coal both fall by about the same percentage (10-11%) - regardless of which one, I knew a 2% decline was wrong.

(over)

③ Since the document stated gas and not natural gas, I looked at gasoline prices. Their subsequent statement that gas prices are relatively flat because they increase 0.1%/yr is correct.

④ Evidently, they have added gasoline and deleted oil.

The Role of Technology

There are three ways to reduce greenhouse emissions:

- Energy Efficiency (i.e. reduce the energy intensity of the economy)
- Clean Energy (i.e. reduce the carbon intensity of the economy)
- Carbon Sequestration (i.e. remove carbon from the economy)

Emission reductions need to occur in four areas:

- Buildings
- Transportation
- Industries
- Utilities

Substantial new investment is needed in three areas:

- Basic Research
- Applied Research and Development
- Deployment

Current Technology Reports

- ◆ **Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy Technologies by 2010 and Beyond**
“The 5 Lab Study” - 9/25/97
 - Technology can keep the cost of carbon mitigation low

- ◆ **Report of the President’s Committee of Advisors Science and Technology, “PCAST Report” - 9/28/97**
 - Distinguished scientific panel calls for major growth in climate related Research & Development

- ◆ **Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions “11 Lab Study” - October 1997 Draft**
 - National Laboratories outline climate technology paths

A Technology Portfolio for Reducing Carbon Emissions: Current Programs and Initiatives

Federal agencies, in partnership with U.S. industry are currently developing and accelerating the use of a variety of energy efficiency and clean energy technologies. These technologies result in more efficient use of energy and increased use of low-carbon energy sources. While these technologies have huge promise and many are making a huge difference in the economy today, they are substantially underfunded and under-used.

Technologies under Development

Partnership for a New Generation of Vehicle: Automobiles with triple the efficiency of today mid-size vehicle with the same, performance, comfort and safety.

Transportation Biofuels: Low carbon transportation fuels made from new energy crops.

Advanced Manufacturing Processes: A wide variety of breakthrough technologies developed through Industries of the Future partnerships to increase industrial productivity while cutting emissions.

Advanced Industrial Turbines: Advanced gas turbines for cogeneration of electricity and steam for low-cost, low-emissions distributed energy in industry.

Energy Efficient Buildings Equipment: Advanced appliances and equipment including refrigerators, clothes washers, office equipment, heating and cooling, and lighting.

Energy Efficient Buildings: New materials, design and construction techniques, and control systems leading to substantially more efficient and lower emissions residential and commercial buildings.

Renewable Electric Technologies: Energy technologies that produce electricity with virtually zero carbon - including photovoltaics, wind power, bioenergy, geothermal and solar thermal.

Deployment of Current Technologies

In addition to technology development, a variety of programs at the Departments of Energy, Commerce, Transportation and Defense and the Environmental Protection Agency focus on accelerating the use of current energy efficiency and renewable energy technologies. However, these programs are quite modest. Examples include:

DOE EPA Energy Star: Promotion of and technical assistance for a wide variety of energy efficient buildings technologies.

Industrial Technology Access: DOE and EPA programs to accelerate the use of efficient motor systems, pollution prevention technologies, and productive manufacturing processes.

Federal Energy Management: Programs to increase the efficiency of federal facilities through technical assistance, training and energy savings performance contracting.

A Technology Portfolio for Reducing Carbon Emissions: \$500 Million Level

It is clear that no single strategy, whether economic or technological, will ensure that the U.S. can reduce and stabilize carbon emissions while maintaining a robust and healthy economy. The US however can develop technologies that if deployed, will be able to reduce emissions in the U.S. with little impact on economic productivity or consumer preferences. A multi-pronged approach to technology investment would include three kinds of actions: R&D investments; public-private partnerships; and implementation initiatives.

If successful, the set of technologies and initiatives proposed here could help reduce potential emissions by more than 175 MMT by 2010 at an annual incremental investment above the FY1997 appropriation of about \$500 million.

| | Federal Costs (\$millions above FY97 appropriated) | | 2010 Potential Carbon Savings | 2020 Potential Carbon Savings |
|--|--|--------------|--|--|
| | FY99 | FY03 | MMT | MMT |
| Equipment Efficiency | 50 | 150 | 15-20 | 30-75 |
| 21 st century housing | 35 | 60 | 3-5 | 15-20 |
| Expanded PNGV (including expansion to light trucks) | 100 | 160 | 30-60 | 100-150 |
| PNGV for heavy trucks | 40 | 100 | 10-20 | 30-50 |
| Advanced Aircraft | 40 | 40 | 10-20 | 30-40 |
| Biofuels | 25 | 55 | 5-10 | 20-40 |
| Combined Heat and Power | 30 | 60 | 15-35 | 30-70 |
| Industries of the Future | 20 | 60 | 10-20 | 20-40 |
| Motors and other systems efficiency | 15 | 25 | 5-10 | 10-30 |
| Renewables R&D | 95 | 140 | 5-10 | 40-60 |
| Renewables Deployment | 25 | 50 | 15-30 | 40-50 |
| Carbon Sequestration R&D | 50 | 100 | 0 | 50-75 |
| TOTAL | 500 | 1,000 | | |

Buildings

Energy Efficient Equipment: Improve equipment efficiency including lighting, commercial air conditioning loads and demonstrating fuel-cell systems. This will be accomplished with increased federal research partnerships to develop advanced building equipment and appliances; a public service campaign to attract increased attention to the "Energy Star" label; and accelerated work on energy efficiency standards for appliances under existing authority.

21st Century Housing: Create a partnership with builders, suppliers, insurance companies and state

and local governments that will undertake a program to accelerate development and demonstration of inexpensive, efficient, attractive housing and streamline federal, state, and local building and utility regulations in ways that encourage innovation in construction.

Transportation

Expanded Partnership for the Next Generation Vehicle (PNGV): Increase the probability of meeting the original PNGV goals by increased funding; expand work on the next generation vehicle technologies including fuel cells; and expand PNGV to include light trucks/sport-utility vehicles.

PNGV for Heavy Trucks: Expand partnership with engine manufacturers to double the efficiency of heavy-duty trucks for civilian and military applications, which produce about 15% of CO₂ in transportation.

Advanced Air Traffic Control, Advanced Aircraft: Create technologies and practices to produce a 35% reduction in greenhouse gases per passenger miles traveled by 2020.

Biofuels: Accelerate R&D on the number of crop species under development, crop harvest, handling and storage systems and crop to fuel conversion processes to significantly expand use of biomass fuels as new automobile technologies are developed.

Industry

Combined Heat and Power: Accelerate the development and widespread use of combined heat and power systems in industry. Widespread use of these very efficient technologies can be accomplished largely through regulatory reform and streamlined permitting.

Industries of the Future: Enhance industry/government research partnerships in areas such as chemicals, aluminum, forest products and steel manufacturing technologies that can lead to large emissions savings.

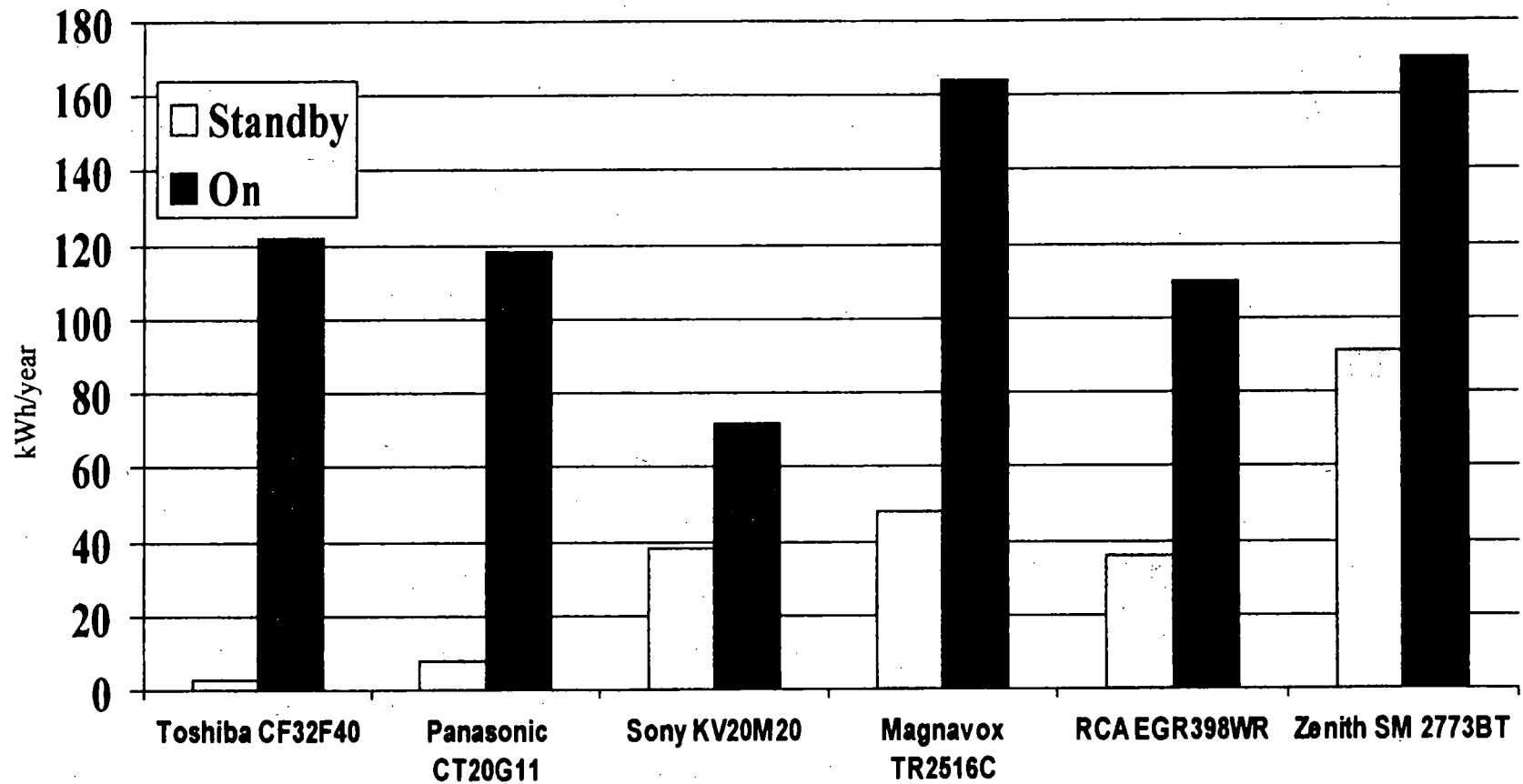
Motors and Related Systems: Accelerate the use of market-ready industrial motor systems, steam systems and compressed air storage to improve efficiency and productivity across industry.

Renewable Energy

Renewables R&D: Expand research partnerships in key renewable technologies such as wind, photovoltaics, geothermal, biomass and hydropower to accelerate cost reductions.

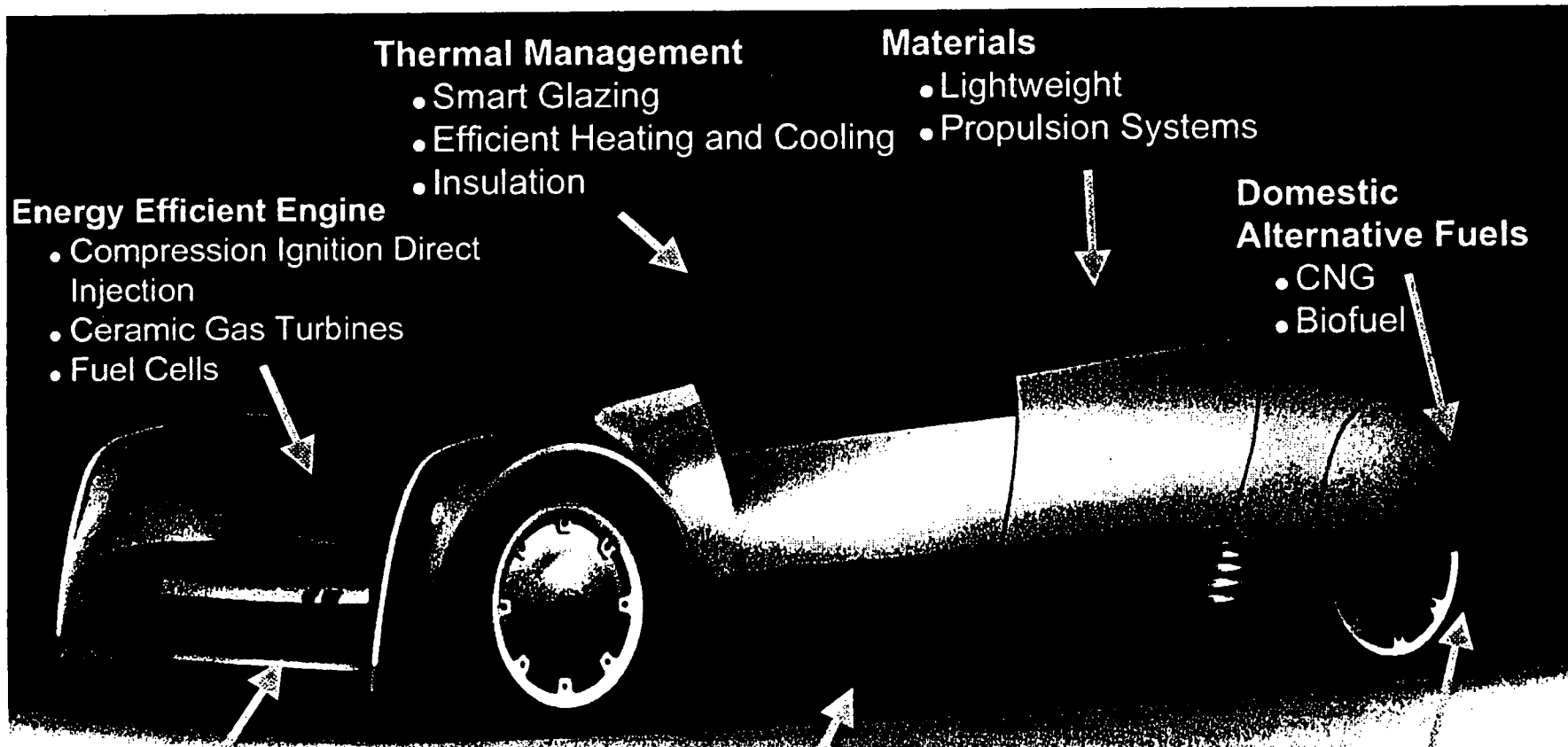
Renewables Markets: Support early demonstrations of renewable technologies through federal procurement of solar rooftops, cost-shared demonstrations of early biomass cofiring, expanded field verification of wind energy and other actions.

Televisions - kWh/year (assuming 4 hr/day)



sales = 25 M/year

PNGV Advanced Automotive Technologies



Storage Technologies

- Batteries
- Ultracapacitors
- Flywheels

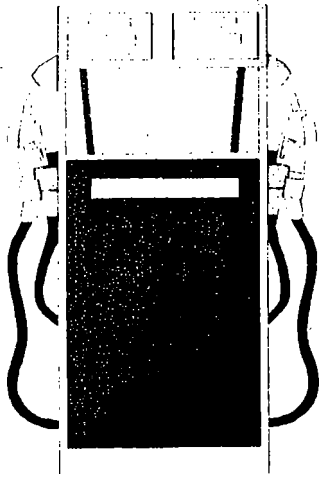
Electric/Electronic Components

- Electric Motors
- Controls

Emission Controls

- Sensors
- On-board diagnostics

Biofuels



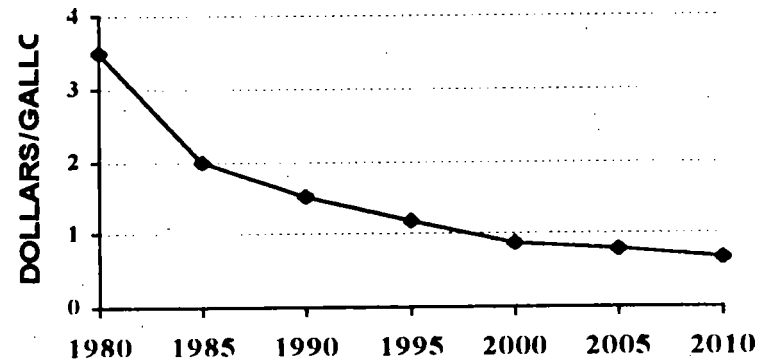
Impacts

- Reduce 2010 Carbon Emissions by 15MMTCE
- Domestic Fuel Diversity (130 million barrels/year)
- New domestic agricultural industry
- Competitive substitute for gasoline by 2005 - 2010

Recent Accomplishments

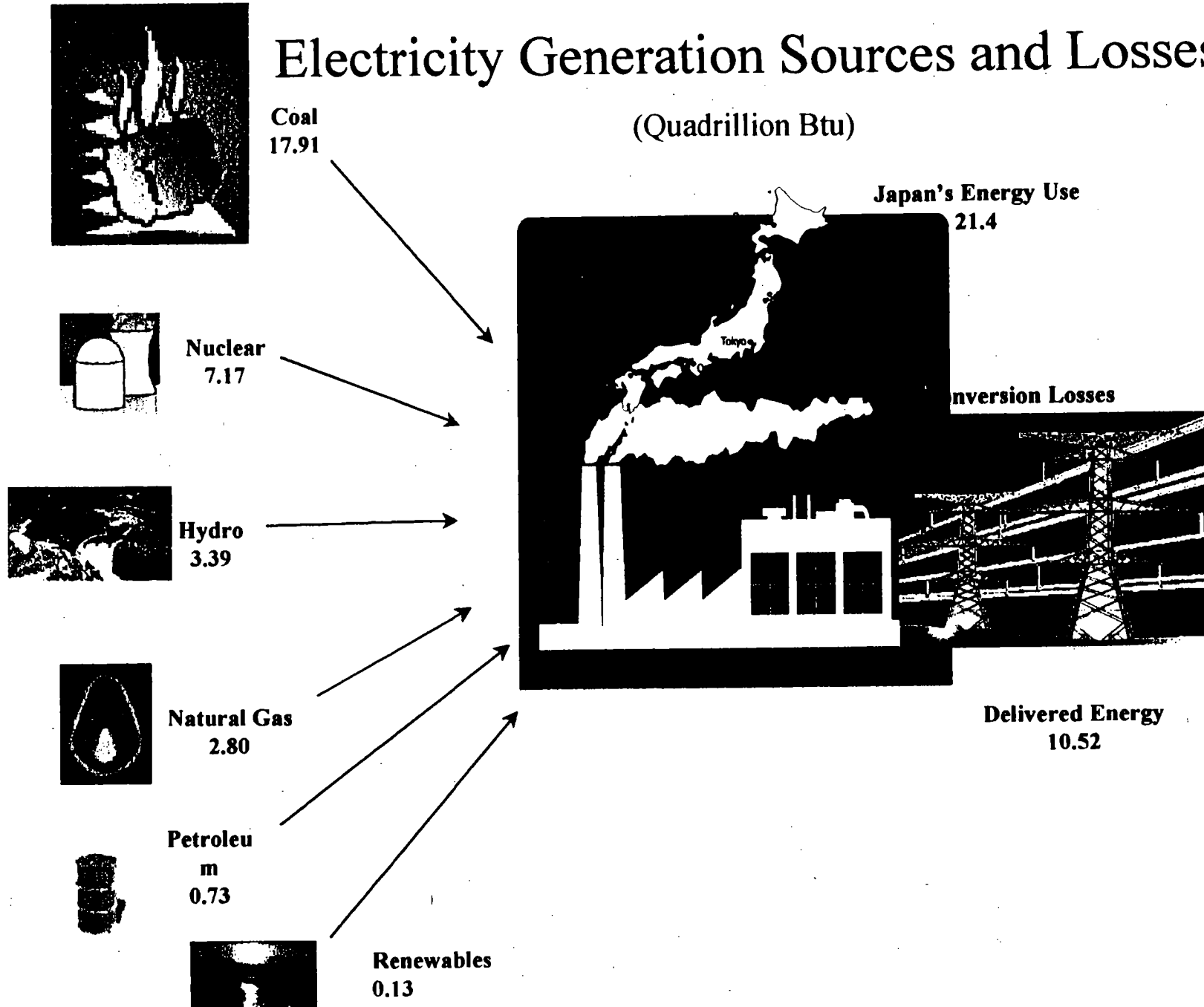
- Operated 1st Generation Technology processor with Industrial Partners.
- Received two R & D 100 awards
- Technology adopted by forest products industry, planting 50,000 acres yielding 10 tons per acre per year.

Cost of Ethanol



Electricity Generation Sources and Losses

(Quadrillion Btu)



Advanced Turbine Systems (ATS)

Lab Study Results

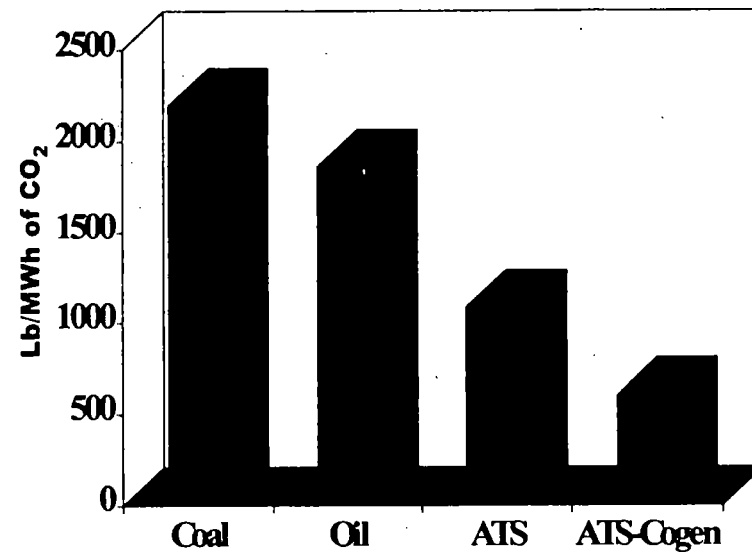
Low-Carbon Case:

Carbon Savings = 15-25 MtC

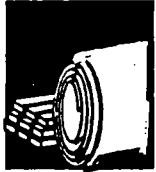
Installed Costs = \$350,000 /
MW

Electricity Costs = 3-4 ¢ per
kWhr

Power Generation Technologies CO₂ Emissions in 2010



Industry Visions



Forest Products

- Recycling ↑ 25%
- Over 60% self-generation



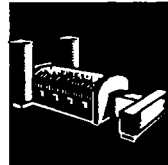
Steel

- Zero emissions + waste
- Recycling ↑ 40%



Metalcasting

- Recycling = 100%
- Energy Use ↓ 20%



Glass

- Energy use ↓ 50%
- Recycling = 100%



Aluminum

- Energy use ↓ 15%
- Smelting CO2 = zero



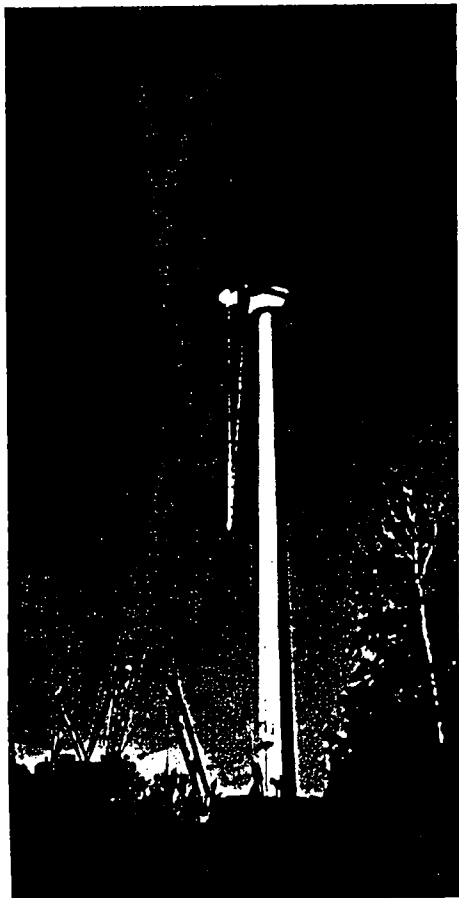
Chemicals

- Biocatalyst and Materials performance ↑



Refining

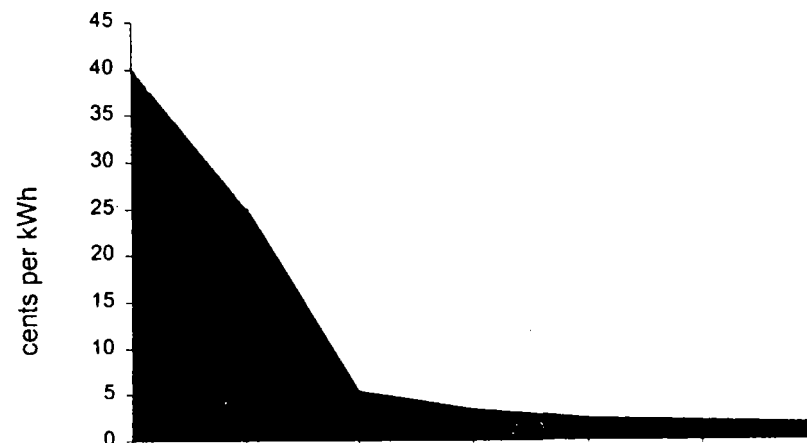
Wind Turbines



Impacts:

- 2010 Carbon savings of 5 MMTCE
- 2020 Carbon savings of 30 MMTCE
- Renewable fuel electricity at market prices
- International sales of US technology/products

Cost Curve for Wind Generated Electricity



Next Generation R and D

- ◆ Biotechnology
- ◆ Ceramics
- ◆ Combustion
- ◆ Fermentation
Microbiology
- ◆ Genetic Engineering
- ◆ Hydrogen
- ◆ Information Technology
- ◆ Nanotechnology
- ◆ Photoluminescence
- ◆ Photosynthetic
Mechanisms
- ◆ Polymers
- ◆ Process technology
- ◆ Sequestration
- ◆ Superconductivity

A Technology Portfolio for Reducing Carbon Emissions: \$1 Billion Level

The next \$500 million increment would have two basic components. The first is mid- to long-term basic and applied research and development and carbon sequestration R&D described in the draft DOE report *Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions* prepared by the directors of eleven National Laboratories. This investment will create the foundation for substantial reductions in U.S. emissions *below* 1990 levels in the long term. The second component is tax incentives to accelerate the use of current energy efficient and clean energy technologies. These incentives will reduce the direct cost to consumers and businesses of near-term emissions reductions.

If successful, the initiatives proposed here could result in additional emissions reductions by 2010 and substantially higher reductions in the post-2010 period.

| | Federal Costs (\$millions above FY97 appropriated) | | 2010 Savings in | 2020 Savings in |
|--|---|------|--------------------|--------------------|
| | FY99 | FY03 | MMT Carbon | MMT Carbon |
| \$500 Million Technology Increment | 500 | 1000 | | |
| Basic Research: | 100 | 150 | TBD | TBD |
| Materials Science | | | | |
| Chemical Sciences | | | | |
| Biotechnology | | | | |
| Geosciences, Computation, etc. | | | | |
| Cross-Cutting Technology Research | 100 | 100 | TBD | TBD |
| Fuel Cells | | | | |
| Hydrogen energy | | | | |
| Sensors and Controls | | | | |
| Electricity Transmission | | | | |
| Energy Storage | | | | |
| Carbon Sequestration | 50 | 50 | TBD | TBD |
| Tax Incentives to Accelerate PNGV Introduction | n/a | 100 | TBD | TBD |
| Renewable Energy Tax Credits | 100 | 100 | TBD | TBD |
| Accelerated Depreciation for Efficient Industrial Equipment | 150 | 100 | TBD | TBD |
| SUBTOTAL | 500 | 600 | | |
| TOTAL (at \$1,000 Million Level) | 1000 | 1600 | | |

Basic Research

Materials Science: Conduct research and development to create advanced materials for critical components in a variety of advanced energy systems - including lightweight vehicles, high temperature turbines, fuel cells, advanced engines and a variety of new smart systems.

Chemical Sciences: Accelerate research in a variety of chemical processes vital to an array of energy technologies. Such processes include materials separations in industry, chemical catalysts and combustion.

Biotechnology: Expand R&D in a range of areas including bioprocessing, energy crops, photosynthesis, and genetic engineering to increase the carbon fixation of some plant species.

Geosciences, Computation, Environmental and Ecological Sciences and Nuclear Sciences: Expand and create public/private partnerships to pursue a variety of breakthrough science and technologies including atmospheric and ocean carbon cycles, geophysics for CO₂ injection into underground aquifers, response of ecosystems to increased CO₂, advanced nuclear systems, advanced computation for energy systems component design, and computational techniques to increase understanding of a wide variety of natural and artificial processes.

Cross-Cutting Technology Research

Fuel Cells: Accelerate research and development on fuel cells, highly efficient devices which produce electricity and hot water with virtually zero emissions and have broad potential applications in power generation, buildings, industry and transportation vehicles.

Hydrogen Energy: Expand R&D on hydrogen production, storage and use. This clean burning fuel has wide potential in transportation, industry and power generation.

Sensors and Controls: Accelerate R&D on a wide array of sensors and controls. These technologies play a critical role in clean energy production, efficient industrial processes and carbon sequestration through ensuring maximum process efficiency at minimum cost.

Electricity Transmission and Distribution: Develop new materials and technologies to reduce electrical transmission losses - including superconducting cables, sophisticated control systems, and superconducting transformers.

Energy Storage: Expand R&D on energy storage technologies such as advanced batteries, ultracapacitors and superconducting storage to efficiently and inexpensively store energy.

Carbon Sequestration

Given the huge global resources of fossil fuels, the world economy will likely continue to use large quantities of fossil energy for the foreseeable future. A variety of technologies have the potential to separate out carbon and sequester that carbon. This initiative will establish a substantial R&D effort to develop technologies such as decarbonization of fuels, ocean storage, injection of underground aquifers and increased biological absorption of atmospheric CO₂.

Tax Incentives

Tax Incentives to Accelerate PNGV Introduction: A tax credit could be provided for early purchasers of PNGV vehicles. This credit could partially defray the additional capital cost of these vehicles and would end when initial higher purchase prices fall.

Renewable Energy Tax Credits: Tax credits and other financial incentives could be provided to investors in renewable power systems. These incentives could be performance based and also be available to municipal utilities. These incentives would phase out as renewable energy system costs decrease.

Accelerated Depreciation for Efficient Industrial Equipment: Investments in energy efficient and low-carbon industrial technologies could be eligible for accelerated depreciation. Eligibility would be based on improvements in performance.

A Technology Portfolio for Reducing Carbon Emissions: \$2 Billion Level

An additional federal budget expenditure of \$1 billion would focus largely on a long term objective of further reducing emissions in the 2020-2030 period. The science and technologies developed would have large global market potential - putting the U.S. in the position of leadership in the technologies and science needed to reduce global atmospheric concentrations of greenhouse gases.

The portfolio of initiatives at this level focus on rapid acceleration of breakthrough energy efficiency and clean energy technologies, critical basic research and cross-cutting technology development, advanced carbon sequestration and selected tax incentives to accelerate use of not only current advanced technologies but also more advanced technologies as they become available.

The breakthrough R&D on energy efficiency, clean energy, basic research, cross-cutting technologies and carbon sequestration are described in the draft DOE report *Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions* prepared by the directors of eleven National Laboratories. These investments will further establish a solid foundation not only for substantial reductions in U.S. emissions in the long term, but also expanded U.S. leadership in energy and environmental technologies in the coming decades.

| | Federal Costs (\$millions above FY97 appropriated) | |
|---|--|-------------|
| | FY99 | FY03 |
| \$1000 Million Technology Increment | 1000 | 1600 |
| Energy Efficiency R&D | 150 | 150 |
| Advanced Buildings Technologies | | |
| Advanced Industrial Technologies | | |
| Advanced Transportation Technologies | | |
| Advanced Agriculture and Forestry | | |
| Clean Energy R&D | 150 | 150 |
| Fossil Resource Development | | |
| Fossil Power Generation | | |
| Nuclear Energy | | |
| Renewable Energy | | |
| Basic Research: | 200 | 200 |
| Materials Science | | |
| Chemical Sciences | | |
| Biotechnology | | |
| Geosciences, Computation, etc. | | |
| Cross-Cutting Technology Research | 100 | 100 |
| Fuel Cells | | |
| Hydrogen energy | | |
| Sensors and Controls | | |
| Electricity Transmission | | |
| Energy Storage | | |
| Carbon Sequestration | 100 | 100 |
| Tax Incentives | 300 | 300 |
| Accelerated PNGV Introduction | | |
| Renewable Energy | | |
| Accelerated Depreciation for Efficient Industrial Equipment | | |
| Biofuels Production | | |
| Accelerated Depreciation for Low Carbon Industrial Technologies | | |
| SUBTOTAL | 1000 | 1000 |
| TOTAL (at \$1,000 Million Level) | 2000 | 2600 |

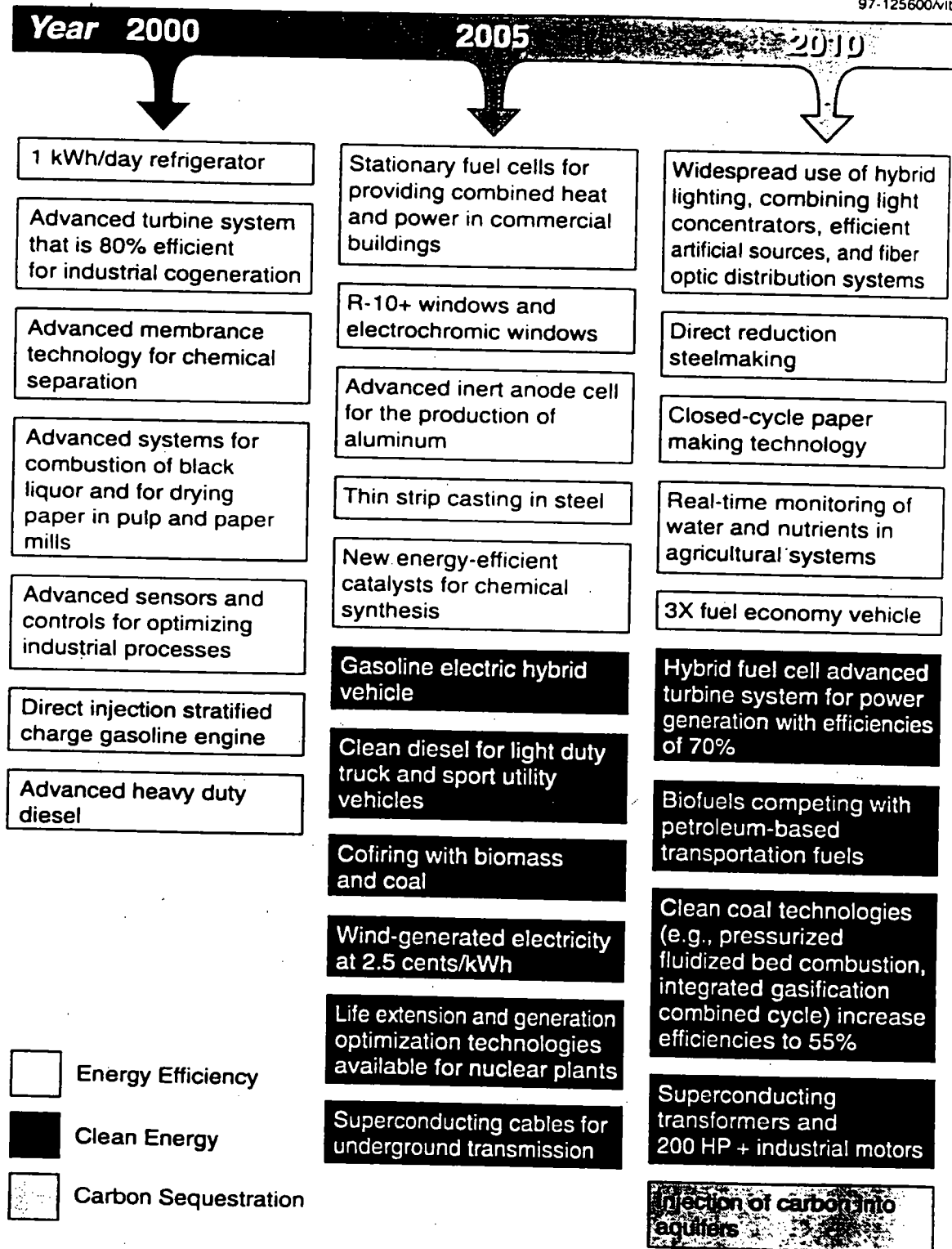


Fig. 5.2. Illustrative time-line of anticipated technology products: 2000-2010.

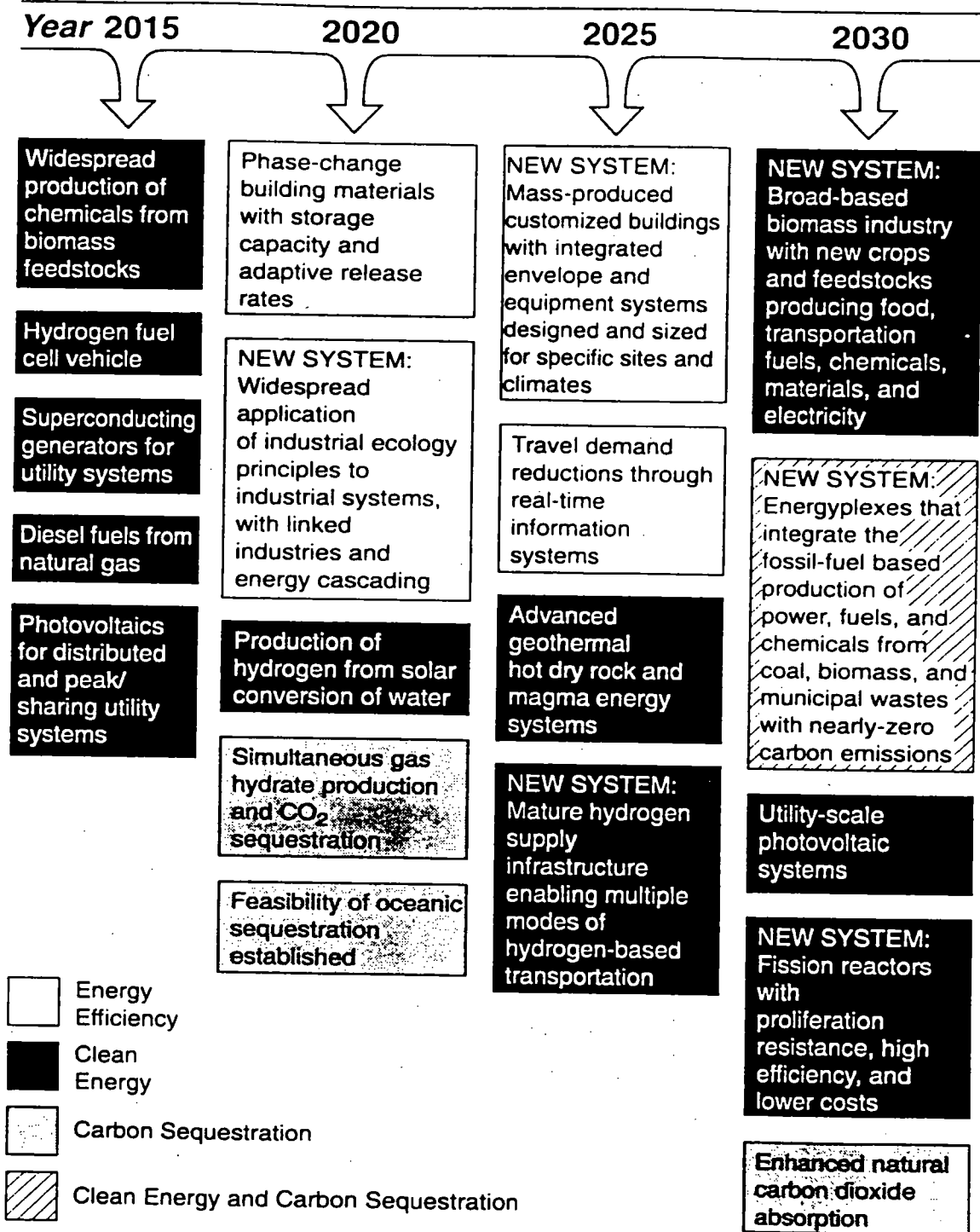


Fig. 5.3. Illustrative time-line of anticipated technology products: 2015-2030.

Comments on \$500 million/year Technology Proposal

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

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

General Comments

- The 5 Labs Study indicates that government programs, utility programs, and state programs cost 15% of technology costs (p. 1.13). Since DOE apportions all carbon savings in their proposal to the federal programs listed in the summary chart, we assume that all costs accrue to the federal government. In the "optimistic" assessment of the costs and benefits, DOE claims that government programs will likely only cost about 7% of technology costs, because half of emissions reductions occur through standards (see below). Assuming that this is true, and that the technology costs of the efficiency case range between \$26 - \$49 billion/year in the optimistic assessment (p. 1.14), then government programs should cost between \$1.82 - \$3.49 billion/year. However, using a 13.5% government cost stipulation (based on a 15% government program cost, minus 10% [instead of 50%] of these costs because of standards), the costs of government programs would range between \$3.51 - \$6.62 billion/year. The proposal presented on 9/29 costs 3 to 13 times less than projected by the 5 Labs Study, and yet generates greater carbon savings.
- The proposal employs standards to a much lesser extent than the 5 Labs Study. In the Study, "at least half of the efficiency occurs as a result of federal policies (e.g., standards and carbon permit charges)" (p. 1.13). Since the efficiency case does not include a carbon permit system, we assume that half of the carbon savings in the efficiency case result from standards. However, in this proposal, only about 10% of the emissions reductions occur due to standards (on the high ends of the ranges, 20 MMTCE out of 206 MMTCE).

- The projected carbon savings for 2010, while indicated as approximately 155 MMTCE, has a range of 127-206 MMTCE. Note that this large range does not overlap with the 5 Labs Study projection of 126 MMTCE (p. 1.12).
- The efficiency case is portrayed in the 5 Labs Study as carbon savings that occur because of already available and cost-effective technologies. In effect, government policies are only necessary to overcome market barriers. However, this proposal appears to be more reliant on R&D than on deployment and diffusion of existing technologies. Using the upper bounds of the ranges of carbon savings, we find that more than half of emissions reductions (104 of 206 MMTCE) result from R&D programs.

Specific Comments

Buildings Sector

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

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

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

Transportation Sector

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

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

ten times what is presently being spent” (p. 5.7). The proposal increases funding to just the lower end of this required spending level.

Industry Sector

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

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

Utilities Sector

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

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

A ROADMAP FOR STABILIZING CARBON EMISSIONS IN 2010 AT LOW COST

EXECUTIVE SUMMARY

Building on the results of the 5-Lab study from DOE, this analysis suggests that a U.S. goal of stabilizing carbon emissions in 2010 at 1990 levels could be achieved with a tradable permit price of as low as \$25 a ton under three conditions:

- o First, international trading and joint implementation allow us to purchase internationally roughly one-third of the tons needed for us to stabilize.
- o Second, we adopt the aggressive policies needed to achieve the penetration of energy-efficient and low-carbon technologies assumed in the \$25/ton case: significantly increased funding for R&D and deployment, tax incentives, and environmental regulatory reinvention.
- o Third, policies not explicitly considered in the 5-lab study—such as utility deregulation—allow us to achieve a few tens of tons additional carbon savings domestically at low cost.

Stabilizing U.S. carbon emissions in 2010 will require the country to lower emissions by 390 million metric tons (MMT's) compared to projected levels. The study performed by five DOE national laboratories examined a number of scenarios for reducing carbon emissions, but did not explicitly consider international trading and joint implementation. Separate analysis suggests that the U.S. could purchase more than 130 MMT's of the carbon reductions necessary to reach 1990 levels by 2010 from other countries through international emissions trading and joint implementation at \$25/ton. Therefore, domestic actions alone would have to reduce carbon emissions by about 260 MMT's.

The 5-lab study also did not consider the impact of utility deregulation, including a renewable portfolio standard and green power marketing, together with regulatory streamlining for combined heat and power. Under these policies, the 5-lab study suggests we could achieve some 274 to 305 MMT's of carbon reductions domestically at \$25/ton. Thus a stabilization goal is possible (see attached table).

In this scenario, the United States is essentially stabilizing its domestic emissions at current 1997 levels. Overall energy use will continue to grow, albeit at a reduced rate, with a gradual switch to lower carbon fuels (natural gas and renewables). Coal use would decline by 10% to 15%, a significant impact but far less than other approaches would entail. The nation's total energy bill for consumers and businesses might not rise at all. The international permits purchased would cost about \$3 to \$4 billion a year while U.S. oil imports would decline \$20 billion a year.

Summary of Potential Carbon Emissions Reductions in 2010
(Needed for stabilization: 390 MMT)

| | Emissions Reductions (MMT) |
|--|-------------------------------|
| S-Lab Study at \$25/ton | 234 |
| Additional Reductions from Electricity Restructuring and Other Policies | 40-71 |
| International Trading and JI | 130 |
| Total | 404 - 435 |

ELECTRIC UTILITY SECTOR SAVINGS

Substantial carbon emissions savings are possible in the electric utility sector. The 5-lab study estimated that 48 to 54 MMTs of carbon emissions reductions in 2010 could result from domestic carbon trading at \$25/ton in this sector. However, additional measures, especially federal electric utility restructuring legislation, could result in an additional 27 to 37 MMTs of savings in 2010 also identified in the 5-lab study. Initiatives needed to reach these total emissions savings levels of 75 to 91 MMTs at \$25/ton include domestic emissions trading; electricity industry restructuring; expanded technology research, development, and deployment; and targeted tax incentives to accelerate the use of renewable technologies.

Domestic trading of carbon permits will have five major effects on the business of producing and selling electricity—each of which will reduce utility sector carbon emissions. First, the order in which power plants are used (dispatched) will change, resulting in more natural gas and less coal use. Second, some existing coal plants with high operating costs will be converted to natural gas. Third, some power producers will invest in additional renewable energy technologies. Fourth, increased investments will be made to increase the efficiency of existing power plants. Finally, independent power producers and industrial users will increase investments in cogeneration that will result in new very efficient decentralized electricity production (this is discussed in the industrial sector). The reductions from renewable energy, power plant efficiency and cogeneration will be relatively modest unless federal electricity restructuring legislation includes key provisions to help reduce emissions.

CARBON-BASED DISPATCH OF POWER PLANTS: Currently, power plants in a typical utility system are used in such a way that the plants with the lowest operating costs—typically coal—are run the maximum amount, while plants with higher operating costs are run less. This is known as economic dispatching of power plants. Carbon trading at \$25/ton will change the economics for many plants so that some gas plants will be less expensive to operate than some coal plants—resulting in higher gas and lower coal use in electricity generation. The utility model used in the 5-lab study estimated the impact of \$25/ton trading on electricity dispatching would be an emissions reduction of 25 MMT in 2010.

POWER PLANT CONVERSIONS TO NATURAL GAS: Technology is available to convert coal-based power plants to natural gas. Such conversions, known as site repowering, would reduce carbon emissions substantially because of the lower carbon content of gas and the higher efficiency of current combined cycle gas turbine technology. For the 5-lab study, the most detailed plant-by-plant analysis to date of the costs of converting coal plants to natural gas was performed. While most conversions are not economic until permit prices are above \$25/ton, conversions resulting in 9 to 15 MMT of emissions reductions are possible with \$25/ton permits. Another technical approach, known as partial repowering, involves the use of existing gas pipelines into many coal plants. However, these potential emissions reductions are not included in the analysis presented here.

RENEWABLE ENERGY TECHNOLOGIES: Federal research and development of renewable energy such as wind, biomass combustion and solar photovoltaics has resulted in rapidly declining costs for these technologies. Continued R&D will be needed to keep reducing the cost of renewables. Carbon trading with \$25/ton permits will result in some expansion of renewables, generating emissions reductions estimated at 9 MMT in 2010. With additional measures, such as federal legislation on electricity restructuring discussed below, a total of 30 to 40 MMT of carbon emission reductions from renewable energy could be expected.

EXISTING POWER PLANT EFFICIENCY: Experience at selected electric utilities suggests that low-cost incremental improvements can be made to the efficiency of existing fossil fuel power plants. The 5-lab study estimates potential emissions reductions of 7-13 MMTs. However, most utilities have no economic incentive to make these low-cost investments in a regulated environment because their return on investment is unlikely to be allowed to increase and may actually decrease. The 5-lab study conservatively estimates that only 2 MMT of emissions reductions would occur by 2010 at \$25/ton. However, utility restructuring should allow a much larger fraction of the potential to be captured in the competitive marketplace—a total of 8 MMT.

NUCLEAR LIFE EXTENSION: Extending the life of existing nuclear power plants as projected in the 5-lab study would reduce emissions by 3 MMT in 2010 because carbon trading at \$25/ton would improve the economics of existing nuclear power plants.

ELECTRICITY RESTRUCTURING LEGISLATION: Federal legislation on electricity restructuring could remove market barriers and promote emissions reductions from renewable electric technologies, power plant efficiency gains, and cogeneration. Legislation including a renewable energy portfolio standard and facilitating "green power" purchases where consumers choose to pay slightly higher electricity rates for renewable (green) power should make possible the additional savings from renewables and increased power plant efficiency.

A STRATEGY TO REDUCE UTILITY SECTOR EMISSIONS: A carbon emissions trading system with \$25/ton permits will motivate the utility sector to reduce emissions by an estimated 48 to 54 MMT. Passage of federal electricity restructuring legislation containing the appropriate provisions could increase that to a total of 75 to 91 MMT. Additional emissions reductions in the longer term are likely to be dependent upon the costs of low and zero-carbon technologies such as renewable energy and advanced fossil energy technologies such as fuel cells. Substantial emissions reductions will only be possible with advanced technologies resulting from expanded RD&D of renewable energy, high-efficiency fossil electricity and nuclear energy. Federal programs to increase the supply of low-cost natural gas will be critical to keeping the costs of carbon reductions low. Targeted tax incentives to encourage the early adoption of new zero-carbon technologies such as wind power, photovoltaics and fuel cells can help accelerate the commercial availability of these critical means of carbon emissions reductions.

INDUSTRY SECTOR SAVINGS

The industrial sector is projected to produce 548 MMTs in 2010 under business as usual. The 5-lab study projects emissions reductions of 64 to 74 MMTs in 2010. Of that, 44 MMTs come from energy efficiency and 20 to 30 MMTs come from low carbon technologies, particular advanced cogeneration using either natural or industrial biomass feedstocks.

ENERGY EFFICIENCY

The 5-lab study achieves the 44 MMTs in increased efficiency in industry by modeling energy as a strategic investment for industry (i.e., lowering the hurdle rate for corporate investments in energy efficient and pollution prevention technologies). Achieving these emission reductions would require expanded federal investments in developing and deploying such technologies, tax incentives to promote adoption of these technologies, and continued environmental regulatory reinvention.

INDUSTRIES OF THE FUTURE: The seven most energy-intensive industries—steel, aluminum, petroleum refining, chemicals, pulp and paper products, glass, and metal casting—account for about 80% of the carbon emissions in U.S. manufacturing and more than 90% of the hazardous waste. The Department of Energy has formed partnerships with each of these industries in which the industry takes the lead in developing visions of energy-efficient, low-polluting, highly competitive "Industries of the Future" as well as technology roadmaps to identify an R&D and deployment pathway to achieving the vision.

The industry visions typically foresee between a 1% to 1.5% per year improvement in energy efficiency for two decades, while reducing pollution and increasing productivity. The vision process accelerates market entry of new technologies because industry has already identified a niche for each technology pursued, so R&D is no longer government technology push, a traditionally slow process. We have already seen in the metal casting area one new technology leap from idea to actual prototype in 18 months.

An expanded Industry of the Future program could achieve the bulk of the 44 MMTs of carbon emission reductions from industrial energy efficiency, but only with a much greater government and industry effort consisting of three components: R&D and deployment, tax and market incentives, and regulatory reinvention. First, on the government side, significantly expanded funding for the Industry of the Future Program is a crucial step toward achieving the needed carbon reductions.

MARKET INCENTIVES: Second, fiscal tools and market mechanisms can be harnessed to reduce carbon emissions. Tax incentives for very efficient industrial technologies would speed deployment and encourage investment in innovation. Also, since these energy-intensive industries are more sensitive to energy prices than most, an emissions cap and trading system at a price level of \$25/ton will spur adoption of energy-efficient technologies.

REGULATORY REINVENTION: If federal pollution prevention technology development is to achieve significant greenhouse gas reduction, the Administration must complete its regulatory reinvention effort. Regulations that focus on prevention rather than end-of-pipe solutions save the energy used to create the pollution as well as the energy needed to treat, burn, or transport it. Preliminary evidence with the pulp and paper industry suggest that compliance savings of \$8 billion are possible using this approach, while achieving environmental goals and advancing technologies that reduce greenhouse gas emissions. Achieving projected emissions reductions

would be facilitated by flexible implementation of the recently promulgated particulate and ozone provisions of the Clean Air Act.

MOTORS AND INDUSTRY AUDITS: Motors consume 70% of industrial electricity and are especially important to small and medium-sized industries and the fast-growing emissions of the light industrial sector. Significant savings are possible through programs aimed at speeding deployment of energy-efficient motors, computer-controlled adjustable speed drives, and efficient motor system design, which also increase productivity. Expanding federally-sponsored informational programs like Motor Challenge and Industrial Assessment Centers (which perform energy, waste, and productivity audits), and making sure the Manufacturing Extensions Centers have expertise in motors and energy, could provide carbon reductions of 5 to 10 MMTs (which together with the expanded Industry of the Future effort would bring the industrial efficiency total to 44 MMTs).

COGENERATION

Not only can we reduce the energy intensity of industry, but we can help industry reduce its carbon intensity by accelerating the use of advanced cogeneration, also called combined heat and power. The average fossil fuel plant is 34% efficient in generating electricity, meaning that three units of primary energy are used to produce one unit of electric energy. Each year the utility sector throws away as much energy in waste heat as the entire country of Japan uses. Advanced turbines developed by DOE partnering with industry that will be available in three years (and for which orders are already being taken), have an overall efficiency of 80% to 90%, produce steam together with electricity under 3 cents per kilowatt-hour, and significantly reduce NO_x emissions. These turbines can run on natural gas or biomass.

Policies not considered in the 5-lab study could allow us to achieve carbon savings from industrial cogeneration of natural gas or biomass of 20 to 30 MMTs at \$25/ton (rather than the \$50/ton the lab study posits to achieve such savings). These policies would include tax incentives and utility deregulation coupled with the removal of other regulatory barriers to cogeneration. Some industries have their own low-cost biomass feedstocks (for example, black liquor gasification in the pulp and paper industry), which makes possible cogeneration with nearly zero carbon emissions.

BUILDINGS SECTOR SAVINGS

The buildings sector is projected to produce 571 MMTs in 2010 under business as usual. The 5-lab study projects emissions reductions of 47 to 52 MMTs in 2010. Of that, 42 MMTs comes from energy efficiency and 5 to 10 MMTs comes from expanded use of combined heat and power. Almost all of these savings come from deploying existing technology. We do not assume premature stock retirement, although this may be cost-effective in many whole-building retrofits.

ENERGY EFFICIENCY

The 42 MMTs of emissions reductions from energy efficiency comes primarily from looking at the natural rate of stock turnover of existing building equipment and assuming that half of all cost-effective technologies (payback of 10 years or less) available today are used when equipment is replaced. These technologies include improved lighting, heating, cooling, windows, insulation, office equipment, and energy management systems. Many of these technologies improve the quality of service delivered (i.e., higher quality lighting) and have been documented in a number of cases to improve productivity.

STANDARDS: About half of the 42 MMTs of carbon emissions reductions can be achieved through existing authority of the DOE to establish efficiency standards for appliances, such as the super-efficient refrigerator announced earlier this year. The DOE uses a consensus-based approach in which manufacturers, environmentalists, consumer advocates, and the states work together to develop standards.

VOLUNTARY PROGRAMS: The other half of the 42 MMTs will be achieved primarily by the expansion of a number of voluntary programs, such as the joint EPA-DOE Energy Star program. The Energy Star labeling program has already transformed a number of markets, for instance cutting the energy used by computers, monitors, and printers 50% at virtually no incremental cost, and is being extended by EPA and DOE to dozens of other products. Electronic equipment consumes the electricity of ten large power plants, generating 12 MMTs of carbon emissions each year, just from the power they consume in stand-by mode when they are not even being used. Preliminary analysis suggests that up to 90% of that could be saved through best engineering practices without reducing service.

RESEARCH AND DEVELOPMENT: Designing new buildings with advanced technology can reduce energy consumption by 25% to 50% without increasing the building's initial cost. The extra cost of some of the energy-efficient equipment is paid for by the smaller required heating and cooling system. A partnership for 21st Century Housing can achieve 2 to 3 MMT of the 42 MMTs in building efficiency emissions reductions in 2010 (and far more in later years as more new buildings are constructed).

COMBINED HEAT AND POWER

As in the case of industry, we can reduce the carbon intensity of the buildings sector by accelerating the use of combined heat and power. The 5-lab study only modeled one technology for cogeneration in buildings—proton-exchange membrane (PEM) fuel cells. With accelerated R&D, PEMs could become one of the most cost-competitive energy provider for buildings, converting natural gas to electricity and hot water with 80% to 90% efficiency. The 5-lab analysis found 2-3 MMT carbon emissions reductions possible from PEMs by 2010 (with substantially larger savings in subsequent years).

Policies not examined in the 5-lab study, such as utility restructuring, tax incentives and regulatory reinvention, would accelerate cogeneration in buildings. Micro-turbines have achieved efficiencies exceeding 90% in converting natural gas to electricity, steam, and chilled water in more than 6,000 buildings. Combined heat and power from both fuel cells and microturbines could achieve carbon emission reductions in the buildings sector of 5 to 10 MMT by 2010.

MARKET AND REGULATORY INCENTIVES

Capturing the large potential for carbon emissions reductions in the buildings sector would be made much easier if end users could obtain credits for emission reductions achieved through on-site energy efficiency and low-carbon technologies in the buildings sector. If the domestic carbon emissions trading allowed this, then significant capital investment could be expected to flow into the buildings sector to capture the low-cost savings possible. Tax incentives would also be beneficial.

FEDERAL ENERGY MANAGEMENT

The Federal government owns or operates half a million buildings and is the largest single consumer of energy in the buildings sector. Achieving the emissions reductions in the buildings sector projected by 5-lab study, both from energy efficiency and cogeneration, would be greatly facilitated by a significantly enhanced federal energy management effort.

TRANSPORTATION SECTOR SAVINGS

The transportation sector is projected to produce 616 MMTs in 2010 under business as usual. The 5-lab study projects emissions reductions of 88 MMTs. Of that, 74 MMTs comes from energy efficiency (greater fuel efficiency) and 14 MMTs comes from the use of low-carbon fuels (primarily ethanol).

ENERGY EFFICIENCY

HIGH EFFICIENCY CARS AND LIGHT TRUCKS: The President's Partnership for a New Generation of Vehicles has a goal of developing a generation of cars that will be three times more efficient than current vehicles with no compromises in size, safety, comfort or cost. The goal is a production prototype 80 mpg vehicle in 2004 and commercial availability soon after. A variety of efficient technologies such as hybrid vehicle design, advanced engines, regenerative braking, and lightweight materials are under development. These technologies are also applicable to light trucks and sport utility vehicles, so that a PNGV for these heavier passenger vehicles is quite possible with an expanded research effort. In the \$25/ton case, the 5-lab study assumes that the efficiency of new autos is only 40 mpg and the efficiency of new light trucks and sport utility vehicles is 29 mpg in 2010. Thus, only a fraction of the cars on the road need to be PNGV vehicles or make use of some PNGV technologies. This results in projected carbon emission reductions of about 46 MMTs in 2010.

In order to reach the PNGV goals and have these vehicles command a significant market share by 2010, two initiatives are needed. First, the R&D effort must be substantially expanded. Second, tax incentives provided to early purchasers of these vehicles could boost market confidence and create early markets for manufacturers.

HIGH EFFICIENCY HEAVY TRUCKS: Ongoing federal R&D on advanced diesel engines and lightweight materials could substantially reduce carbon emissions from heavy trucks. These technologies are projected to be available by about 2003 and be quickly adopted by trucking manufacturers since energy is a major cost component of freight transportation (which typically gets 7 to 8 miles per gallon while traveling over 50,000 miles a year). In the \$25/ton case, the 5-lab study estimates carbon emission reductions of about 12 MMTs in 2010.

ADVANCED HIGH EFFICIENCY AIRCRAFT AND RAIL: Ongoing federal R&D on advanced aircraft engines, lightweight materials and improved aerodynamics have the potential to improve aircraft energy efficiency by 40%, substantially reducing carbon emissions. These technologies are projected to be available by about 2005 and be quickly adopted by the manufacturing industry because energy represents a major cost component of air travel. In the \$25/ton case, the 5-lab study estimates carbon emission reductions of about 12 MMTs in 2010. Improvements in the energy efficiency of trains is responsible for an additional 4 MMTs.

LOW-CARBON FUEL

Government-industry R&D partnerships have brought the cost of ethanol from \$3.60 per gallon in 1980 to \$1.20 per gallon. Continued R&D in bio-engineered organisms and fast-growing crops is expected to produce ethanol for under 70 cents a gallon by 2005, competitive with oil-based fuels at current prices. The ethanol would be derived not from the starchy (i.e. edible) part of corn, as it is now, but from cellulosic waste (such as waste paper or crop waste) and dedicated crops such as switchgrass or hybrid poplar trees—resulting in a transportation fuel with virtually no net carbon emissions. By blending 5% ethanol into gasoline in 2010, 14 MMTs in carbon reductions can be achieved.

| | | | | | | | |
|---------|--|-----------|----------|---------|-------|-----------|-----------|
| lgdpcap | | .659232 | .1013007 | 6.508 | 0.000 | .460246 | .8582179 |
| time | | -.0105244 | .0023186 | -4.539 | 0.000 | -.0150789 | -.00597 |
| _cons | | -18.66542 | .9050468 | -20.624 | 0.000 | -20.44321 | -16.88763 |

counindx | F(24,547) = 3491.152 0.000 (25 categories)

13. regress lemiscap lgdpcap lgdpcaps time; *Squared term Annex I, OLS*

| Source | SS | df | MS | Number of obs = | 574 |
|----------|------------|-----|------------|-----------------|--------|
| Model | 238.334358 | 3 | 79.4447861 | F(3, 570) = | 26.72 |
| Residual | 1694.93204 | 570 | 2.97356499 | Prob > F = | 0.0000 |
| | | | | R-squared = | 0.1233 |
| | | | | Adj R-squared = | 0.1187 |
| Total | 1933.2664 | 573 | 3.37393787 | Root MSE = | 1.7244 |

| lemiscap | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] | |
|----------|-----------|-----------|--------|-------|----------------------|----------|
| lgdpcap | 4.082181 | 2.023378 | 2.018 | 0.044 | .1079941 | 8.056368 |
| lgdpcaps | -.1881469 | .1165717 | -1.614 | 0.107 | -.4171093 | .0408155 |
| time | -.0103029 | .011287 | -0.913 | 0.362 | -.032472 | .0118663 |
| _cons | -34.11905 | 8.727837 | -3.909 | 0.000 | -51.26169 | -16.9764 |

xtreg lemiscap lgdpcap lgdpcaps time, fe i(counindx); *Annex I, Fixed Effect*

| | | | Fixed-effects (within) regression | | |
|-------------------------------|---|----------|-----------------------------------|--------|--|
| sd(u_counindx) | = | 1.748911 | Number of obs = | 574 | |
| sd(e_counindx_t) | = | .1281364 | n = | 25 | |
| sd(e_counindx_t + u_counindx) | = | 1.753598 | T-bar = | 22.96 | |
| corr(u_counindx, Xb) | = | 0.0265 | R-sq within = | 0.2645 | |
| | | | between = | 0.1222 | |
| | | | overall = | 0.1228 | |
| | | | F(3, 546) = | 65.45 | |
| | | | Prob > F = | 0.0000 | |

| lemiscap | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] | |
|----------|-----------|-----------|---------|-------|----------------------|-----------|
| lgdpcap | 4.764622 | .3761053 | 12.668 | 0.000 | 4.025832 | 5.503412 |
| lgdpcaps | -.231501 | .0205733 | -11.253 | 0.000 | -.2719135 | -.1910885 |
| time | -.0077195 | .0021057 | -3.666 | 0.000 | -.0118558 | -.0035832 |
| _cons | -36.73382 | 1.801243 | -20.394 | 0.000 | -40.27204 | -33.19561 |

counindx | F(24,546) = 4278.515 0.000 (25 categories)

ni
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counindx | F(117,2567) = 340.099 0.000 (118 categories)

8. regress lemiscap lgdpcap lgdpcaps time; *All countries, OLS*

| Source | SS | df | MS | Number of obs = | 2687 |
|----------|------------|------|------------|-----------------|---------|
| Model | 7293.58323 | 3 | 2431.19441 | F(3, 2683) = | 1808.82 |
| Residual | 3606.15935 | 2683 | 1.34407728 | Prob > F = | 0.0000 |
| | | | | R-squared = | 0.6692 |
| | | | | Adj R-squared = | 0.6688 |
| Total | 10899.7426 | 2686 | 4.05798309 | Root MSE = | 1.1593 |

| lemiscap | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] |
|----------|-----------|-----------|---------|-------|----------------------|
| lgdpcap | -.3881612 | .0992047 | -3.913 | 0.000 | -.5826866 -.1936358 |
| lgdpcaps | .0969609 | .0067839 | 14.293 | 0.000 | .0836587 .1102632 |
| time | .000798 | .0033993 | 0.235 | 0.814 | -.0058676 .0074635 |
| _cons | -17.37004 | .3562284 | -48.761 | 0.000 | -18.06855 -16.67153 |

9. xtreg lemiscap lgdpcap lgdpcaps time, fe i(counindx); *All countries, Fixed Effects*

sd(u_counindx) = 1.418067
 --- 'e_counindx_t) = .2991913
 Cap,e_counindx_t + u_counindx) = 1.449286
 corr(u_counindx, Xb) = 0.3395

Fixed-effects (within) regression
 Number of obs = 2687
 n = 118
 T-bar = 22.7712
 R-sq within = 0.1918
 between = 0.5546
 overall = 0.5419
 F(3, 2566) = 203.00
 Prob > F = 0.0000

| lemiscap | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] |
|----------|-----------|-----------|---------|-------|----------------------|
| lgdpcap | 1.717447 | .1479939 | 11.605 | 0.000 | 1.427248 2.007647 |
| lgdpcaps | -.0766359 | .009793 | -7.826 | 0.000 | -.0958389 -.0574329 |
| time | .0060664 | .0009234 | 6.569 | 0.000 | .0042556 .0078772 |
| _cons | -23.15315 | .5537947 | -41.808 | 0.000 | -24.23908 -22.06722 |

counindx | F(117,2566) = 322.388 0.000 (118 categories)

10. gen annex1 = counindx == 3 | counindx == 4 | counindx == 8 | counindx == 17 |
 > counindx == 28 | counindx == 35 | counindx == 36 | counindx == 40 | counindx == 4
 > 6 |
 > counindx == 47 | counindx == 51 | counindx == 53 | counindx == 55 | counindx == 6
 --- 2 |
 counindx == 74 | counindx == 75 | counindx == 79 | counindx == 86 | counindx == 9
 > 7 |
 > counindx == 102 | counindx == 103 | counindx == 110 | counindx == 111 | counindx

```
== 112|
counindx == 118;
```

```
11. replace lgdpcap = . if annex1 == 1;
(575 real changes made, 575 to missing)
```

```
12. replace lemiscap = . if annex1 == 1;
(574 real changes made, 574 to missing)
```

```
13. regress lemiscap lgdpcap time;
```

| Source | SS | df | MS | |
|----------|------------|------|------------|------------------------|
| Model | 3472.15584 | 2 | 1736.07792 | Number of obs = 2113 |
| Residual | 2136.37595 | 2110 | 1.01250045 | F(2, 2110) = 1714.64 |
| Total | 5608.53179 | 2112 | 2.65555483 | Prob > F = 0.0000 |
| | | | | R-squared = 0.6191 |
| | | | | Adj R-squared = 0.6187 |
| | | | | Root MSE = 1.0062 |

| lemiscap | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] | |
|----------|----------|-----------|----------|-------|----------------------|-----------|
| lgdpcap | .9834178 | .0168273 | 58.442 | 0.000 | .950418 | 1.016418 |
| time | .0071194 | .0033304 | 2.138 | 0.033 | .0005882 | .0136506 |
| _cons | -22.1012 | .1199121 | -184.312 | 0.000 | -22.33636 | -21.86604 |

```
xtreg lemiscap lgdpcap time, fe i(counindx);
```

```
sd(u_counindx) = 1.057425
sd(e_counindx_t) = .3279552
sd(e_counindx_t + u_counindx) = 1.107115
corr(u_counindx, Xb) = 0.4241
```

```
Fixed-effects (within) regression
Number of obs = 2113
n = 93
T-bar = 22.7204
R-sq within = 0.2021
between = 0.6454
overall = 0.6182
F( 2, 2018) = 255.59
Prob > F = 0.0000
```

| lemiscap | Coef. | Std. Err. | t | P> t | [95% Conf. Interval] | |
|----------|-----------|-----------|---------|-------|----------------------|-----------|
| lgdpcap | .6380502 | .0335849 | 18.998 | 0.000 | .5721855 | .7039149 |
| time | .0092905 | .001107 | 8.393 | 0.000 | .0071195 | .0114614 |
| _cons | -19.82543 | .2217861 | -89.390 | 0.000 | -20.26038 | -19.39047 |

```
counindx | F(92,2018) = 193.969 0.000 (93 categories)
```

```
regress lemiscap lgdpcap lgdpcapssquared term time; Non-Annex I, Fixed Effects
```

| Source | SS | df | MS | |
|--------|----|----|----|-----------------------|
| | | | | Number of obs = 2113 |
| | | | | F(3, 2109) = 1573.81 |

```

Model | 3876.81018      3 1292.27006
-----+-----
Residual | 1731.72161 2109 .821110294
-----+-----
Total | 5608.53179 2112 2.65555483
    
```

```

Prob > F      = 0.0000
R-squared     = 0.6912
Adj R-squared = 0.6908
Root MSE     = .90615
    
```

```

-----+-----
lemiscap |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
lgdpcap  |  -.9495023   .0883796    -10.743  0.000   -1.122823   -.7761819
lgdpcaps |  .1438931    .0064818    22.199  0.000    .1311816    .1566046
time     |  .0081621    .0029995     2.721  0.007    .0022797    .0140445
_cons    | -15.86642    .3008979   -52.730  0.000   -16.45651   -15.27634
    
```

Squared term

16. xtreg lemiscap lgdpcap lgdpcaps time, fe i(counindx); *Non-Annex I, fixed effects*

```

sd(u_counindx)          = 1.094035
sd(e_counindx_t)       = .3271232
sd(e_counindx_t + u_counindx) = 1.141894

corr(u_counindx, Xb)    = 0.2841
    
```

```

Fixed-effects (within) regression
Number of obs = 2113
n = 93
T-bar = 22.7204
    
```

```

R-sq within = 0.2065
R-sq between = 0.5722
R-sq overall = 0.5499
    
```

```

F( 3, 2017) = 175.02
Prob > F = 0.0000
    
```

```

-----+-----
lemiscap |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----+-----
lgdpcap  |  1.231508    .1798674     6.847  0.000    .8787626    1.584253
lgdpcaps | -.0409889    .0122057    -3.358  0.001   -.064926    -.0170518
time     |  .0088402    .0011123     7.948  0.000    .0066588    .0110215
_cons    | -21.8852     .6520356   -33.564  0.000   -23.16393   -20.60646
    
```

```

counindx |              F(92,2017) = 153.977  0.000              (93 categories)
    
```

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Stata Corporation
 702 University Drive East
 College Station, Texas 77840
 409-696-4600, fax 409-696-4601

cap

White House Climate Change Task Force

734 Jackson Place, NW • Washington, DC 20503
202/343-1060 • fax 202/343-1163

Fax Cover Sheet

To: Jason Shogren, CEA
From: Paul Risley, WHCCTF
Phone: 202-343-0484
Date: Tuesday, August 5, 1997
Re: Draft Surrogates List
Pages
(Including Cover): 10

As we discussed, please review and edit the attached draft surrogates list at your earliest convenience. Please add additional names of potential surrogates and fax back if possible. We would like to get an improved list back to Todd Stern within 24 hours.

Our fax: 343-1163. Let me know if I can be of further assistance.

NOTE TO TODD STERN

RE: Draft Surrogates List

Attached is a first cut at a list of possible surrogates.

Along with the list of possible surrogates, it might be useful for our coordinator to have a list of contacts within the Administration to discuss who from this list might be most appropriate. The following is a start at such a list:

Physical science and impacts: Rosina Bierbaum, OSTP
Economics/competitiveness: Peter Orzag, NEC; Jeffrey Hunker, Commerce; Janet Yellin, CEA
Technology: Dan Reicher, DOE; Henry Kelly, OSTP
International Issues: Rafe Pomerance, State; David Sandalow, CEQ/NSC

Steve Seidel

DRAFT 7/30

POSSIBLE SURROGATES ON CLIMATE CHANGE

- 1 - Experience includes testifying, op-eds, etc.
 2 - Could assist in identifying and working with surrogates

I. PHYSICAL SCIENTISTS

| Name | Title/Affiliation | Background | Phone # | Fax # |
|-------------------------------------|---|---|------------------|------------------|
| Wallace Broecker ¹ | Lamont-Doherty Lab, Columbia University, New York | Basic climate science; climate surprises (sudden changes) | 714/365- 8413 | 714/365- 8163 |
| Stephen Schneider ¹ | Stanford University, California | Basic climate science; participant in President's briefing | 415/725- 9978 | 415/725- 2592 |
| Robert Watson ¹ | Senior Advisor, World Bank, Chair --IPCC Third Assessment; ex-Associate Dir. For Environment, OSTP, Wash. D.C. | Climate science, impacts, and mitigation | 202/473- 1755 | 473-0565 |
| Michael Oppenheimer ¹ | Environmental Defense Fund, New York | Climate science and impacts | 212/505- 2100 | 212/505- 2375 |
| Eric Barron ¹ | Penn State University College Park, Pa. | Basic climate science, regional impacts, and climate models | 814/865- 1619 | |
| Dan Albritton ¹ | Director, Aeronomy Lab, NOAA/Commerce, Boulder Co. | Basic climate science | 303/497- 5785 | 303/497- 5340 |
| Jerry Mahlman ¹ | Director, GFDL, NOAA/Commerce, Princeton, NJ | Basic climate science; climate models | 609/452- 6502 | 609/987- 5070 |
| Tom Karl ¹ | Senior Scientist, National Climate Data Center, NOAA/Commerce, Ashville, NC | Historic trends in temperature and precipitation, extreme events | 704/271- 4319 | 704/271- 4328 |
| Kevin Trenberth ¹ | National Center for Atmospheric Research, Boulder, Co. | Basic climate science; climate trends | 497-1318 | 497-1314 |
| James Hansen ¹ | Director, Goddard Institute for Space Studies/NASA, New York, NY | Basic climate science; climate models | 212/678- 5500 | 212/678- 5622 |

| | | | | |
|-----------------------------|--|--|--------------|--------------|
| Michael McCracken | Global Change Research Program, Washington D.C | Basic climate science; answers to common misperceptions | 202/358-1837 | 202/358-4103 |
| Sherry Rowland ¹ | U. Of California, Irvine | Basic climate science; participant in President's briefing; Nobel winner | 714/824-6016 | 714/824-2905 |
| Mario Molina | MIT | Basic climate science; participant in President's briefing; Nobel winner | 617/253-5081 | 617/253-8298 |
| Warren Washington | National Center for Atmospheric Research, Boulder, CO | Basic climate science, climate modeler | 497-1321 | 497-1314 |
| Richard Somerville | Scripps Oceanographic Institute, San Diego, CA | | 619/534-4644 | 619/534-8561 |
| Alan Robock | U. Of Maryland | Basic climate science | 301/405-5377 | 301/314-9482 |
| John Firor | National Center for Atmospheric Research, Boulder, CO | Basic climate science | 497-8104 | 4497-8709 |
| John Townsend | Chair, UNEP/IOC/WMO/ICSU Global Climate Observing System. U. Of Maryland | Climate change in general, Forests, observations of climate | 301/405-4050 | 301/314-9294 |
| Berrien Moore III | Director, Institute for the Study of Earth, Oceans, and Space. U. Of New Hampshire | Climate change, relation of physical climate and biosphere | 603/862-1766 | 603/862-1915 |
| Alan Robock | Dep. Of Meteorology, U. Of Maryland | Climate change, modeling | 301/405-5377 | 301/314-9482 |

II. IMPACTS ON AGRICULTURE, NATURAL ECOSYSTEMS, WATER RESOURCES, AND FORESTRY

A. Human Health Impacts

| Name | Title/Affiliation | Background | Phone # | Fax # |
|---------------------------|------------------------|---|--------------|--------------|
| Eric Chivian ¹ | Harvard Medical School | Spread of infectious disease | 617/738-9443 | 617/734-8822 |
| Paul Epstein ¹ | Harvard Medical School | Spread of infectious disease; impacts of coastal algae on fish and pests on agriculture | 617/731-3167 | 617/432-2595 |

| | | | | |
|---------------------------------|------------------|--|--|--|
| Lawrence Kalkstein ¹ | U. Of Delaware | Impacts of heat stress on mortality | | |
| Robert Shope | U. Of Texas | Impacts of infectious diseases; participated in President's briefing | | |
| Rita Colwell | U. Of Maryland | Infectious diseases | | |
| Jonathan Patz ¹ | Johns Hopkins U. | Spread of infectious diseases | | |

B. Impacts on Agriculture

| Name | Title/Affiliation | Background | Phone # | Fax # |
|---------------------------------|--|--|--------------|--------------|
| Stan Chagnon ¹ | Illinois Water Survey Chief - Emeritus | Agriculture & water resources | | |
| Ron Neilson | Oregon State University | Forestry and water resources | | |
| Jerry North ¹ | Texas A & M | Climate impacts on Texas | | |
| Steven Hamburg ¹ | Brown University | Forestry and wildlife | | |
| Jane Lubchenco ¹ | Oregon State; past president AAAS; organizer of scientists letter | Impacts on ecosystems, biodiversity, forests | | |
| Adam Markham ¹ | World Wildlife Fund | Impacts on National Parks, wildlife | | |
| Cynthia Rosenzweig ¹ | Goddard Institute for Space Studies/NASA, New York | Impacts on agriculture | | |
| Peter Raven | Director of the Missouri Botanical Garden; Home Sec. Of The National Academy of Sciences | Impacts on ecosystems; biodiversity | 314/577-5111 | 314/577-9595 |
| Don White | Director, International Drought Information Center, U. Of Nebraska | Drought | 402/472-6707 | 402/472-6614 |
| Walter Oechel | Dept. Of Biology, San Diego St. University | Arctic ecosystems | 619/594-4818 | 619/594-7831 |
| Jerry Franklin | College of Forest Resources U. Of Washington | Forests | 206/543-2730 | |

| | | | | |
|-----------------------------|---|---|--------------|--------------|
| Herman Shugart | W.W. Corcoran Professor of Environmental Sciences and Chairman, Dept. Of Environmental Sciences U. Of Virginia | Forests | 804/924-7642 | 804/982-2137 |
| Helen Ingram | Director, Udall Studies in Public Policy. U. Of Arizona | Water | 520/521-7189 | 520/621-9234 |
| Diana Liverman | Director, Latin America Area Center. U. Of Arizona | Human dimensions of climate change | 520/626-7242 | |
| William C. Clark | JFK School of Gov't Harvard University | Assesing climate change, human dimensions | 617/495-3981 | 617/495-8963 |
| Michael H. Glantz | Program Director, Environmental and Societal Impacts Group, National Center for Atmospheric Research, Boulder, CO | Societal impacts | 303/497-8119 | 303/497-8125 |
| Pamela Matson | U. Of California | Ecological impacts | | |
| Peter Vitousek | Stanford University | Ecological impacts | 415/725-1866 | |
| Virginia Van Sickle-Burkett | Branch Chief of Wetlands Ecology, U.S. Fish and Wildlife Service | Wetlands | 318/266-8637 | 318/231-7510 |
| Richard Adams | Professor of Resource Economics, Oregon State University | Agriculture | 503/737-1435 | 503/737-2563 |
| Bill Easterling | Penn State University | Agriculture | 814/865-3433 | |
| George Woodwell | Director, Woods Hole Reaearch Center, Mass. | | | |

C. Sea level Rise

| Name | Title/Affiliation | Background | Phone # | Fax # |
|--------------------|-------------------|---|---------|-------|
| Stephen Leatherman | U. Of Miami | coastal impacts on Chesapeake, east coast | | |

D. Insurance Industry

| Name | Title/Affiliation | Background | Phone # | Fax # |
|-------------|--------------------------------------|------------|---------|-------|
| Bill Nelson | Florida State Insurance Commissioner | | | |

| | | | | |
|---------------------------|--|---|------------------|------------------|
| Frank Nutter ¹ | Executive Director, Reinsurance Industry Association | | 202/638- 3690 | 202/638- 0936 |
| Kaj Ahlman ¹ | CEO, Employers Reinsurance Corp. | Only U.S. insurance company to sign UNEP Initiative | | |
| Evan Mills | Lawrence Berkeley Labs/DOE | Energy efficiency and reduced insurance risk | 510/486- 6784 | 510/486- 5394 |

III. ECONOMISTS

| Name | Title/Affiliation | Background | Phone # | Fax # |
|------------------------------|---|--|------------------|------------------|
| Robert Repetto ¹ | Senior Economist, World Resource Institute | authorized report explaining economic models related to climate | | |
| Stephen DeCanio ¹ | U. Of California, Santa Barbara | organized economists letter; staff at CEA during Reagan Administration | 805/893- 3130 | |
| Paul Krugman ¹ | Stanford University | original signor of economists letter | | |
| Peggy Duxbury ² | Program Manager, Redefining Progress | organization sponsored economists letter | 202/588- 8900 | |
| Joseph Stiglitz ¹ | Chief Economists, World Bank, ex-chair CEA | involved in economics section of IPCC | | |
| Richard Sandor ¹ | President, Centre Financial | emissions trading of sulfur and carbon dioxide | | |
| Dan Dudek ¹ | Environmental Defense Fund | Emissions trading proponent | 203/938- 3392 | 203/938- 4172 |
| John Palmisano ¹ | Enron Corp. | proponent of emissions trading | | |
| Jae Edmonds ¹ | Batelle Labs | Economic modeler; focus on trading and technology issues | | |
| Ev Ehrlich ¹ | President, ESC Company | Ex-Under secretary of Commerce; directed Administration's economic analysis | 347-3200 | |
| Robert Solow | MIT, Cambridge MA | Nobel winner and original signer of economists letter | | |
| Paul Portney | Resources for the Future, Washington, D.C. | Resource economists | | |

| | | | | |
|--------------------------|--|------------------|--------------|----------|
| Roger Dower ¹ | Ex-WRI and CBO economists, Sycom Enterprises; Washington, D.C. | Energy economist | 625-4118 | 625-1067 |
| Bill Moomaw | Tufts University, Ex-WRI policy director | | | |
| Irving Mintzer | Ex-WRI and Center for Global Change; Washington D.C. | | 301/587-8714 | |
| Alan Blinder | Princeton University, NJ Ex-member CEA | | | |

IV. PRIVATE SECTOR, TECHNOLOGY, AND EXPERT OPPORTUNITIES

| Name | Title/Affiliation | Background | Phone # | Fax # |
|------------------------------|--|--|--------------|--------------|
| Terry Thorne ¹ | Senior Vice President, Enron Corp. Houston, TX. | International energy markets, alternatives | 713/853-3071 | 713/646-4831 |
| Bruce McCrodden ¹ | Vice President, British Petroleum, Ohio | BP's leadership calling for action now | 212/207-6703 | 212/207-6755 |
| Ken Karas | President, Zond Corp. | Wind Energy | 703/351-5288 | 703/525-8841 |
| Roger Sant | AES Corp. | Energy in developing countries; joint implementation | 703/522-1315 | 703/276-6758 |
| Bud Cherry | Oxbow Corp. | Geothermal and other power in Florida | 407/697-4300 | 407/640-8847 |
| Glen Scovlatt | Honeywell Corp. | Potential for energy efficiency | 612/951-0050 | 612/951-0110 |
| Jim Wolfe | Vice President, United Technologies; Washington D.C. | Potential for energy efficiency technologies | | |
| David Nemptow ^{1,2} | Executive Director, Alliance to Save Energy; Washington D.C. | Potential for energy efficiency | 202/857-0666 | 202/331-9588 |
| Michael Marvin ² | Executive Director, Business Council for Sustainable Energy; Washington D.C. | Trade association of industries marketing efficient technologies; help line up industry | 202/785-0507 | 202/785-0514 |
| Daniel Lashoff | Senior Scientist, NRDC Washington D.C. | Climate specialist, co- authored NGO study, Energy Innovations | 202/289-2399 | 202/289-1060 |

| | | | | |
|----------------------------|--|---|--------------|--------------|
| John Holdren ¹ | Harvard University Cambridge, MA | Participated in President's briefing; chair of PCAST review of DOE's energy R & D | 617/495-1464 | |
| Robert Stempel | CEO, Energy Conversion Devices | Ex-CEO, GM | | |
| Alden Meyer | Union of Concerned Scientists | | | |
| Harvey Forest | Solarex, Frederick, MD | PV manufacturer | | |
| James Key | Johnson Controls | Go thru Doug Decker | | |
| Jared Blum ^{1,2} | Insulation Manufacturers Association | Big picture as well | | |
| Tom Dreissen | EPS | Energy service companies overseas | | |
| Scott Sklar ^{1,2} | Solare Energy Industries Association, Washington, D.C. | | 383-2611 | 383-2670 |
| Mark Spurr | District Heating Industry Association | | 612/227-8452 | 612/292-0014 |
| Amory Lovins ¹ | Director, Rocky Mountains Institute | Energy efficiency/business opportunities | 970/927-3851 | 970/927-4178 |
| Joseph Romm ¹ | Acting Ass't Sec., Energy Efficiency and Renewable/DOE | | 586-9220 | 586-9260 |

V. MISCELLANEOUS

| Name | Title/Affiliation | Background | Phone # | Fax # |
|---------------------|---|---------------------|--------------|--------------|
| Karl Rabago | Environmental Defense Fund, Texas | Former DOE official | | |
| Susan Tierney | Consultant, former Ass't Sec at DOE, Boston, Ma | | 617/491-4900 | |
| William Ruckelshaus | CEO, BFI Industries | | | |
| William Reilly | Former EPA Administrator | | | |
| Eileen Claussen | Alcalde and Fay, former State Dept. And NSC, Washington, D.C. | | 703/841-0626 | 703/243-2874 |
| Maxine Savitch | Allied Signal, former DOE official | | | |

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|-----------------|---|--|--------------|--------------|
| Henry Kendall | Founder, Union of Connecticut scientists | Participated in President's briefing | | |
| Roy Romer | Former Governor of CO | | | |
| James Florio | Former Gov. Of New Jersey | | | |
| Robert Shinn | Commissioner, NJ Dept of Environmental Protection | Chair of ECOs task force on climate | | |
| Charles Curtis | Former Deputy Secretary of DOE | | | |
| Jim Cooper | Former Sen. From Tennessee | | 615/780-4100 | 615/780-9420 |
| Phil Sharp | Chair of House energy power subcommittee; Director, Harvard Kennedy School Institute for Politics | Former Rep. From Indiana | | |
| Susan Savage | Mayor of Tulsa, member of PCSD | | 918/596-2100 | 918/596-9010 |
| Dennis Knobloch | Former Mayor of Valmeyer, Il | Town wiped out by flood in '94 and rebuilt | | |